All You Need is Cash: Corporate Cash Holdings and Investment after the Global Financial Crisis*

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Abstract

Cash holdings at the onset of a financial crisis are a key determinant of investment by SMEs not only during the crisis but also during the recovery period. Cash-rich SMEs could maintain their capital stock during the global financial crisis, while cash-poor rivals reduced theirs. This gave cash-rich SMEs an advantage when the economy rebounded, resulting in a persistent investment gap which grew over the seven years following the shock. The amplification effect was present for SMEs with both volatile and stable cash holdings and was particularly pronounced for younger and smaller firms. Competition dynamics and borrowing constraints seem to drive this amplification effect.

JEL classification: E22, E32, E44, G32

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1 Introduction

In many countries small and medium-sized enterprises (SMEs) account for the lion's share of employment and output and are important drivers of innovation and growth (Haltiwanger, Jarmin and Miranda, 2013; Acemoglu et al., 2018). However, as the Covid-19 pandemic once again demonstrates, economic and financial crises are particularly challenging for these firms. Their activities tend to be less diversified and downsizing is often difficult, making them more vulnerable to a sudden fall in demand. They also typically require more screening and monitoring by lenders, so banks tend to cut credit to SMEs more aggressively during crises (Chodorow-Reich, 2014; Chodorow-Reich et al., 2021; Greenwald, Krainer and Pascal, 2020). And when they do so, they are less able to switch to other types of external funding and have to rely on internal sources of finance instead (Iyer et al., 2014; Cingano, Manaresi and Sette, 2016). This suggests that SMEs are particularly dependent on their cash buffers during downturns and that their cash holdings can affect the speed at which economies recover.

Yet we still know surprisingly little about the role cash buffers play when SMEs are hit by a shock. 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 during the crisis and the subsequent recovery period. Using balance sheet data for a large sample of UK SMEs, we find that having cash at hand enabled SMEs, particularly younger and smaller ones, to maintain their capital stock during the crisis when industry rivals had to reduce theirs. This gave initial cash-rich firms an advantage when the recovery set in, leading to a persistent investment gap between cash-rich and cash-poor firms which grew over the seven years following the shock. Competition dynamics and borrowing constraints affecting cash-rich and cash-poor SMEs differently seem to drive this amplification effect.

There are several reasons why having cash buffers at the onset of a crisis make 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. 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 more likely have sufficient funds to replace fixed assets that have depreciated and to seize profitable investment opportunities. Their cash-starved rivals by contrast may lack the funds to finance investment and may even struggle to survive.[1]

[1] 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.

Differences in firm behavior during the crisis can subsequently impact investment during the recovery. Competition dynamics can change if cash-rich firms are able to maintain their productive capacity during the downturn and cash-poor firms have to reduce theirs. When the recovery sets in and demand returns, 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 have lost productive capacity have difficulties meeting demand in the recovery phase. They can therefore generate less revenue, have less funds for reinvestment and see their positions weaken further. These effects are reinforced if weaker initial cash holdings and lower earnings (post-)crisis result in tighter borrowing constraints for cash-poor firms not only during the crisis but also during the recovery period. Due to these feedback effects, the investment gap between cash-rich and cash-poor SMEs that opens up during a crisis might become larger during the recovery period.

Simple correlations between initial cash and subsequent investment suggest that having cash at the right moment in time can indeed have long-term implications: 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 1, top panel). While SMEs with a lot of cash maintained or even increased their fixed assets between 2007 and 2009, cash-poor firms decreased their stock of fixed assets. 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, 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 1, bottom panel).[2]

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). 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 broad set of pre-crisis firm characteristics and include 4-digit industry and regional fixed effects. Our sample consists of surviving SMEs to ensure that changes in cash-investment sensitivities across different horizons are not driven by firm entry or exit.

Similar to the findings for publicly listed firms in the US (Duchin, Ozbas and Sensoy, 2010), we show that SMEs with high initial levels of cash relative to their industry rivals invested more during the crisis. The differential effect was the result of two opposing forces: Firms with large cash buffers (90th percentile of the distribution) maintained their stock of fixed assets while firms with less cash (the 10th percentile) reduced theirs between 2007 and 2009, resulting in

[2]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 initial cash holdings in the two periods.

an investment gap of 4.7 percentage points. In line with the mechanism described above, we find that the positive effect of cash not only persisted but became larger during the recovery phase: By 2014 cash-rich SMEs had increased their stock of fixed assets by 4.6 percent relative to 2007, while cash-poor SMEs had decreased their fixed assets by 6.6 percent. This implies that the size of the investment gap between cash-rich and cash-poor firms more than doubled during the recovery period to reach 11.2 percentage points. To the best of our knowledge, this long term effect of pre-crisis cash buffers on investment has not been documented yet.

A key concern with our identification strategy is that cash positions of SMEs might be endogenously related to their investment opportunities during and after a crisis. We address this concern in several ways. First, we measure a firm's cash holdings just before the start of the crisis and 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 range of firm characteristics that are correlated with a firm's cash holdings and could potentially affect its ability or willingness to invest. In addition, the 4-digit industry and regional fixed effects absorb for each investment horizon the impact of industry and regional conditions, such as industry specific uncertainty and demand shocks.

Third, we exploit the empirical regularity that for a significant number of SMEs cash holdings fluctuate substantially year-on-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. We document a positive impact of having cash on investment during the crisis and a significant amplification effect during the recovery period for both firms with stable and with volatile cash holdings. Furthermore, we show that our results continue to 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).

Fourth, we conduct a placebo test and show 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) and we do not find an amplification of the cash-effect in the long term. This suggests that SMEs do not systematically hoard cash in anticipation of investment opportunities in the longer term. Finally, we exploit heterogeneity in our sample of firms. We show that the impact of cash was particularly large for young and small SMEs, 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). Similarly, the cash-effect was larger in industries where credit conditions likely tightened more during the crisis. Taken all this evidence together significantly reduces concerns that our results are driven by unobserved

firm characteristics that are correlated with cash holdings.[3]

In the final section, we explore two potential mechanisms that can explain the growing investment gap that we document for the recovery period. The first mechanism relates to a shift in competition dynamics. During the 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 potentially 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 might have further advanced their competitive position if they were able to 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 might have exploited 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 document a positive effect of pre-crisis cash holdings on market share growth and profits during the crisis which was amplified during the recovery phase.

The second mechanism relates to borrowing constraints. It assumes that the crisis-induced tightening of borrowing constraints affected cash-rich SMEs 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 SMEs more likely maintained access to credit on affordable terms during the crisis when banks withdrew credit more aggressively from smaller firms (Chodorow-Reich, 2014; Iyer et al., 2014). When credit conditions improved during the recovery period this might not have benefited initial cash-poor firms in the same way as their cash-rich rivals. The loss of fixed assets could have made it difficult for cash-poor firms to borrow if banks, which emerged from the crisis with weaker balance sheets and faced tighter regulation, preferred to lend to low-risk firms with sufficient assets to pledge as collateral. 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 have been easier for cash-rich firms to borrow 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

[3]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., 2021; 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).

firms experienced a sharper decline in their debt levels during the crisis and that the effect was again 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 can potentially underestimate the true effect of the shock. As we show, the cash position of SMEs going into the crisis has long-lasting effects on their ability to invest due to self-reinforcing dynamics. This result contrasts with Duchin, Ozbas and Sensoy (2010) who find that the positive impact of initial cash holdings on investment of publicly listed US firms is only short-lived. This highlights once more the importance of studying the whole firm size distribution as SMEs can and often do react differently to shocks. Second, our findings support the prediction of recent macro-finance models that a financial shock can lead to a long-lived misallocation of resources (e.g. Jermann and Quadrini, 2012; Khan and Thomas, 2013). Our results highlight a selection of winners and losers from the crisis on the basis of initial cash holdings. However cash-rich firms were not necessarily the best performing ones.[4] The need to rely on internal funds when financial constraints suddenly tighten and the self-reinforcing dynamics that this triggers can thus lead to a reallocation of resources away from the most productive companies. As cash is not the negative of debt (Acharya, Almeida and Campello, 2007), our findings suggest a role for cash holdings in addition to debt when modeling the macroeconomic effects of financial shocks.[5] Third, our results show that when faced with a financial shock, cash-poor SMEs reduce their capital stock with lasting effects on their productive capacity. This highlights the importance of a resilient financial system which continues to provide credit during a crisis. In addition, liquidity provision by governments especially to young and small firms during crises may 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 SME investment and Section 5 presents evidence on two potential underlying mechanisms. Section 6 concludes.

2 Contribution to the literature

This paper contributes to several strands of the literature. First, it relates to the literature on the real effects of the global financial crisis, which has mainly focused on short-term effects

[4] In normal times current cash holdings are only weakly correlated with past performance and future investment.

[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.

and the role of leverage. 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 were an important determinant of how firms responded to the crisis. 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). The role of cash holdings has received much less attention, but there is evidence that publicly listed US firms with limited cash invested less (Duchin, Ozbas and Sensoy, 2010) and cut employment more (Schoefer, 2015) during the global financial crisis. Our work complements these findings in several ways. First, we focus on SMEs rather than large, publicly listed firms. Second, we explicitly compare the short-term and the long-term impact of the crisis. We show that, in contrast to publicly listed firms, for SMEs the effect of initial cash-holdings is not only persistent but grows over time. Third, we 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. Partly due to data limitations, this literature 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).[6] Firms dynamically adjust the proportion of the cash flow they save to avoid having to finance their growth in the future at a higher cost (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 (Bancchetta, Benhima and Poilly, 2019; Melcangi, 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, 2020, Jeenas, 2018) or a credit supply shock (Beck, Da-Rocha-Lopes and Silva, 2021). A liquid balance sheet also allows 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

[6]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).

and their long-term investment decisions after a large financial shock.

Third, our paper contributes 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 Pappada, 2015) or even reversing it (Barlevy, 2003; Ouyang, 2009).[7] A shock to the financial system amplifies these effects and can distort the allocation of capital over longer periods of time through collateral constraints (Khan and Thomas, 2013) or debt enforcement constraints (Jermann and Quadrini, 2012).[8] The crisis-induced selection on cash that we document can also contribute to a persistent misallocation of 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 stifled especially among younger firms (Foster, Grim and Haltiwanger, 2016), we show that low cash reserves particularly suppress (long-term) investment by young SMEs.

3 Empirical methodology and data

Our paper aims to test whether the pre-crisis cash position of a 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.

3.1 Empirical methodology

We use a local projections framework (Jordà, 2005) to study how an SME's cash position going into the crisis affects its investment during and after the crisis.[9] 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.

[7] 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).

[8] 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.

[9] 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).

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:

$$\Delta lnFA_{i,07+j} = \beta_j Relative\ cash_{i,06} + \gamma_j X_i + \sum_{k=0}^{1} \theta_{kj} \Delta lnFA_{i,07-k} + \rho_s + \vartheta_r + \varepsilon_{i,j} \quad (1)$$

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. *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 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_s is a vector of 4-digit industry fixed effects, ϑ_r 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 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 regression results as graphs and plot our estimates of β_j over horizons $j = 1, \ldots 7$.

3.2 Firm balance sheet data

Our primary data source is the FAME database provided by Bureau van Dijk (BvD). The FAME database is a subset of the more commonly used Amadeus (European firms) and Orbis

(global firms) datasets that BvD compiles. 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 much of the UK's corporate universe.[10] Datasets such as Compustat and Worldscope that are commonly used in the literature on the real effects of financial crises and the literature on corporate cash holdings 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 were more likely to be affected by a tightening of financial conditions during the crisis.

Part of our identification strategy relies on the comparison of 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 on 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 of firm accounting data and overlay the balance sheet information from these different vintages.[11] Each vintage contains ten years of financial accounts for active companies and five years for inactive or dissolved companies.[12] 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.[13] Furthermore, UK

[10] 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.

[11] As discussed in great detail by Kalemli-Ozcan et al., 2015 construct 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 BvD.

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

[13] See Bahaj, Foulis and Pinter (2020) for a detailed description of firm reporting requirements in the 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. 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.[14]

Firms are classified using 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.[15] 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 definition of SMEs as firms with less than 250 employees. Instead, we rely on the criteria set out in the UK Companies Act of 2006 and only include firms with total assets of less than £18 million. Furthermore, we focus on the set of firms that survived both the crisis and the recovery period. This ensures 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 232,157 SMEs and the sample for our extended analysis which also controls for pre-crisis turnover consists of 33,564 SMEs. Descriptive statistics for these firms are shown in Table 1.

3.3 Regression variables

Our dependent variable is the growth rate of 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 invest-

[14]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.

[15]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.

ment is zero. We focus on net investment 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 an SME holds relative to its rivals in the same industry. This is because the competitive advantage that an 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. This accounts for the fact that a firm with a cash to asset ratio that exceeds the industry mean by 5 percentage points provides more value in an industry with a standard deviation of 3 percent than it does in an industry with a standard deviation of 10 percent. In robustness tests (Section 4.4) we show that our results are robust to using alternative measures of cash holdings.

We include a number of firm-specific variables to control for the main determinants of investment. Small and young SMEs 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 was between 10 and 19 years and *Old* which was 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. To control for the firm's pre-crisis performance 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.[16]

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.

We have more detailed balance sheet information for a subset of (older and larger) SMEs and can include an additional control variable for 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 of 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 Cash holdings of SMEs

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. In this section we therefore show 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 the smallest SMEs holding on average 33 percent of assets in cash and the largest ones on average 13 percent (Figure 2). The variation is substantial across all size categories, ranging from 26 percent for the smallest firms to 17 percent for the largest ones. Second, the correlation between cash holdings just before the crisis and firms' profits in the preceding three years is positive but rather weak with past-profits varying substantially across firms in each of the bins of the cash distribution (Figure 3). 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 4).[17] 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 varies substantially for most firms, possibly because of volatile revenues and lumpy investment.

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 5). Industry averages of cash holdings range from seven up to around 60 percent of total assets, with a mean

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

[17] On average the 1-lag autocorrelation of a firm's cash holdings is only 0.15. The distribution of the 1-lag autocorrelation of firm's relative cash holdings looks very similar with a mean autocorrelation of 0.16.

across all industries of 21 percent. This wide variation in average cash holdings reflects the fact that 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). In addition, the within-industry variation is large. The standard deviation of firms' cash holdings as a share of total assets is on average 20 percent. This means that when a financial crisis hits, some SMEs in an industry have large amounts of cash while others have very little. These within-industry differences in firm cash holdings is the variation we will exploit throughout the paper.

Table 2 provides a comparison of balance sheet characteristics of SMEs with high or low cash holdings relative to their industry rivals measured just before the global financial crisis. Cash-rich SMEs are defined as those in the top quartile of the relative-to-rivals cash distribution and cash-poor SMEs are those in the bottom quartile. Cash-rich SMEs hold on average 56 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 smaller, slightly younger, have less fixed assets, are less leveraged and the profits they made that year were slightly higher. The difference in pre-crisis investment between cash-rich and cash-poor SMEs is not significant. While cash-poor and cash-rich firms clearly differ in some observable characteristics, our empirical methodology allows us to control for those differences.

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 affected its investment during the financial crisis and whether the impact was 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. This is in line with the findings of a positive impact of cash on investment for publicly listed firms in the US (Duchin, Ozbas and Sensoy, 2010). Our findings are also in line with those of Berg (2018) and Beck,

Da-Rocha-Lopes and Silva (2021) 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. 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 than 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^{th} percentile of the relative cash distribution and cash-poor firms are those at the 10^{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. Hence, the cash-rich firm was able to replace its fixed assets that had depreciated during the crisis, i.e. its gross investment was positive, but its net investment zero. The fixed assets of the cash-poor firm decreased by 4.7 percent instead; a difference of close to 5 percentage points. By 2014 the cash-rich firm had increased its stock of fixed assets by 4.6 percent, while the cash-poor firm had decreased its fixed assets by 6.6 percent. In other words, the difference in investment more than doubled during the recovery period to 11.2 percentage points.

Our findings show that focusing exclusively on the direct crisis episode can underestimate the impact of a financial crisis on investment. Our evidence also highlights that the behavior of publicly listed (US) firms may differ from that of SMEs. Duchin, Ozbas and Sensoy (2010) show that for publicly listed firms in the US, the effect of cash on investment turns insignificant in the second phase of the crisis (July 2018-March 2019). Similarly, Schoefer (2015) finds for listed US firms that companies with low excess cash going into the crisis have lower capex growth at the height of the crisis, but investment of these firms rebounds more sharply in 2010. This difference in adjustment is consistent with credit supply shocks affecting SMEs and large publicly listed firms very differently because SMEs are subject to greater lender discretion (Chodorow-Reich et al., 2021).

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 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 instead. Firms that perform well have higher earnings that they can use to build cash buffers. 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 older and 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.[18]

As discussed in Section 3.4, the persistence of cash holdings tends to be low for most SMEs (on average the autocorrelation over the period 2000-2006 was only 0.15). But there is a lot of heterogeneity across SMEs: some SMEs are 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 was the result of a long-term strategy to maintain a liquid or illiquid balance sheet. For other firms, it was more the outcome of year-on-year variation in production and sales patterns and resulting volatile cash flows. This 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, how much cash a firm held when the credit cycle turned involved an element of luck. Therefore the cash holdings of these firms going into the crisis were plausibly exogenous to their ability to perform well during the crisis. Exploiting these to some extent random fluctuations in production and sales and resulting cash holdings at the time a financial shock hits is similar in spirit to exploiting variation in the amount 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 also holds for firms with more volatile cash holdings, we split our sample into firms with volatile and with stable cash holdings. We define firms with stable cash holdings as firms with a cash autocorrelation of 0.6 or higher, and firms with volatile cash holdings as firms with a cash autocorrelation between -0.2 and 0.2.[19] We find that for both groups, the cash coefficient is positive and significant for the investment horizons 2007-2009 and beyond and the investment gap increases over time (Figure 8).[20] Thus, 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.

[18] 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.

[19] We also use narrower bands (stable cash holdings for autocorrelations of 0.8 and higher and volatile cash holdings for autocorrelations between -.01 and 0.1) and the results are very similar.

[20] 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 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.

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

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 coefficients capturing cash-investment sensitivities for this period.

We focus on firms' initial cash positions in 2000 and trace out the effect of cash on investment over the period 2001-2007.[21] 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 155,913 firms.

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 at the 10 percent level for the first two years and become insignificant thereafter. The coefficients for the pre-crisis sample are much smaller than (and statistically different from) the coefficients for the crisis sample and 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 during the pre-crisis and crisis periods. Based on the estimated β_j-coefficient for the 6^{th} 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 4.5 percent and a cash-poor firm by 3.9 percent. The difference between the two was 1.1 percentage points and statistically significant at the 10 percent level.[22] By contrast, over the period 2007-2013 a cash-rich firm grew its stock of fixed assets by 3 percent, while a cash-poor firm shrank its stock by 8.2 percent. Hence, the difference in fixed asset growth amounted to 11.2 percentage points. This shows that the difference between the two periods is mainly driven by the behavior of cash-poor firms: While initially 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. One possible reason for the differences between the two periods could be that the pre-crisis sample contains a larger share of SMEs which, for example due

[21] 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.

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

to their production technology have lower cash-investment sensitivities. To ensure that this is not driving our results, we rerun our regressions for the subset of firms that are included in both the pre-crisis and the crisis sample. The estimates for β_j using the balanced samples are shown in the right-hand side panel of Figure 10. The results are very similar to those for the unbalanced samples, highlighting the difference between the two periods. Notice that for the balanced sample the estimated coefficients for the crisis period are smaller for each horizon which reflects the fact that this sample contains mostly older SMEs and, as we will show in the next section, for these firms the cash-effect is smaller.

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 smaller than in the US. To ensure that our findings using 2001 as the starting year are representative of pre-crisis trends more 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 base years and capture the effect of 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 1).

Summarizing, the results show that the long-term impact of initial cash holdings on investment was very different in the pre-crisis period and in the crisis period. 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 evidence in favor of the hypothesis that a tightening of credit conditions makes cash more valuable for SMEs and to strengthen the causal interpretation of our results, we next exploit cross-sectional firm and industry heterogeneity.

4.3.1 Firm-level

This part analyses variation in firms' access to external finance using firm-level measures. If liquid assets were beneficial because credit conditions deteriorated during the crisis, this effect should be larger for those SMEs that were more affected by a reduction of banks' credit supply. We use the age and the size of a firm to proxy for financial constraints at the firm-level. While SMEs in general require more lender screening and monitoring compared to large firms, younger and smaller SMEs typically require even more as they tend to be more opaque. Within the group of SMEs these firms should therefore have been more 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 show the cash coefficients. The p-value associated with the F-test that compares the coefficients between the two groups is derived from a 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 14.5 percentage points more than a young and cash-poor firm by 2014. For old SMEs, this difference was only 6.8 percentage points.

Next we split out sample of SMEs into small firms (firms in the lowest quartile of the size distribution) and medium-sized firms (firms 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, with the difference statistically significant at the 10 percent level. Quantitatively, a small and cash-rich firm grew its stock of fixed assets by 18.8 percentage points more by 2014 than a small and cash-poor firm. For medium-sized firms, this difference was only 12.2 percentage points.

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

4.3.2 Industry-level

We now exploit industry diversity in our dataset. First, to further 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 tend to be small or young.

To test this, 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.[23] We then rank the industries based on each of the two variables and identify firms in the bottom and top quartile of the industry distributions. For each industry characteristic we estimate equation (1) separately for firms in the bottom and the top quartile and compare the cash-investment sensitivities for the longest horizon, i.e fixed asset growth between 2007 and 2014.

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

The results in Panel A of Table 4 are 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 firms tend to be small or young. The cash coefficient is also significant in industries where rivals are older and larger, but the effect is much smaller. Cash coefficients for firms operating in industries in the top and bottom quartile of the age and size distributions are significantly different from each other at the one percent level.

Other industry characteristics might also affect cash-investment sensitivities. We investigate these in panel B of Table 4. First, we examine whether the capital intensity of an industry matters. We capture this by averaging the fixed asset to total asset ratio across firms within a 4-digit industry in 2006 and compare firms in the top and bottom quartile of the industry distribution. The results indicate that the cash-investment sensitivity is similar for firms in both subsamples.

The fierceness of competition a firm faces in an industry could also 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 both concentrated and competitive industries. The coefficient is larger for firms operating in concentrated markets, but the difference is not statistically significant.[24] [25]

Finally, we examine if the extent to which an industry suffered during the crisis affected cash-investment sensitivities. 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 struggling rivals could arise in industries that were hit hard by the crisis. Furthermore, lenders were more likely to 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 have been 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 industry value added between 2007 and 2010. The data are again from the ONS. When we compare firms in industries in the bottom quartile of the industry growth distribution with those in the top quartile, we find a positive cash effect in both subsamples but the difference in coefficients is not significant.

Overall, these results support the view that cash holdings provided firms with a strategic

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

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

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. Other industry characteristics mattered less.

4.4 Post-crisis investment and alternative cash measures

Our preferred cash measure is based on a firm's cash holdings relative to the cash holdings of its rivals within narrowly defined 4-digit industries and is calculated using z-scores. It gauges the competitive advantage that an SME gains from holding cash. In this section we examine whether our results are robust to using alternative measures of cash holdings.

We start by examining the role of "excess cash", i.e. the amount of cash a firm holds in a given year in excess of what it likely needs to perform its daily operations and to finance its investments. Excess cash measures have been used extensively in the literature (see for example Duchin, Ozbas and Sensoy, 2010, Opler et al., 1999 and Dittmar and Mahrt-Smith, 2007). An estimate of firms' "normal" cash needs is obtained by regressing cash on a number of balance sheet characteristics which typically affect the amount of cash a firm chooses to hold. Excess cash is the difference between a firm's predicted cash holdings and its actual cash holdings.

We follow the approach of Duchin, Ozbas and Sensoy (2010) and Dittmar and Mahrt-Smith (2007) to determine how much cash a firm would normally be expected to hold given its balance sheet characteristics but adapt the methodology to SMEs for which we do not observe several variables that are available for larger firms. Our cash regressions 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 minus cash). The cash regression also includes past investment, the growth rate of cash balances, total liabilities and cash flow as proxied by a firm's profit, and controls for firm and (4-digit) industry-year fixed effects. We estimate this for the period 2000-2006 for the sample of firms which are also included in our crisis regressions. The residuals from the regression for the year 2006 capture a firm's excess cash holdings.

The results from estimating our regressions with this arguably more exogeneous measure of cash are presented in Table 5. In line with our previous evidence we find that excess cash had a positive effect on fixed asset growth during the crisis (column (1)) and that this effect was amplified during the recovery period (column (2)). This suggests that excess cash, despite being potentially expensive to hold in normal times, can have important long-term benefits when the credit cycle turns.

Finally, we show that our results are robust to two additional measures of cash. The results in columns (3) and (4) show that are results continue to hold when we use simple cash-to-asset ratios which are not z-scored. 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 although most firms submit their accounts at the end of the calendar year or at the end

of the fiscal year (beginning of April). We assign accounts submitted 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 and are thus included in our cash measure. Problems in the UK financial sector already emerged in the summer of 2007 which led to the run on Northern Rock. Because of this measuring a firm's cash holdings prior to this event reduces concerns that firms were hoarding cash in anticipation of a credit supply shock. However, one could argue that our cash measure for 2006 does not fully capture cash holdings at the onset of the crisis as the crisis only really took hold in 2008. Therefore, we examine whether our results are robust to measuring relative cash in 2007. The results in columns (5) and (6) show that this is the case. Note that the effect of relative cash is now slightly larger in line with what we would expect if cash holdings have a significant random component to them.

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 tangible fixed assets such as property, plant and equipment, and of intangible fixed assets such as copyrights, trademarks, patents, licenses and brand value. In this section we examine these two sub-components separately in order to shed light on which type of investment is driving our findings.

Only a small subset of medium-sized firms (16,075) 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 in Figure 11 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 replacing its old machines, 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 intangible assets. As they are non-physical assets, simple depreciation rates cannot be applied. Third, accounting standards allow businesses to recognize intangible assets only under strict rules, which implies that not all investment in intangible fixed assets is captured on a firm's balance sheet.[26]

[26]FRS-IAS 38 requires an entity to recognize an intangible asset, whether purchased or self-created (at cost) if, and only if, it it is probable that there will be future economic benefits from the asset and the cost of the asset can be reliably measured. Otherwise expenditure for an intangible item is recognized as an expense. See https://www.ifrs.org/issued-standards/list-of-standards/ias-38-intangible-assets/.

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. We end this section by studying how cash buffers evolved over time.

5.1 Competition dynamics

In this part, we examine whether a change in competition dynamics is a possible driver behind the widening investment gap. Due to their ability to invest during the crisis, cash-rich SMEs are able to preserve or expand their productive capacity. At the same time, the productive capacity of cash-poor SMEs declines. Thus, even if demand falls during a crisis, cash-rich firms may be able to expand their market share and improve their competitive position. They can advance their position even further 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 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). Cash reserves may also allow firms to strategically lower their prices to capture market share from financially weak competitors that have to maintain or increase their prices to generate sufficient cash flow (Gilchrist et al., 2017).

When the recovery sets in and demand rebounds, SMEs that were able to invest and capture market share during the crisis are in a better position to meet demand. This may give them the opportunity to improve earnings and strengthen balance sheets further, allowing them to keep investing and to capture even more market share. Firms that were cash-poor at the onset of a crisis find it hard to catch up with their cash-rich rivals and may continue to see their positions weaken. As a result of these feedback effects, the initial shift in competition dynamics during the crisis is reinforced during the recovery phase.

In order to assess whether there is evidence in favor of the mechanism outlined above, we test how pre-crisis cash holdings affected firms' market shares and performance during the crisis and the recovery phase. To capture a firm's market share we divide the firm's assets by the sum of total assets in its 4-digit industry, i.e. we measure competition among SMEs active in the same 4-digit industry. We then assess how a firm's cash position affects the growth rate of its market share. Firm performance captures to what extent having cash enabled firms to generate higher earnings that could be reinvested. We proxy for this using cumulative profits scaled by total assets in 2007 and average return on assets (as measured by profits over total assets) over the respective time horizon. We estimate a model similar to regression model (1)

but replace fixed asset growth with the new dependent variables:

$$\Delta Y_{i,07+j} = \beta_j Relative\ cash_{i,06} + \gamma_j X_i + \sum_{k=0}^{1} \theta_{kj} \Delta Y_{i,07-k} + \rho_s + \vartheta_r + \varepsilon_{i,j} \quad (2)$$

where $\Delta Y_{i,07+j}$ is the firm's market share growth or profit 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 include pre-crisis values of the respective dependent variables (one and two periods lagged).[27] In the performance regressions we include 4-digit industry and region fixed effects. In the market share regressions we only include region fixed effects as the dependent variable is a relative-to-industry variable and hence 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. Our sample includes only SMEs with data on relative-to-rivals cash, the control variables and the respective dependent variable for all horizons to ensure that changes in the parameter over time are not caused by sample selection issues.

In Table 6 we present the estimates for each dependent variable for the direct crises period (2007-2009) and the crisis and recovery period combined (2007-2014). We find that SMEs with high levels of cash relative to their rivals going into the crisis grew their market share more during the crisis and this effect became larger during the subsequent recovery period (columns (1) and (2)). Having cash at hand when the credit cycle turned also positively affected firms' cumulative profits (columns (3) and (4)) and their average return on assets (columns (5) and (6)). Our finding that the cash-effect becomes larger for all dependent variables when we take the recovery period into account points to a self-reinforcing feedback mechanism.

It is challenging to measure competition accurately. First, we do not have information on sales for most firms in our sample and therefore measure market shares in terms of total assets. Second, as is common in the literature (e.g. Fresard (2010)), we measure competition by focusing on industrial sectors. However, this assumes that a firm competes with all the other firms in the same industry regardless of their geographical location. This assumption is more likely to hold for large, publicly listed firms. For SMEs, especially in sectors such as hospitality or retail, competition is likely more localized. Nevertheless, our findings are consistent with the idea that cash buffers allowed firms to maintain their productive capacity during the crisis and gave them a competitive edge. When the recovery set in, initially cash-rich firms could invest more compared to their rivals and further enhance their competitive position.

[27] In the regressions where cumulative profits and ROA are the dependent variables the lagged dependent variables are included in the regression and profit is excluded as a control variable.

5.2 Borrowing constraints

Another driver behind the amplification effect that we document can be persistent differences in access to external finance by cash-rich and cash-poor firms during the crisis and recovery period. When credit conditions tighten during financial crises and vulnerabilities of the banking sector are exposed, SMEs are particularly affected as they tend to be more reliant on bank lending. They are also riskier and more opaque than large firms and therefore have more difficulties accessing credit when a flight to quality sets in ((Iyer et al., 2014; Cingano, Manaresi and Sette, 2016). Furthermore, banks tend to exercise more discretion when setting loan terms for smaller firms while large firms benefit from pre-committed credit (Chodorow-Reich et al., 2021). This makes loan supply for SMEs more sensitive to bad news and repayment prospects. Furthermore, collateral constraints tighten when a financial crisis hits leading more firms to become financially constraint (e.g Kiyotaki and Moore, 1997; Khan and Thomas, 2013). This disproportionally affects SMEs as their loans are more often collateralized compared to those of larger firms (Chodorow-Reich et al., 2021). In fact, in the UK around 75-80% of SME loans are collateralized (Bahaj, Foulis and Pinter, 2020).

Corporate cash buffers when the shock hits can mitigate these effects. Larger cash balances protect a firm's net worth and, all else equal, make it less risky for banks to continue to lend. Hence, cash-rich SMEs more likely maintain access to credit on affordable terms during a crisis and can use these funds to finance investment. Furthermore, it is more likely that they can roll over their debt, thus freeing up cash flow that can be used for investment instead of repayments. By contrast, cash-poor SMEs more likely face binding borrowing constraints and may have to reduce their stock of fixed assets. These differences in borrowing constraints faced during the crisis can propagate when the recovery sets in. First, as cash-rich SMEs grow their stock of tangible assets which can be pledged as collateral (see Section 4.5) their borrowing constraints likely ease over time.[28] Initial cash-poor firms, whose stock of tangible assets declines, likely see their collateral constraints tighten further as time passes. Second, the ability to invest allows cash-rich SMEs to generate higher cash flow and profits compared to their cash-poor rivals (see Section 5.1). To the extent that banks take firms' recent earnings histories into account when extending loans (Ivashina, Laeven and Moreno, 2020; Lian and Ma, 2021) this also makes it easier for cash-rich firms to borrow. These effects are further enhanced if banks emerging from the crisis with weaker balance sheets and facing tighter regulation, apply more conservative lending standards during the recovery period. In other words, the gradual easing of credit conditions observed during the recovery period may not have benefited initially cash-poor SMEs making it increasingly harder for them to break the negative feedback loop and to catch up with their cash-rich rivals.

[28] See for theoretical and empirical contributions on the use of tangible and intangible assets as collateral for example Hart and Moore (1994); Shleifer and Vishny (2009);Sibilkov (2009); Rampini and Viswanathan (2010) and Falato et al. (2021).

To assess whether differences in access to credit by cash-rich and cash-poor firms could have been a driver behind the widening investment gap that we document, we test if initial cash holdings affected the growth of firms' stock of debt over time. We estimate a model similar to regression model (2) but replace the dependent variable with log differences of corporate debt between 2007 and the year 2007+j. We run separate regressions for three measures of debt: The first is a comprehensive measure of debt which includes trade credit, short term loans, overdrafts and long-term loans. The second focuses on the short-term component and includes trade credit, short-term loans and overdrafts. Finally, we test how cash affects the growth rate of long-term loans.[29] We restrict our sample to the 34,334 firms for which we have information for all debt components for all years between 2007 and 2014.[30]

In Table 7 we 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 debt growth for all three measures of debt during the crisis. In line with the hypothesis that after the crisis borrowing constraints affected initial cash-rich and cash-poor firms differently, we find that the cash-effect is amplified during the recovery period.

5.3 Cash dynamics

We showed that having cash at hand enabled SMEs to maintain their capital stock during the crisis when industry rivals had to reduce theirs. This gave cash-rich SMEs a competitive advantage when the economy rebounded, resulting in a persistent investment gap which grew over the seven years following the shock. We also provide suggestive evidence that competition dynamics and borrowing constraints drive this amplification effect. In this final section, we check whether the evolution of cash holdings over time for initially cash-rich and cash-poor firms mirror the investment patterns that we documented in Section 4.1 and whether movements in cash holdings are consistent with the mechanisms that we propose.

To this end we estimate a model similar to regression model (2) but replace the dependent variable with the log difference of cash holdings between 2007 and the year 2007+j. Figure 12 shows the relationship between pre-crisis relative cash holdings and firms' subsequent growth in their cash holdings. We find that the cash buffers of cash-rich firms decline during the crisis. This is consistent with the idea that during a downturn cash-rich SMEs use some of their buffers to maintain or even increase their capital stock. Cash balances are still below their pre-crisis values seven years later. This is consistent with cash-rich firms financing their net investment during that period with earnings or credit.

[29] Another interesting angle to explore would be the extent to which firms drew down their credit lines during the crisis (e.g Ivashina and Scharfstein, 2010; Acharya et al., 2021; Greenwald, Krainer and Pascal, 2020; Chodorow-Reich et al. (2021)). Unfortunately, this information is not available in the dataset we use.

[30] These tend to be larger SMEs. In unreported regressions we verify the existence of a persistent and growing investment gap between cash-rich and cash-poor SMEs for this subsample of SMEs as well (results available upon request).

By contrast, initially cash-poor SMEs increase their cash buffers during the crisis, in line with the findings of Almeida, Campello and Weisbach (2004) and Song and Lee (2012). Interestingly, during the recovery period they continued growing their cash holdings with the large growth rate reflecting the fact that these firms started with a very low base (see Table 2). This suggests that firms face a trade-off when credit conditions tighten. Increasing cash holdings today reduces the probability of being credit-constrained in the future. But improving the balance sheet by saving cash requires cutting back on investment and reducing productive capacity. Due to the feedback mechanisms that we document this adjustment can have long-term consequences. While public listed US firms were able to increase their cash holdings through increased borrowing (Xiao, 2019), as the previous section shows cash-poor SMEs did not have this option. This again highlights the differences in adjustment mechanisms that apply to SMEs compared to large, publicly listed firms.

6 Concluding Remarks

This paper identifies a strong positive link between the pre-crisis cash holdings and long-term investment of SMEs after the global financial crisis. Firms with large initial cash holdings could continue to invest during the crisis while their cash-poor rivals had to divest. This gave cash-rich SMEs an advantage when the economy rebounded, resulting in a persistent investment gap which grew over the seven years following the shock. This persistent and widening investment gap between cash-rich and cash-poor SMEs was absent in the pre-crisis period. We find that cash had a persistent effect on investment of SMEs, irrespective of whether their cash holdings in the run-up to the crisis were relatively stable or fluctuated over time. This suggests that long-term investment paths were not necessarily the outcome of careful cash management but were partly determined by luck.

We present evidence consistent with two possible mechanisms that can explain the widening of the investment gap during the recovery period. The first mechanism relates to the ability of cash-rich SMEs to persistently outcompete their cash-poor rivals. We find that cash holdings at the onset of the crisis had a positive effect on market share growth during the crisis and this effect was amplified during the recovery phase. We also show that cash contributed positively to a firm's profitability. The second mechanism is a cash-dependent tightening of borrowing constraints during the crisis that persists during the recovery period. In line with borrowing constraints binding differently both during the crisis and the recovery period for initial cash-rich and cash-poor firms we find that the latter experienced a sharper decline in their debt levels during the crisis and that this effect became larger during the recovery period.

Our findings have several 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 can significantly underestimate the true effect of the shock. Second, our findings highlight the

importance of studying the whole firm size distribution in order to understand how different parts of the corporate sector react and adjust to shocks. Relying solely on evidence from publicly listed firms, who in general face less financial constraints, can obscure our understanding of a vital part of the economy and can limit the effectiveness of policy interventions (see also Brunnermeier and Krishnamurthy (2020) in the context of Covid-19). Third, firms may hold cash at the time when a crisis hits due to sheer luck or due to prudent cash management but not necessarily because they are the most productive firms. In the presence of financial frictions, the crisis-induced selection on cash that we document has long-term consequences due to self-reinforcing mechanism. This can slow down or reverse a reallocation of resources towards the most productive companies after a crisis, including to dynamic, young firms which tend to face tighter financial constraint. This suggests a role for initial cash holdings when modeling the macroeconomic effects of financial shocks. Fourth, we find that cash-poor SMEs reduce their capital stock substantially during downturns. This highlights the importance of well-designed public lending schemes in helping solvent firms bridge periods of liquidity shortfalls when a financial crisis hits in order to avoid lasting damage to the economy's productive capacity.

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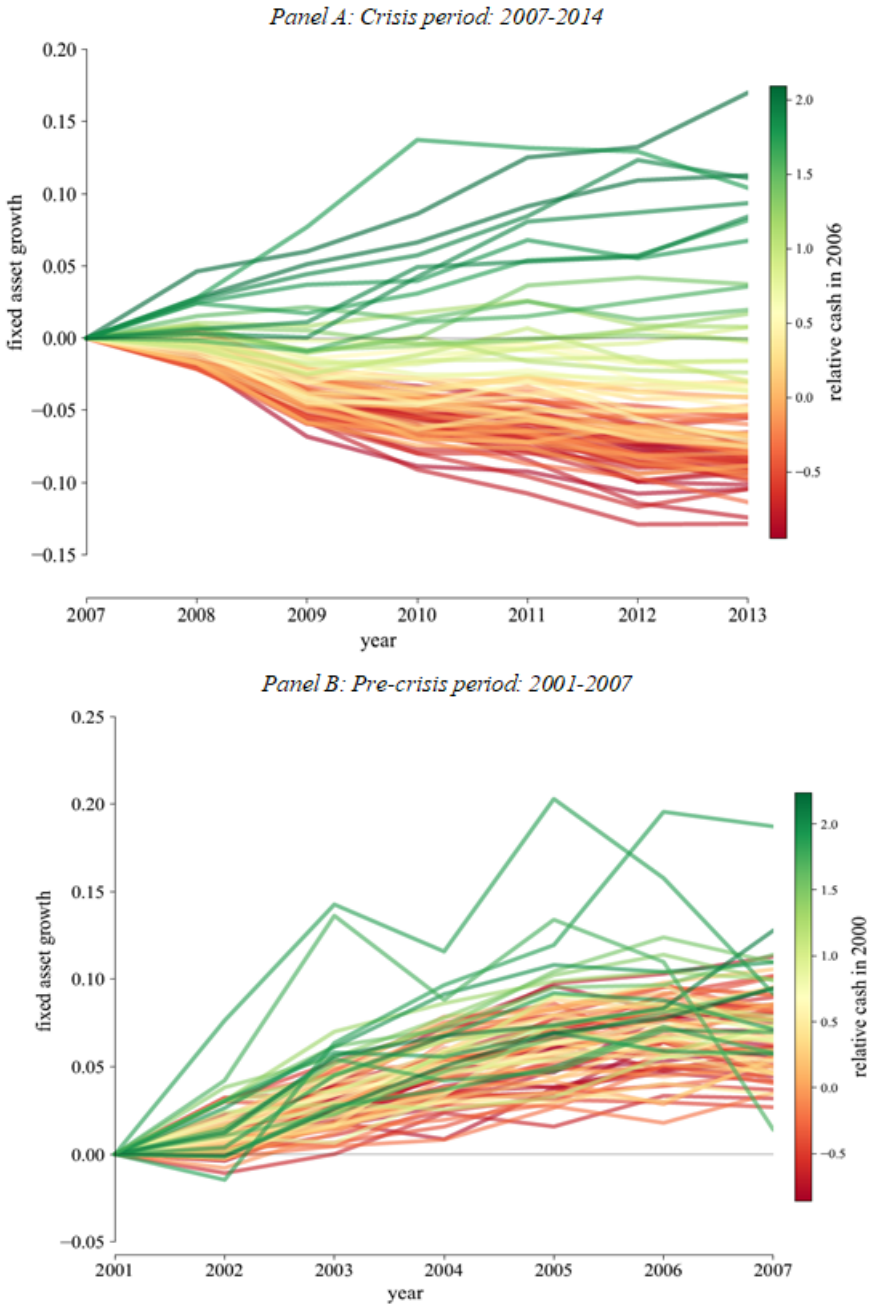
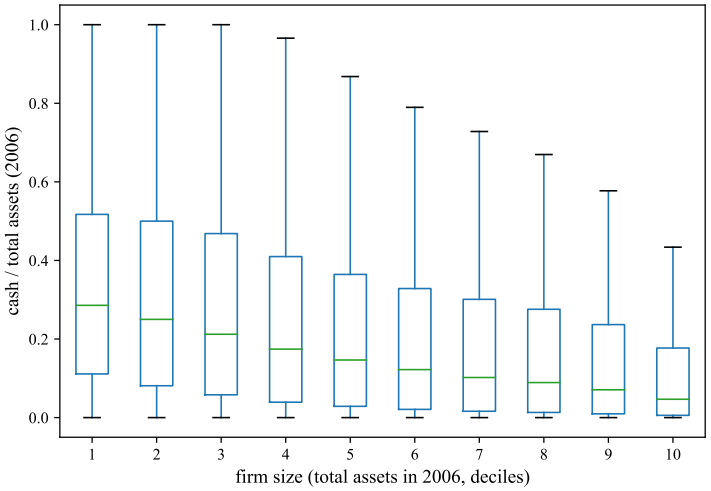
Figure 1: **Investment high vs low cash firms: crisis and pre-crisis period**



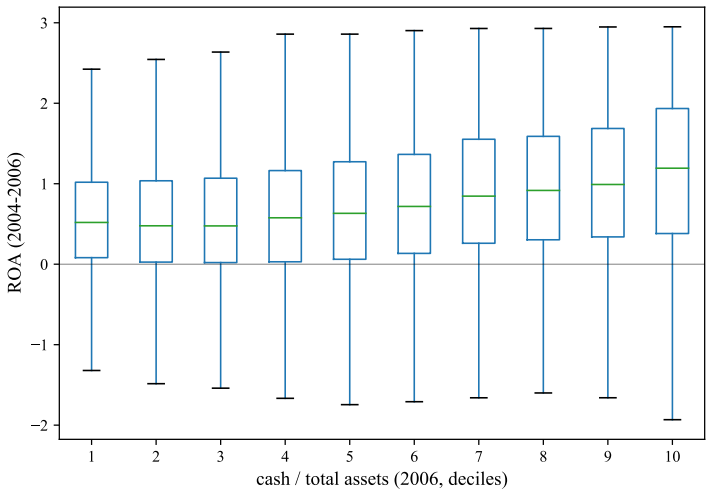
Notes: These figures plot the average fixed asset growth for firms in each percentile of relative-to-rivals cash within the 90 percent interquantile range. In panel A average fixed asset growth is tracked over the period 2007-2014 and in panel B over the period 2001-2007. Fixed asset growth is defined 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 2: **Cash holdings and firm size**



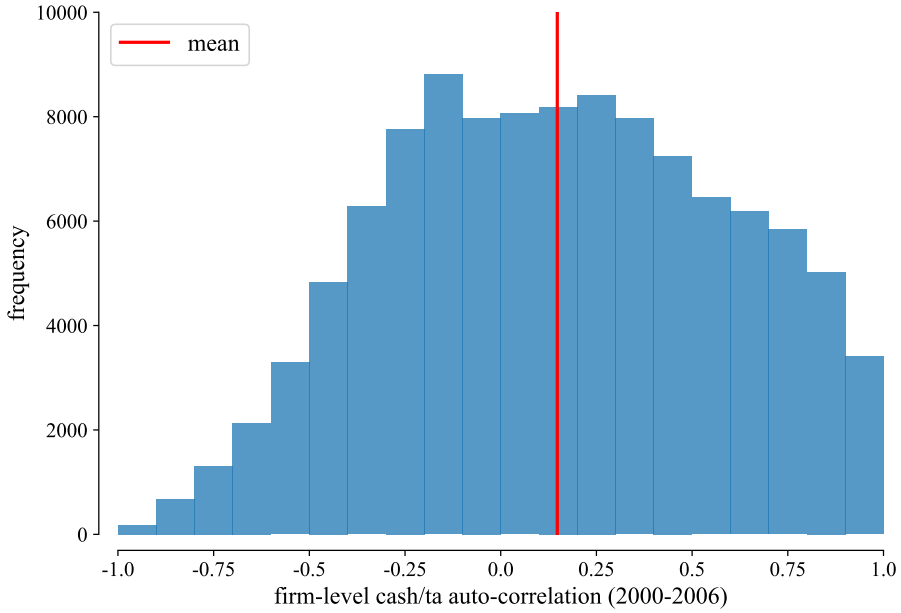
Notes: This figure shows box and whisker plot of cash holdings by firm size in deciles of total asset. Both cash holdings and total assets are measured in 2006.

Figure 3: **Current cash holdings and past profitability**



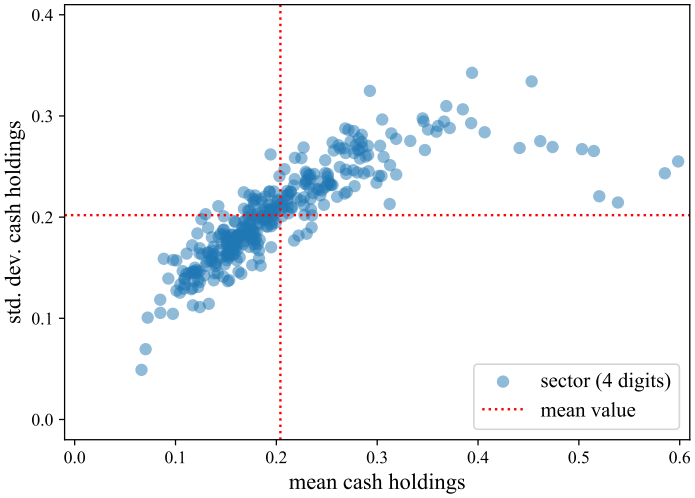
Notes: This figure shows a box whisker plot of past profitability for firms ranked by their cash holdings by deciles. Cash holdings are defined as deposits over total assets and measured in 2006. Profitability is defined as the cumulative profits over total assets of the firm measured over the period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

Figure 4: **Autocorrelation cash holdings**



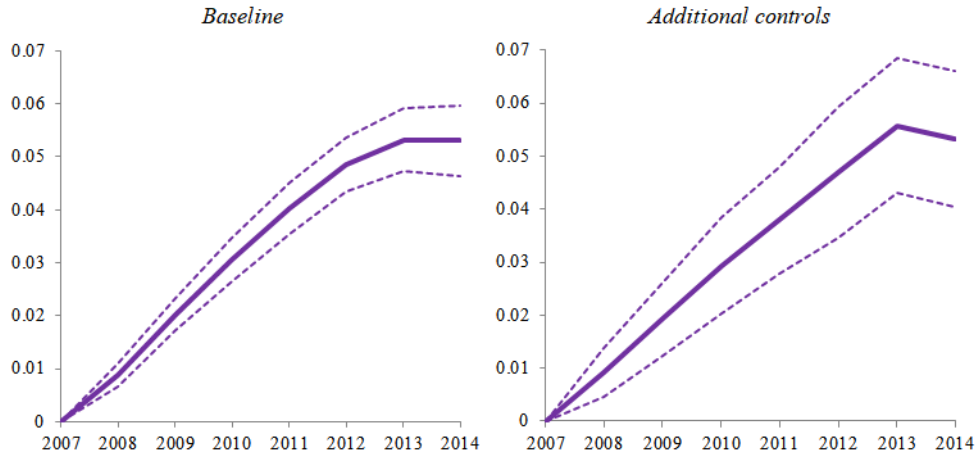
Notes: This figure plots the distribution of the one-lag auto-correlation coefficient of cash holdings over the period 2000 to 2006 of firms that are active during the period 2000-2014. Cash holdings are defined as deposits over total assets. The vertical red line marks the mean of the distribution.

Figure 5: **Variations in cash holdings by industry**



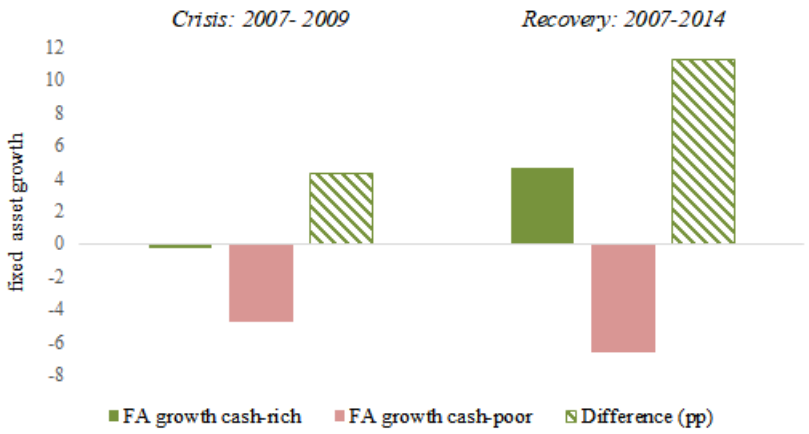
Notes: This figure plots the correlation between the mean and standard deviation of cash holdings of UK firms at the 4-digit industry level. The red lines depict the mean of each measure across industries. Cash holdings are defined as deposits over total assets and measured in 2006.

Figure 6: **Long-term impact of cash on investment**



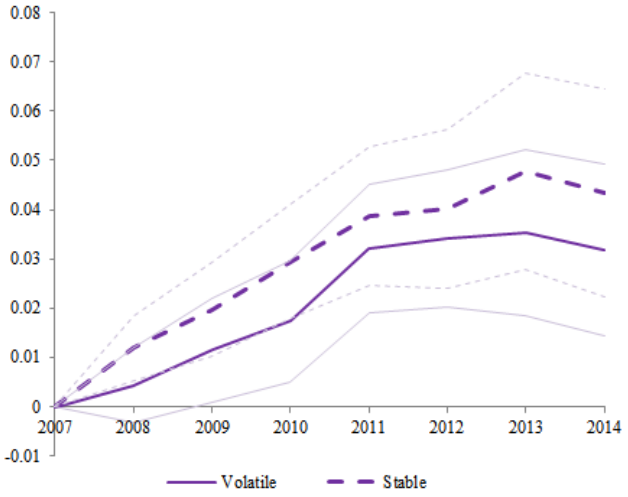
Notes: These figures plot the impact of relative-to-rivals cash on investment over different horizons using local projections. The dependent variable is the cumulative fixed asset growth between 2007 and 2007+j, where j ranges from 1 to 7. The model specification used in the left-hand side panel includes controls for leverage, size, age category, group, 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**



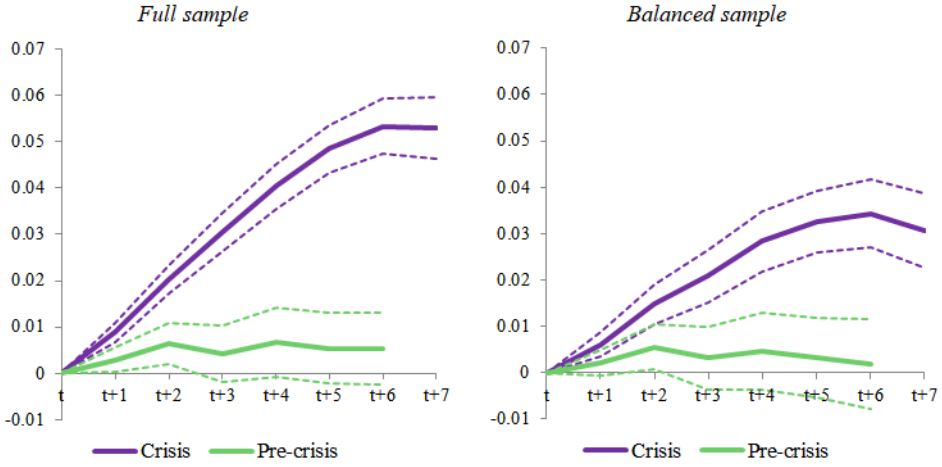
Notes: This figure plots the estimated cumulative fixed asset growth of cash-rich and cash-poor firms and the difference between the two based on the estimated coefficients of the baseline model. The left hand side panel shows fixed asset growth between 2007 and 2009, the right hand side panel between 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: Volatile vs stable cash holdings



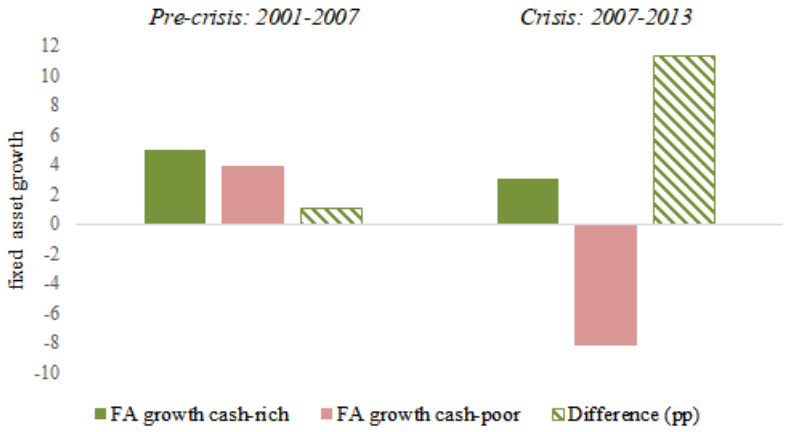
Notes: This figure plots the impact of relative-to-rivals cash on investment over different horizons using local projections for subsets of firms with voaltile or stable relative-to-rivals cash holdings. Cash persistence is measured as the one-lag auto-correlation coefficient of *Relative cash* over the period 2000 to 2006. Firms with stable cash holdings are firms with a cash autocorrelation of 0.6 or higher, and firms with volatile cash holdings as firms with a cash autocorrelation between -0.2 and 0.2. 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 sub-sets of 31,818 and 23,741 firms who report information on their cash holdings each year between 2000 and 2006 and whose cash autocorrelation falls within either of the two bands. 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**



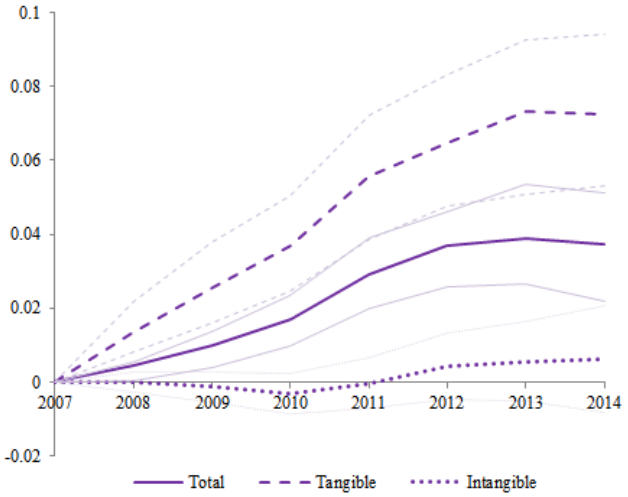
Notes: These figures plot the impact of relative-to-rivals cash on investment over different horizons using local projections for the crisis and pre-crisis periods. The dependent variable is the cumulative fixed asset growth between 2007 and 2007+j, where j ranges from 1 to 7 for the crisis sample and 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**



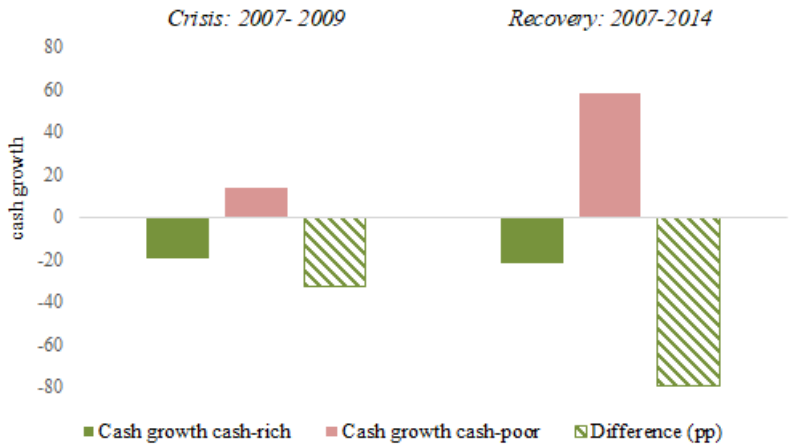
Notes: This figure plots the estimated cumulative fixed asset growth of cash-rich and cash-poor firms and the difference between the two based on the estimated coefficients of the baseline models for the pre-crisis and the crisis periods. The left hand side panel shows fixed asset growth between 2001 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 16,065 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.

Figure 12: **Estimated growth cash holdings of cash-rich and cash-poor firms during crisis and recovery**



Notes: This figure plots the estimated cumulative growth in cash holdings of cash-rich and cash-poor firms and the difference between the two based on the estimated coefficients for the regression model 2 where the dependent variable is the log difference of cash holdings between 2007 and the year 2007+j. The left hand side panel shows growth of cash holdings 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.

Table 1: **Summary Statistics**

Variable Name	Obs	Mean	Median	Std. Dev.	Min	Max
Crisis sample						
ΔlnFA (2007-2014)	232,157	-0.06	-0.02	1.00	-3.45	4.09
Relative cash	232,157	-0.14	-0.42	0.85	-1.42	2.89
Leverage	232,157	0.62	0.60	0.37	0.00	3.38
Size	232,157	5.52	5.51	1.61	1.10	10.30
Mature	232,157	0.19	0.00	0.39	0.00	1.00
Old	232,157	0.24	0.00	0.43	0.00	1.00
Group	232,157	0.09	0.00	0.28	0.00	1.00
Profit	232,157	0.30	0.31	0.38	-2.09	0.96
Pre-Investment (1st lag)	232,157	0.03	0.00	0.38	-1.34	2.20
Pre-Investment (2nd lag)	232,157	0.05	0.00	0.40	-1.26	2.27
Pre-Turnover growth (1st lag)	33,564	0.05	0.05	0.41	-6.04	7.38
Pre-Turnover growth (2nd lag)	33,564	0.09	0.05	0.45	-6.76	5.99
Excess cash	187,397	0.11	0.08	0.18	-0.40	0.71
Cash holdings	232,157	0.23	0.14	0.24	0.00	1.00
Relative cash (2007)	223,863	-0.12	-0.39	0.85	-1.42	2.88
%ΔMshare (2007-2014)	222,562	0.15	-0.08	0.94	-0.95	9.04
$\sum$ Profit (2007-2014)	215,368	2.76	2.38	3.22	-10.73	20.26
ROA (2007-2014))	217,491	0.31	0.32	0.36	-1.67	0.95
ΔlnDebt (2007-2014)	34,334	-0.80	0.00	2.10	-7.32	6.15
ΔlnST Debt (2007-2014)	34,334	-0.48	0.00	1.51	-6.71	6.15
ΔlnLT Debt (2007-2014)	34,334	-0.60	0.00	1.96	-7.23	6.08
ΔlnCash (2007-2014)	175,931	0.24	0.21	1.37	-4.25	4.88
Pre-crisis sample						
ΔlnFA (2001-2007)	155,913	0.07	0.00	0.96	-3.40	3.87
Relative cash	155,913	-0.12	-0.44	0.84	-1.30	3.11
Leverage	155,913	0.63	0.62	0.37	0.00	3.24
Size	155,913	5.64	5.68	1.56	1.10	10.39
Mature	155,913	0.26	0.00	0.44	0.00	1.00
Old	155,913	0.32	0.00	0.46	0.00	1.00
Group	155,913	0.13	0.00	0.34	0.00	1.00
Profit	155,913	0.27	0.28	0.37	-2.01	0.96
Pre-Investment (1st lag)	155,913	0.03	0.00	0.39	-1.50	2.14
Pre-Investment (2nd lag)	155,913	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	0.56	0.03	0.53***
Size (th)	542	913	-371***
Young (< 10y)	0.58	0.57	0.01***
Fixed assets	0.20	0.44	-0.24***
Leverage	0.49	0.76	-0.28***
Profit	0.13	0.10	0.03***
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)	
	132,150	56,685	
Size	*Small*	*Large*	
	0.087***	0.057***	0.08*
	(0.009)	(0.008)	
	57,898	58,027	

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***	0.044***	0.00***
	(0.005)	(0.005)	
	98,858	*37,806*	
Size	0.068***	0.036***	0.00***
	(0.005)	(0.008)	
	101,353	*47,388*	
	Panel B		
Capital intensity	0.052***	0.056***	0.68
	(0.009)	(0.007)	
	69,083	*55,573*	
Concentration	0.045***	0.055***	0.51
	(0.006)	(0.014)	
	114,588	*27,547*	
Depth crisis	0.056***	0.045***	0.25
	(0.0069)	(0.009)	
	81,335	*23,356*	

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	0.120***	0.364***	0.076***	0.203***	0.030***	0.065***
	(0.011)	(0.026)	(0.001)	(0.016)	(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	0.028	0.029	0.025	0.036	0.026	0.039
No. Observations	187,397	187,397	232,157	232,157	223,863	223,863

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 2009 in the uneven columns and between 2007 and 2014 in the even columns. 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***	0.016***	0.035***	0.231***	0.017***	0.027***
	(0.004)	(0.006)	(0.0043)	(0.023)	(0.001)	(0.002)
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	0.016	0.691	0.441	0.754	0.574
No. Observations	222,562	222,562	215,368	215,368	217,491	217,491

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 average 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.

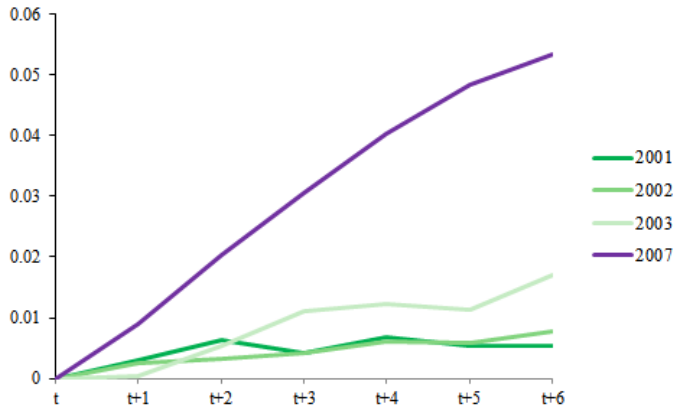
Table 7: **Borrowing constraints channel**

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	0.101***	0.145***	0.042***	0.094***	0.092***	0.132***
	(0.012)	(0.015)	(0.008)	(0.012)	(0.011)	(0.016)
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	0.116	0.121	0.112	0.122	0.119	0.126
No. Observations	34,333	34,333	34,333	34,333	34,333	34,333

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: 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, 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
Excess cash	Difference between a firm's actual and predicted cash holdings	FAME
%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 the 4-digit level).	FAME
$\sum$ Profit	Cumulative profits over the period 2007 to 2009/2014 scaled by total assets in 2007	FAME
ROA	Average ROA (profit/ta) over the period 2007 to 2009/2014	FAME
ΔlnTotalDebt	Log difference of total debt (short-term loans and overdrafts + trade credit + long-term debt) over the period 2007 to 2009/2014	FAME
ΔlnSTDebt	Log difference of short-term debt (short-term loans and overdrafts + trade credit) over the period 2007 to 2009/2014	FAME
ΔlnLTDebt	Log difference of long-term debt over the period 2007 to 2009/2014	FAME
ΔlnCash	Log difference of cash holdings over the period 2007 to 2009/2014	FAME