All You Need is Cash: Corporate Cash Holdings and Investment after a Crisis*

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Abstract

Cash holdings going into a financial crisis are key to who emerges as long-term winner of loser from a financial crisis. SMEs with cash could maintain their capital stock during the global financial crisis, while cash-poor rivals had to reduce theirs. This gave cash-rich SMEs a competitive advantage during the recovery period, resulting in a persistent and growing investment gap. The amplification effect was present for SMEs with volatile and with stable cash holdings and was particularly pronounced for young firms. Changes in competition and borrowing constraints affecting cash-rich and cash-poor SMEs differently seem to drive the amplification effect we document.

JEL classification: E22, E32, E44, G32
Keywords: SMEs, investment, cash holdings, financial crisis, misallocation

1 Introduction

The Covid-19 pandemic demonstrates once again that economic and financial crises are particularly challenging for small and medium-sized enterprises (SMEs). Their activities tend to be less diversified and downsizing is often difficult which makes them more vulnerable to a sudden fall in demand. Furthermore, as smaller firms typically require more lender screening and monitoring, banks tend to cut lending to these firms more aggressively during crises (Chodorow-Reich, 2014; Chodorow-Reich et al., 2020; Greenwald, Krainer and Pascal, 2020). And when they do so, SMEs are not able to switch to other types of external funding and have to rely on internal resources instead (Iyer et al., 2014; Cingano, Manaresi and Sette, 2016). At the same time, SMEs account for the lion share of employment and output and are important drivers of innovation and growth (Haltiwanger, Jarmin and Miranda, 2013; Acemoglu et al., 2018). Their resilience to shocks is therefore a key determinant of the speed at which economies recover.

Nevertheless, and partly due to data limitations, we still know surprisingly little about the long-term effects of crises on SMEs and the factors driving a fast recovery.[1] In this paper, we shed light on this issue by studying how cash holdings at the onset of the global financial crisis affected the investment behavior of SMEs in the UK during and after the shock. Having cash at hand enabled SMEs, particularly young ones, to maintain their capital stock during the financial crisis when industry rivals had to reduce theirs. This gave initial cash-rich firms a competitive advantage when the recovery set and led to a persistent and growing investment gap between initially cash-rich and cash-poor firms. A firm's cash balance when a financial crisis hits is a key determinant of who emerges as a long-term winner or a loser from a financial shock.

While cash holdings of large, publicly listed firms have been studied extensively (see Almeida et al. (2014) for a review), we still know very little about cash holdings of SMEs. We therefore start by documenting a number of stylized facts about cash holdings of UK SMEs at the onset of the global financial crisis. First, SMEs' cash holdings are negatively correlated with firm size with larger variation for the smallest firms (Figure 1). Second, the correlation between cash holdings just before the crisis and firms' profits in the preceding three years is positive but rather weak and profits vary substantially across firms in each of the bins of the cash distribution (Figure 2). This indicates that SMEs' current cash holdings are not a strong proxy for past firm performance. Third, for many SMEs cash holdings tend to fluctuate substantially year-on-year (Figure 3).[2] While the cash position of some firms is relatively stable over time, either due to active cash management or due to stable production patterns and sales revenues, it

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[1] Two notable exceptions are Duval, Hong and Timmer (2020) and Kalemli-Ozcan, Laeven and Moreno (2018) who show that high leverage and the inability to roll-over debt negatively impacts productivity and investment of SMEs and larger firms in the medium to long-term.

[2] On average the 1-lag autocorrelation of a firm's cash holdings is only 0.20.

varies substantially for most firms, possibly because of volatile revenues and lumpy investment.[3] Finally, partly as a consequence of the previous facts, SMEs' cash holdings show large variation not only *across* but also *within* narrowly defined 4-digit industrial sectors (Figure 4).[4] This means that when a crisis hits, some SMEs in an industry have large amounts of cash while others have very little.

There are several reasons why having cash buffers at the onset of a crisis makes it easier for firms to continue to operate and to invest. First, cash provides a firm with an internal source of funds when credit conditions tighten, external finance becomes more costly and cash flow declines. A firm can use these internal funds to cover its expenditures, pay off debt, replace capital equipment and finance profitable new investment projects (Froot, Scharfstein and Stein, 1993).[5] Second, when asset prices decline cash preserves its value which protects the firm's net worth. This reduces lenders' exposure to losses and can prevent a rise of the external finance premium (Bernanke and Gertler, 1989). Third, a cash-rich firm does not have to increase its cash holdings for precautionary motives in the wake of a negative shock and can use these funds for investment instead (Almeida, Campello and Weisbach, 2004, Berg, 2018).

For these reasons, SMEs with ample cash at hand are more likely to have sufficient funds to replace fixed assets that have depreciated and to seize profitable investment opportunities. Their cash-starved rivals by contrast find it harder to replace depreciating capital stock and have to forgo profitable investment opportunities.[6] They may even struggle to survive. Thus, while the stock of fixed assets of cash-poor SMEs likely falls, cash-rich ones can maintain or even increase theirs, allowing an investment gap between cash-rich and cash-poor firms to open up. During the recovery phase when demand returns and credit conditions improve, cash-rich firms have more capacity to meet this demand. They can subsequently reinvest their earnings, increasing their productive capacity further. Cash-poor rivals which lost productive capacity have difficulties meeting demand. They can therefore generate less revenue and will see their

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[3]For the SMEs in our sample with volatile cash holdings, the correlation between year-on-year changes in cash holdings and 1-period ahead fixed asset growth varies widely and is on average close to zero (see Appendix Figure 1). This suggests that for most of our firms, year-on-year fluctuations in cash positions are not determined by their immediate investment plans (i.e. a firm reducing its cash buffer today in anticipation of a lack of investment opportunities tomorrow).

[4]It is well-established in the literature that cash holdings differ importantly across industries. Cash holdings are for example more valuable in industries with volatile cash flows (Kim, Mauer and Sherman, 1998, Opler et al., 1999, Han and Qiu, 2007) and in industries where the correlation between cash flows and investment opportunities is low (Acharya, Almeida and Campello, 2007).

[5]Standard valuation models treat cash like the negative of debt which implies that cash does not have an independent impact and only net leverage (debt minus cash) should matter. The key underlying assumption of these models is that financing is frictionless: a firm that uses cash to pay off its debt today is expected to be able to issue new debt tomorrow under the same conditions. This assumption has been challenged even for publicly listed firms and during non-crisis times (Acharya, Almeida and Campello, 2007) and is even less likely to hold for SMEs during crisis episodes.

[6]While not focusing explicitly on the role of cash, Campello, Graham and Harvey (2010) show that firms that identify themselves as financially constrained during the crisis planned deeper cuts in employment and capital spending, were forgoing otherwise attractive investment opportunities and sold assets in order to fund operations.

positions weaken further. As a consequence of these self-reinforcing dynamics, the investment gap between cash-rich and cash-poor SMEs that opened up during the crisis is amplified during the recovery period.

This feedback loop implies that a firm's pre-crisis cash position relative to its industry rivals is a strong predictor of its investment not only during the crisis itself but also during the recovery phase. To test this prediction we use a firm-level dataset for SMEs active in the UK. Unlike datasets from census sources, our data cover a large number of balance sheet variables. The dataset is manually constructed from Bureau van Dijk's FAME database. It covers the period from 1999 to 2014 and thus includes the period leading up to the global financial crisis, the crisis itself and the recovery phase. This allows us to compare cash-investment sensitivities during the crisis and its aftermath with the sensitivities during the pre-crisis period. We focus on SMEs that survived both the global financial crisis and the recovery period to ensure that firm entry or exit does not drive our findings.

Simple correlations between cash and subsequent investment trajectories highlight the long-term benefits of having cash at the right moment in time: When we rank SMEs according to the size of their cash holdings relative to their industry rivals just before the start of the global financial crisis, a striking relationship with investment over the period 2007-2014 emerges (Figure 5, top panel). While SMEs with a lot of cash maintained or even increased their fixed assets throughout the crisis, cash-poor firms decreased their stock of fixed assets between 2007 and 2009. Importantly, this divergence in investment behavior became even more pronounced during the recovery period. The correlation between SMEs' cash holdings and their subsequent investment is very different in normal times. When we rank firms according to the size of their cash holdings relative to their industry rivals in the year 2000, only a weak relationship with investment over the subsequent period emerges: Both cash-rich and cash-poor firms increased their fixed assets between 2001 and 2007 (Figure 5, bottom panel).[7]

To examine formally how pre-crisis cash holdings affected investment during the global financial crisis and recovery period, we use a local projections framework (Jordà, 2005). Specifically, we estimate how investment over different horizons between 2007 and 2014 responded to the financial crisis conditional on pre-crisis cash holdings. We control for a wide set of pre-crisis firm characteristics such as age, size, leverage, performance and past investment, that might be correlated with a firm's cash position and could potentially affect its ability or willingness to invest during the crisis and the recovery period. To control for demand shocks and investment opportunities we use 4-digit industry and regional fixed effects. The fixed effects absorb for each investment horizon the impact of industry and regional conditions, including industry-specific uncertainty, demand and other factors affecting all firms in an industry or region in the same way.

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[7]The variation in cash holdings within industry is very similar in the two years. As such the differential pattern cannot be explained by sharp differences in cash holdings in the two periods.

The key concern with our identification strategy is that the cash position of SMEs might be endogenously related to their investment opportunities during and after a crisis. We address this concern in several ways. First, we exploit the fact that the sharp tightening of credit conditions after the collapse of Lehman Brothers was unexpected. It is therefore unlikely that a firm was hoarding cash prior to the crisis in anticipation of a credit supply shock that would affect its future ability to invest. Second, we control for a wide range of firm characteristics that are correlated with a firm's cash holdings and might also explain its (post-)crisis investment. Third, we test whether the results we document are a distinct feature of the crisis and its aftermath and check whether the same patterns emerge in normal times. Fourth, we use cross-sectional analysis based on firm- and industry-level measures of financial constraints as an additional source of identification. Fifth, we test if our results hold if we use a measure of "excess cash" which is orthogonal to firm characteristics that are considered as the main factors explaining firms' cash positions (e.g.Opler et al., 1999; Dittmar and Mahrt-Smith, 2007). Finally, we exploit the empirical regularity that for a significant number of SMEs cash holdings fluctuate substantially year-on-year and that current cash holdings are only weakly correlated with past performance and fixed asset growth in the subsequent year. This suggests that for many SMEs cash holdings at the onset of the crisis were partly determined by luck and were not systematically related to unobserved firm characteristics that correlate with a firm's future investment opportunities. [8]

Focusing on the crisis period itself, we find that SMEs with high initial levels of cash relative to their industry rivals invested more between 2007 and 2009. The differential effect is the result of two opposing forces: Firms with large cash buffers maintained or even grew their stock of fixed assets while firms with less cash reduced theirs. This result is robust to controlling for a wide set of firm characteristics including pre-crisis performance and investment, and 4-digit industry fixed effects. These results for UK SMEs thus mirror the findings for publicly listed firms in the US (Duchin, Ozbas and Sensoy, 2010).

Importantly, and as suggested by the mechanism described above, we find that the positive effect of cash not only persisted but became larger during the recovery phase. And the magnitude of the increase was significant. When taking the average across all industries, our estimates indicate that a cash-rich SME (a firm in the 90th percentile of the relative cash distribution)

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[8]Another concern can be the presence of unobserved credit lines. As shown by Ivashina and Scharfstein (2010) firms were drawing down their credit lines during the global financial crisis. This can positively affect their ability to invest during the crisis and the subsequent recovery period. However, access to credit lines and the draw down of pre-existing credit lines following a shock is heavily skewed towards the largest firms (Chodorow-Reich et al., 2020; Greenwald, Krainer and Pascal, 2020). Furthermore, during the global financial crisis firms that had enough internal funds available choose not to use their credit lines (Campello et al., 2011), suggesting that credit lines are more expensive than having cash at hand especially for firms that become financially constraint. Indeed, Sufi (2009) finds that access to credit lines becomes more restricted following declines in borrower profitability. Acharya et al. (2014) provide a theoretical rationale for this behavior by showing that credit lines can serve a liquidity monitoring role. This makes the cost of credit lines greater for firms with high liquidity risk. In addition, banks tend to increase interest rates and make loan provisions less borrower-friendly when firms, faced with a cash flow shock, draw on or increase their credit lines (Brown, Gustafson and Ivanov, 2020).

kept its stock of fixed assets between 2007 and 2009 constant, i.e. this firm was able to replace all of its depreciating fixed assets during the crisis.[9] A cash-poor SME (a firm in the 10th percentile) decreased its stock of fixed assets by 4.7 percent instead, resulting in an investment gap of 4.7 percentage points. By 2014 the cash-rich SME had increased its stock of fixed assets by 5.0 percent relative to 2007, while the cash-poor SME had decreased its fixed assets by 6.3 percent. This implies that the size of the investment gap more than doubled during the recovery period to reach 11.3 percentage points.

The cash effect was present for SMEs whose cash holdings were relatively stable and for SMEs whose cash holdings fluctuated significantly in the period leading up to the crisis. For both cases we document a positive impact of having cash on investment during the crisis and a significant amplification effect during the recovery period. In addition, we show that our findings continue to hold when we consider firms' "excess" cash holdings. This reduces concerns that our results are driven by unobserved firm characteristics that are correlated with cash holdings.

If it were generally the case that cash-rich SMEs invest more in the long-term than their cash-poor rivals, we should find that cash holdings also drive long term investment during a tranquil period. Instead, we find that during the period that preceded the crisis both cash-rich and cash-poor firms were growing their fixed assets. The effect of initial cash holdings was only significant in the short-term and much smaller than during the crisis period. Importantly, we do not find an amplification of the cash-effect in the period preceding the financial crisis. This suggests that the tightening of credit conditions played a significant role in driving the effect we document for the crisis and the recovery period.

Cross-sectional analyses utilizing firm and industry heterogeneity lends additional support to our hypothesis. In line with the well-documented fact that young and small firms are more affected by credit supply shocks (Chodorow-Reich, 2014, Ongena, Peydro and Van Horen, 2015, Cingano, Manaresi and Sette, 2016), we find that the impact of cash was particularly large for young and (to a lesser extent) small SMEs.[10] In addition, cash-investment sensitivities were larger for SMEs operating in industries where the average firm was younger or smaller, i.e. those industries where firms more likely experienced a credit supply shock. Other industry characteristics such as capital intensity, concentration or the depth of the downturn in an industry do not seem to play a role.

In the final section, we explore two potential mechanisms that can explain the persistence of the effect of initial cash holdings and the growing investment gap that we document for the recovery period. The first mechanism is related to a shift in competition dynamics. During the

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[9]For this firm gross investment is positive as investment expenditure equals the depreciation of capital equipment, but net investment is zero.

[10]This finding is in line with Cloyne et al. (2018) who show that especially young firms in the UK tend to adjust their capital expenditure in reaction to monetary policy shocks. Furthermore, age, and not size, has been shown to be a critical determinant for employment dynamics over the business cycle (Haltiwanger, Jarmin and Miranda, 2013).

crisis cash-rich SMEs were able to maintain or even increase their productive capacity while their cash-poor rivals were forced to shrink theirs. This gave cash-rich firms a competitive edge during the recovery period and allowed them to increase their income, reinvest these earnings and capture more market share over time. Cash-rich firms could further advance their competitive position if they could acquire assets at discounted prices from their struggling competitors or if their presence deterred other firms from entering or investing (Benoit, 1984). In addition, they could exploit the weakness of their cash-poor rivals by strategically investing in R&D, the location of stores and plants, distribution networks or advertising (Campello, 2006) or by lowering their prices (Gilchrist et al., 2017). In line with this mechanism, we find that pre-crisis cash holdings had a positive effect on market share growth during the crisis and that this effect was amplified during the recovery phase. We also show that cash improved firms' profitability.

The second mechanism relates to borrowing constraints. It assumes that the crisis-induced tightening of borrowing constraints affected cash-rich firms less compared to their cash-poor rivals. Larger cash balances protect a firm's net worth and, all else equal, make it less risky for lenders to continue to lend. Hence cash-rich firms were more likely to have access to credit on affordable terms during the crisis. When credit conditions improved during the recovery period this might not have benefited initial cash-poor firms if banks, which emerged from the crisis with weaker balance sheets and faced tighter regulation, preferred to lend to low-risk firms. Furthermore, to the extent that banks take firms' recent earning history into account when extending loans (Ivashina, Laeven and Moreno, 2020; Lian and Ma, 2021), it would be easier for cash-rich firms to borrower compared to cash-poor ones as the former were able to generate more cash flow and profits. Consistent with this mechanism, we find that cash-poor firms experienced a sharper decline in their debt levels during the crisis and that the effect of initial cash holdings was amplified during the recovery period.

Our findings have three key implications. First, our analysis suggests that estimates of the impact of a crisis should take long-term effects into account. Focusing only on the crisis years significantly underestimates the true effect of the shock as a firm's balance sheet position going into the crisis can have long-lasting effects on its ability to invest due to self-reinforcing dynamics. Second, the crisis-induced selection of winners and losers on the basis of cash holdings that we document points to another mechanism through which financial shocks can lead to a long-lived misallocation of resources (e.g. Jermann and Quadrini, 2012; Khan and Thomas, 2013) which affects especially young firms (Ouyang, 2009; Foster, Grim and Haltiwanger, 2016). If high-performing SMEs that happened to be cash-poor when the crisis hit were not able to catch up with their under-performing but cash-rich rivals, this would imply a persistent misallocation of capital. As cash is not the negative of debt (Acharya, Almeida and Campello, 2007), our findings suggest that there is a role for cash holdings when modeling the macroeconomic effects of financial shocks. Third, our results show that when faced with a (financial) shock, cash-poor

SMEs reduce their capital stock with long-lasting effects on their productive capacity. This highlights the importance of a resilient financial system which continues to provide credit during a crisis. Additional liquidity provision by governments especially to young and small firms during crises may also be necessary to avoid a selection of long-term winners on the basis of past cash holdings.

The remainder of the paper is structured as follows. The next section discusses how our paper contributes to the literature. Section 3 introduces the empirical strategy and the data. Section 4 reports the results on the long-run effects of cash on firm investment and Section 5 presents evidence on one of the underlying mechanisms. Section 6 concludes.

2 Contribution to the literature

This paper contributes to several strands of the literature. First, it relates to the recent literature on the real effects of the global financial crisis, which has mainly focused on short-term effects. When banks with weakened balance sheets reduced their credit supply (Ivashina and Scharfstein, 2010; Santos, 2011; Puri, Rocholl and Steffen, 2011), firms, especially small and young ones, responded by cutting employment and investment (Chodorow-Reich, 2014, Ongena, Peydro and Van Horen, 2015, Cingano, Manaresi and Sette, 2016). The strength of firms' balance sheets played an important role. Firms that identified themselves as financially constrained planned deeper cuts in their workforce and capital expenditure (Campello, Graham and Harvey, 2010). Firms that were more leveraged or faced bigger roll-over risks going into the crisis experienced sharper declines in employment, investment and productivity (e.g. Almeida et al., 2012; Giroud and Mueller, 2017; Wix, 2017; Kalemli-Ozcan, Laeven and Moreno, 2018; Duval, Hong and Timmer, 2020). While receiving a lot less attention, low cash reserves also seem to have made firms vulnerable. Publicly listed US firms with limited cash invested less at the height of the crisis, but this effect was short-lived (Duchin, Ozbas and Sensoy, 2010). Our work adds to these findings in several ways. First, we study how cash holdings at the onset of the crisis affected investment by SMEs. Specifically, we study the long-term impact of the shock and highlight self-reinforcing dynamics. We show that the positive impact of cash on investment was not only present during the crisis itself but was amplified during the recovery period and provide evidence consistent with two mechanisms, competition dynamics and borrowing constraints, that can explain this amplification effect.

Second, our paper relates to the literature on the use of corporate liquidity management to ease financial constraints which, partly due to data limitations, has mostly focused on large, publicly listed (US) firms. It has been shown that financially constrained firms hold more cash for precautionary motives (e.g. Opler et al., 1999; Faulkender and Wang, 2006; Acharya, Almeida and Campello, 2007; Cunha and Pollet, 2020) and that cash reserves allow financially constrained firms to invest more, especially when hedging needs are large (Denis and Sibilkov,

2010).[11] Firms dynamically adjust the proportion of their cash flow they save to avoid high cost in the future to finance their growth (Begenau and Palazzo, 2021). When faced with a negative macroeconomic or funding shock firms tend to increase their cash holdings (Almeida, Campello and Weisbach, 2004, Song and Lee, 2012) which leads them to reduce investment (Berg, 2018) and employment (Banchetta, Benhima and Poilly, 2019). In addition, a liquid balance sheet has been shown to protect firm investment in the face of a contractionary monetary policy shock (Ottonello and Winberry, 2018, Jeenas, 2018) or a credit supply shock (Beck, Da-Rocha-Lopes and Silva, 2020) and to enable suppliers to provide liquidity insurance to their constrained clients by increasing the amount of trade credit (Garcia-Appendini and Montoriol-Garriga, 2013). Our paper adds to this literature by providing novel insights into the relationship between SMEs' cash holdings and their long-term investment decisions after a large financial shock.

Third, our paper is related to the literature on the role of financial frictions in distorting the allocation of productive resources. The presence of credit market frictions can cause highly productive but financially vulnerable firms to exit the market and less productive firms to survive, thus dampening the cleansing effect of recessions (Osotimehin and Pappadan, 2015) or even reversing it (Barlevy, 2003; Ouyang, 2009).[12] A shock to the financial system amplifies these effects and can lead to long-lived disruptions to the allocation of capital through collateral constraints (Khan and Thomas, 2013) or debt enforcement constraints (Jermann and Quadrini, 2012).[13] The crisis-induced selection on cash that we document can also lead to a misallocation of productive resources as firms with large cash reserves when a crisis hits are not necessarily the best performing ones. Consistent with the empirical finding that productive reallocation during the global financial crisis was especially stifled among younger firms (Foster, Grim and Haltiwanger, 2016), we show that low cash reserves particularly suppress investment by young SMEs.

3 Empirical methodology and data

Our paper aims to test whether the pre-crisis cash position of a small or medium-sized firm relative to its industry rivals is a strong predictor of long-term investment after a financial crisis. In this section, we explain the empirical methodology for our investment regressions and discuss the data and variables used for this analysis.

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[11] The findings in these papers are consistent with the idea that higher cash holdings are a value-increasing response to costly external finance. An alternative view presented in the literature is that financially constrained firms hold high cash reserves due to value-reducing agency problems and empire-building behavior of managers (Jensen and Meckling, 1976; Harford, 1999; Pinkowitz, Stulz and Williamson, 2006; Dittmar and Mahrt-Smith, 2007; Harford, Mansi and Maxwell, 2008).

[12] Other studies highlight that financial frictions can increase misallocation by preventing an optimal allocation of resources toward, and the entry of, more credit-constrained firms (Midrigan and Xu, 2014; Moll, 2014)

[13] Kiyotaki and Moore (1997) were the first to show that collateral constraints can have a large role in amplifying and propagating shocks to the value of collateral, but they abstract from heterogeneity in production efficiency.

3.1 Empirical methodology

We use a local projections framework (Jordà, 2005) to study how a SME's cash position going into the crisis affects its investment decisions during and after the crisis.[14] Local projections allow us to estimate how a firm's investment over horizon $j > 0$ responds to the financial crisis conditional on the firm's pre-crisis cash position relative to its rivals. As the global financial crisis was unexpected, it is unlikely that firms were hoarding cash prior to the crisis in anticipation of a credit supply shock that would affect their ability to invest once the crisis hit.

We regress fixed asset growth of firm i between 2007 and horizon j on the firm's initial cash position and a number of control variables. We estimate the following regression model:

$$\Delta lnFA_{i,07+j} = \beta_j Relative\ cash_{i,06} + \gamma_j X_i + \sum_{k=0}^{1} \theta_{kj} \Delta lnFA_{i,07-k} + \rho_{sj} + \vartheta_{rj} + \varepsilon_{i,j} \qquad (1)$$

where i indexes the firm and j the horizon over which fixed asset growth is measured. We set j to range from one to seven years to study firms' fixed asset growth up to 2014. $\Delta lnFA_{i,07+j}$ is defined as the log difference of fixed assets between 2007 and year 2007+j. As our focus is on fixed asset growth between two periods we implicitly control for all time-invariant firm characteristics. *Relative cash* captures the firm's cash holdings in 2006 as a share of its total assets and is measured relative to the cash holdings of the firm's rivals within narrowly defined 4-digit industries using z-scores; γ_j is a coefficient vector and X_i is a matrix of firm-level control variables that might affect a firm's investment decisions and may directly correlate with its cash position. In particular, we include two age dummies, *Mature* and *Old*, and the dummy variable *Group* which indicates whether a firm is part of a corporate group or not. We also include three continuous variables: *Size* which is defined as the log of total assets, *Leverage* which is defined as total liabilities over total assets and *Profits* which equals profits over total assets. All these control variables are measured in 2006. To control for the fact that investment decisions can be lumpy the model also includes pre-crisis annual fixed asset growth between 2005 and 2006 and between 2006 and 2007. In an extension of the model, we also include turnover growth over these years. ρ_{sj} is a vector of 4-digit industry fixed effects, ϑ_{rj} is a vector of regional fixed effects, and ε_{ij} is the error term at horizon j. More detailed definitions of all variables are provided in the next section.

Regressions are estimated for each horizon separately using OLS and standard errors are clustered at the 4-digit industry level. As we estimate a separate regression for each horizon, including industry and region fixed effects is akin to including industry-year and region-year fixed

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[14]Local projections have several advantages over computing impulse responses using vector autoregressions (VAR). They can be estimated by simple regression techniques, they are more robust to misspecification, analytical inference is simple and they can easily accommodate non-linearities and multiple fixed effects (Jordà, 2005).

effects in a panel regression. These fixed effects thus absorb all demand and productivity shocks at the industry and regional level that can affect a firm's investment decisions throughout the crisis and its aftermath.

The main coefficients of interest in Equation 1 are the β_j coefficients. Our estimates for β_j measure the sensitivity of firms' investment decisions over horizon j to their cash holdings before the onset of the crisis. A positive estimate for β_j implies that fixed assets of firms with larger initial cash holdings relative to their rivals grow more over horizon j. Because of the dynamic nature of the coefficients, we will present the estimation results as graphs and plot the estimates of β_j over horizons $j = 1, ... 7$.

3.2   Firm balance sheet data

Our primary data source is the FAME database provided by Moody's (previously by Bureau van Dijk). The FAME database is a subset of the more commonly used Amadeus (European firms) and Orbis (global firms) datasets that Moody's provides. It includes balance sheet information, cash flow statements and profit and loss accounts of UK companies. The data are collated from the publicly available filings of each firm at Companies House, the official UK firm registrar, and therefore capture most of the UK's corporate universe.[15] The dataset is different from datasets that are commonly used in the literature on the real effects of financial crises and corporate investment decisions such as Compustat or Worldscope. These datasets only contain information on large and publicly listed companies. The vast majority of companies in FAME by contrast are small and medium sized firms (SMEs) which are privately owned. The FAME dataset therefore allows us to study the post-crisis investment behavior of SMEs, i.e. the kind of firms that are more likely to be affected by a tightening of financial conditions during the crisis.

A critical part of our identification strategy relies on comparing firms' cash-investment sensitivities during the crisis and its aftermath with their sensitivities during the pre-crisis period. This comparison allows us to demonstrate that the usual relationship between cash holdings and long-term investment changed when credit constraints tightened during the crisis. To perform this comparison, we require a dataset that covers not only the global financial crisis and its recovery, but also the tranquil period before the crisis. The key complicating factor is that FAME is a live database and historical information of inactive or dissolved companies is only retained up to five years after firm exit. We would therefore introduce survival bias in the earlier years of our analysis if we relied exclusively on a recent FAME download of the firm data.

To obtain representative firm accounts for the pre-crisis period, we download archived vintages

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[15]Companies House collects and publishes data on registered companies subject to the Companies Act 2006, including limited liability firms and partnerships but excluding sole traders.

of firm accounting data and overlay the balance sheet information from these different vintages.[16] Each vintage contains ten years of financial accounts for active companies and five years for inactive or dissolved companies.[17] The accounts of a firm in each vintage are uniquely identified by the firm's Companies House registration number and the account filing date. When overlaying different vintages of accounts, we retain non-missing balance sheet information from those firm's accounts that were most recently filed. Thus, whenever balance sheet information for a firm and year is available from multiple vintages of data or sets of accounts, we prioritize the most recent vintage. This exercise significantly reduces survival bias and substantially improves data coverage.

All firms are by law required to report to Companies House, but reporting requirements vary by firm size. Basic information is available for all firms but many variables (such as EBITDA, turnover, employment, etc.) are only reported by a subset of larger firms.[18] Furthermore, UK firms are not required to submit their accounts during a specific month of the year. Firms' annual accounts therefore cover different 12-month periods depending on the reporting month. Most firms, however, submit their accounts at the end of the calendar year or at the end of the fiscal year (March). To determine which calendar year the firm's accounts correspond to, we assign accounts reported in the first half of a year to the previous calendar year and reports submitted in the second half of a year to the current calendar year, i.e. accounts submitted until June 2007 are assigned to the year 2006.[19]

Firms are classified by 4- digit codes of the 2007 UK Standard Industry Classification. We follow the literature and exclude firms that operate in industries that provide financial services or are dominated by the public sector.[20] We also exclude industries with less than 30 firms. We only use the unconsolidated accounts of firms to avoid double-counting and to ensure that we focus as much as possible on the domestic component of the activity of firms that operate internationally. Our dataset covers firms that are single entities and firms that are part of a group (10 percent of the firms in our sample). Firms that are part of a group can potentially also access capital from their parent which could reduce the importance of cash holdings as a determinant of a firm's investment decisions. We control for this in our analysis.

Our analysis focuses exclusively on SMEs. Due to lack of data on the number of employees for many firms in the FAME dataset we are not able to use the commonly used definition of SMEs

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[16]As discussed in great detail by kalemli2015construct and implemented for the UK by Bahaj, Foulis and Pinter, 2020, the use of historical information and careful treatment of the data is crucial to construct an accurate firm-level panel using data provided by Moody's.

[17]We use the following vintages: March 2007, April 2012 and May 2017.

[18]See Bahaj, Foulis and Pinter (2020) for a detailed description of firm reporting requirements in the UK.

[19]The vast majority of accounts cover a 12-month period. Occasionally, we also observe irregular filings or multiple filings in a single year. In the case of irregular filings, we assign as the accounting year the year into which most of the accounting period fell. In case of multiple filings, we calculate weighted averages to match the usual 12-month reporting period.

[20]Specifically, we exclude firms operating in finance and insurance, public administration, education, human health and social work, activities of households as employers and activities of extraterritorial organizations and bodies.

as firms with less than 250 employees. Instead, we define SMEs based on their total assets and only include firms with total assets of less than £50 million. Furthermore, we focus on the set of firms that survived both the crisis and the recovery period. This to ensure that any change in the cash-investment sensitivity over time cannot be attributed to firms that are exiting or entering the market. In addition, we only include firms with complete data on relative-to-rivals cash, the control variables and investment over all horizons. The sample for our baseline investment analysis thus consists of 235,396 SMEs and the sample for our extended analysis which also controls for pre-crisis turnover consists of 34,519 SMEs. Descriptive statistics for these firms are shown in Table 1.

3.3 Regression variables

Our dependent variable is the growth in fixed assets. Investment in fixed assets can be measured on a gross or net basis i.e. with or without depreciation. If investment expenditures equal the depreciation of capital equipment, then gross investment is positive, but net investment is zero. We focus on net investment as measured by the log difference in fixed assets since net investment matters most for the productive capacity of the firm.

Our key variable of interest is the level of corporate cash holdings prior to the global financial crisis, as measured by bank deposits over total assets in 2006. We are primarily interested in the amount of cash a SME holds relative to its rivals in the same industry. This is because the competitive advantage that a SME potentially gains by holding cash buffers will depend on the cash holdings of its competitors. Furthermore, as is well established in the literature, the importance of cash holdings to mitigate financial constraints depends critically on industry characteristics. Cash holdings are for example more valuable in industries with volatile cash flows (Kim, Mauer and Sherman, 1998, Opler et al., 1999, Han and Qiu, 2007) and in industries where the correlation between cash flows and investment opportunities is low (Acharya, Almeida and Campello, 2007).

To construct a measure of relative-to-rivals cash holdings, we follow MacKay and Phillips (2005) and Fresard (2010) and standardize the ratio of cash to total assets within each industry at the 4-digit level. Specifically, we compute *Relative cash* by subtracting from the firm's cash holdings its industry mean and divide the difference by the industry standard deviation in 2006. Measuring cash this way accounts for the fact that a 5 percent cash deviation in an industry with a standard deviation of 3 percent provides more value than it does in an industry with a standard deviation of 10 percent.

We include a number of firm-specific variables to control for the main determinants of investment. Small firms and young firms tend to rely more on internal funds to finance their investment. It is therefore important to control for firm size and age to assess the independent effect of relative-to-rivals cash holdings. We define the variable *Size* as the log of total assets in

2006. We measure the age of each firm as the number of years between the firm's incorporation date and 2006. Based on this variable we create two dummy variables to differentiate between firms at different stages of their life cycle: *Mature* which is one if the firm's age in 2006 is between 10 and 19 years and *Old* which is one if the firm is 20 years or older (young firms are therefore in the omitted category).

A number of studies show that the level of debt had a negative effect on investment during the crisis period (see, among others, Duval, Hong and Timmer, 2020, Kalemli-Ozcan, Laeven and Moreno, 2018). As leverage might also be correlated with cash holdings, we control for *Leverage* measured as the firm's total liabilities over total assets in 2006. Firms that have generated profits in the run up to the crisis also likely have higher cash holdings and might be better equipped to perform well during the crisis. To control for this we include *ROA* as measured by the firm's profits over total assets in 2006.

Some of the SMEs in our sample are part of a group structure and have access to liquidity through their corporate group. Access to an internal capital market can mitigate financial constraints of affiliated firms (Boutin et al., 2013). We include a dummy variable *Group* which is one if the firm has a parent and reports an ultimate owner in FAME. Firms that do not report an ultimate owner or whose ultimate owning company name is the same as the firm name are considered as stand-alone entities.[21]

Investment tends to be lumpy and is often partially financed with internal funds. Firms with low cash holdings in 2006 might have invested in the preceding years and might have lower investment needs in the years to come. To control for this we include a variable that captures annual investment of the firm in the pre-crisis period, *Pre-Investment*, and that equals the log difference of fixed assets between 2005 and 2006 and between 2006 and 2007.

For the subset of medium-sized enterprises we have more detailed balance sheet information which allows us to include an additional control variable capturing the firm's pre-crisis performance which could be correlated with both cash holdings and future investment opportunities. We control for *Pre-Turnover* which is defined as the log difference in turnover measured over the same period as *Pre-Investment*. To limit the effect of outliers, we drop observations below the first and above the 99th percentile for the continuous firm variables.

3.4   Characteristics of cash-rich and cash-poor firms

Figure 4 shows that cash holdings vary substantially *across* industries. Industry averages of cash holdings range from seven to around 50 percent of total assets, with a mean across all industries of 20 percent. This wide variation in average cash holdings reflects the fact that hedging needs and the volatility of cash flows differ across industries. Importantly, cash holdings also vary

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[21] We thank Bahaj, Foulis and Pinter (2020) for sharing this information with us.

substantially *within* industries. On average, the standard deviation of firms' cash holdings as a share of total assets is 20 percent. This is the variation we will exploit throughout the paper.

Table 2 sheds light on the characteristics of SMEs with high or low cash holdings relative to industry rivals. Cash-rich SMEs are defined as those in the upper quartile of the relative-to-rivals cash distribution in 2006 and cash-poor SMEs are those in the lower quartile. Cash-rich SMEs hold on average 57 percent of their balance sheet in liquid form, while cash-poor ones only hold 3 percent of total assets in cash. Comparing other pre-crisis characteristics of the two types of SMEs, we find that cash-rich firms tend to be small, somewhat younger, have less fixed assets, are less leveraged and are more profitable. We do not observe a difference in pre-crisis investment between cash-rich and cash-poor SMEs.

4   Long run effects of relative-to-rivals cash on investment

In this section, we examine whether a firm's pre-crisis cash position relative to its industry rivals affects its investment during the financial crisis and whether the impact is amplified during the recovery period.

4.1   Post-crisis investment and relative-to-rivals cash

Figure 6 graphically presents the results from the local projection regressions as specified in equation (1). The solid lines depict the β_j estimates for each horizon. The two dotted lines indicate the 90 percent confidence intervals. The panel on the left shows the estimates for the full sample of firms. The positive and significant coefficient estimates for the first two horizons indicate that firms with high cash holdings going into the crisis experienced higher growth in their fixed assets relative to their cash-poor rivals during the crisis. In other words, similar to publicly listed firms in the US (Duchin, Ozbas and Sensoy, 2010), we document a positive impact of cash on investment behavior for SMEs in the UK during the height of the global financial crisis. These findings are also in line with those of Berg (2018) and **?** who show that firms with cash at hand reduce investment less in the short-term when faced with a credit supply shock.

Importantly, the coefficient continues to be positive beyond the initial crisis years and even increases over the recovery period. In other words, the positive impact of high relative-to-rivals cash is not only persistent but is amplified over time. This suggests that SMEs with relatively high levels of cash prior to the crisis continued to invest more compared to their low-cash rivals even when the crisis subsided, credit became more readily available and demand returned. Figure 7 graphically illustrates the economic magnitude of these results. The figure shows the implied difference in cumulative fixed asset growth between cash-rich and cash-poor firms

during the crisis (2007-2009) and during the crisis *and* recovery period (2007-2014). Cash-rich firms are those firms at the 90$^{\text{th}}$ percentile of the relative cash distribution and cash-poor firms are those at the 10$^{\text{th}}$ percentile. Taking the average across all industries, we estimate that the cash-rich firm kept its stock of fixed assets between 2007 and 2009 stable. In other words, this firm was able to replace all of its depreciating fixed assets during the crisis, i.e. its gross investment was positive, but its net investment zero. The cash-poor firm decreased its stock of fixed assets by 4.7 percent instead; a difference of 4.7 percentage points. By 2014 the cash-rich firm had increased its stock of fixed assets by 5.0 percent, while the cash-poor firm had decreased its fixed assets by 6.3 percent. In other words, the difference in investment more than doubled during the recovery period to 11.3 percentage points. This shows that focusing exclusively on the direct crisis episode importantly underestimates the impact of a financial crisis on investment.

While our model controls for investment opportunities at the industry level by including granular industry fixed effects, it does not control for investment opportunities at the firm level. This could bias our results if cash holdings are correlated with the firms' investment opportunities in the years ahead. Firms might decide to hold more cash precisely because they expect their investment opportunities to be greater in the long run. This is usually addressed by including Tobin's q as a control variable. Since Tobin's q is only available for publicly listed firms, we instead extend the model by controlling for the pre-crisis performance of the firm as captured by its turnover growth in the two years prior to the crisis. Firms that perform well may have higher earnings that they can hold as cash. At the same time, high-performing firms might have better investment opportunities in the future. If this is the case, then the positive relationship between cash and long-term investment might not be driven by a tightening of credit conditions but by firm performance. As only larger firms report turnover in the UK, we estimate this extended model for a much smaller sample of medium-sized enterprises. The coefficients in Figure 6 (right hand panel) show a pattern similar to the baseline regressions including the strong amplification effect over longer horizons.[22]

As argued in the introduction, the persistence of cash holdings tends to be rather low for most SMEs (on average the autocorrelation over the period 2000-2006 is only 0.20).[23] But there exists a lot of heterogeneity across SMEs with some SMEs being persistently cash-rich or cash-poor while others see their (relative) cash holdings fluctuate substantially over time. This indicates that for some firms their cash position in 2006 is the result of a long-term strategy to maintain a liquid or illiquid balance sheet. For other firms, it is more the outcome of year-on-year variation in production and sale patterns and resulting (volatile) profit and cash flow. This

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[22]We also experimented with adding turnover volatility (measured as the standard deviation of turnover relative to total assets between 2000 and 2006) as a proxy for risk as another control variable. The results are materially the same, but the sample halves and turnover volatility is insignificant so we decided not to include it. Results are available upon request.

[23]The distribution of the autocorrelation of relative cash is very similar with a mean of 0.22.

reduces concerns that *Relative cash* proxies for some time-invariant firm characteristic such as prudent management which could be correlated with a firm's ability to invest during a financial crisis. At least for the subset of firms with fluctuating cash holdings there is an element of luck involved as to how cash-rich or cash-poor the firm is when the credit cycle turns and therefore the firms' cash holdings in 2006 are plausibly exogenous to the firm's ability to perform well during a financial crisis. Exploiting these to some extent random fluctuations in production and sales patterns is similar in spirit to exploiting heterogeneity in the share of debt that was scheduled to mature during the crisis as pioneered by Almeida et al. (2012).

To examine whether the cash-effect we document maintains for firm with stable and with more volatile cash holdings, we split our sample into firms with volatile and with managed cash holdings. Firms with volatile cash are those ranked in the lower tercile of the persistence distribution and firms with managed cash are those ranked in the upper tercile of the distribution. When we compare the estimates of the cash-investment sensitivity for these two groups of SMEs (Figure 8) we find that the cash coefficient is positive and significant for both groups from 2009 onward and in both cases the effect is amplified over time.[24] In other words, having high levels of cash when the credit cycle turns, whether due to sheer luck or because of carefully managed cash buffers, positively affects firms' long-term investment patterns after the crisis.

4.2 Investment during the pre-crisis period and relative-to-rivals cash

Next, we examine whether the amplification effect is a distinct feature of the financial crisis and its aftermath (henceforth called "crisis sample" or "crisis period"). To this end we estimate a similar model for the pre-crisis period. If it were generally the case that cash-rich SMEs invest more in the long-term than their cash-poor rivals, we should find a similar trajectory of the cash-investment sensitivity parameter for this period.

We measure a SME's cash position in 2000 and trace out the cash-investment sensitivity parameter for the period 2001-2007.[25] We choose a horizon of six rather than seven years to ensure that our pre-crisis analysis does not overlap with the crisis period. The control variables are the same as in the baseline crisis model and are measured in 2000, except for *Pre-Investment* which is defined as annual fixed asset growth between 1999 and 2000 and between 2000 and 2001. As before, we focus only on the set of SMEs which are active over the full pre-crisis period and that have complete data on relative-to-rivals cash, the control variables and investment for all horizons. This leaves us with a sample of 158,175 firms.

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[24]As we are only able to compute the autocorrelation for the subset of firms which have information on their cash-holdings for each year between 2000 and 2006, these regressions are based on a smaller subset of 115,494 firms. As this sample is biased towards older firms for which (as we will show in the next section) the cash-investment sensitivity is weaker, the coefficients for the different subsets of firms are lower compared to the coefficients for the full sample of firms as used in Figure 6.

[25]The distribution of cash holdings at the 4-digit industry level is very similar in 2000 and in 2006, with an industry mean of 17 percent and a standard deviation of 19 percent.

The results shown in Figure 9 are striking. Contrary to our estimates for the 2007-2014 period, the β_j-coefficients for the pre-crisis period are only significant for the first two years (at the 10 percent level) and become insignificant thereafter. Not only are the coefficients for the pre-crisis sample much smaller than (and statistically different from) the coefficients for the crisis sample, the amplification effect that we document for the crisis period is absent during the pre-crisis period.

Figure 10 graphically illustrates the difference in long-term investment behavior between cash-rich and cash-poor SMEs comparing the pre-crisis and crisis periods. Based on the estimated β_j-coefficient for the 6th horizon (the last horizon of our pre-crisis period), we find that in the pre-crisis period a cash-rich firm increased its stock of fixed assets by 4.9 percent and a cash-poor firm by 3.8 percent and the difference between the two was 1.2 percentage points (and statistically insignificant).[26] By contrast, in the crisis period a cash-rich firm grew its stock of fixed assets by 3.4 percent, while a cash-poor firm shrank its stock by 7.9 percent, a difference of 11 percentage points. These numbers demonstrate that the difference between the two periods is mainly driven by the behavior of cash-poor firms. While initial cash-poor firms increase their fixed assets over the long-run in normal times, they shirk their fixed assets in crisis times instead.

A potential concern with this analysis is that firms in the crisis sample could be different from those in the pre-crisis sample. If the sample of firms we observe in the pre-crisis period contains a larger share of SMEs with a naturally low cash to long-term investment sensitivity this might explain the difference between the two periods. To ensure that this is not driving our results and that SMEs in the two samples are comparable we match a SME from our crisis sample with a SME from the pre-crisis sample along a number of key characteristics and re-estimate the model for the two periods based on this smaller set of matched firms. We require the two firms to match exactly in terms of their 4-digit industry, region, age and size group and the quartiles of leverage, profits and investment, where for the crisis sample all variables are measured in 2006 and for the pre-crisis sample in 2000. This leaves us with a matched sample of 72,366 firms for each period. The estimates for β_j using the matched samples are shown in the right-hand side panel of Figure 10. The results are very similar to those for the unmatched samples, except that for the pre-crisis sample now only the coefficient for the second horizon is statistically significant.

Given that our database starts in 1999, we choose 2001 as the beginning of our pre-crisis period to maximize the horizon over which we can estimate β_j before the start of the financial crisis. This coincides with the aftermath of the dot-com crash in 2000 which could affect our results even though the effect on the UK economy was relatively weak compared to the US. To ensure that our findings using 2001 as the starting year are representative of pre-crisis trends more

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[26]A cash-rich firm is a firm at the 90th percentile of the relative-to-rivals cash distribution and a cash-poor firm is at the 10th percentile.

generally, we test whether results change when we begin our analysis for the pre-crisis period in 2002 or 2003 instead. Reassuringly, when we use 2002 or 2003 as starting years (and accordingly measure relative cash in 2001 or 2002) we find that the results are similar to those obtained for our pre-crisis sample starting in 2001 (Appendix Figure 2).

An additional concern could be that the industries in our sample underwent some structural changes between 2001 and 2007. If industries went through substantial consolidations, this could imply that a observational similar firm has a different position in its industry in 2001 compared to 2007 which might affect its relative investment opportunities and the way they are driven by the firm's cash holdings. However, when we compare concentration measures for our 4-digit industries using firm-level turnover data from the Office for National Statistics in 2001 and 2007 we do not find any material changes in concentration. This implies that it is unlikely that the differences we document between the pre-crisis and crisis period are driven by underlying changes in the industries. Furthermore, the finding that our pre-crisis results are very similar when we take 2003 as our starting year is also reassuring as one would expect structural changes to take longer than 4 years to have a material impact.

Summarizing, the results show that the impact of cash on investment was very different in the pre-crisis period compared to the crisis period and its recovery. This suggests that the tightening of credit conditions played an important role in driving the effect we document.

4.3   Cross-sectional analysis

To provide additional support to the hypothesis that a tightening of credit conditions makes cash more valuable for SMEs, we next perform a number of cross-sectional analyses exploiting firm and industry heterogeneity as they relate to a tightening of financial constraints during the crisis.

4.3.1   Firm-level

First, we conduct a cross-sectional analysis based on firm-level measures of access to external finance. If liquid assets were beneficial because credit conditions deteriorated during the crisis, this effect should be particularly strong for those SMEs that were likely more affected by a reduction of banks' credit supply. We do not observe the bank-firm lending relationship, so we cannot differentiate between firms that had a lending relationship with banks more or less affected by the global financial crisis (e.g. Chodorow-Reich, 2014). Instead, we use two proxies for financial constraints at the firm-level that are commonly used in the literature to test whether cash-investment sensitivities varied with firms' exposure to credit supply shocks: the age and size of the firm. While SMEs in general require more lender screening and monitoring compared to large firms, younger and smaller SMEs will typically require even more as they

tend to be more opaque. Within the group of SMEs these firms are therefor more likely to be affected by a tightening of financial constraints (Almeida, Campello and Weisbach, 2004, Iyer et al., 2014).

First, we split our crisis sample into young firms (less than 10 years old in 2006) and old firms (20 years or older in 2006) and estimate the regression for the longest horizon, i.e. we use fixed asset growth between 2007 and 2014 as the dependent variable. The results are presented in the upper panel of Table 3. For brevity, we only display the cash coefficients. The p-value associated with the F-test that compares the coefficients between the two groups is derived from the pooled regression in which we interact all variables with a dummy that is one if the firm is old. The results show that when comparing young and old firms, the coefficient is significantly larger for young firms. Quantitatively, a young and cash-rich SME had increased its stock of fixed assets by 14.6 percentage points more than a young and cash-poor firm by 2014. For old SMEs this difference was only 7.2 percentage points.

Next we examine the difference between small and medium-sized SME, where small firms are those in the lowest quartile of the size distribution and medium-sized firms those in the highest quartile of the size distribution. The results (Table 3, lower panel) show that, as expected, the cash–investment sensitivity over the horizon 2007-2014 is also larger for small firms, but the difference between medium-sized and small firms is just statistically insignificant (p-value 0.14). Quantitatively, a small and cash-rich firm grew its stock of fixed assets by 18.7 percentage points more than a small and cash-poor firm by 2014. For large firms this difference was only 12.9 percentage points.

These findings are consistent with the idea that a tightening of credit conditions made cash more valuable and enabled firms with cash to continue to invest while their cash-poor rivals needed to divest.

4.3.2 Industry-level

To further uncover the drivers behind our findings, we now exploit the diversity in industries that is present in our dataset. This not only helps us to put aside any possible remaining endogeneity concerns, but also furthers our understanding of the circumstances under which cash is particularly valuable for firms when a financial crisis hits.

First, to strengthen the causal interpretation of our findings we identify sectors in which firms likely became more financially constrained during the crisis. If cash holdings provide a firm with a strategic advantage, the impact of relative-to-rivals cash should be larger in industries where the firm's rivals face more difficulties obtaining external funds during the crisis. As argued previously, firms that are small and young are more likely to become financially constrained during a crisis. We therefore expect a firm's cash holdings to have a bigger impact on its long-term investment if it operates in an industry where other firms (i.e. the firm's rivals) tend to

be small or young.

To test this prediction, we follow Fresard (2010) and measure financial constraints affecting the firm's rivals as the mean size and the mean age of firms within the 4-digit industry in 2006.[27] We then rank the industries based on each of the two variables and assign firms in the bottom and top industry quartiles to the "low" and "high" category, respectively. For each industry characteristic we then estimate equation (1) separately for the "low" and the "high" subsamples and compare the cash-investment sensitivities for the longest horizon, i.e fixed asset growth between 2007 and 2014.

The results in Panel A of Table 4 are fully in line with our predictions. For both industry characteristics, we find that the long-term effect of cash is larger when the firm's rivals are more likely to face tighter financial constraints. The cash coefficient is positive and significant at the one percent level in industries where the mean firm is small or young. The cash coefficient is also significant in industries where rivals are older and larger, but the cash effect is much smaller. Cash coefficients for firms operating in the top and bottom quartile industries are significantly different from each other at the one percent level, irrespective of our measure of financial constraints.

Beyond the financial constraints that rivals' face, other industry characteristics might also affect how beneficial cash is for a firm's investment during the crisis and recovery period. We investigate these in panel B of Table 4. First, we examine whether it matters whether the industry is more labor or more capital intensive. We capture this by taking the mean fixed asset to total asset ratio of firms within the 4-digit industry in 2006 and again compare industries in the top and bottom quartile of the industry distribution. The results indicate that the cash-investment sensitivity is similar for industries that are labor intensive and those that are capital intensive.

The fierceness of competition a firm faces in an industry could determine how beneficial cash is. Using firm-level turnover data from the Office for National Statistics (2017), we calculate the Herfindahl-Hirschman Index (HHI) for each industry at the 4-digit level in 2006. The HHI can range from 0 to 1, where a higher index indicates that an industry is more concentrated. We do not take a stance on how high or low the HHI should be for an industry to be concentrated or competitive but compare firms in the bottom quartile to those in the top quartile of the industry HHI distribution instead. We find that cash has a positive impact on firm investment in industries with both high and low concentration. The coefficient is larger for firms operating in concentrated markets, but the difference is not statistically significant.[28] In both concentrated and competitive industries, cash holdings present an important competitive advantage during a crisis and its recovery phase.[29]

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[27]Results are very similar if we use the median age and size.

[28]Results are very similar when we use a measure of HHI based on employees.

[29]Note that even in concentrated markets, often significant competition exists between small firms that

Finally, we examine if the extent to which an industry suffered from the crisis affected the cash-investment sensitivity. A priori it is not obvious under which conditions cash would be more valuable. On the one hand, more opportunities to purchase fixed assets at discounted prices from failing or shrinking rivals could arise in industries that were hit hard by the crisis. Furthermore, lenders more likely withdraw funding from these sectors, making cash even more valuable. On the other hand, investment opportunities of cash-rich firms in declining industries with weak demand might be limited and very risky reducing the strategic advantage of holding cash.

To test which effect dominates, we measure the depth of the crisis at the 4-digit industry level based on the growth in value added between 2007 and 2010. The data are again from the ONS. Comparing firms in industries in the bottom quartile of the industry growth distribution with those in the top quartile, we find that cash holdings allowed firms to invest more in industries that weathered the crisis relatively well as well as in industries which suffered a severe downturn during the crisis.

Overall, these results support the view that cash holdings provided firms with a strategic advantage over their cash-poor rivals which persisted during the recovery period. Cash benefited especially those firms that were active in industries where rivals' access to external finance deteriorated, while other industry characteristics played less of a defining role.

4.4   Post-crisis investment and alternative cash measures

Our preferred cash measure captures a firm's cash holdings relative to the cash holdings of its rivals within narrowly defined 4-digit industries using z-scores. This enables us to gauge the competitive advantage that a SME potentially gains from its cash buffers. However, there are several other ways to measure cash. In this section we examine whether our results are robust to these alternative definitions.

We start by examining the role of excess cash, i.e. the amount of cash a firm holds in a given year beyond what it needs to perform its daily operations and finance its investments. Our estimation of a firm's excess cash holdings is based onDuchin, Ozbas and Sensoy (2010) (which in turn is based on Opler et al., 1999 and Dittmar and Mahrt-Smith, 2007). First, we estimate a regression to establish the "normal" cash holdings of a UK SME. Excess cash is then defined as the difference between actual cash and predicted, or normal, cash. Duchin, Ozbas and Sensoy (2010) estimate normal cash for a sample of publicly listed firms and their model includes a number of variables that are not readily available for our sample of SMEs, so our model is an adapted version of theirs.

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compete locally. A case in point is the grocery store industry which is dominated by a few large supermarket chains, but in which many small corner stores compete with each other.

To estimate normal cash we run a panel regression where we regress a firm's cash holdings on a set of balance sheet characteristics capturing different potential determinants of cash holdings. We control for firm size and age to capture a firm's access to external finance. The availability of cash substitutes is captured by working capital (net current assets). Precautionary cash holdings in anticipation of new investment opportunities are measured by the growth of cash holdings and past investment by the growth in fixed assets. In addition we control for total liabilities and cash flow (as proxied by the firm's profit or loss). We also include firm and 4-digit-industry-year fixed effects to account for (industry-specific) macroeconomics conditions that might affect cash holdings. We estimate the model for the period 2000-2006 and only include those firms which are present in our post-crisis investment regressions. Our estimation of a firm's excess cash holdings is then the residual taken in 2006.

We examine whether the presence of seemingly excess cash may allow a firm to fund investment during the crisis that it would otherwise not be able to fund. Table 5 (columns (1) and (2)) presents the results. In line with our previous finding we see that excess cash is positively related to fixed asset growth during the crisis and that the effect is amplified during the recovery period. These findings suggest that seemingly excess cash, even though it might be expensive to hold in normal times, can bring important long-term benefits to SMEs when the credit cycle turns.

We also test whether our results are robust to two other cash definitions. In columns (3) and (4) we use the firms cash holdings (as defined by deposits over total assets) without z-scoring the measure. We again find a similar amplification effect. In columns (5) and (6) we measure relative cash in 2007 instead of 2006. UK firms are not required to submit their accounts during a specific month of the year. Most firms, however, submit their accounts at the end of the calendar year or at the end of the fiscal year (March). We assign accounts reported in the first half of a year to the previous calendar year and reports submitted in the second half of a year to the current calendar year. This implies that accounts submitted until June 2007 are assigned to the year 2006. One could argue that this does not fully capture cash holdings of the firm at the onset of the crisis as the crisis only really took hold in 2008. On the other hand, in the summer of 2007 it was already clear in the UK that there were some problems in the financial sector which led to the run on Northern Rock. It is therefore possible that in the second half of 2007 firms already starting hoarding cash in anticipation of the crisis, which would lead to a bias in the estimates. Nevertheless, we examine whether our results are robust to measuring relative cash in 2007. The results in columns (5) and (6) show that this is indeed the case. Summarizing these results show that our main findings are robust to different ways of measuring cash.

4.5 Tangible vs intangible fixed assets

Up till now we focused on investment in total fixed assets, without differentiating between its sub-components. Fixed assets consist of on the one hand tangible fixed assets such as property, plant and equipment and on the other hand intangible fixed assets such as copyrights, trademarks, patents, licenses and brand value. In this section we disentangle these two sub-components in order to shed light on which type of investment is driving our findings.

Only a small subset of medium-sized SMEs (16,616) report tangible and intangible fixed assets. For these firms we trace out the cash-investment sensitivity coefficient separately for total, tangible and intangible fixed asset growth. The results are provided in Figure 11. The estimates clearly show that relative cash only affects investment in tangible fixed assets. Cash does not seem to impact investment in intangible fixed assets.

A number of factors can explain this difference. First, as is evident from Figure 7 the cash effect is the result of two opposing forces: the ability of cash-rich SMEs to continue to invest and the need of cash-poor SMEs to divest. It is easier for a cash-starved firm to reduce its stock of tangible fixed assets, for example by not renewing its car park, compared to reducing its intangible fixed assets. In addition, the weaker results on intangible assets could also be related to the greater difficulty of measuring them. As they are non-physical assets they are harder to value and simple depreciation rates cannot be applied. Third, accounting standards mandate that a business cannot recognize any internally-generated intangible assets (with some exceptions), only acquired intangible assets. This means that intangible assets listed on a balance sheet were most likely gained through the acquisition of another business, or were purchased outright as individual assets. Because of this any investment in internally-generated intangible assets will not be captured by the data.

5 Mechanisms

In the previous section, we documented the emergence of an investment gap between cash-rich and cash-poor SMEs during the crisis which was amplified during the recovery period. In this section, we explore two mechanisms that can potentially explain the worsening relative position of cash-poor firms during the recovery: competition dynamics and borrowing constraints.

5.1 Competition dynamics

We begin by examining whether a change in competition dynamics is a possible driver behind the widening investment gap. When credit conditions tighten, SMEs that are starved of cash find it difficult to replace depreciating fixed assets, might be forced to liquidate fixed assets and need to forgo profitable investment opportunities. Their cash-rich rivals by contrast can draw

on internal resources to continue to operate, to replace depreciating fixed assets and to even seize profitable investment opportunities. These contrasting investment patterns bring about a shift in competition dynamics. Cash-rich SMEs are able to preserve their productive capacity and can even possibly expand it. At the same time the capacity of cash-poor SMEs to meet demand declines. Thus, even if demand contracts during a crisis, the market for cash-rich firms may actually expand.

Cash-rich SMEs can further advance their competitive position if they can acquire assets at discounted prices from their struggling competitors or if their presence deters other firms from entering or investing (Benoit, 1984). In addition, they can invest in competitive strategies that allow them to further increase their market share at the expense of cash-poor rivals, such as investing strategically in R&D, the location of stores and plants, distribution networks or advertising (Campello, 2006). Furthermore, the presence of firms with large amounts of cash can deter other firms from entering a market or from expanding their capacity (Benoit, 1984). Cash reserves may also allow firms to strategically lower their prices to steal market share from financially weak competitors that have to maintain or increase their prices in order to generate cash flow (Gilchrist et al., 2017).

When the crisis subsides and the recovery sets in SMEs that were able to invest and capture market share during the crisis are in a better position to meet the demand. This improves their earnings and strengthens their balance sheets, allowing them to keep investing and to capture even more market share. Firms that were cash-poor at the onset of a crisis will find it hard to catch up with their cash-rich rivals and continue to see their positions weaken even when credit conditions improve. In other words, feedback effects ensure that the shift in competition dynamics during the crisis is amplified during the recovery phase.

In order to asses whether there is evidence in favor of the mechanism outlined above, we test how pre-crisis cash holdings affected a firm's market share growth and performance during the financial crisis and the recovery phase. Market share growth is a direct indicator of the competition channel outlined above. Firm performance captures to what extent having cash enabled the firm to generate income that could be reinvested. Market share growth is defined as the ratio of the firm's assets over the total assets in its 4-digit industry. As measures of operating performance we use the firm's cumulative profits and ROA (as defined by profits over total assets). We estimate a model similar to regression model (1) but replace fixed asset growth with the new dependent variables:

$$\Delta Y_{i,07+j} = \beta_j Relative\ cash_{i,06} + \gamma_j X_i + \sum_{k=0}^{1} \theta_{kj} \Delta Y_{i,07-k} + \rho_{sj} + \vartheta_{rj} + \varepsilon_{i,j} \qquad (2)$$

where $\Delta Y_{i,07+j}$ is the firm's market share or profit growth between 2007 and year 2007+j. Similar to regression model (1) we control for the firm's size, age, leverage, profit and whether it is part of a group and we again the include pre-crisis values of the respective dependent

variables (one and two periods lagged).[30] In the performance regressions we include 4-digit industry and region fixed effects, in the market share regressions only region fixed effects as the dependent variable is a relative-to-industry variable and as such all industry-specific factors are already removed. Regressions are estimated for the different horizons separately using OLS and standard errors are clustered at the 4-digit industry level. We focus exclusively on the set of SMEs with complete data on relative-to-rivals cash, the control variables and the respective dependent variable for all horizons to ensure that any change in the parameter over time is not due to sample selection issues.

In Table 6 we present the estimates for the direct crises period (2007-2009) and the crisis and recovery period combined (2007-2014) for each dependent variable. We find that SMEs with high levels of cash relative to their rivals going into the crisis experienced higher market share growth during the crisis and this effect became larger during the subsequent recovery period (columns (1) and (2)). When focusing on performance (columns (3)-(6)) we find that having cash at hand when the credit cycle turns also positively affected a firm's profitability. Cash-rich firms accumulated more profits during the crisis and this effect was amplified during the recovery period. This finding is confirmed when we examine ROA instead. The fact that in all cases the coefficient becomes larger when we take the recovery period into account suggests the presence of a self-reinforcing feedback mechanism.

It is challenging to precisely measure competition and how it changes over time. First, unfortunately for most firms in our sample we do not have information on sales which implies that we have to measure market share in terms of assets. Second, as is commonly done in the literature (e.g. Fresard (2010)) we measure competition at the 4-digit industry level. However, this assumes that a firm's competitors are all firms in an industry regardless of where they are located. This assumption is more likely to hold for large, publicly listed firms in the manufacturing industry. For SMEs, especially in sectors such as hospitality or retail, competition is likely more localized. Nevertheless, our findings are consistent with the idea that having access to cash when the credit cycle turns allows a firm to maintain its productive capacity during the crisis giving it a competitive edge. When the recovery sets in the firm can continue to invest more compared to its rivals further enhancing its competitive position. Having cash at hand provides a strategic advantage when the credit cycle unexpectedly turns, not only during the crisis episode itself but also several years thereafter.

5.2   Borrowing constraints

Another driver behind the amplification effect we document could be a crisis-induced tightening of borrowing constraints affecting cash-poor and cash-rich SMEs differently. Borrowing

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[30]In the regressions where cumulative profits and ROA are the dependent variables the lagged dependent variables are included and profit is excluded from the control variables

constraints are size dependent (Gopinath et al., 2017) and a tightening of credit conditions affects young and small firms more (e.g.Chodorow-Reich, 2014, Ongena, Peydro and Van Horen, 2015). Furthermore, small and young firms tend to face greater difficulties switching to other sources of external funding and therefore find it hard to compensate for a loss in bank credit (Iyer et al., 2014; Cingano, Manaresi and Sette, 2016). Cash-rich firms however have the ability to compensate for the loss in external finance using their internal resources. Their cash-poor rivals on the other hand cannot. This makes it easier for cash-rich firms to replace depreciating fixed assets and to continue operating close their pre-crisis capacity. Cash-poor firms on the other hand won't have the resources to replace depreciating fixed asset and see their productive capacity and subsequent earning potential shrink.

These differences in earning potential during the crisis might in turn affect a firm's ability to rollover its existing debt during the crisis and recovery period. Recent studies have highlighted that a significant proportion of lending is cash-flow based and that credit supply shocks are primarily propagated through cash-flow loans (Ivashina, Laeven and Moreno, 2020; Lian and Ma, 2021). Cash flows in the form of operating earnings thus directly relax borrowing constraints. This implies that cash-rich firms likely faced less credit tightening during the crisis making it even easier for them to continue operating. When demand returns during the recovery period and cash-rich firms are able to generate even more cash flow relative to their cash-poor rivals, the improvement of credit conditions will disproportionally benefit the former. This makes it even harder for cash-poor firms to catch-up and enables cash-rich firms to invest more and to further expand their productive capacity.

To assess whether cash-dependent borrowing constraints could have been a driver behind the amplification mechanism that we document, we estimate a model similar to regression model (2) but replace the dependent variable with different debt measures: total debt, short-term debt and long-term debt. Total debt growth is defined as the log difference of total long-term and short-term debt between 2007 and year 2007+j. The other two variables are defined the same way but only include short-term or long-term debt, respectively. We restrict our sample to only include firms that provide complete information for all debt components and for all years. This severely restricts our sample to about half of our original sample (but still 108,436 firms).

In Table 7 we again present the estimates for the direct crises period (2007-2009) and the crisis and recovery period combined (2007-2014). We document a positive and significant impact of relative cash on all three debt measures during the crisis. In line with the idea that cash flows relax borrowing constraints we find that this effect is further amplified during the recovery period. These results suggest that cash-dependent borrowing constraints also played a role in generating the amplification mechanism that we document.

6 Concluding Remarks

Studying the investment behavior of SMEs, this paper identifies a strong link between the pre-crisis cash holdings and long-term investment after a crisis. SMEs with high pre-crisis cash holdings were able to replace depreciating fixed assets and could even continue to invest during the global financial crisis while their cash-poor rivals had to divest. This gave cash-rich SMEs a competitive advantage during the recovery period, resulting in an amplification of the investment gap. This persistent and widening investment gap between cash-rich and cash-poor SMEs was not present in the pre-crisis period. We show that the cash-effect was present both for SMEs with stable and with fluctuating cash holdings. This suggests that having high or low levels of cash when a crisis hits, whether due to sheer (good or bad) luck or because of carefully managed cash buffers, had a strong impact on a firm's long-term investment patterns after the crisis.

We present evidence consistent with two underlying drivers behind the amplification of the investment gap. The first driver is the ability of cash-rich SMEs to persistently outcompete their cash-poor rivals. In line with this mechanism, we find that cash holdings before the onset of the crisis had a positive effect on market share growth during the crisis and this effect was again amplified during the recovery phase. In addition we show that cash contributed positively to a firm's operating performance. The second driver is a cash-dependent tightening of borrowing constraints during the crisis and recovery period. In line with the recent literature showing that corporate debt is often collateralized by cash-flow (Ivashina, Laeven and Moreno, 2020; Lian and Ma, 2021), we find that cash-poor firms experienced a sharper decline in their debt levels during the crisis and again even more so during the recovery period. This suggests a role in macro-finance models for not only size-dependent borrowing constraints (Gopinath et al., 2017) or collateral-dependent borrowing constraints (e.g. Kiyotaki and Moore, 1997; Khan and Thomas, 2013) but also cash-dependent borrowing constraints.

Our findings have three key implications. First, our analysis suggests that estimates of the impact of a crisis should take long-term effects into account. Focusing only on the crisis years significantly underestimates the true effect of the shock. Second, we show that SMEs may hold cash going into a crisis due to sheer luck or due to prudent cash management but not necessarily because they are the most profitable or productive firms. If high-productive but cash-poor SMEs are not able to catch up with unproductive but cash-rich rivals persistent disruptions to the efficient allocation of capital can result. The crisis-induced selection on cash is thus another mechanism through which financial frictions can dampen the cleansing effect of recessions and exacerbate the misallocation of resources (e.g. Khan and Thomas, 2013; Foster, Grim and Haltiwanger, 2016) especially affecting young firms (Ouyang, 2009). Third, we find that cash-poor SMEs reduce their capital stock when a shock hits. This points to the need for well-designed public lending schemes to ease the funding shortages of otherwise solvent SMEs

when a (financial or economic) crisis hits in order to avoid lasting damage to the economy's productive capacity.

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Figure 1: **Cash holdings and firm size**
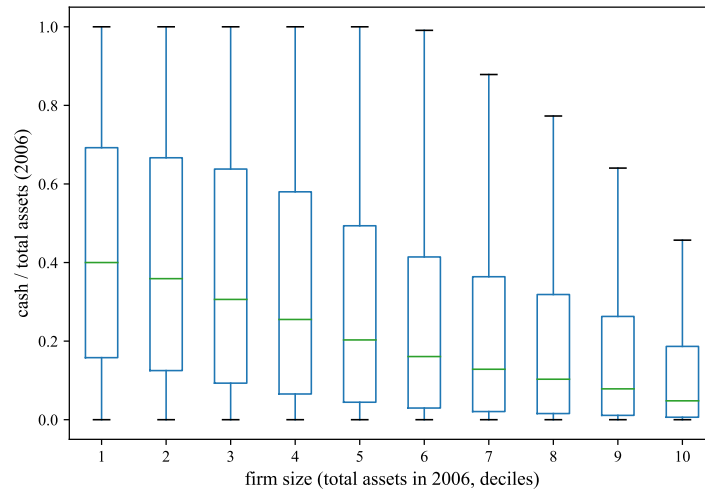
Notes: This figure shows box and whisker plot of cash holdings for various firm sizes. Both cash holdings and total assets are measured in 2006.

Figure 2: **Cash holdings and profitability**
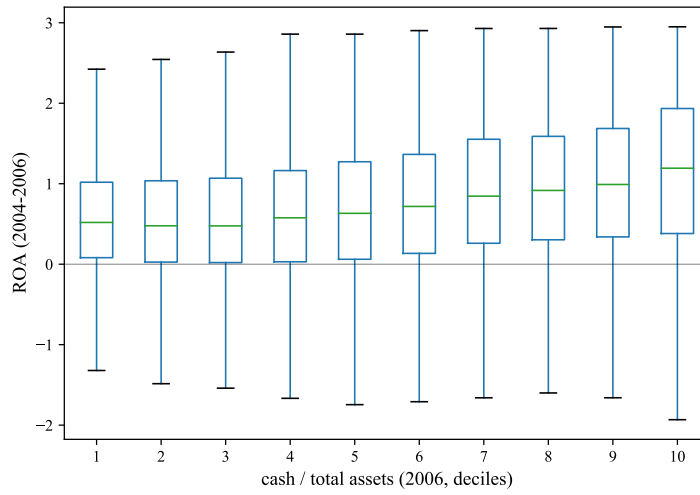
Notes: This figure shows a box whisker plot of past profitability for various groups of firms ranked by their cash holdings. Cash holdings are defined as deposits over total assets and measured in 2006. Profitability is defined as the cumulative profits over total assets of the firm measured over the period 2004-2006.

Figure 3: **Autocorrelation cash holdings**
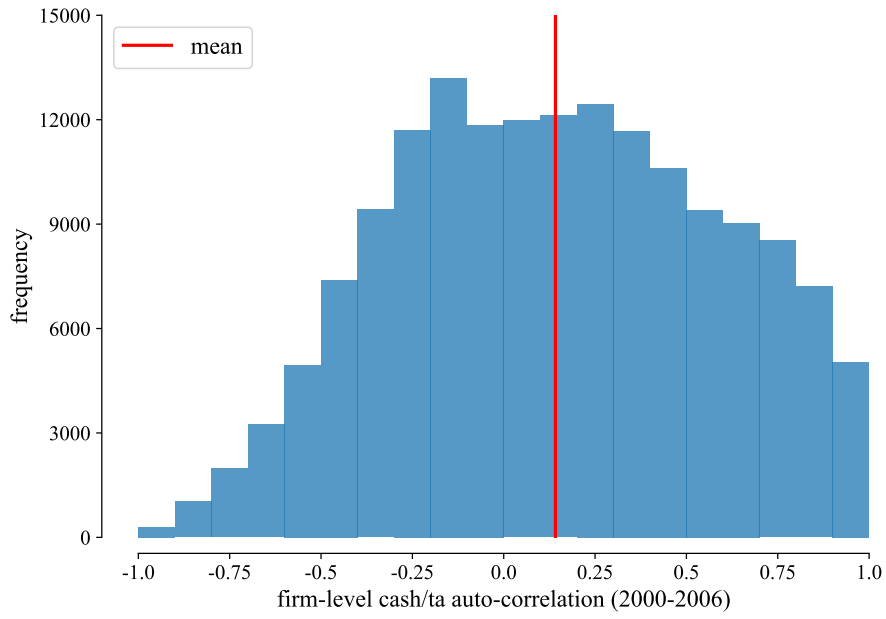
Notes: This figure plots the distribution of the one-lag auto-correlation coefficient of cash holdings over the period 2000 to 2006 of firms that are active during the period 2000-2014. Cash holdings are defined as deposits over total assets. The vertical red line marks the mean of the distribution.

Figure 4: **Variations in cash holdings by industry**
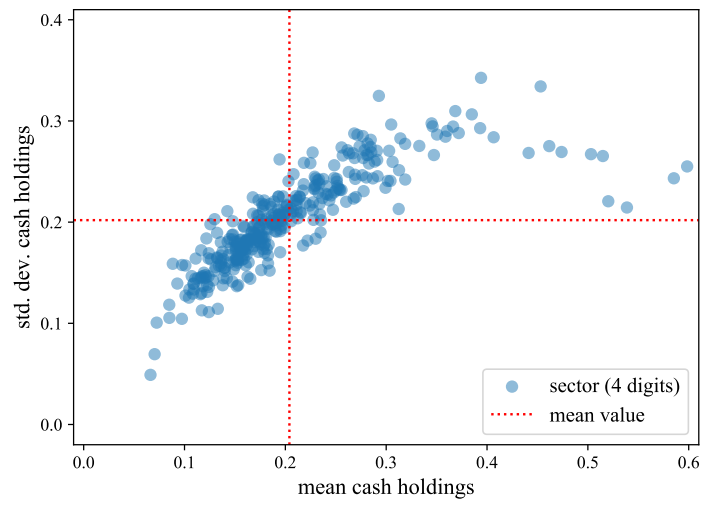
Notes: This figure plots the correlation between the mean and standard deviation of cash holdings of UK firms at the 4-digit industry level. Cash holdings are defined as deposits over total assets and measured in 2006.

Figure 5: **Investment high vs low cash firms: crisis and pre-crisis period**

Panel A: Crisis period: 2007-2014


Panel B: Pre-crisis period: 2001-2007
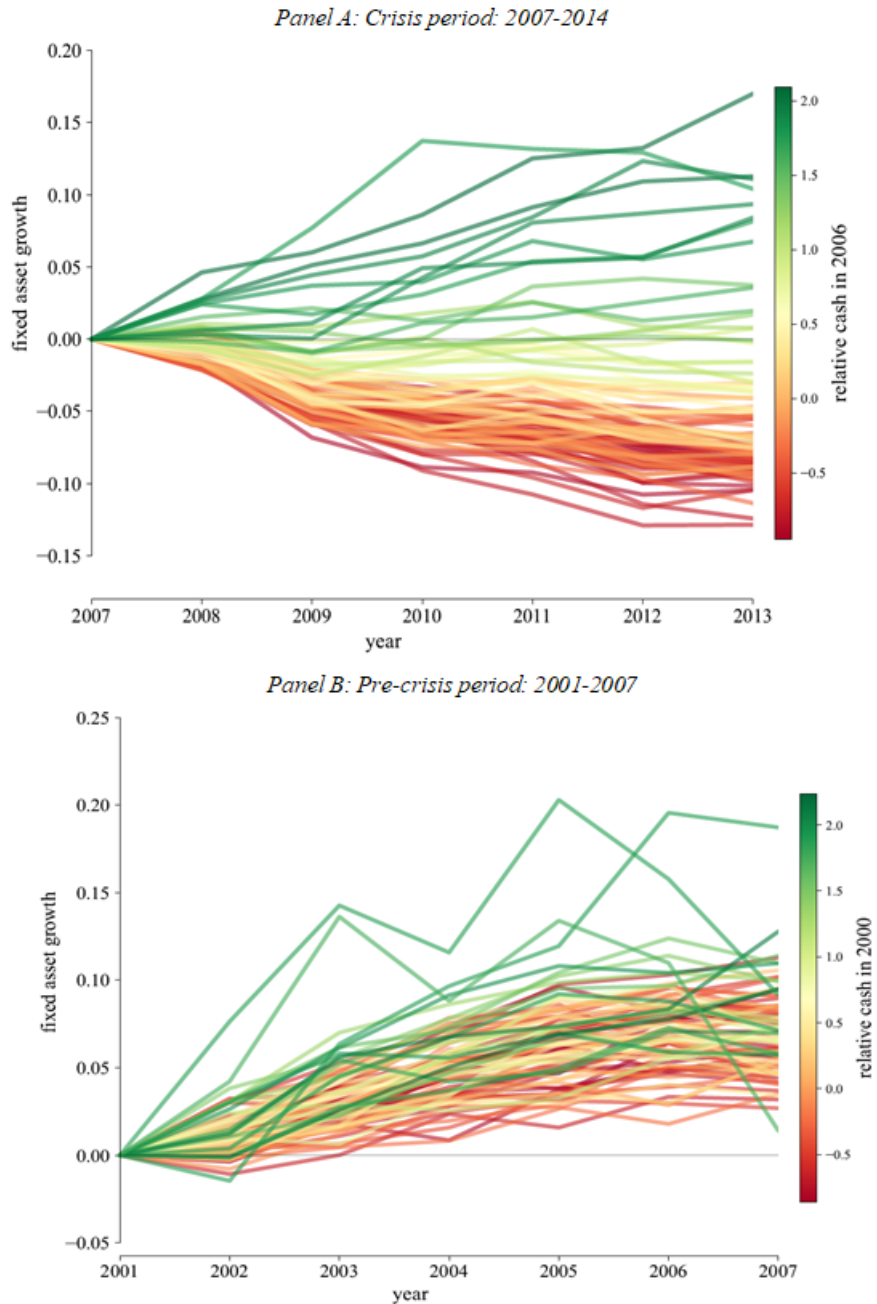
Notes: These figures plot the average fixed asset growth for firms in each percentile of relative-to-rivals cash within the 90 percent interquartile range. In panel A average fixed asset growth is tracked over the period 2007-2014 and in panel B over the period 2001-2007. Fixed asset growth is defined as the log difference between 2007 and $2007+j$ (crisis period) and between 2001 and year $2001+j$ (pre-crisis period). Relative cash is calculated by subtracting from the firm's cash holdings its industry mean and divide the difference by the industry standard deviation and is measured in 2006 for the crisis period and in 2000 for the pre-crisis period. Industry mean and standard deviation are determined at the 4-digit level.

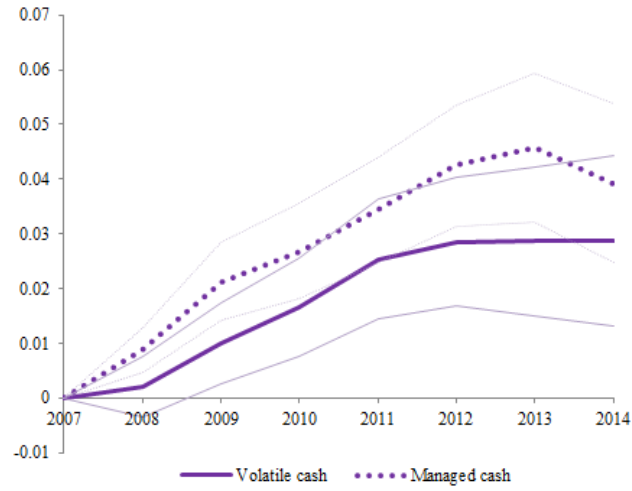Figure 6: **Long-term impact of cash on investment**
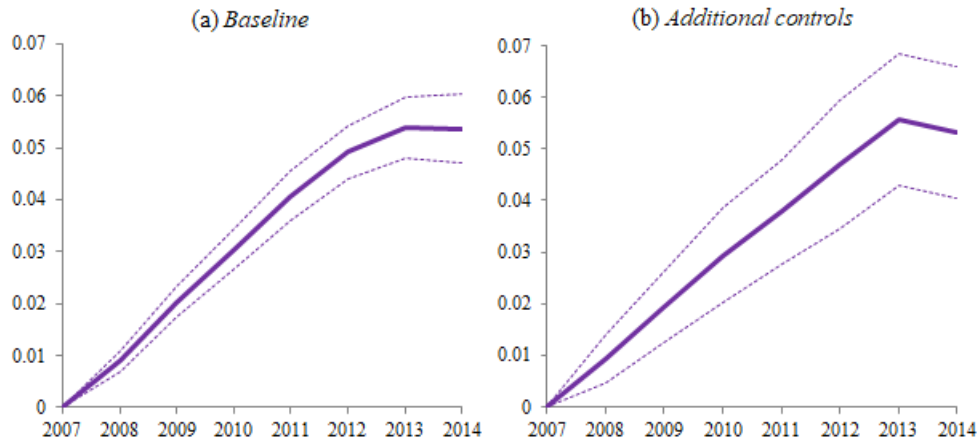
Notes: These figures plot the impact of relative-to-rivals cash on investment over different horizons using local projections. The dependent variable is the cumulative fixed asset growth between 2007 and 2007+j, where j ranges from 1 to 7. The model specification used in the left-hand side panel includes controls for leverage, size, age category, group, publicly listed, profit and investment. The model specification used in the right-hand side panel also includes controls for turnover growth. All variables are measured in 2006, except investment and turnover growth which are measured over 2005-2006 and 2006-2007. Both specifications include region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. The lines correspond to the estimated parameter of Relative cash and the dashed lines show the 90 percent confidence intervals .

Figure 7: **Estimated investment of cash-rich and cash-poor firms during crisis and recovery**
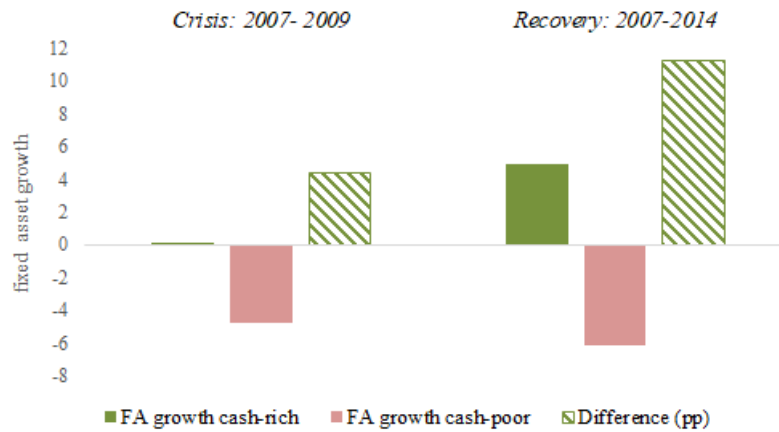
Notes: This figure plots the estimated cumulative fixed asset growth of cash-rich and cash-poor firms and the difference between the two based on the estimated coefficients of the baseline model. The left hand side panel shows fixed asset growth between 2007 and 2009, the right hand side panel between 2007 and 2014. Cash-rich corresponds to the 90th percentile of within industry firm distribution of relative cash. Cash-poor corresponds to the 10th percentile.

Figure 8: Long-term impact of cash on investment - persistence of cash holdings

Notes: This figure plots the impact of relative-to-rivals cash on investment over different horizons using local projections for subsets of firms with volatile or managed cash holdings. Cash persistence is measured as the one-lag auto-correlation coefficient of *Relative cash* over the period 2000 to 2006. Firms with volatile cash are those ranked in the lower tercile of the persistence distribution and firms with managed cash are those ranked in the upper tercile of the distribution. The dependent variable is the cumulative fixed asset growth between between 2007 and $2007+j$, where j ranges from 1 to 7. The regressions are based on a sub-set of 115,494 firms who report information on their cash holdings each year between 2000 and 2006. All regressions include the standard control variables and region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. The dark-colored lines correspond to the estimated parameter of Relative cash and the corresponding light-colored lines show the 90 percent confidence intervals.

Figure 9: **Long-term impact of cash on investment - crisis vs pre-crisis period**
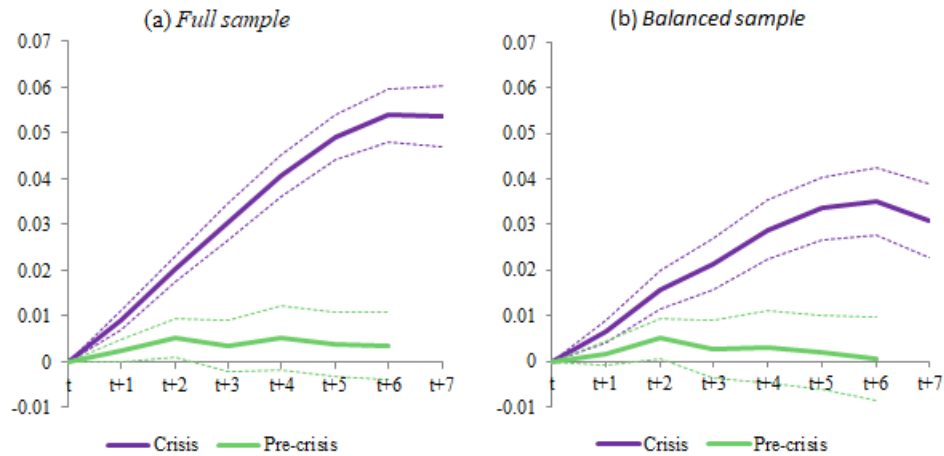
Notes: These figures plot the impact of relative-to-rivals cash on investment over different horizons using local projections for the crisis and pre-crisis periods. The dependent variable is the cumulative fixed asset growth between 2007 and 2007+j, where j ranges from 1 to 7 for the crisis sample and between 2001 and 2001+j, where j ranges from 1 to 6 for the pre-crisis sample. The full sample includes all firms for which information is available. The balanced sample includes the subset of firms that are both present in the crisis and the pre-crisis sample. All regressions include the standard control variables and region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. The lines correspond to the estimated parameter of *Relative cash* for the two periods and the dashed lines show the 90 percent confidence intervals.

Figure 10: **Estimated long-term investment of cash-rich and cash-poor firms - crisis vs pre-crisis period**
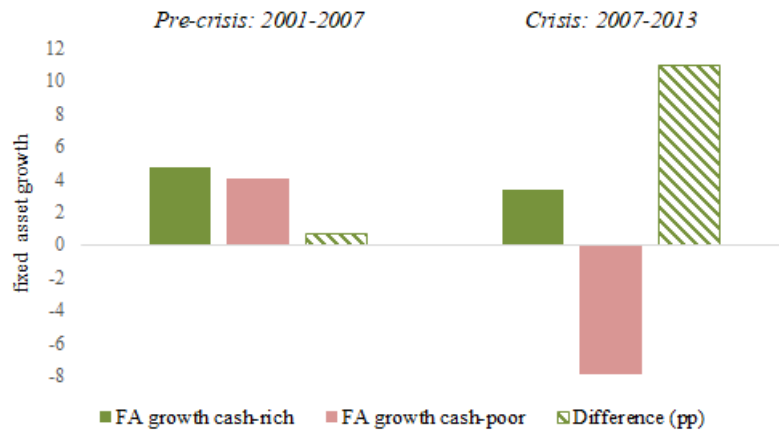
Notes: This figure plots the estimated cumulative fixed asset growth of cash-rich and cash-poor firms and the difference between the two based on the estimated coefficients of the baseline models for the pre-crisis and the crisis periods. The left hand side panel shows fixed asset growth between 2001 and 2007 (pre-crisis) and the right hand side panel between 2007 and 2013 (crisis). Cash-rich corresponds to the 90th percentile of within industry firm distribution of relative cash. Cash-poor corresponds to the 10th percentile.

Figure 11: **Long-term impact of cash on investment - tangible vs intangible**
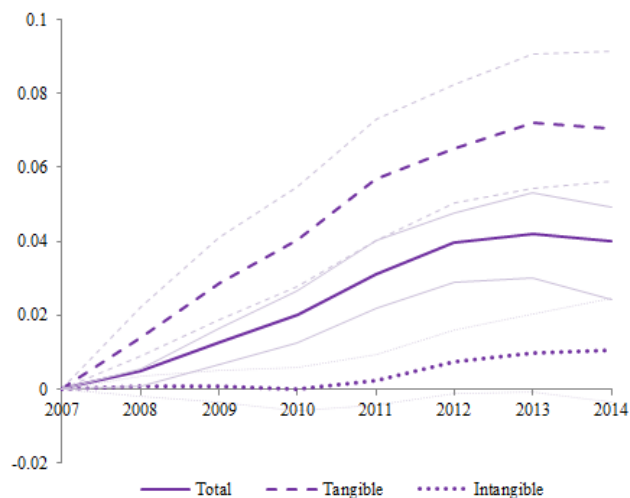
Notes: This figure plots the impact of relative-to-rivals cash on investment in tangible and intangible fixed assets over different horizons using local projections. The dependent variable is the cumulative fixed asset growth between 2007 and $2007+j$, where j ranges from 1 to 7, where fixed asset growth captures the growth in tangible, intangible or total fixed assets respectively. The regressions are based on a sub-set of 16,616 firms that report information on both tangible and intangible assets. All regressions include the standard control variables and region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. The dark-colored lines correspond to the estimated parameter of Relative cash and the corresponding light-colored lines show the 90 percent confidence intervals.

Table 1: **Summary Statistics**

Variable Name	Obs	Mean	Median	Std. Dev.	Min	Max
Crisis sample						
ΔlnFA (2007-2014)	235,396	-0.06	-0.02	1.00	-3.45	40.09
Relative cash	235,396	-0.14	-0.42	0.85	-1.42	2.89
Leverage	235,396	0.62	0.60	0.39	0.00	3.47
Size	235,396	5.55	5.53	1.64	1.10	10.30
Mature	235,396	0.19	0.00	0.39	0.00	1.00
Old	235,396	0.25	0.00	0.43	0.00	1.00
Group	235,396	0.09	0.00	0.29	0.00	1.00
Profit	235,396	0.29	0.31	0.40	-3.18	0.99
Pre-Investment (1st lag)	235,396	0.03	0.00	0.38	-1.35	2.20
Pre-Investment (2nd lag)	235,396	0.05	0.00	0.40	-1.26	2.27
Pre-Turnover growth (1st lag)	34,519	0.06	0.05	0.3	-1.83	1.64
Pre-Turnover growth (2nd lag)	34,519	0.09	0.06	0.33	-1.74	1.99
%ΔMshare (2007-2014)	230,077	0.17	-0.08	1.01	-0.95	9.04
$\sum$ Profit (2007-2014)	220,665	2,241	552	4,835	-11,742	55,379
$\sum$ ROA (2007-2014))	220,665	2.08	2.24	2.72	-14.35	6.62
ΔlnDebt (2007-2014)	108,436	0.05	0.03	0.47	-2.71	1.84
ΔlnST Debt (2007-2014)	108,436	0.05	0.03	0.47	-2.71	1.84
ΔlnLT Debt (2007-2014)	108,436	0.05	0.03	0.47	-2.71	1.84
Pre-crisis sample						
ΔlnFA (2001-2007)	158,175	0.07	0.00	0.96	-3.40	3.87
Relative cash	158,175	-0.13	-0.44	0.85	-1.30	3.11
Leverage	158,175	0.63	0.62	0.38	0.00	3.33
Size	158,175	5.67	5.69	1.60	1.10	19.33
Mature	158,175	0.26	0.00	0.44	0.00	10.39
Old	158,175	0.32	0.00	0.47	0.00	1.00
Group	158,175	0.13	0.00	0.34	0.00	1.00
Profit	158,175	0.27	0.28	0.40	-3.00	0.98
Pre-Investment (1st lag)	158,175	0.03	0.00	0.39	-1.50	2.14
Pre-Investment (2nd lag)	158,175	0.07	0.00	0.41	-1.39	2.30

Notes: The table presents summary statistics for the key variables used in the empirical analyses.

Table 2: **Pre-crisis characteristics high cash and low cash firms**

Variable	High relative cash	Low relative cash	Difference
Cash holdings	0.57	0.03	0.54***
Size (th)	684	1,700	-1015***
Young (< 10y)	0.58	0.56	0.02***
Fixed assets	0.20	0.44	-0.24***
Leverage	0.48	0.77	-0.29***
Profit	0.47	0.15	0.32***
Investment	0.04	0.04	0.00

Notes: This table presents difference-in-differences estimate from a Mann-Whitney two-sided t-test on selected pre-crisis balance sheet characteristics of firms with high and low cash relative to their industry rivals. High relative cash firms are those firms in the top quartile of relative-to-rivals cash distribution and low relative cash firms are those in the bottom quartile of the distribution as measured in 2006. *Cash holdings* denotes the firm's deposits over total assets. *Size* denotes the firms' total assets (in thousands). *Young* is a dummy which is one if the firm is 10 years or younger. *Fixed assets* denotes the firm's share of fixed assets over total assets. *Leverage* denotes the share of total liabilities over total assets. *Profit* denotes the firm's profit over total assets. *Investment* denotes the average of the log difference of the firm's fixed assets between 2005 and 2006 and between 2006 and 2007. All variables are measured in 2006 unless otherwise specified. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 3: **Cross-firm impact cash on investment, 2007-2014**

Financial constraints criteria	Constrained	Unconstrained	Difference (p-value)
Age	*Young*	*Old*	
	0.068***	0.034***	0.00***
	(0.005)	(0.007)	
	132,142	58,162	
Size	*Small*	*Large*	
	0.087***	0.060***	0.14
	(0.009)	(0.009)	
	58,336	58,920	

Notes: This table presents the estimates of relative-to-rivals cash on fixed asset growth from 2007-2014 across different groups of firms. Firms are classified on the basis of proxies for financial constraints based on their age and size. Constrained firms in terms of age are firms that are 10 years or younger and unconstrained firms are firms older than 20 years. Constrained firms in terms of size are firms in the bottom quartile of the total asset distribution and unconstrained firms are those in the top quartile. Age and size are measured in 2006. All regressions include the control variables as specified in model (1) and include 4-digit industry and region fixed effects. Standard errors allow for correlation at the 4-digit industry level. The last column presents the p-value associated with the F-tests that compare the coefficients between the constrained and unconstrained subgroups. The number of firms in each group is in italics. Standard errors are in parentheses. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 4: **Cross-industry impact cash on investment, 2007-2014**

Industry criteria	Low	High	Difference
			(p-value)
Panel A			
Age	0.068***	0.047***	0.00***
	(0.006)	(0.005)	
	86,540	*38,790*	
Size	0.070***	0.038***	0.00***
	(0.005)	(0.008)	
	111,749	*48,557*	
Panel B			
Capital intensity	0.057***	0.061***	0.71
	(0.008)	(0.007)	
	51,963	*60,804*	
Concentration	0.046***	0.056***	0.50
	(0.006)	(0.013)	
	114,057	*29,359*	
Depth crisis	0.058***	0.046***	0.25
	(0.006)	(0.008)	
	82,639	*33,547*	

Notes: This table presents the estimates of relative-to-rivals cash on cumulative investment between 2007-2014 across different industries. The dependent variable is the log difference of fixed assets between 2007 and 2014. Industries are classified on the basis of different criteria. *Age* captures the industry mean firm age and *Size* the industry mean firm size. *Capital intensity* captures the industry mean firm ratio of fixed assets over total assets. *Concentration* equals the industry's Herfindahl index based on turnover. *Depth crisis* captures the mean firm growth in value added between 2007 and 2010. All measures are calculated at the 4-digit industry level. *Low* industries are those ranked in the bottom quartile of the respective distribution and *High* industries are those ranked in the top quartile of the same distribution, except for *Depth crisis* where *Low* captures the top quartile and *High* the bottom quartile. All industry characteristics, except depth crisis, are measured in 2006. All regressions include the control variables as specified in model (1) and include 4-digit industry and region fixed effects. Standard errors allow for correlation at the 4-digit industry level. The last column presents the p-value associated with the F-tests that compare the coefficients between the high and low subgroups. The number of firms in each group is in italics. Standard errors are in parentheses. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 5: **Alternative cash measures**

Cash variable	Excess cash		Cash holdings		Relative cash (2007)	
Horizon	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*
	(1)	(2)	(3)	(4)	(5)	(6)
Cash variables	0.004***	0.013***	0.111***	0.253***	0.031***	0.072***
	(0.000)	(0.006)	(0.009)	(0.015)	(0.002)	(0.004)
Firm controls	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Region fixed effects	yes	yes	yes	yes	yes	yes
R-squared	0.020	0.029	0.025	0.037	0.026	0.039
No. Observations	101,234	101,234	226,405	226,405	227,536	227,536

Notes: This table presents the estimates of various cash measures on cumulative investment between 2007-2014 across different industries. The dependent variable is the log difference of fixed assets between 2007 and 2014. In columns 1 and 2 excess cash is used which is defined as the residual cash to total assets in 2006. In columns 3 and 4 cash holdings are used, which is defined as cash holdings over total assets in 2006. In columns 5 and 6 relative cash is measured in 2007 instead of 2006. All regressions include the control variables as specified in model (1) and include 4-digit industry and region fixed effects. Standard errors allow for correlation at the 4-digit industry level. Standard errors allow for correlation at the 4-digit industry level. Standard errors are in parentheses. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 6: **Competition channel**

Dependent variable	Market share		Profit		ROA	
Horizon	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*
	(1)	(2)	(3)	(4)	(5)	(6)
Relative Cash	0.011***	0.017***	0.020***	0.165***	0.034***	1.197***
	(0.004)	(0.006)	(0.003)	(0.023)	(0.003)	(0.017)
Firm controls	yes	yes	yes	yes	yes	yes
Industry fixed effects	no	no	yes	yes	yes	yes
Region fixed effects	yes	yes	yes	yes	yes	yes
R-squared	0.010	0.012	0.691	0.441	0.754	0.574
No. Observations	224,234	224,234	220,783	220,783	220,783	220,783

Notes: This table presents the estimates of relative-to-rivals cash on market share growth and profit. The dependent variable is cumulative market share growth (columns 1 and 2), cumulative profit (columns 3 and 4), and cumulative ROA (columns 5 and 6). Growth rates are measured between 2007 and 2009 in the uneven columns and between 2007 and 2014 in the even columns. All regressions include all control variables as specified in model (1) plus the first and second lag of the respective dependent variables. Market share regressions include region fixed effects, all other regressions include region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. Standard errors are in parentheses. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Table 7: **Borrowing constraints channel**

Dependent variable	Total debt		Short-term debt		Long term debt	
Horizon	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*	*2007-2009*	*2007-2014*
	(1)	(2)	(3)	(4)	(5)	(6)
Relative Cash	0.058***	0.091***	0.032***	0.062***	0.042***	0.072***
	(0.006)	(0.009)	(0.004)	(0.005)	(0.005)	(0.009)
Firm controls	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes
Region fixed effects	yes	yes	yes	yes	yes	yes
R-squared	0.101	0.106	0.109	0.122	0.076	0.079
No. Observations	108,436	108,436	108,436	108,436	108,436	108,436

Notes: This table presents the estimates of relative-to-rivals cash on debt growth. The dependent variable is cumulative growth in total debt (columns 1 and 2), in short-term (columns 3 and 4), and in long-term debt (columns 5 and 6). Growth rates are measured between 2007 and 2009 in the uneven columns and between 2007 and 2014 in the even columns. All regressions include all control variables as specified in model (1) plus the first and second lag of the respective dependent variables. All regressions include region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. Standard errors are in parentheses. *** indicates significance at the 1% level, ** at the 5% level, and * at the 10% level.

Appendix

Figure 1: **Correlation annual change in relative cash and one period ahead fixed asset growth**
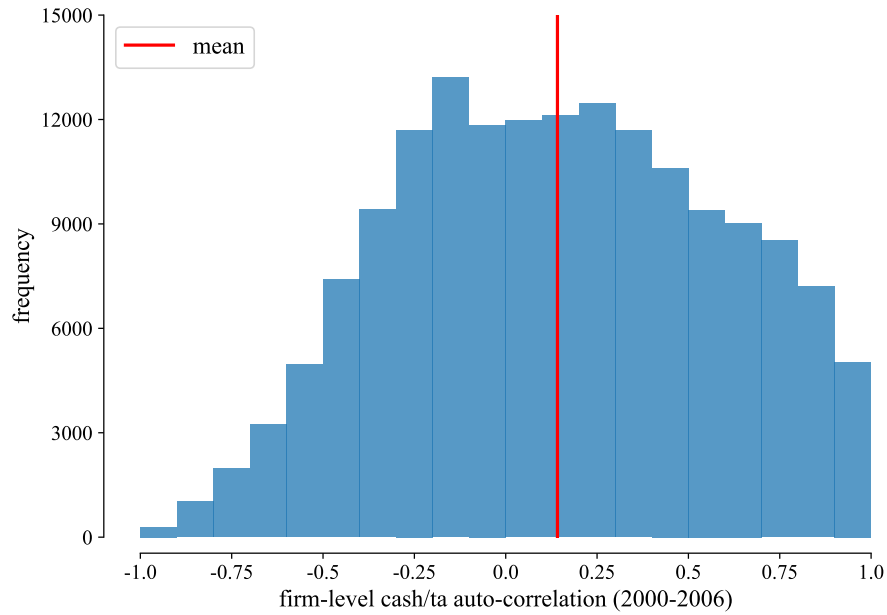
Notes: This figure plots the distribution of the one-lag auto-correlation coefficient of cash holdings over the period 2000 to 2006 of firms that are active during the period 2000-2014. Cash holdings are defined as deposits over total assets. The vertical red line marks the mean of the distribution.

Figure 2: Long-term impact of cash on investment - different tranquil periods
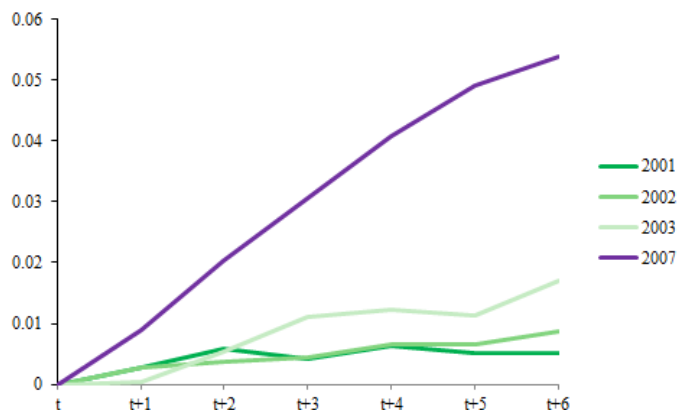
Notes: This figure compares the impact of relative-to-rivals cash on investment for different pre-crisis periods with the impact for the crisis period. It plots the impact of relative-to-rivals cash on investment over different horizons using local projections. The dependent variable is the cumulative fixed asset growth between year t and year t+j, where j ranges from 1 to 6 and where t equals 2001, 2002, 2003 or 2007. Relative cash is measured in year t-1 for all regressions. All regressions include the standard control variables as specified in model (1) and region and 4-digit industry fixed effects. Standard errors allow for correlation at the 4-digit industry level. The lines correspond to the estimated parameter of Relative cash for the four periods.

Table 1: **Variable definitions and sources**

Variable Name	Definition	Source
ΔlnFA	Log difference of fixed assets between 2007 and year 2007+ j (crisis period) or between 2001 and 2001 + j (pre-crisis period)	FAME
Relative cash	Cash holdings of the firm minus the (4-digit) industry mean cash holdings and divided by the (4-digit) industry standard deviation. Cash holdings equal deposits divided by total assets.	FAME
Leverage	Total liabilities over total assets	FAME
Size	Log of total assets	FAME
Mature	Dummy equal to one if the firm is between 10 and 20 years old	FAME
Old	Dummy equal to one if the firm is older than 20 years	FAME
Group	Dummy equal to one if the firm has a parent or is part of a group, which we define as a firm that reports an ultimate owner in FAME	FAME
ROA	Profit over total assets	FAME
Pre-Investment	Log difference of fixed assets between 2005 and 2006 and between 2006 and 2007 (crisis period) or between 1999 and 2000 and between 2000 and 2001 (pre-crisis period)	FAME
Pre-Turnover growth	Log difference of turnover between 2005 and 2006 and between 2006 and 2007 (crisis period) or between 1999 and 2000 and between 2000 and 2001 (pre-crisis period)	FAME
Industry age	Average age of firms in a 4-digit industry	FAME
Industry size	Average size of firms in a 4-digit industry	FAME
Industry capital intensity	Average fixed assets over total assets of firms in a 4-digit industry	FAME
Industry HHI	Herfindahl-Hirschman Index (HHI) based on turnover for each 4-digit industry	ONS
Industry depth crisis	Average growth of value added by firms in a 4-digit industry	ONS
%ΔMShare	Growth rate of the firm's market share over the period 2007 to 2009/2014, where market share is defined as the ratio of the firm's assets over the total industry assets (at 4-digit level).	FAME
$\sum$ Profit	Cumulative profits over the period 2007 to 2009/2014	FAME
$\sum$ ROA	Cumulative ROA (profit/ta) over the period 2007 to 2009/2014	FAME
ΔlnDebt	Log difference of total debt (short-term loans + trade credit + long-term debt) over the period 2007 to 2009/2014	FAME
ΔlnDebt	Log difference of short-term debt (short-term loans + trade credit) over the period 2007 to 2009/2014	FAME
ΔlnDebt	Log difference of long-term debt over the period 2007 to 2009/2014	FAME