Corporate credit booms, financial constraints, and the investment nexus*

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Abstract

Does corporate debt overhang affect investment over the medium term? To better uncover this association, I argue that we need: (i) firm-level data, (ii) a long-time series, (iii) to measure debt overhang with a concept of credit accumulation or credit boom; and (iv) to combine leverage with liquid assets to capture financial constraints. Using firm-level data for a large panel of US non-financial firms over 1985Q1-2019Q1, I find that debt overhang leads financially vulnerable firms – high debt and low liquid asset holdings – to cut back on investment: a 10 p.p. increase in the three-year change in the leverage ratio is associated with 5% lower investment after five years compared to the most resilient firms. My results indicate that financial constraints amplify the negative effects of persistent corporate credit booms on the real economy.

Keywords: Corporate credit booms; Firm investment; Financial constraints; Local projections

JEL classification: D22, E22, E32, G32

*The views in this paper represent only my own and should therefore not be reported as representing the views of the Bank of England.

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1 Introduction

How does corporate debt overhang affect investment growth? This long-standing question goes back to the seminal paper by Myers (1977). His hypothesis was that a highly leveraged firm is unable to raise additional debt to finance new projects, as the profits are appropriated by existing debt holders, not potential new investors. Similarly, in the presence of default risk, there may be underinvestment in projects with positive net present value, because equity holders do not benefit in case of default.[1] Credit or financial constraints, illustrated by high debt levels, would therefore be associated with weaker investment.

The literature has put Myers (1977)'s theory to a test by focusing on the relationship between the *level* of firm leverage and investment. For instance, Lang et al. (1996), Hennessy (2004), and Hennessy et al. (2007) show empirically that leverage is negatively associated with future growth. In particular, Lang et al. (1996) find this negative association for firms whose growth opportunities are not recognised by the capital markets, or for firms that do not have good investment opportunities. Their results are consistent with the view that debt has a disciplinary role in investment decisions (Grossman and Hart 1982). Focusing on the 2007-09 Great Financial Crisis (GFC), research has also found that firms with higher pre-crisis debt experienced weaker investment in the aftermath of the GFC (Campello et al. 2010, Giroud and Mueller 2017, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Barbiero et al. 2020, Blickle and Santos 2020, Demmou et al. 2021). This strand of research has mostly used firm-level data, while placing the focus on high debt as a constraint on investment.

The concept of 'high' or 'excessive' debt is, however, a subjective concept, and potentially firm-specific. The level of debt in itself may thus not be able to capture debt imbalances adequately. In addition, financial imbalances take some time to emerge. To capture debt overhang effects, we may need to look at a concept of credit accumulation for a long period of time, rather than at the level of debt. A large number of papers has found that credit booms or debt misalignments in the private sector are associated with economic slowdowns and future recessions (Schularick and Taylor 2012, Jordà et al. 2013, 2015, 2020, Dell'Ariccia et al. 2016, Baron and Xiong 2017, Krishnamurthy and Muir 2017, Mian et al. 2017, Albuquerque 2019, Greenwood et al. 2020, Richter et al. 2020).

But two recent papers make the case that only credit booms in household debt are associated with lower medium-term growth, while fluctuations in debt in the non-financial corporate (NFC) sector are not (Mian et al. 2017, Jordà et al. 2020). They measure debt overhang as long changes in the debt-to-GDP ratio, and use cross-country aggregate data for several advanced economies. Jordà et al. (2020) suggest that the unique feature and incentives of corporate debt imply that debt of firms in financial distress can normally be restructured and liquidated quickly, unlike household debt, therefore having minimal or no impact on medium-run GDP growth. These findings speak to an earlier literature on the finance-growth nexus, whereby credit deepening and the quality of financial intermediation create the conditions for faster investment and economic growth (King and Levine 1993, Levine 2005, Rancière et al. 2008, Beck et al. 2012).

[1] When a firm defaults, the liquidation of its assets accrues first to senior creditors, then to junior creditors, and only then to equity holders.

Overall, we are left wondering whether the mixed results in the literature on the effect of corporate debt overhang on investment are due to: the nature of the data, aggregate versus firm-level; or/and to the indicator of debt overhangs, level of debt or long changes in debt ratios. I argue that we need to merge both strands of the literature to improve our understanding about the association between corporate debt overhangs and future investment.

This paper contributes to the literature on credit cycles and economic activity by revisiting the corporate debt-investment nexus in a large quarterly panel of US firms from Compustat. Using a concept of a credit boom or credit build-ups, my main finding suggests that corporate debt overhang is associated with weaker future investment growth over the medium term, reminiscent of a debt overhang effect (Eggertsson and Krugman 2012). I show that financially constrained firms drive the results. This paper is closest in spirit to Mian et al. (2017), Blickle and Santos (2020), and Jordà et al. (2020), who study how corporate debt overhangs in the corporate sector transmit to the real economy.

Throughout the paper I make the case for using four key ingredients in the empirical framework. First, I use *micro-level* data for a large panel of listed US non-financial firms to account for the substantial firm heterogeneity in corporate balance sheets. Studies that use cross-country *aggregate* data may mask important relationships between debt overhang and investment (Beck et al. 2012, Mian et al. 2017, Jordà et al. 2020). Not accounting for firm heterogeneity may potentially bias the coefficients towards zero as the micro effects are washed away.

Second, I use data since the mid-80s that span several episodes of firm-specific debt build-ups. This allows me to overcome the challenge of extrapolating findings that focus on a particular episode, such as the GFC. The association between corporate debt and investment during the GFC may be plagued by important confounding effects, such as low bank capital and household deleveraging effects. This suggests that we should look at previous episodes of credit build-ups.

Third, I measure debt overhang by taking the accumulation of debt relative to assets over the preceding three years. This variable does not make a judgement about the level of debt *per se*, but instead identifies the emergence of credit booms or debt misalignments that sow the seeds of damaging and costly financial crises (Kindleberger 1978, Schularick and Taylor 2012, Jordà et al. 2013, 2015).

Fourth, I combine leverage and liquid assets to better capture financially constrained firms in the data. While leverage seems to be a popular proxy in the literature, there is not yet a consensus on which observables better identify constrained firms (Farre-Mensa and Ljungqvist 2016, Melcangi 2019). For instance, a firm with high debt may have a healthy balance sheet as reflected in high liquid asset holdings and high profits, and can thus take on more debt to finance future investment projects. Rather than using leverage or liquid assets in isolation, I show that we get a better proxy for financial constraints when looking at highly indebted firms *and* with limited liquid assets – firms that I label *vulnerable*. Specifically, vulnerable firms belong simultaneously to the top tertile of the leverage ratio, and to the bottom tertile of the net liquid asset ratio.

I study how investment growth evolves in the aftermath of credit build-ups by using Jordà (2005)'s Local Projections on a large panel data set of US non-financial firms over 1985Q1-2019Q1. My main findings are as follows. First, I provide evidence find that corporate credit booms are associated with weaker future investment over the medium term. I find that the negative association between debt and investment is driven by financially vulnerable (constrained) firms. Relative to a scenario of no credit boom, my estimates suggest that a 10 percentage point (p.p.) increase in debt build-ups for these constrained firms is associated with weaker investment of 3.4% after five years. For the same 10 p.p. increase in the pace of credit accumulation, constrained firms experience lower investment of roughly 2.5% compared to unconstrained firms.

Second, within unconstrained firms, I find that firms with low debt and high liquid asset holdings experience *increases* in investment in the aftermath of credit build-ups. This suggests that we are in the presence of 'Resilient' firms with high financial flexibility whose debt accumulation allows them to finance investment (Fahlenbrach et al. 2020). I find a large and statistically significant difference in the investment behaviour between vulnerable and resilient firms: for every 10 p.p. increase in debt build-ups, investment of vulnerable firms is around 5% lower after five years.

Third, using corporate bond yields from TRACE, I offer some evidence that debt build-ups in vulnerable firms are associated with a larger and statistically significant increase in borrowing costs relative to non-vulnerable firms. This highlights the role that financial constraints may have in amplifying the negative effects of a credit boom through higher borrowing costs (Blickle and Santos 2020, Ebsim et al. 2020). Constrained firms arguably face higher (re-)financing costs and therefore tighter credit conditions, which ultimately 'force' them to cut back on investment spending when a credit boom becomes excessive or unsustainable relative to a firm's assets.

Fourth, I also find some supporting evidence showing that constrained firms tend to burn through their liquid assets in the aftermath of credit booms (Campello et al. 2010). The decline in liquid assets may reflect the need to tap into liquidity to mitigate the impact of binding credit constraints. In contrast, I find that resilient firms tend to strengthen their liquid asset position following credit booms – presumably for precautionary reasons and to prevent them from becoming constrained (Melcangi 2019). I hypothesise that the fall in investment for vulnerable firms could have been larger than I estimate, had liquid assets remained stable.

Fifth, the source of financing matters. I find that build-ups in bank loans for vulnerable firms appear to be associated with larger declines in investment than build-ups originated in market debt. My results suggest that the source of the debt build-up, after controlling for the share of bank debt in total debt, is indicative of larger investment cuts in the aftermath of a credit boom. This is a novel result in the literature that complements the view that firms that rely on bank debt to finance investment projects are more exposed to credit supply shocks (Kashyap et al. 1993, Becker and Ivashina 2014).

Sixth, using quantile panel regressions (Machado and Santos Silva 2019, Jordà et al. 2020, Adrian et al. 2021), I find that corporate debt booms affect more the left tail of the investment growth distribution. This suggests that credit booms amplify downside risks to the real economy (Aikman et al. 2019, Adrian et al. 2021).

Finally, I focus on the GFC as a laboratory experiment to study the cross-sectional behaviour of investment during a period of large credit supply shocks. In line with my full sample results, I find that firms that increased their pre-crisis leverage ratio by more, also experienced a sharper decline in the capital stock over 2007-10. I also find that cash-rich firms experienced smaller reductions in investment (Joseph et al. 2019).

My main findings remain robust to: (i) using alternative measures of financial constraints, such as the Hoberg and Maksimovic (2015) index, and to a lesser extent firm age (Bahaj et al. 2019, Cloyne et al. 2019, Durante et al. 2020); (ii) adding more controls variables; (iii) allowing for more persistent credit booms; (iv) using alternative definitions of vulnerable firms; (v) controlling for industry-specific shocks; and (vi) to excluding the GFC.

The rest of the paper is organised as follows. In Section 2 I look at some stylised facts about the US aggregate corporate credit cycle, and in Section 3 I describe the firm-level Compustat data. In Section 4 I discuss the econometric approach. I present my main results on the relationship between corporate credit booms and investment in Section 5. I run panel quantile panel regressions in Section 6 to explore how credit booms affect the distribution of investment growth. Section 7 include a battery of robustness checks. Section 8 focuses on the GFC. Section 9 concludes the paper. The Online Appendix includes additional figures, and replicates some of the main regressions at the industry level.

2 Corporate debt cycles

Even before the COVID-19 shock struck the world economy in March 2020, concerns about the sustainability of the US corporate credit cycle had already been in the radar of the media and policymakers alike.[2] The corporate sector had been accumulating debt – debt securities and loans – at a rapid pace since the end of 2010, leading to a record-high debt of 47% relative to GDP at the end of 2019 (left panel of Figure 1). The fast leveraging process in the NFC sector was presumably supported by increasing risk appetite and loose financial conditions, amid an environment of low interest rates.

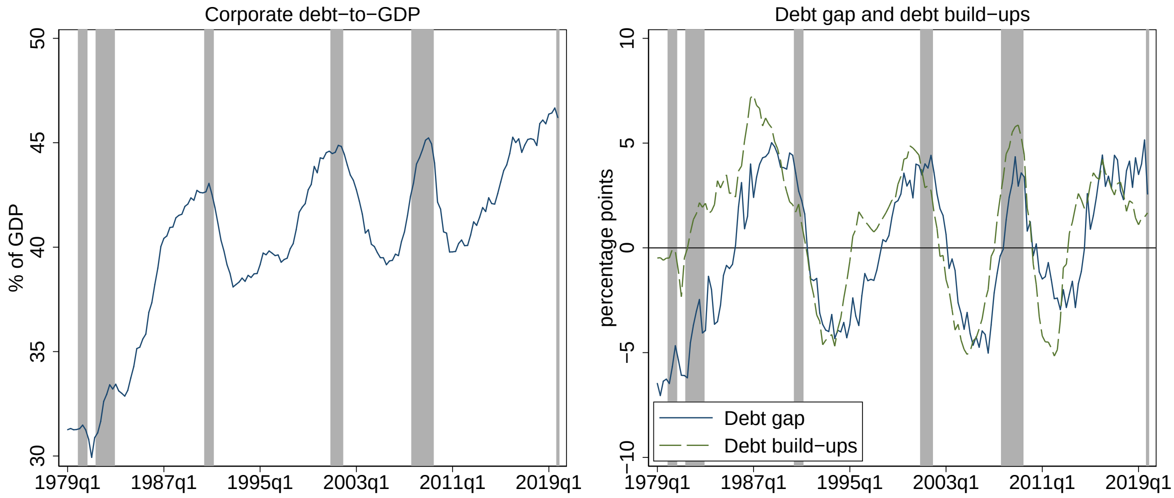
The large swings in corporate debt over the past 15 years – deleveraging after the GFC and debt build-up afterwards – are not a unique feature of the most recent cycle; in fact, they are a common pattern of business cycles over the past 40 years. Leverage typically spikes just before or during a recession, and then declines substantially. This was particularly evident in the run-up to past US recessions since the early 90s: the accumulation of debt at a significant stronger pace than GDP over the preceding three years had opened up a considerable debt gap in the NFC sector (right panel of Figure 1). This variable will be used throughout the paper to capture credit booms or debt build-ups (Schularick and Taylor 2012, Jordà et al. 2015, Dell'Ariccia et al. 2016, Krishnamurthy and Muir 2017, Mian et al. 2017, Greenwood et al. 2020).[3] It is highly correlated with the debt gap, measured as the cyclical component of the debt ratio, suggesting that both indicators proxy debt imbalances.[4]

[2]See, for instance, reports by the International Monetary Fund, the Federal Reserve, and media articles in The Economist and Financial Times.

[3]I use the terms debt build-ups and credit booms interchangeably.

[4]I detrend the non-stationary debt-to-GDP ratio with the new method developed by Hamilton (2018). This approach overcomes the typical issues associated with the HP filter, namely the spurious dynamic relations with no basis in the underlying data generating process produced by the HP filter, and the well-known end-of-sample issue. The Hamilton method essentially translates into regressing a given non-stationary variable at $t{+}h$ on a constant and on the four most recent values of the dependent variable available at time t. To capture the long cycles in debt, I set the forecasting horizon at $h{=}20$ quarters.

Figure 1: Corporate debt imbalances



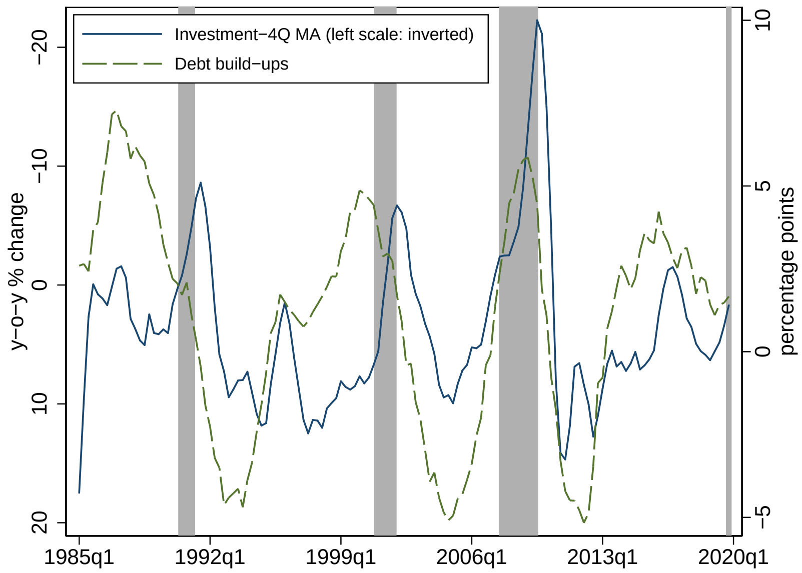
Sources: Bureau of Economic Analysis, Flow of Funds, and author's calculations.
Notes: The left panel shows the sum of debt securities and loans of the non-financial corporate business divided by GDP. The right panel shows corporate debt build-ups computed by taking the three-year change in the corporate debt-to-GDP ratio; the debt gap plots the cyclical component of the Hamilton (2018) filter. The shaded area indicates recessions as defined by the NBER.

The question is whether these debt cycles may amplify business cycles through the direct impact on investment.[5] A quick look at aggregate data for the US economy seems to point in the direction of corporate credit cycles and investment cycles going hand-in-hand: credit booms typically coincide with investment growth slowdowns (Figure 2). The univariate correlation between credit booms and investment is particularly high over the past 20 years (correlation of -0.66). The average path of investment growth during corporate credit booms can illustrate this relationship further. I identify credit booms as periods when the the three-year change in the corporate debt ratio is above its sample standard deviation. This approach is similar to the one used in Richter et al. (2020), who use the Hamilton filter to look at the cyclical component of debt. In Figure 3 I plot the average path of the debt build-up variable, and of investment growth. It is striking to observe that investment growth starts to slow down roughly two years before the credit boom reaches its peak – the zero in the x-axis – and only starts to recover one year after the peak. Although I am silent on causal effects, the evidence here is suggestive of long and protracted build-ups of debt imbalances being associated with a decline in investment several quarters before the credit boom comes to an end.

In Figure 4 I look at price variables, measured with the Moody's Baa spread relative to the ten-year Treasury yield, and with the excess bond premium (EBP) from Gilchrist and

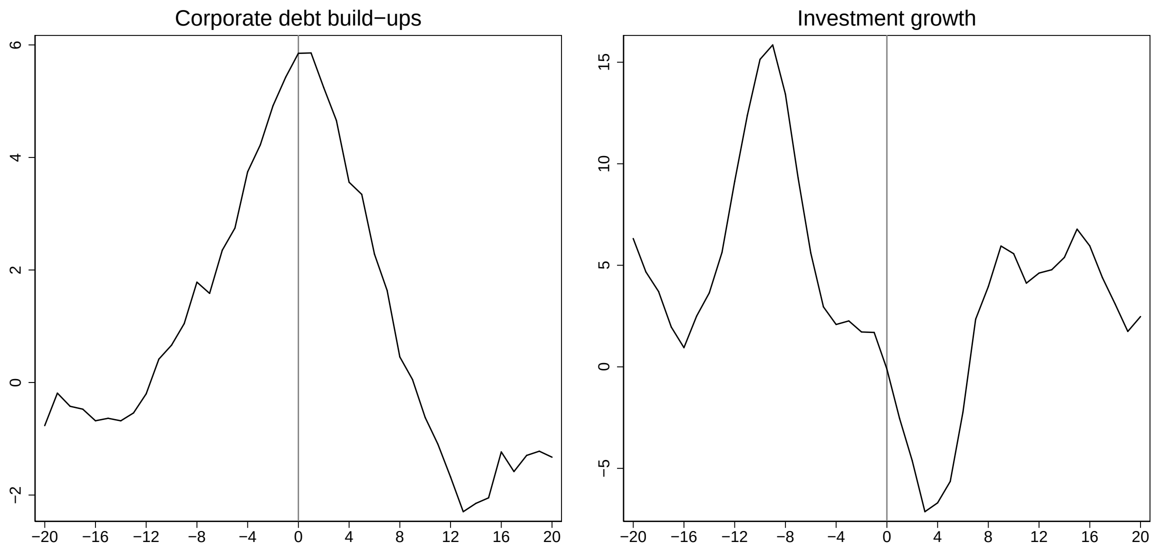
[5]There is a plethora of papers finding that household debt build-ups are associated with large consumption cuts and economic slowdowns, and raise the probability of a financial crisis ahead (Mian and Sufi 2010, 2011, Schularick and Taylor 2012, Jordà et al. 2013, 2015, Dell'Ariccia et al. 2016, Albuquerque and Krustev 2018). Research has predominantly focused on the household sector arguably because of two main reasons. First, household debt was at the centre of the GFC. Large levels of debt accumulated in the run-up to the crisis forced households to default or to delever significantly and cut consumption (Mian and Sufi 2010, 2011). The household sector was then the natural place for researchers to start uncovering the relationship between debt and economic activity. And, second, the strong rise in private debt in several Western countries in the second half of the twentieth century appears to have been driven mainly by credit to households, particularly mortgage debt, as documented by Jordà et al. (2015). At first glance corporate debt worldwide seems to have gone through much smoother cycles over the last decades. This created the notion that research should look primarely at the household sector to understand how fluctuations in private credit determine business cycles.

Figure 2: Investment growth and corporate debt build-ups



Sources: Bureau of Economic Analysis, Flow of Funds, and author's calculations.
Notes: Investment growth refers to the year-on-year percentage change in the four-quarter moving average of real gross private domestic investment from the National Income and Product Accounts. The y-axis for investment is inverted. I compute debt build-ups by taking the three-year change in the corporate debt-to-GDP ratio. The shaded area indicates recessions as defined by the NBER.

Figure 3: Average path of debt build-ups and investment around corporate credit booms

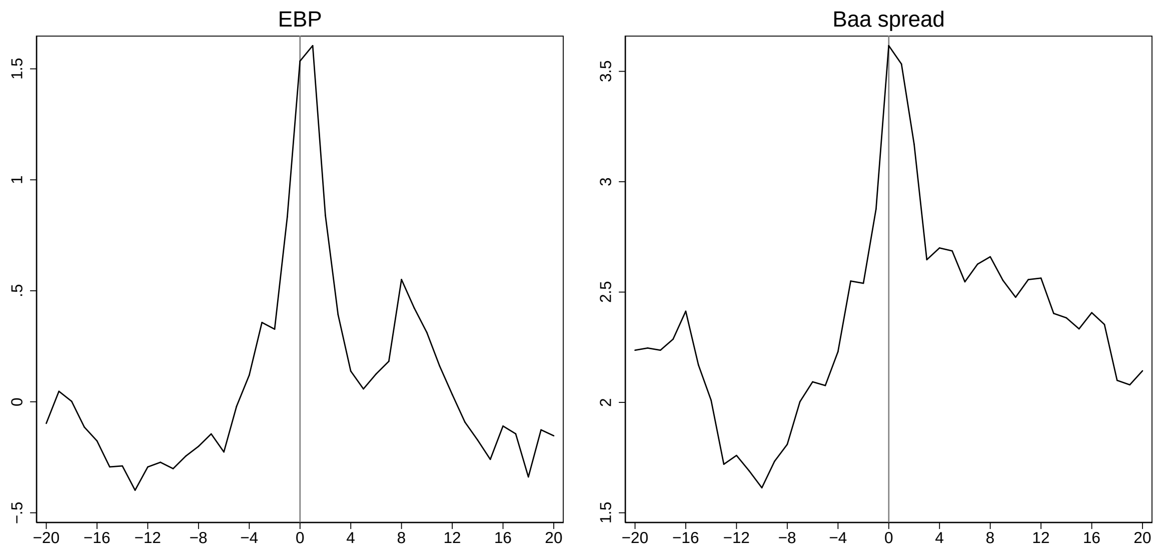


Sources: Bureau of Economic Analysis, Flow of Funds, and author's calculations.
Notes: Average path of the three-year change in corporate credit to GDP ratio and investment growth around episodes of corporate credit booms. The x-axis shows quarters before and after the peak in the credit boom.

Zakrajšek (2012).[6] I find that corporate spreads tend to be low before the credit boom reaches its peak, starting to rise faster once the credit boom reaches its peak. Low corporate spreads during credit booms is in line with the notion that credit booms fuelled by expansions in the supply side of credit are a precursor to financial crises (Kindleberger 1978, Schularick and Taylor 2012, Jordà et al. 2013, 2015, Dell'Ariccia et al. 2016, Baron and Xiong 2017, Krishnamurthy and Muir 2017, Greenwood et al. 2020). In addition, Greenwood and Hanson (2013) uncover another central feature of the credit cycle: credit expansions are followed by a deterioration in the average quality of corporate debt issuers, adding some more evidence that credit supply expansions may be behind the emergence of corporate debt booms. Although the evidence here is not definitive – and is beyond the scope of the paper – debt accumulation by firms for a long period of time seem to be driven by credit supply shocks.

The analysis so far has relied on univariate correlations from US aggregate data, which only provide a partial picture of the relationship between debt and investment. In the rest of the paper I will use firm-level data to better inspect how investment growth evolves in the aftermath of credit booms in the corporate sector.

Figure 4: Average path of corporate credit spreads around corporate credit booms



Sources: Bureau of Economic Analysis, Flow of Funds, and author's calculations.
Notes: Average path of Gilchrist and Zakrajšek (2012)'s EBP and of the Moody's Baa corporate bond yield relative to the ten-year treasury constant maturity yield around episodes of corporate credit booms. The x-axis shows quarters before and after the peak in the credit boom.

3 Firm-level data

While aggregate data are informative to track trends and discern patterns, I argue in this paper that using more granular data is key to accounting for the significant heterogeneity across firms. Specifically, I use quarterly data from Compustat (Wharton Research Data Services) with balance sheet information on US non-financial listed companies. I exclude firms in the

[6] The EBP is a measure of investor sentiment or risk appetite in the corporate bond market that is not directly attributable to expected default risk. The EBP is defined as the spread between the rate of return on corporate securities and a similar maturity government bond rate that is left after removing the default risk component.

'Finance, Insurance and Real Estate' sectors, and make some other adjustments to the sample, in line with standard practice in the literature (see Appendix A for the details). My final sample covers an unbalanced panel of 4,742 distinct non-financial firms over 1985q1-2019q1, resulting in 246,835 firm-quarter observations. I deflate nominal variables with the national Consumer Price Index for All Urban Consumers (CPI-U).

To zoom in on the heterogeneity across firms, I first split firms into three equal bins of leverage and liquidity at each point in time. I measure leverage with the book value of total debt (short plus long term), and liquidity with current assets (cash and short-term investments, receivables, inventories, and other current assets) net of current liabilities (short-term debt, accounts payable, income taxes payable, and other current liabilities). I show both indicators as a fraction of total assets. I define firms with low debt/liquid assets as those belonging to the first tertile of the respective sample distribution, firms with moderate debt/liquidity to the second tertile, and firms with high debt/liquidity to the third tertile.

The first three rows of Table 1 show that firms with high debt are typically larger – as measured by median total real assets in 2009 USD – have limited liquid assets, and record the lowest capital spending growth in the sample. High-debt firms also appear to be associated with higher default risk, as reflected in the lowest interest coverage ratio (ICR) – the ratio of EBIT (earnings before interest, and taxes) to interest expenses (Palomino et al. 2019).[7] In the middle panel I split the sample by liquid asset holdings: firms with greater liquid asset holdings tend to be smaller, with low leverage relative to their assets, tend to invest more than other firms, and seem to be more financially resilient, as indicated by a higher ICR.

In the last rows, I combine leverage with liquid asset holdings, and split the sample into three bins of the debt-to-liquid asset ratio. Firms with high debt relative to liquid asset holdings are large, have substantial leverage, hold moderate levels of liquid assets, and have the lowest ICR. In turn, while firms with low debt relative to liquid assets appear to have healthier balance sheets, as seen in low leverage levels and moderate ICRs, the typical firm in this bucket does not hold any positive amount of net liquid assets.

Table 1: Descriptive statistics (median values)

		Size	Leverage	Liquidity	Δ log($capex$)	ICR
Leverage	Low	93.15	0.01	0.38	9.31	20.26
	Moderate	451.62	0.23	0.17	6.06	5.44
	High	507.32	0.43	0.07	4.16	2.06
Liquidity	Low	944.49	0.33	0.00	4.09	2.98
	Moderate	330.77	0.23	0.20	6.05	4.62
	High	87.94	0.06	0.47	10.00	7.00
Debt to liquid assets	Low	179.62	0.09	0.00	6.16	3.37
	Moderate	160.51	0.14	0.34	8.09	7.92
	High	609.08	0.34	0.10	4.88	2.94

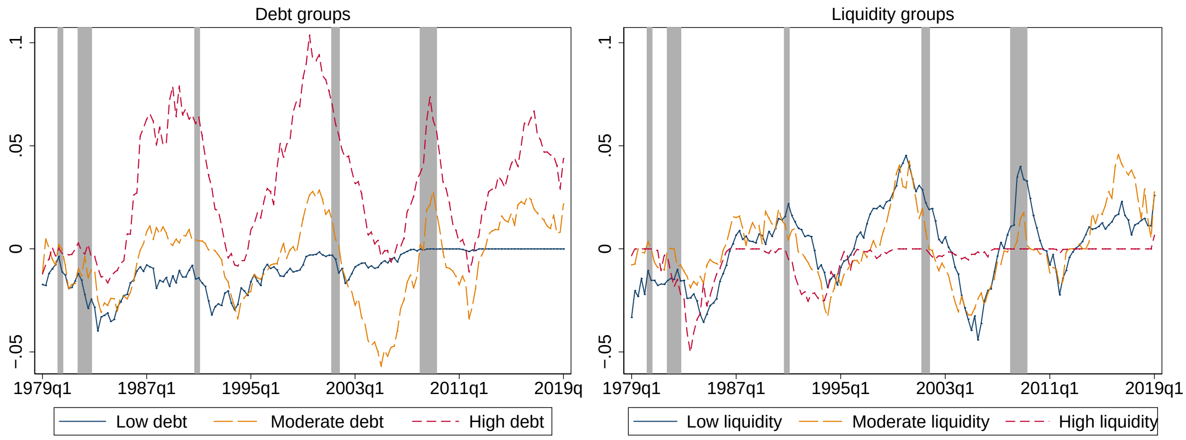
Notes: Size refers to total real assets in 2009 USD, leverage to the ratio of short-term and long-term debt to total assets, liquidity to the ratio of net current assets to total assets, capex to capital spending, and ICR to the ratio of EBIT to interest expenses.

I also find substantial cross sectional and time variation in the credit accumulation dynam-

[7]The ICR measures the ability of a company to service its debt with internal cash flows.

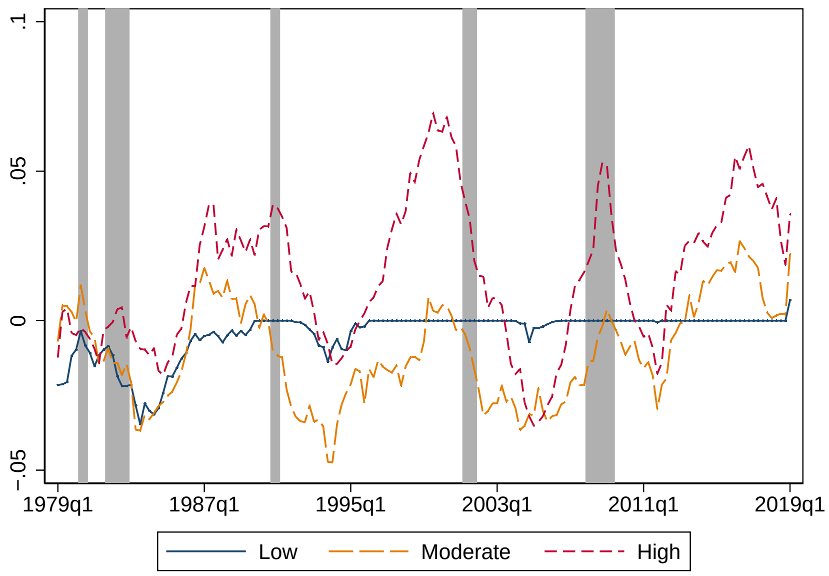
ics. The left panel of Figure 5 shows that the typical highly indebted firm has experienced large swings in debt build-ups over the last decades: the pace of debt accumulation increases substantially in the run-up to recessions, but then declines as deleveraging takes place and as the economy slows down. By contrast, firms with low debt have a rather stable debt-to-asset ratio. The right panel shows that firms holding a greater share of liquid assets have barely recorded a credit boom. A similar picture emerges when I split the sample based on the debt-to-liquid asset ratio: firms with low debt relative to their assets typically do not experience a credit boom (Figure 6).

Figure 5: Corporate debt build-ups for leverage and liquidity groups



Sources: Compustat, and author's calculations.
Notes: Debt build-ups take the three-year change in the corporate credit-to-asset ratio. Low debt (liquidity) refers to the first tertile of the ratio of debt (net current asset) to total assets distribution, moderate debt (liquidity) to the second tertile, and high debt (liquidity) to the top tertile. The shaded area indicates recessions as defined by the NBER.

Figure 6: Corporate debt build-ups for debt-to-liquidity groups



Sources: Compustat, and author's calculations.
Notes: Debt build-ups take the three-year change in the corporate credit-to-asset ratio. Low refers to the first tertile of the debt-to-liquid asset ratio distribution, moderate to the second tertile, and high to the top tertile. The shaded area indicates recessions as defined by the NBER.

4 Econometric framework

I make the case for using four key ingredients in the empirical framework to better uncover the association between corporate credit booms and investment spending. First, I use *micro-level* data on a panel of non-financial firms to account for the heterogeneity in corporate balance sheets across firms. Studies that use cross-country *aggregate* data, such as Beck et al. (2012), Mian et al. (2017) and Jordà et al. (2020) may mask important relationships between corporate credit booms and investment, potentially biasing the coefficients towards zero as the micro effects are washed away.

Second, I use data since the mid-80s that span several episodes of firm-specific debt build-ups. This allows me to overcome the challenge of extrapolating findings from a particular episode, such as the GFC (Campello et al. 2010, Giroud and Mueller 2017, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Barbiero et al. 2020, Blickle and Santos 2020). For instance, the association between corporate debt and investment during the GFC may be plagued by important confounding effects, such as low bank capital and household deleveraging effects. In fact, the decline in investment we see in the data around this period may reflect other factors than just debt overhang: impaired banks had to cut credit supply to meet capital requirements. This suggests that we should look at previous episodes of credit build-ups.

Third, I take the accumulation of debt relative to assets over the preceding three years (12 quarters) as the measure of credit booms or debt build-ups. This variable captures sustained increases in debt over a specific period of time; it does not make a judgement about the level of debt *per se*, whether it is excessive or high, but instead identifies the emergence of credit booms or debt misalignments that sow the seeds of damaging and costly financial crises (Kindleberger 1978, Schularick and Taylor 2012, Jordà et al. 2013, 2015). Using the cumulative change in the debt ratio instead of the level of debt-to-assets or the first difference in the ratio allows the researcher to take into account the slow-moving properties of the debt variable, since financial imbalances take some time to emerge (Schularick and Taylor 2012, Jordà et al. 2013, 2015, 2020, Dell'Ariccia et al. 2016, Baron and Xiong 2017, Krishnamurthy and Muir 2017, Mian et al. 2017, Greenwood et al. 2020).[8] In addition, the relatively large window of three years reduces the risk of capturing short-run fluctuations in the debt ratio due to the need to rollover existing debt, or due to other normal day-to-day operational decisions.

Fourth, I combine leverage and liquid assets to better capture financially constrained firms in the data. In Section 5.2 I will show empirically that it is challenging to use leverage or liquid assets in isolation to explain why some firms cut investment spending more than other firms in the aftermath of a credit boom (a similar point made by Jeenas 2019, in the context of a monetary policy shock). For instance, it is perfectly possible that a firm with high debt has a healthy balance sheet, and can thus take on more debt to finance future investment projects. High debt can, for instance, also be matched by considerable liquidity levels and high profits that make debt not that relevant as a proxy for borrowing constraints. By the same token, firms may choose higher liquidity because they may be credit constrained or for precautionary

[8] Other papers have used a concept of a debt gap by detrending the debt ratio from its cyclical movements (Albuquerque 2019, Richter et al. 2020). The debt gap and long changes in the debt ratio, either three-year or five-year changes, are highly correlated, as we have seen in Figure 1.

reasons (Bacchetta et al. 2019, Melcangi 2019, Cunha and Pollet 2020). I will argue that financial constraints are better captured by *combining* high levels of debt with limited liquid assets.

Armed with these four key ingredients, I revisit the relationship between corporate debt build-ups and investment spending in a large panel of US firms. I regress capital expenditures (capex) on debt build-ups and firm fundamentals over 1985q1-2019q1. I use Local Projections (LP) methods (Jordà 2005), which involve running separate regressions for each horizon h=0, 1,. . . , 20 quarters:

$$\Delta_h \log(I_{i,t+h}) = \beta^h \Delta_{12} Debt_{i,t-1} + \sum_{j=1}^{4} \lambda_j^h X_{i,t-j} + \eta_i^h + \zeta_t^h + \epsilon_{i,t+h}, \tag{1}$$

where the dependent variable $I_{i,t+h}$ is the cumulative percentage change in the logarithm of real investment spending (capex) from period t to $t+h$ for firm i, $\Delta_{12} Debt_{i,t-1}$ refers to corporate debt build-ups, measured with the 12-quarter change in the debt-to-asset ratio, and $X_{i,t-j}$ is a vector of firm-specific variables that include the debt-to-asset ratio in levels, the logarithm of real assets to proxy for the size of the firm, liquid asset holdings computed as the ratio of net current assets to total assets, and lags of the dependent variable. I add these controls to minimise the possibility that the association between debt build-ups and future investment spending may be capturing other time-varying firm-specific factors. The baseline model has four lags. Fixed effects η_i^h control for time-invariant idiosyncratic firm characteristics, and time-fixed effects ζ_t^h account for unobserved aggregate shocks. Results are robust to controlling for time-varying industry-specific shocks (see Section 7).

The key parameter of interest is β^h which gives us the sensitivity of investment spending growth to debt build-ups over a five-year horizon. With the LP method, the impulse responses of investment growth at $t+h$ should be interpreted as a forecast of how investment will evolve at a given h horizon when the debt build-up variable changes by one unit at time $t-1$. Although I am not interpreting here the coefficients as a *causal* effect of debt on investment, the fact that the debt build-up variable and a rich set of controls are all pre-determined reduces the chances that the investment behaviour after a credit build-up can be explained by other factors than debt (Jordà et al. 2020).[9]

I adjust standard errors with the Driscoll and Kraay (1998) estimator to account for correlation in the error term across firms and time, as the LP method with panel data usually exhibits cross-sectional and temporal dependence. This clustering method is also particularly helpful to deal with within-country correlation induced by overlapping observations from the way the corporate debt build-up variable is constructed.

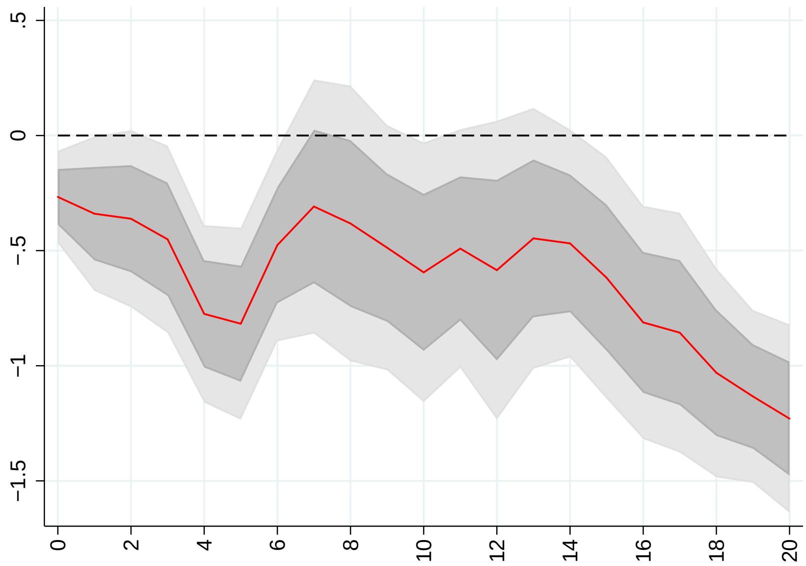
[9]The regressions describe the dynamic relationship between past debt accumulations and future investment spending. The impulse responses from the local projections can be thought of as responses of investment to reduced-form innovations in debt accumulation, after controlling for a set of firm-level characteristics.

5 Main results

5.1 Average response

I run regressions of Equation (1) for each horizon and plot the β^h coefficients in Figure 7. I find that corporate debt build-ups are associated with weaker future investment spending over the medium term: a 10 p.p. increase in corporate debt build-ups is associated with lower investment of around 1.2% during the subsequent five years (Figure 7). Investment tends not to recover during the five-year period, suggesting that credit booms tend to scar investment permanently. Although these results do not allow me to disentangle the mechanisms behind the negative association between credit accumulation and investment, my findings are in line with the notion that the (excessive) accumulation of debt would eventually lead to a contraction in credit and lower output over the medium term, i.e. a debt overhang effect, or forced-deleveraging mechanism described in Eggertsson and Krugman (2012). In a scenario where fast build-ups in leverage may prevent firms to raise new debt to finance their activity, my results suggest that in order to avoid insolvency, a firm is left with the option of cutting investment, other costs or downsizing.

Figure 7: Impulse responses of investment spending to corporate debt build-ups



Notes: Cumulative impulse responses of capex 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.

I re-run the same type of regression but with corporate bond yields as the dependent variable to track whether credit booms are associated with increased borrowing costs for firms. I use data from the Trade Reporting and Compliance Engine (TRACE), which provides daily transaction-level data on bond trades with information on several characteristics, including price and quantity traded. The data are available since 2002. I compute the quarterly average yield of firm i by taking the volume-weighted average of the trading yield for a bond within the quarter. I am able to match 1,165 of unique firms, resulting into 40,622 firm-quarter observations. This is a substantially smaller sample than the one used throughout the paper (16% of the main sample), making comparability regarding firm composition and time span quite challenging. With this caveat in mind, Figure B.1 in Appendix B shows that borrowing costs increase in the aftermath of a build-up in corporate debt (Krishnamurthy and Muir 2017).

My specification estimated on micro data points to corporate credit booms being associated with persistent investment spending contractions and higher borrowing costs. How does this square with the related literature? Earlier findings pointed to a link between the *level* of debt and lower future investment growth (Myers 1977, Bernanke et al. 1990, Lang et al. 1996, Hennessy 2004, Hennessy et al. 2007). Recent papers using micro data on US firms (Campello et al. 2010, Giroud and Mueller 2017, Blickle and Santos 2020), and on EU firms (Kalemli-Ozcan et al. 2019, Demmou et al. 2021) have also found important debt overhang effects around the GFC: the amount of debt firms held pre-crisis – proxy for financial constraints – was associated with weaker investment during the GFC.[10]

The literature on predicting financial crises or recessions has found that credit booms in *both* the household sector and in NFCs contain relevant information for predicting the severity of a future recession (Bridges et al. 2017, Greenwood et al. 2020). Moreover, using quantile panel regressions, Aikman et al. (2019) and Adrian et al. (2021) find that loose financial conditions coupled with rapid growth in either household or corporate debt raise downside risks to GDP growth over the medium term.

In contrast, two recent papers using cross-country aggregate data provide evidence that credit booms in the NFC sector do not seem to be associated with lower economic activity (Mian et al. 2017, Jordà et al. 2020). Mian et al. (2017) use data for 30 mostly advanced countries from 1960 to 2012, and find that only household debt build-ups predict lower GDP growth, not NFC debt. Using a panel of 17 advanced economies dating back to the 19^{th} century, Jordà et al. (2020) also do not find any link between corporate credit booms and lower future investment or economic growth during recessions and recoveries. Jordà et al. (2020) argue that the unique feature and incentives of corporate debt imply that debt of firms in financial distress can normally be restructured and liquidated quickly, unlike household debt, therefore having minimal or no impact on medium-run GDP growth.[11] These two papers seem more aligned with an earlier literature on the finance-growth nexus: there is an investment channel through which credit deepening and the quality of financial intermediation is associated with faster economic growth (King and Levine 1993, Levine 2005, Rancière et al. 2008, Beck et al. 2012). The argument is that financialisation stimulates economic growth by increasing the rate of capital accumulation and by improving the efficiency with which economies use that capital (King and Levine 1993). For instance, using cross-country growth regressions over 1994-2005, Beck et al. (2012) argue that changes in bank credit to firms are positively associated with

[10] A large number of papers has looked at the role of debt in the transmission of monetary policy to investment using firm-level data. On the one hand, there is evidence that investment of credit-constrained firms are more responsive to monetary policy, alluding to Bernanke and Gertler (1995)'s financial accelerator theory (Bahaj et al. 2019, Cloyne et al. 2019, Jeenas 2019, Anderson and Cesa-Bianchi 2020, Durante et al. 2020). But, on the other hand, Ottonello and Winberry (2020) find the opposite result that firms with low default risk or low debt burdens are the most responsive to monetary policy shocks because they face a flatter marginal cost of investment finance.

[11] Wittry (2020) finds that only non-traditional debt – unsecured reclamation liabilities – induces a debt overhang effect on investment, as this debt overhang is costly to resolve, leading firms to forgo and postpone high net present value investments. In contrast, traditional debt is not associated with falls in investment in positive present value projects. Wittry (2020) suggests that studies that find a negative relationship between leverage ratios and capital expenditure are not necessarily identifying a debt overhang effect, but could just be capturing a decrease in the firm's investment opportunity set or even a decrease in negative net present value projects.

economic growth, while changes in bank credit to households are not.

Overall, it seems that the literature using firm level-data tends to find a negative association between debt and investment growth (Lang et al. 1996, Hennessy 2004, Hennessy et al. 2007, Giroud and Mueller 2017, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Blickle and Santos 2020, Demmou et al. 2021), while studies employing aggregate macro data do not (King and Levine 1993, Rancière et al. 2008, Beck et al. 2012, Mian et al. 2017, Jordà et al. 2020). My conjecture is that aggregate data may not be very informative when there is substantial heterogeneity across firms' balance sheets.

I illustrate further the point that aggregate data may yield different results when the considerable heterogeneity in corporate balance sheets across firms is not taken into account. I run regressions similar to Equation (1) but using US aggregate data from the Flow of Funds (FoF), and the 12-quarter cumulative change in the debt to GDP ratio for both households and corporates, as in Mian et al. (2017). The dependent variable is the cumulative change in real GDP up to ten years ahead. I run specifications with and without controls; in the latter, I add several economic and financial variables, namely the growth rate of household debt and of NFC debt, the fed funds rate, the EBP, a time trend, and a recession dummy. Both specifications, with and without controls, are in line with Mian et al. (2017) and Jordà et al. (2020): only debt build-ups in the household sector are associated with future economic slowdowns (Figure B.2 in Appendix B). The results remain robust to excluding the GFC (Figure B.3). All in all, this exercise shows that using *aggregate* country data may mask important relationships between corporate credit booms and the real economy, as the micro effects can only be uncovered when using more more granular data.

5.2 Non-linearities: credit and liquidity constraints

I explore non-linearities in the data by investigating which firm characteristics may contribute to the association between rapid increases in leverage and weaker future investment. My conjecture is that the debt overhang effect may be stronger for firms that are more financially constrained. But it well may be the case that credit build-ups are fundamentally detrimental to the economy, irrespective of the health of the balance sheet of a firm.[12]

The main challenge is in identifying firms in the data that are more financially vulnerable or credit constrained. While leverage seems to be a popular proxy, the literature is still debating which observables better identify credit-constrained firms (Farre-Mensa and Ljungqvist 2016, Melcangi 2019). The most common measures used in the literature to capture financial constraints include regression-based indices that focus: on the reliance of a firm on external financing (Kaplan and Zingales 1997); on firms with low cash flows, high leverage, weak growth, among others (Whited and Wu 2006); and on younger and smaller firms (Hadlock and Pierce 2010, Fort et al. 2013). But these reduced-form regressions estimated on small samples suffer

[12] This question resonates with managers when facing the difficult decision of determining the importance of the debt overhang in the capital structure of the firm. This is a complex issue because contracting and debt composition mechanisms endogenously arise to mitigate debt overhang effects (Wittry 2020). In addition, to identify the full costs of debt overhang requires the firm to observe its investment opportunities for alternative projects, which is arguably subject to extreme uncertainty. I abstract from these issues in this paper and just let the data speak about the path that investment growth typically follows in the aftermath of credit build-ups.

from out-of-sample extrapolation issues, as the estimated coefficients are applied to a different sample of firms, while assuming parameter stability across firms and time (Hoberg and Maksimovic 2015, Farre-Mensa and Ljungqvist 2016). Farre-Mensa and Ljungqvist (2016) find that the majority of 'constrained' firms identified through these three indices do not behave as if they were constrained; constrained firms are actually able to raise additional debt following an exogenous debt increase (a tax increase), and can use the proceeds of equity issues to increase payouts to shareholders. The authors suggest that constraints identified in the literature may just reflect differences in the growth and financing policies of firms at different stages of their life cycles.

Other measures of financial constraints include firm size (Gertler and Gilchrist 1994, Bernanke et al. 1999), firms that do not pay dividends (Fazzari et al. 1988), the age of the firm (Gertler 1988, Bahaj et al. 2019, Durante et al. 2020), and young firms that do not pay dividends (Cloyne et al. 2019). One of the caveats is that liquid assets do not play a direct role in determining how financially constrained a firm is. The exception includes Jeenas (2019) and Joseph et al. (2019) who argue for using liquid asset holdings, or cash, rather than just leverage alone, to proxy for credit constraints. Moreover, Hoberg and Maksimovic (2015)'s index of financial constraints identifies firms with liquidity issues based on the textual analysis of the Management's Discussion and Analysis (MD&A) section in firms' 10-Ks.

Against this background, I explore the heterogeneous responses of investment following credit booms with three simple – regression-free – proxies of credit constraints: leverage, liquid assets, and the combination of both.[13] I investigate, in particular, whether the relationship between past credit booms and investment growth is monotonic in these three measures. I start by splitting the sample into the same bins of firms as used in Section 3, and adapt Equation (1) to allow for heterogeneous coefficients across groups:

$$\Delta_h \log(I_{i,t+h}) = \sum_{k=1}^{N} \left[\beta_k^h \Delta_{12} Debt_{i,t-1} + \sum_{j=1}^{4} \lambda_{j,k}^h X_{i,t-j} \right] + \eta_i^h + \zeta_t^h + \epsilon_{i,t+h} \tag{2}$$

The parameters of interest are β_k^h=$\{1,2,3\}$ which show the relationship between investment spending and debt build-ups for each k bins (low, moderate, and high) of leverage, liquid asset holdings, and debt to liquid assets.

The left panel of Figure B.4 in Appendix B shows that it is not clear that high-debt firms are associated with lower investment in a statistically significant way after a credit boom. In addition, the decline in investment appears to be non-monotonic in leverage: firms with moderate debt levels (second tertile of the distribution) tend to be associated with larger declines in investment than high-debt firms: the right panel depicts the difference in the estimates between high-debt firms and the other debt groups. There is also no evidence that high-debt firms experience different investment dynamics compared to low-debt firms. At face value, it seems that leverage may not be capturing credit constraints adequately (Jeenas 2019).

When I break the sample into bins of liquid asset holdings, I get more precise estimates for firms with low liquid asset holdings: credit build-ups are associated with statistically significant

[13] In Section 5.4 I also consider Hoberg and Maksimovic (2015)'s index, firm age, and firm size.

lower future investment (left panel of Figure B.5 in Appendix B). The coefficients are statistically different from firms with high liquid assets, but not from firms with moderate levels of liquid assets (right panel). This non-monotonicity in liquidity levels suggest that liquid assets may be only capturing financial constraints partially.

Just taking one of the dimensions of a firm balance sheet at a time – leverage or liquid assets – may provide us with an incomplete picture of how financially vulnerable and credit constrained a firm is. For example, high debt may simply reflect access to credit markets, so we cannot make a direct link to credit constraints. It can also be related to good investment opportunities, in which higher debt is anticipating future investment growth (Lang et al. 1996, Barbiero et al. 2020) In addition, an highly indebted firm may have considerable liquid assets that make debt not that relevant as a proxy for financial constraints (Fahlenbrach et al. 2020). A similar ambiguity may exist for liquidity asset holdings. Firms may choose higher liquidity because they may be credit constrained or for precautionary reasons, so as to provide them with a cushion against unfavourable 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). Management of debt and liquid assets should thus be seen as distinct processes given the different hedging and liquidity properties of cash and debt (Jeenas 2019).

I now combine leverage with liquid assets to proxy for financial constraints and check the investment response following a credit boom. Specifically, I divide leverage by liquid asset holdings, and split the sample into three bins of the debt-to-liquid asset ratio. I find that firms with a high debt relative to their liquid assets are associated with a larger decline in investment spending following debt build-ups (Figure B.6 in Appendix B). This difference is statistically significant vis-à-vis firms with a low ratio, and for longer horizons relative to firms with a moderate ratio. Overall, combining leverage and liquid assets seems to contain more information to uncover the heterogeneity in the dynamics of investment following prolonged periods of debt accumulation than just using leverage or liquidity separately.

A high debt-to-liquid asset ratio results from either high debt for a given level of liquid assets, or from low liquid assets for a given level of debt. Ideally, I would like to study the behaviour of those firms that are most likely *both* credit and liquidity constrained. In this spirit, the rest of the paper will go a step further and proxy for financial constraints based on firms with high levels of debt *and* with limited liquid assets. My assumption is that firms that are both highly indebted and hold limited liquid assets may find it more difficult to avoid cutting investment in the medium term following credit booms; because they cannot raise additional funding, or not as much as they would like to, *and* because they cannot tap into their liquid assets.

I look at firms that belong simultaneously to the top tertile of the leverage ratio distribution, and to the bottom tertile of the liquidity ratio distribution.[14] I will call these firms 'Vulnerable'; they account for around 14% of the sample. This definition is similar to Fahlenbrach et al. (2020)'s, who define firms as having low financial flexibility if they belong to both the bottom quartile of the cash over assets distribution and to the top quartile of the long-term debt over assets distribution. They find that stock returns of firms with less financial flexibility performed

[14]My main results are not sensitive to selecting different cuts of the data, such as the top quartile/quintile of leverage and the bottom quartile/quintile of liquid assets.

substantially worse than firms with greater financial flexibility during the GFC in 2008 and the COVID-19 shock in 2020. They explain their results with the difficulty that firms with less financial flexibility face in funding their cash flow shortfall, so that the implication is that they descend more rapidly into financial distress. Along similar lines, Ding et al. (2021) find that the fall in stock prices during the early months of the COVID-19 shock was milder for firms with stronger balance sheets, as reflected in greater cash ratios and lower leverage, greater unused lines of credit, and larger profits.

Table 2 shows that the typical vulnerable firm is characterised by weak fundamentals, such as negative net liquidity asset holdings, and may face high corporate financing costs as indicated by a lower ICR than the rest of the other firms (Palomino et al. 2019). Recall that, by construction, these firms also have high leverage which, combined with the other characteristics, could make it challenging for firms to mitigate the effects of a negative shock. In addition, these firms tend to be large and experience lower investment growth than the rest of the firms in the sample. Furthermore, the typical vulnerable firm has experienced substantial swings in debt build-ups over the last decades: firms accumulate substantial debt in the run-up to recessions, but then delever sharply as the economy enters a recession (Figure 8). By contrast, the typical non-vulnerable firm goes through much smoother credit cycles.

Table 2: Descriptive statistics for vulnerable firms vs other firms (median values)

	Size	Leverage	Liquidity	Δ log(*capex*)	ICR
Vulnerable firms	1508.10	0.37	-0.01	3.58	2.85
Other firms	212.31	0.19	0.24	6.83	4.54

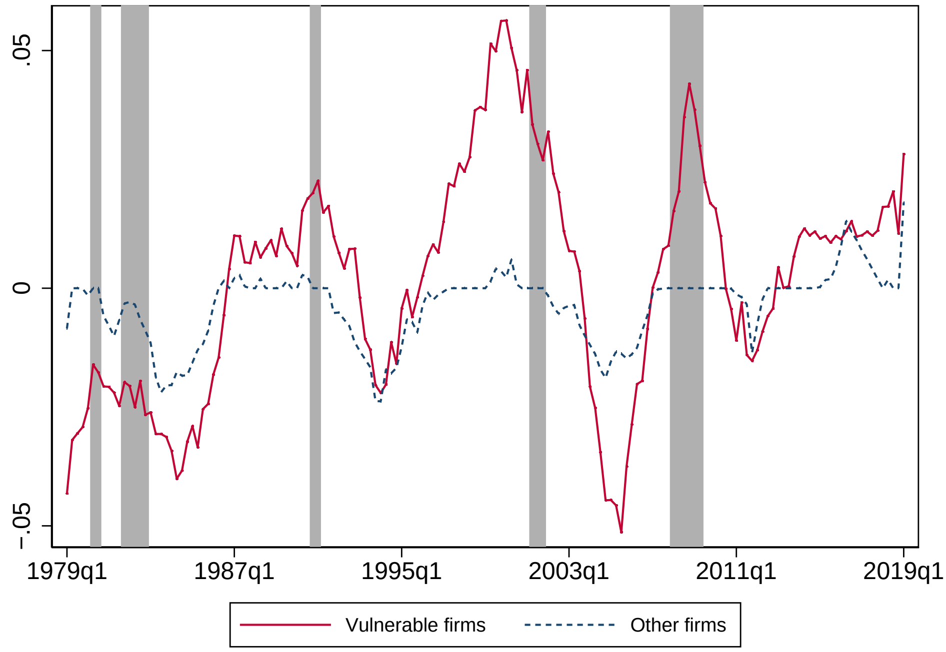
Notes: Size refers to total real assets in 2009 USD, leverage to the ratio of short-term and long-term debt to total assets, liquidity to the ratio of net current assets to total assets, capex to capital spending, and ICR to the ratio of EBIT to interest expenses.

I adjust Equation (2) so that the beta coefficients refer to the elasticity of investment spending to debt build-ups for vulnerable and other firms: β_k^h={Vulnerable, Other}. Note that the concept of vulnerability for a specific firm is allowed to change over time: the estimated coefficients in the LP framework measure the average effect of debt build-ups on investment growth, as a function of state-dependent financial constraints. If the average effect of debt build-ups is likely to affect the state-dependencies in the forecasting horizon, for instance by making a non-vulnerable firm become vulnerable, this will be reflected in the estimated coefficient. The other transitions between states (vulnerable or non-vulnerable) that are independent of the debt build-up will be captured by the state-dependent control variables.[15]

The impulse responses in Figure 9 show that sustained increases in leverage for highly indebted firms and with low liquid assets are associated with substantially lower investment spending over the medium term. At the peak impact, reached after four years, a 10 p.p. increase in debt build-ups is associated with lower investment of 4.6%. The contraction in investment for the other firms in the sample (the non-vulnerable) is less obvious to discern; the estimates include the zero for most short- to medium-term horizons, and only become statistically significant after four years. The magnitude of the decline is also much smaller

[15] The LP method offers advantages in this regard relative to Markov-switching or threshold VAR models. In these models the impulse responses assume that there is no change in the state-dependencies, potentially biasing the coefficients.

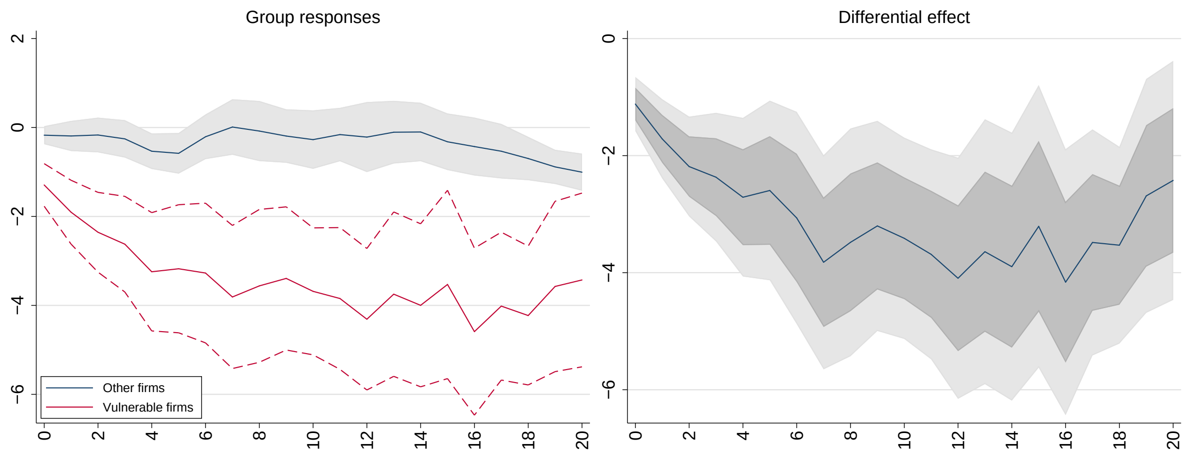
Figure 8: Corporate debt build-ups for vulnerable firms vs non-vulnerable firms



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

compared to vulnerable firms. For every 10 p.p. increase in the pace of credit accumulation, vulnerable firms reduce their investment spending by roughly 2.5% more than other firms after five years. This difference is statistically significant at the 90% confidence level (right panel). This result highlights the role that financial constraints may have in amplifying the negative effects of a credit boom on investment.

Figure 9: Impulse responses of investment spending: vulnerable 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 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.

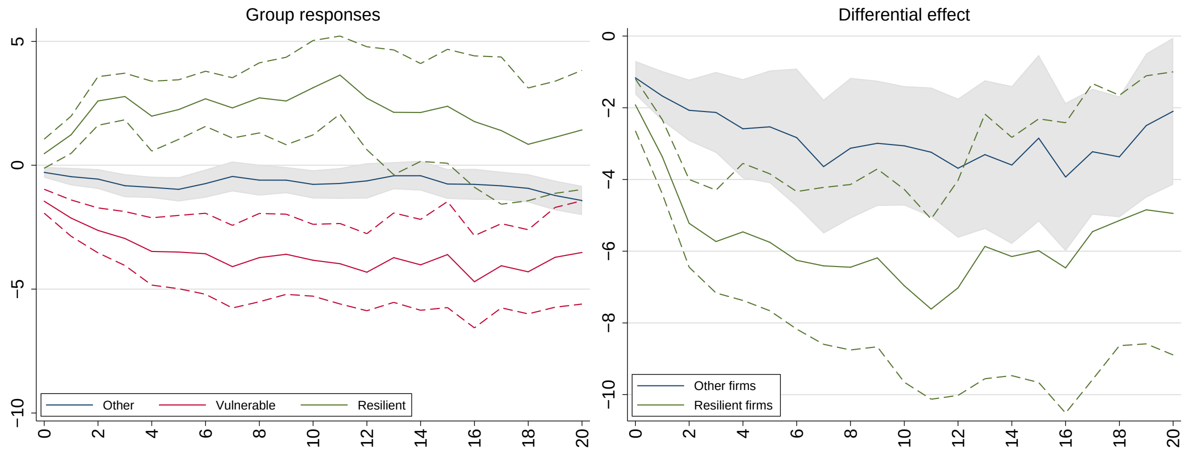
In Figure B.7 in Appendix B I document that debt build-ups in vulnerable firms are associated with a larger and statistically significant increase in corporate yields relative to non-vulnerable firms (up to four years ahead). This is suggestive of financial constraints amplifying the negative effect of credit booms through higher borrowing costs, in line with highly leveraged firms experiencing higher credit spreads around the GFC (Blickle and Santos 2020, Ebsim et al. 2020). The increase in bond yields for vulnerable firms may be a lower bound, as suggested by Blickle and Santos (2020), given that some vulnerable firms may not have been able to issue new debt during a debt overhang.

I check the robustness of my results by breaking down the 'Other firms' component. This group is rather large in my dataset, and potentially heterogeneous across several balance sheet characteristics. Within these firms, I select those with low debt to assets (bottom tertile) and high liquid asset holdings (top tertile), which account for around 19% of the sample. In theory, a firm with low debt relative to their assets and high liquid asset holdings may reflect deliberate decisions by the manager to keep the firm healthy and with strong balance sheets. In this case I would expect debt accumulation to lead to *higher* investment spending, in line with the literature that establishes a positive relationship between finance and growth (King and Levine 1993, Levine 2005, Rancière et al. 2008, Beck et al. 2012). But it is also perfectly possible that firms with low debt and high liquidity may face some form of credit constraints, given the possible endogeneity in the choice of how much liquid assets to hold (Bates et al. 2009, Melcangi 2019, Bacchetta et al. 2019). If this is true, any prolonged debt build-up would inevitably lead to lower investment spending over the medium term. I let the data speak and check which theory fits best the empirical findings.

I draw three main findings from Figure 10. First, the response of vulnerable firms remains robust to estimating the model with one additional group of firms. Second, debt build-ups for the 'other' firms in the sample are also associated with declines in investment, but to a much smaller extent. Third, firms with low debt and high liquid asset holdings experience *increases* in investment in the aftermath of credit build-ups. This suggests that we are in the presence of 'Resilient' firms whose debt accumulation process does not harm investment; actually the opposite. These firms resemble Fahlenbrach et al. (2020)'s firms with high financial flexibility, which can easily fund a cash flow shortfall and, therefore, are less affected by negative shocks. I find a large and statistically significant difference in the investment behaviour between vulnerable and resilient firms: for every 10 p.p. increase in debt build-ups, vulnerable firms experience weaker investment spending of roughly 5% after five years.

I have shown that high debt *and* low liquid asset holdings constitute key ingredients for signalling financial risks and weaker investment in the aftermath of a credit boom. The central takeaway in this paper supports the view that persistent credit booms ultimately become unsustainable, leading firms who are financially constrained, and that may face higher (re-)financing costs and tighter credit conditions, to cut back on investment (Campello et al. 2010, Hoberg and Maksimovic 2015, Giroud and Mueller 2017, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Barbiero et al. 2020, Blickle and Santos 2020). Credit booms or debt misalignments in the corporate sector may thus sow the seeds of damaging and costly financial crises in the spirit of Kindleberger (1978).

Figure 10: Impulse responses of investment spending: adding resilient 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 (green) lines refer to the response of vulnerable (resilient) 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 90% confidence bands, between the responses of vulnerable firms and resilient firms (green lines), and between vulnerable and all other firms (blue line and grey area).

5.3 Debt structure and rollover risk

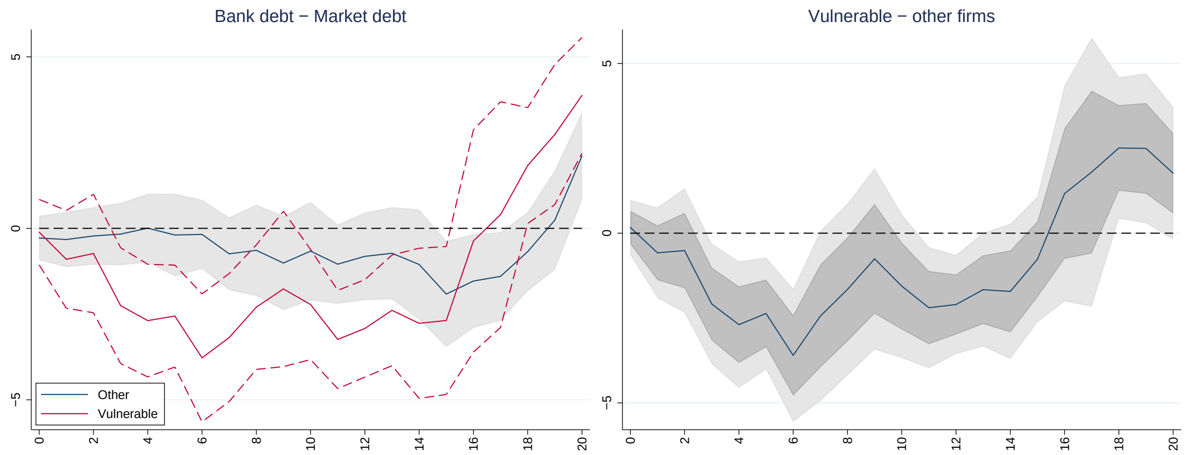
The literature has found that firms that rely mostly on bank debt to finance investment projects may be more exposed to credit supply shocks, given their limited ability to substitute bank debt with external market financing (Kashyap et al. 1993, Becker and Ivashina 2014).[16] My aim here is to ask a related question but from a different angle: do firms with credit booms originating from traditional bank loans experience larger investment contractions than firms that have credit booms in market debt? My hypothesis is that banks may be unwilling to extend credit to firms that are accumulating too much bank loans, even after *controlling* for the share of bank loans in total debt. Lenders may realise that firms with booms in bank loans may be more exposed to credit supply shocks, and thus may be at a higher risk of default.

I match Compustat data with information on the firms' debt structure from Capital IQ. The sample is much smaller than the baseline sample due to missing information for some of the firms (data cover around 39% of the original sample). I break down debt build-ups into market-based and bank-based in Equation (2). I also control for the share of bank debt in total debt. The left panel in Figure 11 shows the difference in the response of bank debt build-ups and market debt build-ups for vulnerable and non-vulnerable firms. I find that build-ups in bank loans for vulnerable firms appear to be associated with larger slowdowns in investment than build-ups originated in market debt (up to four years ahead). In contrast, I do not find any statistical support for a differential effect between bank debt and market debt build-ups for non-vulnerable firms, suggesting that investment growth for these unconstrained firms evolves the same way irrespective of the source of the credit boom. The right panel indicates that the fall in investment associated with booms in bank loans seems to be statistically larger for vulnerable firms than for the other firms up to three years ahead. Overall, I believe this is a

[16] The literature on the transmission of monetary policy shocks has found that firms with a higher share of bank debt in total debt tend to be more responsive to monetary policy. This result is rationalised in a context where a large portion of bank debt carries a floating rate, while most market debt is issued at a fixed rate (Ippolito et al. 2018). But Darmouni et al. (2020) find the opposite result; firms with a larger share of bond financing may face greater frictions in bond markets and have more difficulty to refinance debt.

novel result in the literature: the source of the debt build-up, after controlling for the share of bank debt in total debt, is indicative of larger investment cuts in the aftermath of a credit boom only for vulnerable firms.

Figure 11: Differences in responses between bank debt and market debt build-ups



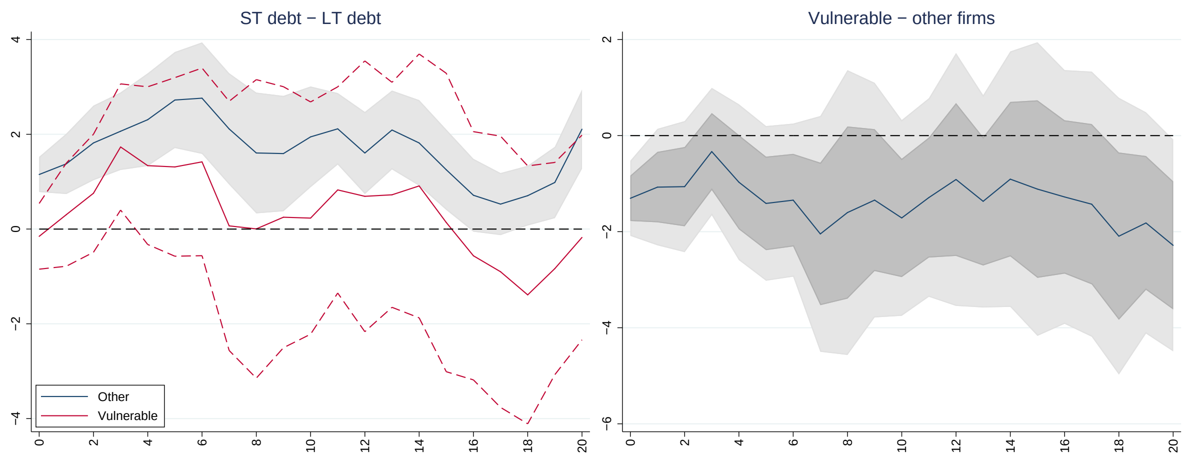
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in the difference between bank debt build-ups and market debt build-ups up to 20 quarters ahead. The right panel shows the difference between vulnerable and other firms. The dark (light) grey area refers to the 68% and 90% confidence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

I now focus on understanding how the debt maturity structure matters to uncover the association between credit booms and investment. The literature has found that the debt overhang effect might be amplified for firms that rely more on short-term debt financing and are therefore more subject to rollover risk (Acharya et al. 2011, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Barbiero et al. 2020, Fahlenbrach et al. 2020). Such risks appear to be particularly elevated around crisis periods, when the value of the collateral falls (Acharya et al. 2011). Kalemli-Ozcan et al. (2019), for instance, provide evidence that EU firms with a shorter maturity of debt reduced investment more in the aftermath of the GFC. Along the same lines, Barbiero et al. (2020) find that firms with a larger share of short-term debt invest relatively less if they are facing good growth opportunities. In addition, using the 2010 Portuguese sovereign debt crisis as an example of a large financial shock, Buera and Karmakar (2019) show that highly leveraged firms and firms that had a larger share of short-term debt on their balance sheets recorded a stronger contraction in credit, investment and employment.

Against this background, I ask a related question: do firms with booms in short-term debt experience larger investment contractions than firms that have credit booms in long-term debt? My assumption is that investors may not be willing to extend credit to firms that run considerable booms in short-term debt, even after *controlling* for the share of short-term debt in total debt. I would expect this effect to be stronger for vulnerable firms, as they may be more exposed to repricing risks from investors or banks.

I break debt build-ups into short- and long-term debt in Equation (2), and also control for the share of short-term debt in total debt. Against my initial prior, I do not find any statistical support for a boom in short-term debt having a stronger impact than a credit boom in long-term debt for vulnerable firms (left panel of Figure 12). Unconstrained firms that have credit booms in short-term debt tend to actually experience smaller declines in investment than firms with credit booms in long-term debt. While long-term debt may insulate firms from a potential fall in credit spreads, short-term debt is usually cheaper. The mixed results I find may thus reflect a small trade-off between short- and long-term debt that a firm with a healthy balance sheet may be willing to pay. But we should take some caution in drawing strong conclusions from these results; the difference between vulnerable and other firms in the investment response to a credit boom in short-term debt relative to a credit boom in long-term debt is not significant at conventional levels of significance (right panel). Overall, my results suggest that the maturity of debt *does not* seem to play a role in determining the investment path in the aftermath of a credit boom.

Figure 12: Differences in responses between short-term debt and long-term debt build-ups



Notes: Cumulative impulse responses of capex to a 10 p.p. increase in the difference between short-term debt build-ups and long-term 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.

5.4 Alternative measures of financial constraints

I have argued that combining the right tail of the firms' leverage distribution with the left tail of their liquid asset distribution provides a reasonable indication of financial constraints. In this section I use three alternative measures of financial constraints to check the sensitivity of my results: (i) Hoberg and Maksimovic (2015)'s (HM) index of financial constraints based on firms' 10-Ks reports, (ii) the age of the firm (Gertler 1988, Bahaj et al. 2019, Cloyne et al. 2019, Durante et al. 2020), and (iii) and the firm size (Gertler and Gilchrist 1994, Bernanke et al. 1999).

First, I match my data with the HM index; I am able to match 4,302 unique firms, resulting in 153,058 firm-quarter observations. The HM index identifies firms with liquidity issues based on the textual analysis of the Management's Discussion and Analysis (MD&A) section in firms' 10-Ks. Specifically, I use the index *delaycon*, where higher values represent firms that are at risk of delaying their investments due to issues with liquidity. Hoberg and Maksimovic (2015)'s find that firms that are more financially constrained cut investment more following negative shocks. Their measure also performs better in predicting underinvestment than the traditional measures of financial constraints, such as those from Kaplan and Zingales (1997), and Whited and Wu (2006). Using the same HM index, Fahlenbrach et al. (2020) find that firms that are financially constrained had lower stock returns during the worse period of the COVID-19 shock.

One of the limitations of the HM index is the frequency and time span: annual data over 1997-2015. In addition, it is highly autocorrelated, around 0.5, a bit higher than my definition of vulnerable firms (a one-year autocorrelation of 0.37). I run a modified version of Equation (1) by interacting the debt build-up variable with the HM index. I then define constrained firms as those belonging to the 90^{th} percentile, and unconstrained as those in the 10^{th} percentile. Figure B.10 in Appendix B shows that the investment of firms in the 90^{th} percentile experienced statistically significant weaker investment after debt build-ups, in line with my main results.

Second, I use the age of the firm as an alternative proxy for financial constraints. Recent literature has argued that young firms tend to be more responsive to monetary policy shocks, as they typically face more difficulties in securing credit, and are therefore more prone to being financially constrained (Bahaj et al. 2019, Cloyne et al. 2019, Durante et al. 2020). But Hoberg and Maksimovic (2015) cautions that a large fraction of constrained firms cannot be identified just by using age, or/and firm size.

The age variable is sparsely populated in Compustat, so I match my data with Jay Ritter's database on founding dates of firms since 1975 (Field and Karpoff 2002, Loughran and Ritter 2004). I am able to match 1,011 unique firms, resulting in 82,328 firm-quarter observations. I define young firms as those less or equal than ten years old, and old firms as those older than ten years. Figure B.11 in Appendix B shows that a credit build-up in young firms is associated with weaker investment compared to old firms. The picture is relatively unchanged when I use 15 years in Figure B.12 as the threshold (Bahaj et al. 2019, Cloyne et al. 2019). The main difference when using age as a measure of financial constraints relative to my baseline results is larger standard errors. This implies a lower degree of confidence in establishing a statistically significant difference in the investment response between constrained and unconstrained firms.

My third proxy of financial constraints considers the size of the firm, measured with total real assets in 2009 USD. An early literature dating back to Gertler and Gilchrist (1994) shows that small firms are more financially constrained, making them more responsive to monetary policy shocks.

Using the bottom tertile of the firm size distribution to capture financially constrained firms, I do not find any statistical significant association between investment and credit build-ups for small firms (Figure B.13 in Appendix B). My results seem to actually point in the opposite direction. In addition, large firms tend to experience statistically significant weaker investment compared to small firms (right panel of Figure B.13). This goes against the notion that small firms may be more financially constrained. My apparent counter-intuitive result may be related to the fact that a typical large firm has high levels of debt, small liquidity buffers, and weaker balance sheets as measured by low ICRs. Moreover, Crouzet and Mehrotra (2020) argue that firm size may not be a good proxy for financial constraints because of the lack of co-movement between investment and debt over the cycle for small firms after a monetary policy shock. Farre-Mensa and Ljungqvist (2016) also argue that small (and younger) firms do not behave differently from unconstrained firms (a similar point made by Hoberg and Maksimovic 2015).

5.5 The response of liquid assets

We have seen that firms that accumulate credit 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 credit 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).[17]

I use the the cumulative change in the liquid asset ratio as the dependent variable in Equation (2) 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 credit boom (Figure B.8 in Appendix B). 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 B.9.

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 credit 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 credit 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.

6 Tail risk

The central argument in the paper is that corporate debt booms are associated with lower future investment growth, particularly for the tail of firms that may be more financially constrained. Another way to look at these non-linearities is by using quantile regressions to investigate how corporate debt booms affect the distribution of investment growth conditional on a set of control variables. I am particularly interested in studying the left tail of investment growth, to check whether credit booms in the corporate sector amplify downside risks to investment. This exercise is in the spirit of the so-called 'Growth-at-Risk' approach, which uses quantile

[17] 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.

regressions to estimate the distribution of GDP growth conditional on economic and financial variables (Adrian et al. 2019, 2021).

The general form of the estimator beta for each quantile τ at each horizon h that minimises the quantile weighted absolute value of errors if given by:[18]

$$\hat{\beta}^h(\tau) = argmin_{\beta^h(\tau)} \sum_{t=1}^{T-h} (\tau.\mathbb{1}_{\Delta_h I_{i,t+h} > X_{i,t}\beta_\tau^h} |\Delta_h I_{i,t+h} - X_{i,t}\beta_\tau^h| \\ + (1-\tau).\mathbb{1}_{\Delta_h I_{i,t+h} < X_{i,t}\beta_\tau^h} |\Delta_h I_{i,t+h} - X_{i,t}\beta_\tau^h|), \tag{3}$$

where $\mathbb{1}$ denotes the indicator function, $\Delta_h I_{i,t+h}$ is investment growth at horizon h, and $X_{i,t}$ is a vector of all explanatory variables. Since my framework is a panel quantile regression, I need to deal with fixed effects to avoid estimation bias. The literature has estimated panel quantile regressions mostly by restricting fixed effects to be the same across different quantiles (Canay 2011). One of the few recent exceptions is Adrian et al. (2021), who estimate panel quantile regressions with quantile-specific country fixed effects. They are able to do so because their time series (quarterly data since the mid-70s) is much larger than their N (11 advanced economies). But since I have a traditional panel setting with N larger than T, I follow Machado and Santos Silva (2019) who use a quantiles-via-moments estimator that is valid in my context. Specifically, I consider the following location-scale model that allows for quantile-specific fixed effects:

$$\Delta_h I_{i,t+h} = \eta_i^h + \beta^h X_{i,t} + \zeta_t^h + (\delta_i^h + \gamma^h X_{i,t})\epsilon_{i,t+h} \tag{4}$$

The quantile of $\Delta_h I_{i,t+h}$ conditional on $X_{i,t}$, where τ refers to the quantiles under consideration is given by:

$$Q(\Delta_h I_{i,t+h}|X_{i,t}) = (\eta_i^h + \delta_i^h q_\tau^h) + X_{i,t}(\beta^h + \gamma^h q_\tau^h) \tag{5}$$

The quantile-τ fixed effect for each horizon h is given by:

$$\hat{\eta}_i^h(\tau) = \hat{\eta}_i^h + \hat{\delta}_i^h q_\tau, \tag{6}$$

where δ_i^h allows fixed effects to affect the entire distribution of investment growth. The beta β^h coefficient of interest that measures how credit booms affect the τ quantile of the conditional distribution of investment growth can then be estimated as follows:

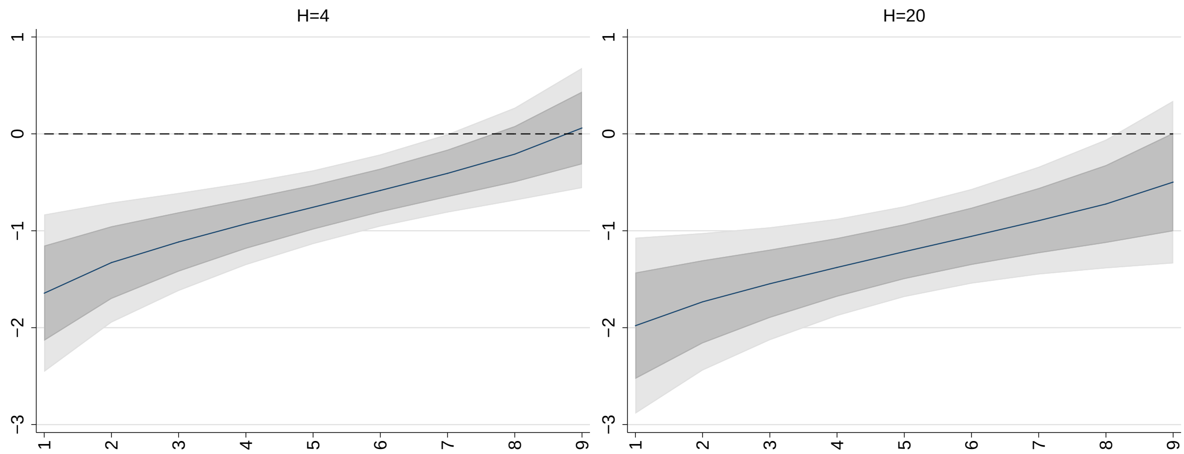
$$\hat{\beta}^h(\tau|X_{i,t}) = \hat{\beta}^h + \hat{\gamma}^h q_\tau^h, \tag{7}$$

The $\hat{\beta}$ coefficients track how the conditional distribution of investment growth evolves after credit booms, while in previous regressions I had only looked at the mean response of investment. I find strong statistical evidence that corporate credit booms typically affect more the left tail of the investment growth distribution – Figure 13 plots the $\hat{\beta}$ for each percentile after four quarters (left panel) and 20 quarters (right panel). This indicates that credit booms amplify

[18] To simplify the exposition, I omit from the notation the logarithm on the left-hand side, the lags on the right-hand side, and consider $X_{i,t}$ as a vector of all explanatory variables, including the debt build-up variable and the lags of the dependent variable.

the decline in investment growth in periods of low investment growth. For example, following a 10 p.p. increase in corporate debt build-ups, investment for the 10^{th} percentile declines by 2% after five years, which compares with 1.2% for the median, and 0.7% for the 80^{th} percentile.[19] In contrast, there is no statistical support at the 90% confidence level of significance of weaker investment for the top two percentiles. My results contrast with those from Jordà et al. (2020), who find that corporate credit booms do not increase downside risks to GDP growth, measured with the 20^{th} percentile; they find that only household credit booms affect the economy's tail risk. But my results are aligned with those in Aikman et al. (2019) and Adrian et al. (2021), who find that rapid growth in both household or corporate debt raise downside risks for GDP growth.

Figure 13: Impulse responses of investment spending: quantile regressions



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

7 Robustness checks

In this section I run alternative specifications of Equation (2), taking the split between vulnerable and other firms in Figure 9 as the main benchmark model. The aim is to check the sensitivity of my results to a set of robustness checks. All figures can be found in the Online Appendix.

Alternative dependent variables

I use capital expenditures divided by the net capital stock, measured with the sum of the net property, plant and equipment (PPE), as an alternative dependent variable. This ratio can be thought of as the investment rate.[20] Figure B.1 in the Online Appendix shows that the main baseline result – weaker investment for vulnerable firms in the aftermath of credit booms – remains qualitatively unchanged when using the investment rate as the dependent variable.

[19] The decline in investment is larger for the 5^{th} percentile – of around 2.2% – the common metric used in the GaR literature to analyse tail risks.

[20] The relationship between capital expenditures (capex) and net capital stock is given by the following:

$$\text{Net PPE} = \text{Gross PPE} + \text{Capex} - \text{cumulative depreciation}$$

Additional firm-specific controls

To minimise the possibility that the dynamics in investment spending in the aftermath of credit booms is not plagued by an omitted variable bias, I add the following firm-specific variables to the main benchmark model: (i) the log change in real corporate debt, (ii) the log change in real assets, (iii) the log change in real sales, (iv) the share of short-term debt in total debt, and (v) the ICR. The results of this expanded model suggest that adding more firm-specific variables yield exactly the same type of responses: vulnerable firms experience a statistically significant larger fall in investment spending following debt build-ups (Figure B.2).

Build-ups in debt net of liquid assets

Throughout the paper I have used total debt relative to total assets as the debt build-up variable. Although I am controlling for liquid assets in the regression model, one may argue that it is still possible that some debt build-ups may not be problematic for the firm if they are matched one-to-one by increases in liquid assets. I use debt net of liquid assets, deflated by total assets, as the credit boom variable to check whether my results may be biased by this. The new results in Figure B.3 show that the difference in investment between vulnerable and non-vulnerable firms continues to be statistically significant.

More persistent credit booms

The literature has also used five-year changes in debt ratios to capture credit booms, particularly those studies that use long series of annual data (Schularick and Taylor 2012, Jordà et al. 2015, 2020, Krishnamurthy and Muir 2017). Although the standard errors are somewhat larger for vulnerable firms than in my baseline, I still find the response of investment for vulnerable firms to be statistically larger for most horizons (Figure B.4).

Alternative liquidity indicators

I have proxied liquidity constraints in the baseline model with current assets (cash and short-term investments, receivables, inventories, and other current assets) net of current liabilities (short-term debt, accounts payable, income taxes payable, and other current liabilities). This indicator measures the liquidity a firm can tap into, after paying all short-term commitments, to soften the impact of shocks. I redefine vulnerable firms based on two alternative versions of this indicator. The first one only looks at gross current assets, thus not subtracting the short-term liabilities; the second indicator only looks at cash and short-term investments (the main components of current assets). I show in Figures B.5 and B.6 that my baseline results remain robust to different measures of liquidity constraints.

Narrower definition of vulnerable firms

I measure financial constraints (vulnerable firms) with the top tertile of the leverage ratio, and the bottom tertile of the liquidity ratio. These firms are most likely liquidity- and borrowing-constrained, and therefore cut investment spending by significantly more when the accumulation of debt becomes excessive relative to their assets. In an alternative specification, I zoom in on my sample of vulnerable firms and select those that also have an ICR below two. The fraction of vulnerable firms in my sample declines from around 14% to 6%. While the cut-off point is a bit arbitrary, it is within the range used by the International Monetary Fund in its Global Financial Stability Report to track financial vulnerabilities in NFCs.[21] There is also some evidence that firms with a low ICR are characterised by high financial distress: they face more constraints to service their debt with internal cash flows and therefore are characterised by lower investment (Palomino et al. 2019). Figure B.7 shows that my baseline results remain strongly robust to this narrower definition of vulnerable firms. Once again, the robustness of my main findings adds more evidence to the view that combining the tails of the distribution of liquid assets and total debt provide a reasonably good picture of financial constraints in the data.

Time-varying industry-specific shocks

I take into account industry-specific factors that may allow firms within a particular sector to cope better with credit booms. For instance, more capital-intensive industries, such as telecommunications, oil and gas, and large manufacturing firms require initial significant financial resources to finance capital expenditures before they are able to sell their goods and services. An apparent unsustainable credit boom may just reflect a timing mismatch between large investment needs and future revenues. In addition, some sectors, such as utility firms, usually face stable demand and therefore generate a stable amount of income. This may potentially make debt and credit booms less concerning than in other more capital-intensive sectors.

I add industry-by-time fixed effects in Equation (2) to account for possible time-varying industry-specific shocks. I show in Figure B.8 that my baseline results are unaffected when accounting for industry-specific shocks. In the Online Appendix I also run regressions for each one of the nine industries to allow all the coefficients to vary across industries. I find the largest declines in investment to be in transportation, construction, and retail trade, sectors that typically display weaker balance sheets.

Vulnerable firms within each industry

Related to the previous point, one may argue that it is better to define vulnerable firms within each industry, as the nature of the business in some sectors may make firms cope better with high levels of debt, or limited liquid assets.

In this context, vulnerable firms are those that belong to the top tertile of the leverage ratio distribution and to the bottom tertile of the liquidity ratio distribution *within* each industry. Figure B.9 shows that my main results remain robust. The only difference relates to the lack of strong statistical evidence after about four years in the difference in investment responses of vulnerable firms versus non-vulnerable firms.

Pre-GFC period

The large credit supply shock during the GFC may be driving the link between credit booms and

[21] Until very recently, the IMF considered firms with an ICR of less than one as 'weak', and firms with an ICR between one and two as 'vulnerable'. In its April 2019 GFSR the IMF considers firms' debt service capacity as 'low' for an ICR below one, and as 'subpar' for an ICR below three.

subsequent lower investment spending. One could argue that my results could be driven by this period of a substantial credit tightening, both in price and quantity terms, when constrained firms had no other means to finance investment, since external finance was not available, and internal resources were scarce. I exclude the GFC to shed some light on this hypothesis. When I stop the estimation sample in 2007Q4, the investment responses are qualitatively similar to the baseline (Figure B.10). Although the standard errors are slightly larger, I still find a statistically significant difference for most of the horizons between the responses of vulnerable firms and other firms.

Business cycle

Can credit booms be more harmful for investment if the economy is already in a recession (Dell'Ariccia et al. 2016, Jordà et al. 2020, Blickle and Santos 2020)? I account for the state of the business cycle by allowing credit booms to transmit differentially to investment in recessions and expansions. According to the NBER business cycles dates, my sample covers three recessions: 1990Q3-1991Q1, 2001Q1-2001Q4, and 2007Q4-2009Q2. Figure B.11 shows that investment spending of vulnerable firms appears to fall more strongly in the short term during recessions. Yet the difference in point estimates between expansions and recessions is short-lived and subject to large standard errors.

An alternative way to deal with the business cycle is by considering major tightening episodes in credit supply conditions, as measured with the Senior Loan Officer Opinion Survey (SLOOS) on bank lending practices (data available since 1990Q3). Specifically, I define a dummy that takes the value of one for periods when the net percentage of banks reporting a tightening in standards for C&I loans to large and middle non-financial firms is above 50%, and zero otherwise. Figure B.13 shows that vulnerable firms tend to cut investment more in the short term during periods when banks tighten credit substantially. But, again, the large standard errors do not allow me to conclude that this is indeed the case in a statistically significant way.[22]

These results contrast with Blickle and Santos (2020), who find that episodes of tightening in credit conditions, or recessions, amplify the negative correlation between debt overhang and firm investment. What my results show consistently is that rapid debt build-ups, most prominently for vulnerable firms, are detrimental to the real economy, irrespective of the state of the business cycle: Figures B.12 and B.14 show that investment is weaker for vulnerable firms compared to non-vulnerable firms in both recessions and expansions, and during periods of major tightenings in credit conditions. In a nutshell, financial vulnerabilities – high leverage ratios and low liquid assets – seem to explain investment growth slowdowns after a credit boom, not business cycles.

Smaller lag structure

I run the main model with just one lag to test the sensitivity of the four-lag structure that I have adopted for the baseline specification. Figure B.15 shows that the main results remain robust and with similar standard errors.

[22]Results are similar if I use credit standards to small firms, or credit standards on commercial real estate loans with construction and land development purposes. In addition, I get a similar picture if I define credit tightening periods when the net percentage of banks tightening credit conditions goes above 10%, as in Blickle and Santos (2020).

8 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 three main reasons. First, the GFC provides a laboratory experiment for the differential behaviour of firms following a large credit supply shock. Recall that I did not find evidence that recessions or episodes of tightenings in bank lending conditions amplify the relationship between corporate debt build-ups and investment slowdowns (Figures A.15 to A.18 in the Online Appendix). Yet, the previous analysis focused on the expected effects of the *average* recession or credit tightening. 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.[23] Third, I will expand the analysis by tracking not only how (tangible) capital expenditures evolved during the GFC, but also intangible investment, liquid assets, debt, and acquisitions. The central argument in the paper is that credit booms can weigh negatively on aggregate demand via subdued tangible investment growth. The GFC episode will allow me to explore other indirect effects of credit booms, particularly the impact on long-run productivity growth.[24]

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. The macro implications of a firm-specific credit boom preceding a financial crisis may be very 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. More specifically, I run the following regression:

$$\Delta Y_i^{07-10} = \alpha + \beta_1 \Delta Y_i^{04-07} + \beta_2 \Delta Debt_i^{04-07} + \beta_3 Z_i^{07} + \zeta_j + \epsilon_i, \tag{8}$$

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) R&D (intangible investment), (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

[23] 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.

[24] I did not investigate in the previous sections how intangible investment, measured with R&D spending, and acquisitions evolved in the aftermath of credit booms due to far fewer observations for the 1985-2019 period. For instance, I have only roughly 95,000 firm-quarter observations (39% of the main sample) on R&D spending.

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 3 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.

Table 3: 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

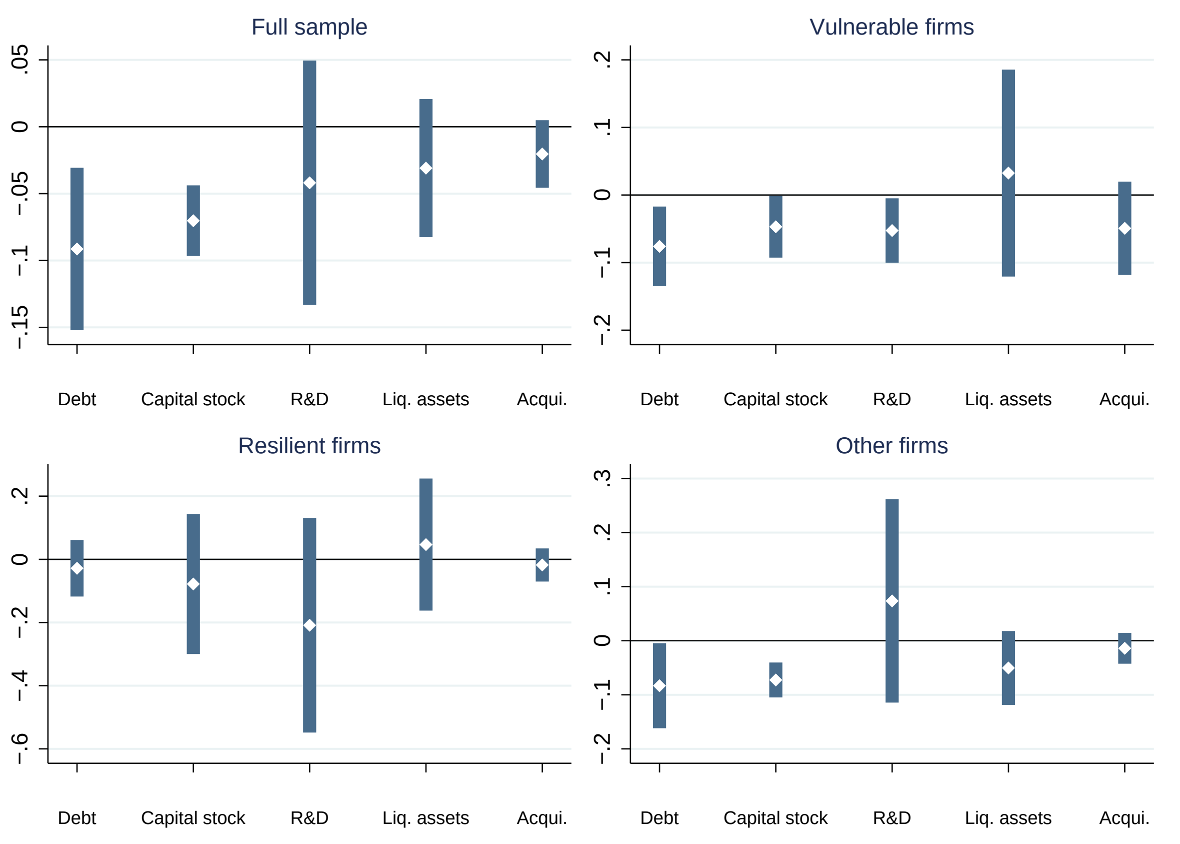
Notes: Regression estimates of Equation (8), where the dependent variable is the cumulative change in the capital stock ratio from 2007q4 to 2010q4. The constant and the industry dummies are omitted. Robust heteroskedastic standard errors in parentheses. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

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).

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 (R&D) 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 14. 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.

Figure 14: 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.

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 14 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.

9 Conclusion

In this paper I study how firm investment evolves in the aftermath of corporate credit booms. The aim has been to shed more light on the lack of consensus in the literature on the effects of corporate debt overhangs. In this context, I have argued that we need four key ingredients to better uncover this association.

First, we need firm-level data to account for the substantial heterogeneity in balance sheets across firms. Studies that use aggregate data, such as Beck et al. (2012), Mian et al. (2017), and Jordà et al. (2020), may mask important relationships between debt overhang and investment, as the micro effects are washed away. Second, I use data since the mid-80s that span several episodes of firm-specific debt build-ups to overcome the challenge of extrapolating findings from a particular episode, such as the GFC. Third, I measure debt overhang through a concept of credit boom – the three-year change in debt to assets – rather than the level of debt. Fourth, I combine leverage and liquid assets to better capture financially constrained firms. Specifically, I define financially constrained/vulnerable firms as those that belong to the top tertile of the leverage ratio, and to the bottom tertile of the net liquid asset ratio.

Using Compustat data for a large panel of US non-financial firms over 1985Q1-2019Q1, my main findings point to a clear link between corporate credit booms and weaker future investment. I rationalise this finding through financial constraints: following a 10 p.p. increase in debt build-ups, firms that are more financially vulnerable experience weaker investment of 2.5% after five years relative to unconstrained firms. The difference is larger when I compare these firms with unconstrained firms that have low debt and high liquid asset holdings: investment of vulnerable firms is roughly 5% lower after five years. I also show that vulnerable firms face increased borrowing costs in the aftermath of a credit boom, signalling tighter credit conditions and increased default risk (Krishnamurthy and Muir 2017, Blickle and Santos 2020).

Moreover, I find that the source of financing matters to explain the negative association between credit booms and investment. I find that build-ups in bank loans for vulnerable firms, irrespective of the share of bank debt in total debt, are associated with larger declines in investment than build-ups originated in market debt. I argue that this result is consistent with, but goes over and above, the well-established finding in the literature that firms with a higher share of bank debt are more exposed to credit supply shocks (Kashyap et al. 1993, Becker and Ivashina 2014).

I zoom in on the GFC as a laboratory experiment to study the cross-sectional behaviour of investment during a period of large credit supply shocks. In line with my full sample results, I find that firms that increased their pre-crisis leverage ratio the most experienced a sharper decline in investment during 2007-10. I also find that liquidity played an important role in mitigating the negative shocks: cash-rich firms experienced smaller reductions in investment, in line with recent evidence shown in Joseph et al. (2019). Moreover, I also find that credit booms may affect long-run productivity growth, via lower R&D, for vulnerable firms.

All in all, the central takeaway in this paper supports the view that persistent credit booms ultimately become unsustainable, leading firms who are financially constrained – high debt *and* low liquid asset holdings – to cut back on investment (Campello et al. 2010, Hoberg and Maksimovic 2015, Giroud and Mueller 2017, Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Blickle and Santos 2020).

What lessons can we draw for the COVID-19 crisis? Although the root causes of the ongoing crisis are very different from the previous crises, particularly the GFC (Brunnermeier and Krishnamurthy 2020), I believe this paper may offer some lessons about the possible implications of credit booms for the real economy. Similarly to previous credit boom episodes, we saw large pre-crisis build-ups in private debt, reaching historically high levels of corporate debt. Furthermore, a large fraction of US corporate debt is now rated BBB, the lowest investment grade rating, while corporate debt rated below investment grade is at an all-time high. It is true that several policy measures, including credit guarantees, the issue of new debt, and the restructuring of existing debt contracts, may have helped firms withstand a severe loss in earnings. But, as a result, a large fraction of firms find themselves with substantially higher leverage than before the COVID-19 shock. In this context, my paper shows that the vulnerabilities in corporates' balance sheets may amplify the ongoing crisis, and delay the recovery: the rapid rise in leverage ratios may leads firms to shift their focus to meeting debt obligations rather than pursuing new investment projects. In addition, some firms may file for bankruptcy, exacerbating the scarring of the COVID-19 shock. If the GFC is any guide, my analysis shows that the accumulation of debt that precedes a large recession may lead firms to cut back on investment and amplify the downturn in economic activity.

Appendix A: Sample selection

I use Compustat data (Wharton Research Data Services) for listed non-financial corporations in the United States. I exclude firms in the 'Finance, Insurance and Real Estate' sectors according to the Standard Industrial Classification (SIC) codes ranging from 6000 to 6799. I use nine main industries, aggregated according to the range of codes shown in Figure A.1.

Table A.1: Industry composition

Industry	Range
Agriculture	0100-0999
Mining	1000-1499
Construction	1500-1799
Manufacturing	2000-3999
Transportation*	4000-4999
Wholesale Trade	5000-5199
Retail trade	5200-5999
Services	7000-8999
Other	9900-9999

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

I follow standard practice in the literature, such as Ottonello and Winberry (2020), and adopt the following procedure to select only US firms in my sample, since in the Compustat dataset there is not a direct way to identify non-US firms. First, I give a score of 50% if the Compustat's Incorporation Code is foreign. Second, I give a score of 25% if the company name includes the term 'ADR', i.e. American Depositary Receipts, which means that the stocks of foreign companies can be traded on the US stock exchanges. Third, I give a score of 25% if the ADR ratio for a particular firm is greater than zero. Finally, I drop firms from the dataset that have a weighted score from the three criteria above that is equal or larger than 0.5, an indication that they are most likely foreign companies outside of the United States.

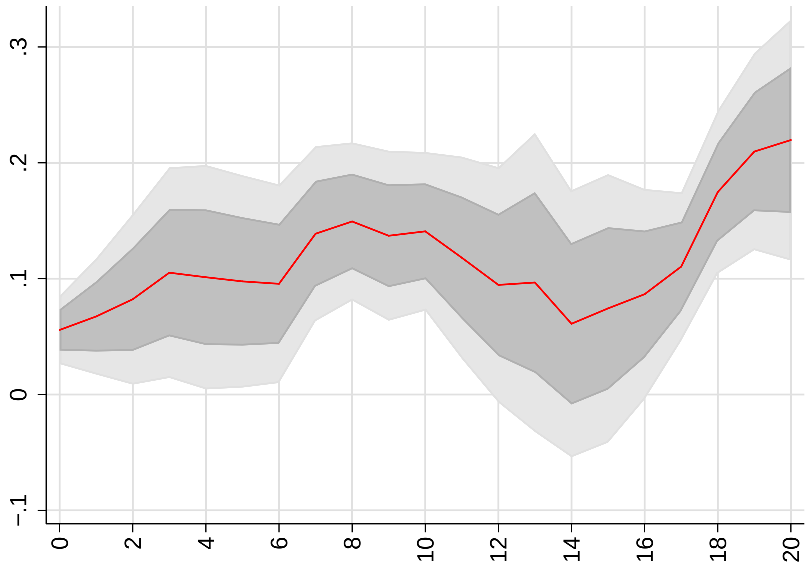
I make additional adjustments to the sample by removing the following firm-quarter observations:

- debt-to-asset ratios larger than 10
- net current assets as a fraction of total assets greater than 10 or smaller than -10
- the growth in real sales and in total assets larger than 100%
- acquisitions larger than 5% of total assets

For the sake of estimating more precisely the fixed effects, I only keep firms that have a minimum of 30 data points for the debt build-up variable and for investment. My final estimation sample covers an unbalanced panel of 4,742 distinct non-financial firms over 1985q1-2019q1, resulting in 246,835 firm-quarter observations.

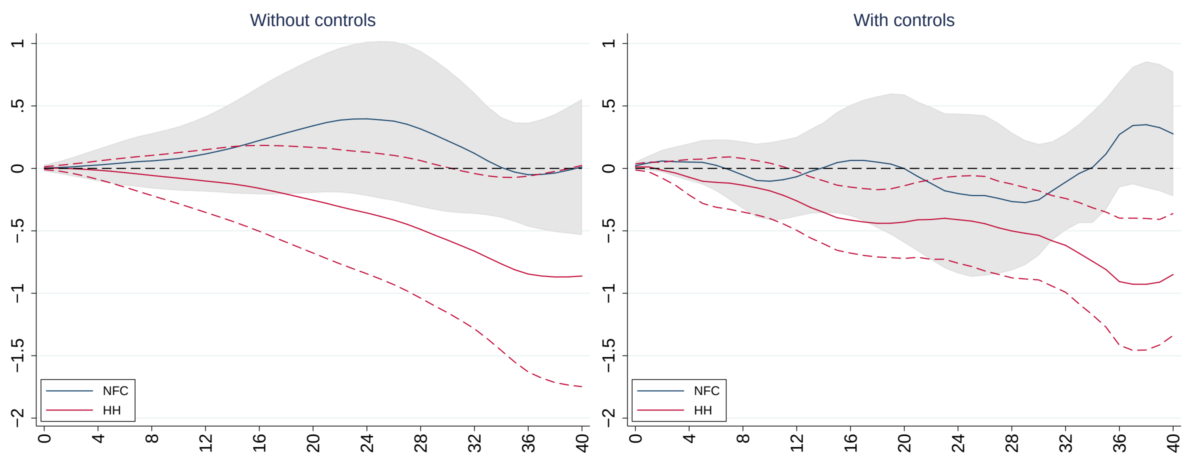
Appendix B: Additional figures

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



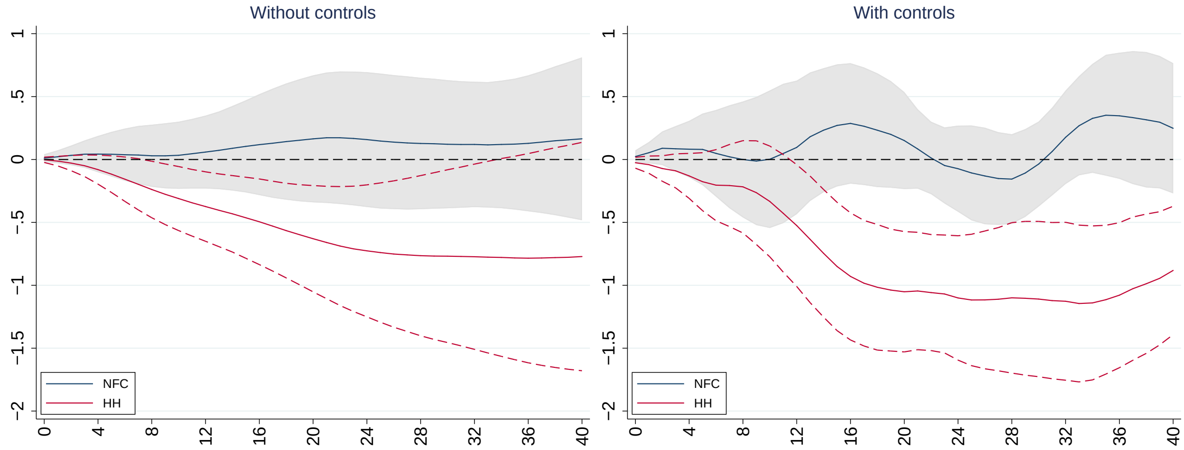
Notes: Cumulative impulse responses of corporate bond yields to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dark (light) grey area refers to the 68 (90)% confidence bands.

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



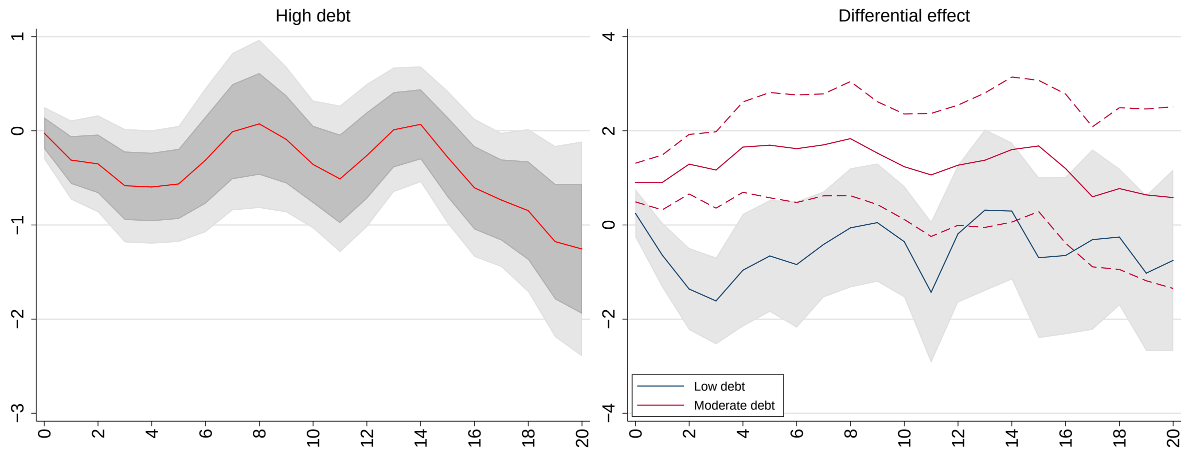
Notes: Cumulative impulse responses to a 1 p.p. increase in debt build-ups in the household and NFC sectors up to 20 quarters ahead. The grey area and dashed red lines refer to the 90% confidence bands.

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



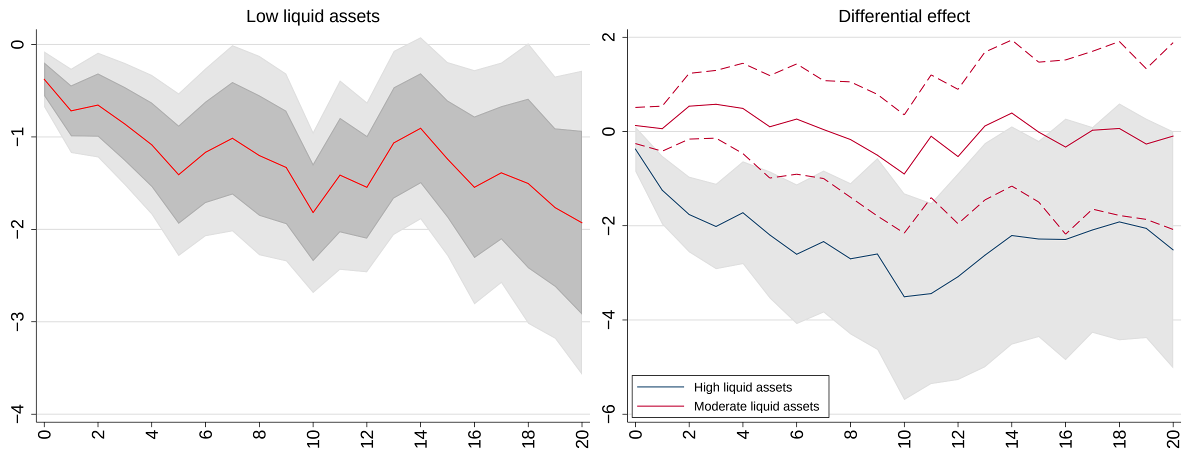
Notes: Cumulative impulse responses to a 1 p.p. increase in debt build-ups in the household and NFC sectors up to 20 quarters ahead. The grey area and dashed red lines refer to the 90% confidence bands.

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



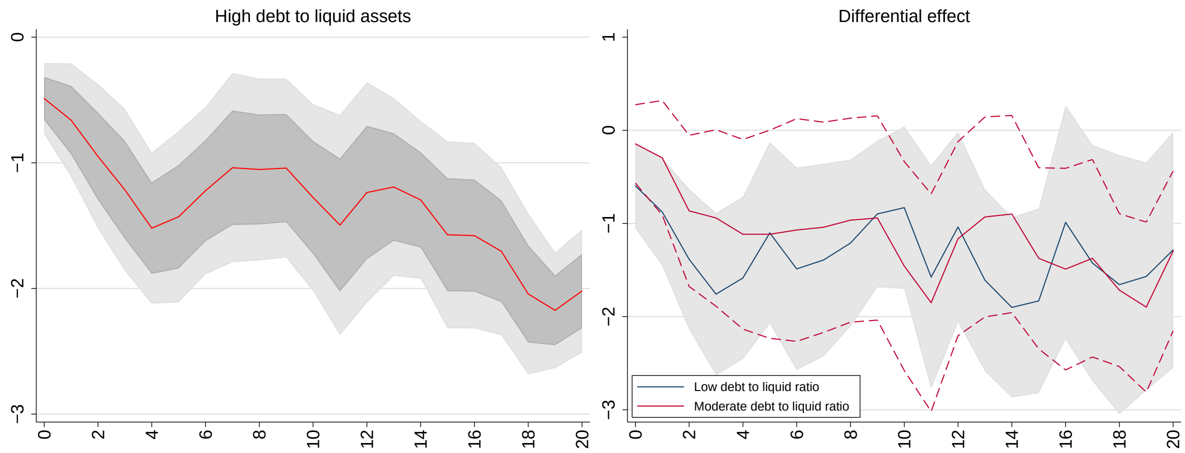
Notes: The left panel shows the cumulative impulse responses of capex for firms with high debt to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The right panel shows the differences in point estimates, and associated 90% confidence bands, between the latter group and firms with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

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



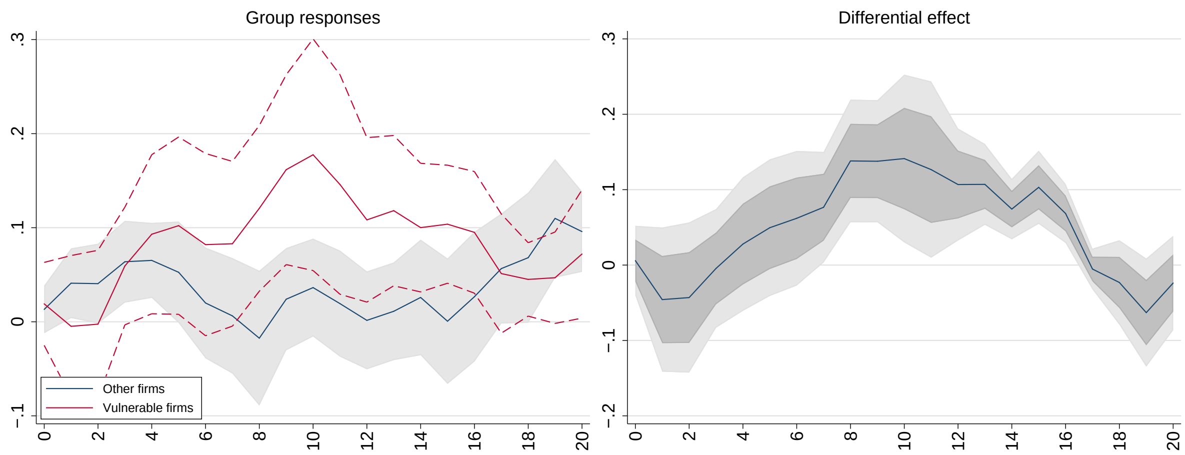
Notes: The left panel shows the cumulative impulse responses of capex for firms with low liquid assets to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The right panel shows the differences in point estimates, and associated 90% confidence bands, between the latter group and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

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



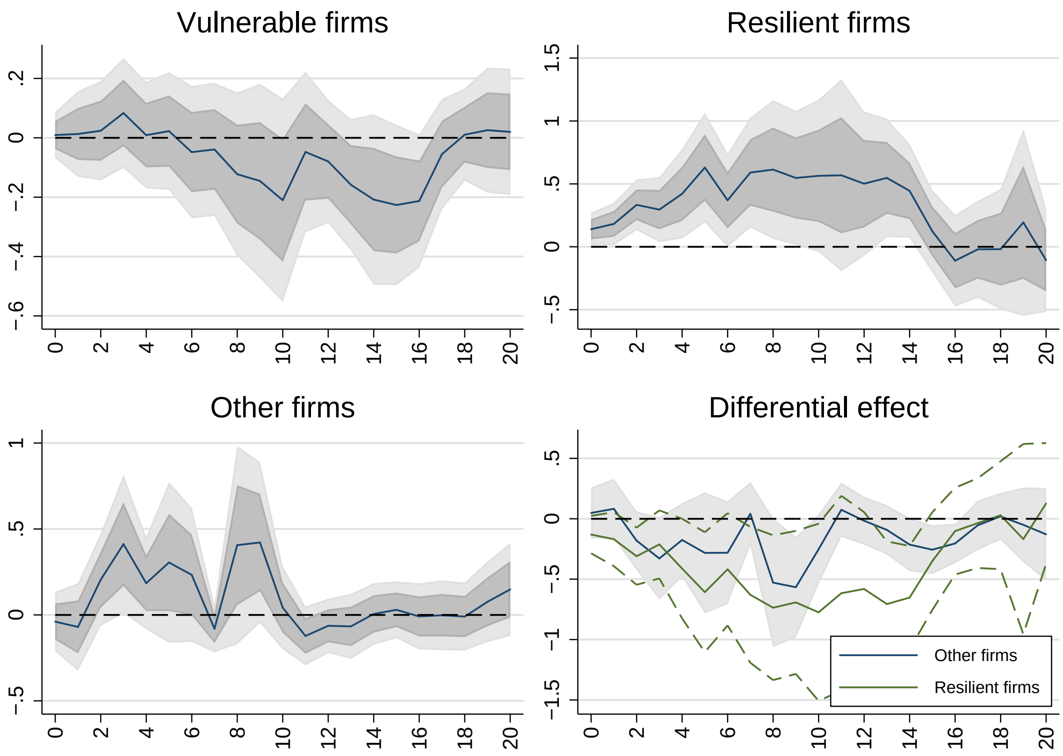
Notes: The left panel shows the cumulative impulse responses of capex for firms with high debt and low liquid assets to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dark (light) grey area refers to the 68 (90)% confidence bands. The right panel shows the differences in 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 B.7: Impulse responses of corporate bond yields: vulnerable firms



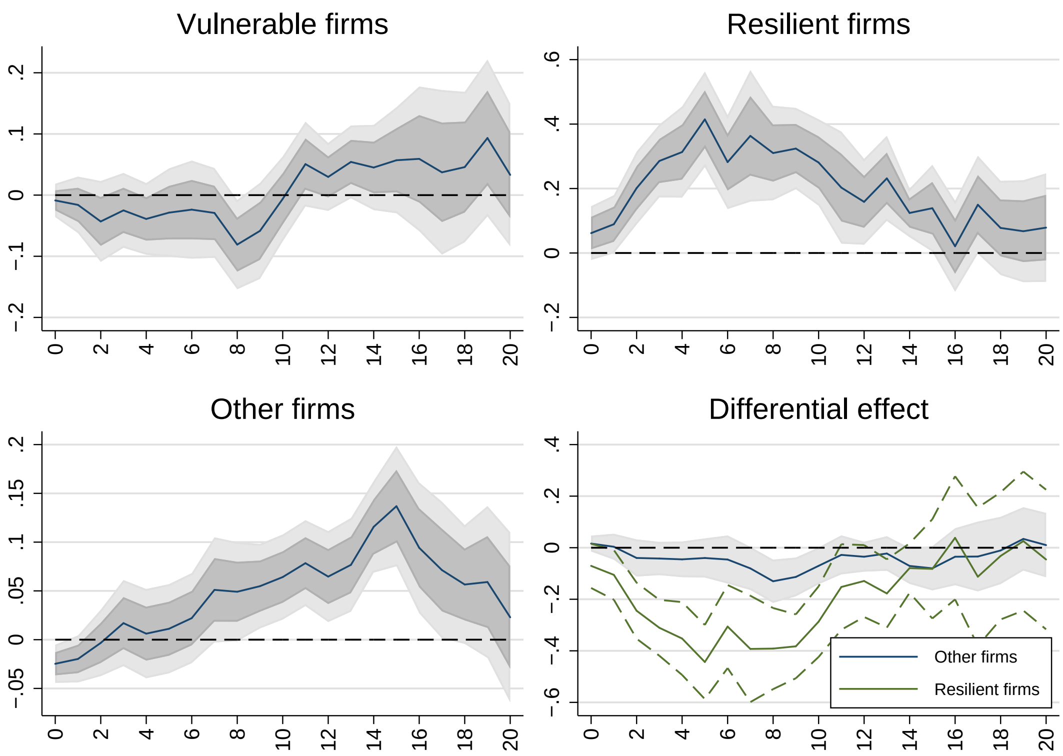
Notes: Cumulative impulse responses of corporate bond yields to a 10 p.p. increase in debt build-ups up to 20 quarters ahead. The right panel shows the difference between vulnerable and other firms. The dark (light) grey area refers to the 68% and 90% confidence bands.

Figure B.8: Impulse responses of net current asset ratio



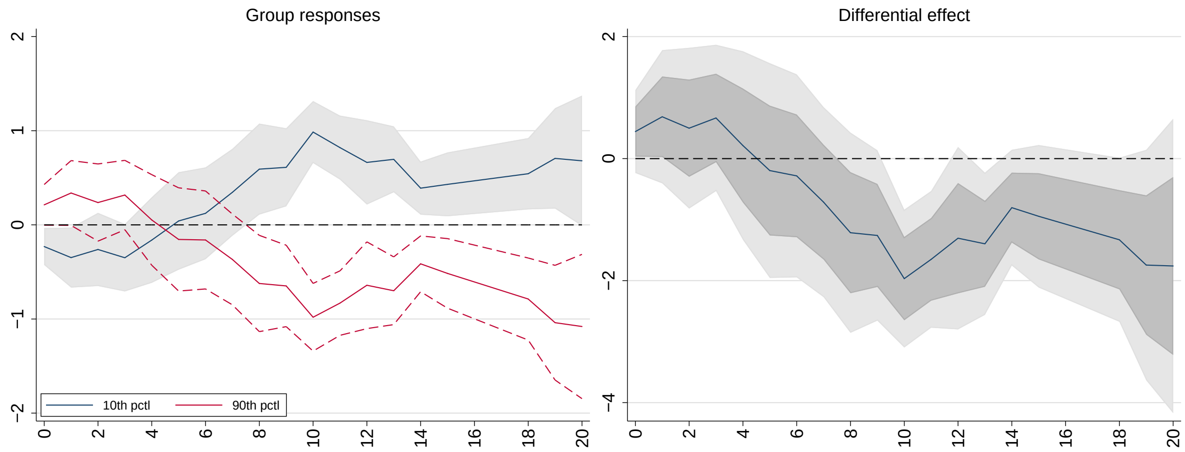
Notes: Cumulative impulse responses of the net current asset ratio to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. Each panel shows the average response and associated 68% and 90% confidence bands for vulnerable, resilient, and other firms. The bottom-right panel depicts the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

Figure B.9: Impulse responses of cash to assets



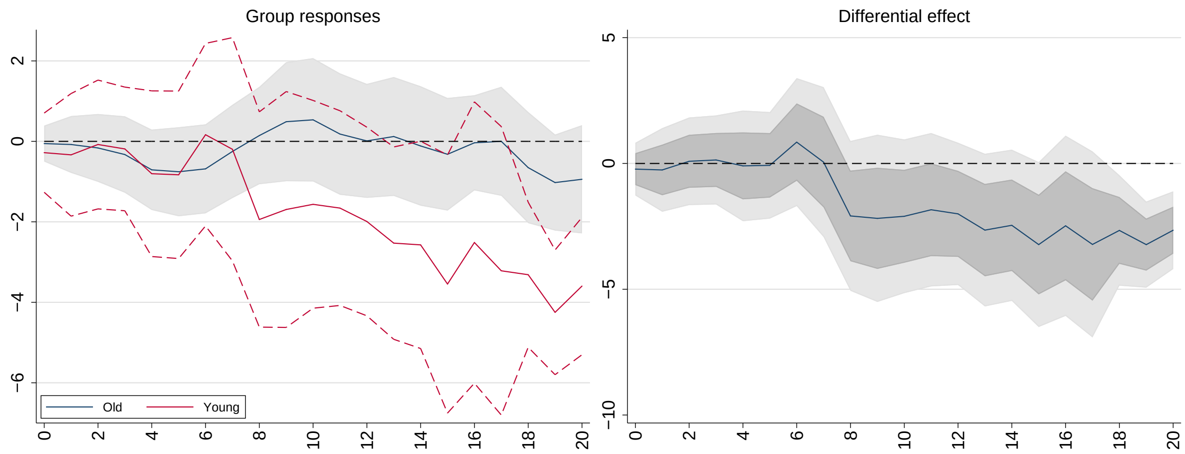
Notes: Cumulative impulse responses of the cash to asset ratio to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. Each panel shows the average response and associated 68% and 90% confidence bands for vulnerable, resilient, and other firms. The bottom-right panel depicts the difference,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

Figure B.10: Financial constraints based on the HM index



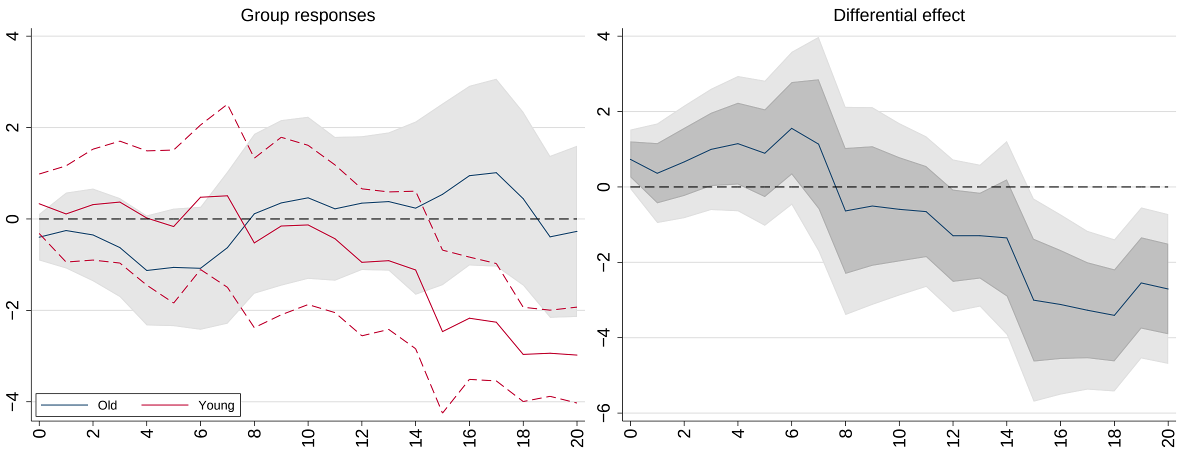
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The grey area (red lines) refer to the mean response of the 10^{th} (90^{th}) percentile of the Hoberg and Maksimovic (2015)'s index and associated 90% confidence bands. The right panel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

Figure B.11: Financial constraints based on firm age: young firms <=10 years



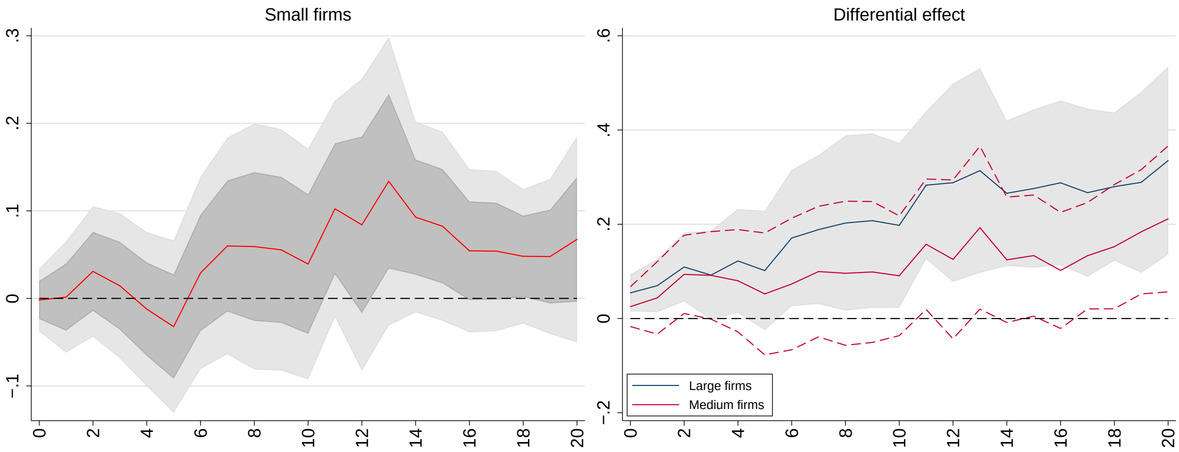
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The grey area and red lines refer to the response of old and young firms and associated 90% confidence bands. Young firms are defined as firms that are less or equal than ten years 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 B.12: 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 B.13: 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).

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