The Effects of Capital Investment and R&D Expenditures on Firms' Liquidity

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Abstract

This paper empirically examines whether additional future fixed capital and R&D investment expenditures induce firms to accumulate cash reserves while considering the role of market imperfections. Implementing a dynamic framework on a panel of US, UK and German companies, we find that firms make larger additions to cash holdings when they plan additional future R&D rather than fixed capital investment expenditures. This behavior is particularly prevalent among small and non-dividend paying firms that are heavily involved in R&D activities. We also show that the cash flow sensitivity of cash is substantially higher for financially constrained firms than for their unconstrained counterparts in the US and the UK, but only marginally higher in Germany. (JEL Classification Numbers: G31, G32)

Key words: cash holdings, fixed investment, R&D investment, dynamic panel regression

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1. Introduction

It is important to understand why firms hold substantial amounts of cash, which earns little or no interest, rather than channelling those funds towards capital investment projects or dividends to shareholders. In an environment with no market imperfections, firms can tap into financial markets costlessly and need not hold cash Keynes (1936) as cash has a zero net present investment value Modigliani & Miller (1958). However, in the presence of financial frictions, firms do not undertake all positive net present value projects, but rather choose to save funds for transactions or precautionary motives. In that sense, firms facing market imperfections must choose their level of liquidity at each point in time while taking into account current and future capital investment expenditures.

In this paper we empirically examine the changes in firms' cash holdings to understand the factors that lead to accumulation or decumulation of firms' cash reserves in the context of market imperfections. Although we are not the first to investigate the impact of market imperfections on cash holding behavior of firms, our study differs from the rest of the literature on several grounds. While researchers have recognized the significance of current and future investment plans for liquidity management, there seems to be no consensus on how to capture those effects. Some researchers use current investment expenditures in their investigations, while others use Tobin's Q as a proxy of future investment opportunities of the firm. However, both of these strategies have their drawbacks, as we later discuss. To mitigate these problems, we examine the effect of one-period-ahead additional fixed capital and R&D investment expenditures on firms' liquidity management behavior. We invoke the hypothesis of rational expectations on the part of firms' managers to proxy for changes in expected investment spending with their actual values. In our investigation, we hypothesize that in the presence of external or internal financial constraints, a manager planning to increase investment expenditures in the next period should add to the firm's cash buffer in the current period.

Our second objective is to scrutinize which type of investment, fixed capital *versus* R&D expenditures, leads to higher accumulation of cash buffer stocks. We conjecture that future R&D expenditures will require firms to increase their cash holdings by more than that of fixed capital expenditures. Our reasoning can be explained as follows. In contrast to fixed capital investment, R&D investment contributes to the stock of intangible capital and cannot be used as collateral. Thus, firms undergoing large R&D expenditures do not have the financial flexibility as do firms mainly investing in physical capital that may be pledged as collateral. In particular, much of the R&D capital stock is represented by human capital that could be lured away by another company.[1] Furthermore, as most of the R&D expenditures represent the salaries and benefits of highly-paid skilled labor, a greater R&D effort will immediately impact firms' cash flow. Therefore, R&D-intensive companies are likely to face greater obstacles in accessing external financing in comparison to those firms that invest in physical assets that may be pledged as collateral.

Third, we aim to study these questions not only for the US but also for the UK and Germany. Hence our results can shed light at the differences and similarities of liquidity behavior of companies operating in different financial environments. While the UK and US are known as examples of market-based financial systems, the German financial architecture relies heavily on the functioning of bank credit. Last but not least, in contrast to much of the literature that investigates cash holding behavior, we implement a dynamic framework to consider the potential impact of adjustment and transaction costs which may prevent firms from achieving their target cash holding levels instantaneously.[2] In estimating our models, we take into account firm-level fixed effects and time effects as well as other firm-specific factors.

We evaluate the role of future fixed capital and R&D investment behavior of firms using large panels of quoted manufacturing firms obtained from Global COMPUSTAT for the US, UK and Germany over the 1991–2006 period, employing the Dynamic Panel Data System GMM estimator Blundell & Bond (1998). As the impact of additional investment expenditures may differ across categories of firms due to the presence of financial frictions, we consider two sample categorizations based on size and the dividend payout ratio. Our analysis reveals that firms in all three countries increase their cash holdings by a larger amount when they incur additional future R&D expenditures than they do in response to future fixed capital investment. Scrutinizing the data in more detail, we find that this behavior is particularly prevalent among small firms and non-dividend paying firms that are heavily involved in R&D activities. Also, similar to the earlier literature, we show that the cash flow sensitivity of cash is higher for constrained firms with respect to their unconstrained counterparts in the US and the UK, whereas the difference is only marginally significant for German firms.

The rest of the paper is organized as follows. Section 2 briefly reviews the literature. Section 3 presents the model and describes our data. Section 4 provides the empirical results and Section 5 concludes.

2. Literature Review

2.1. Determinants of Cash Holdings

The current literature presents the transaction costs motive and the precautionary motive as the two major reasons why firms hold cash buffers.[3] Although firms can raise funds by selling assets or issuing new debt or equity, there are significant costs associated with any of these strategies.[4] The precautionary motive emphasizes the costs associated with missing capital investment opportunities due to financial constraints as well as managers' desire to avoid financial embarrassment in the case of an unexpected shortfall in cash flow. Many firms have imperfect access to external funds in the sense that they cannot borrow sizable sums on short notice: particularly likely in the case of cash flow shortfalls. If funds are available, they are likely to involve a significant premium or covenants on the firm's financial operations. In this context, pecking order theory maintains that in the presence of financial frictions, firms follow a financial hierarchy, tapping into cheaper internal sources of funds followed by more expensive alternatives in financing their activities Myers (1984), Myers & Majluf (1984). Hence, it should not be surprising to see that those firms which are adversely affected by financial frictions make use of a cash buffer in order to minimize the explicit and implicit costs of liquidity management.

The subsequent empirical literature on the effects of financial frictions that built upon the seminal work of Fazzari et al. (1988) has helped us appreciate why the cash flow of so-called 'financially constrained' firms is an important determinant of capital or R&D investment behavior. The basic premise in this line of empirical work is to capture the differential impact of cash flow on capital or R&D investment expenditures of firms that are constrained *versus* those that are not. In other words, the focus of attention is placed on the dependence of constrained firms on internally generated sources of funds. Although there are some challenges regarding the modeling of the problem, the methodology that one uses to categorize firms, or the control variables used in the model, it is widely accepted that financial market frictions adversely affect capital investment expenditures of the constrained firms in comparison to others.[5]

When we turn to the research that investigates firms' cash holding behavior, we see that those methodologies initially developed for understanding capital investment spending have been applied to model firms' liquidity behavior. Kim & Sherman (1998), using a sample of US firms, show that firms facing higher costs of external financing, having more volatile earnings and exhibiting lower returns on assets carry larger stocks of liquid assets. In a similar vein Opler et al. (1999) provide evidence that small firms and firms with strong growth opportunities and riskier cash flows hold larger amounts of cash.[6]

To further examine cash holding behavior and to determine whether cash holding is a response to financial frictions rather than empire-building motives, researchers have endeavored to measure the value of cash, with mixed results. On the one hand Faulkender & Wang (2006) and Pinkowitz & Williamson (2007) present evidence that the value of cash is higher for constrained firms than for unconstrained firms. On the other hand, Dittmar & Mahrt-Smith (2007) and Harford et al. (2008) present evidence that cash has lower value for firms with weak shareholder rights, pointing out the presence of agency problems. Ozkan & Ozkan (2004), using a panel of UK firms, show that there is a non-monotonic relationship between managerial ownership and cash holdings.

In contrast to the above lines of research, several recent studies, including ours, focus on firms' cash accumulation behavior to investigate the effects of financial market frictions. Almeida et al. (2004) provide evidence that constrained firms have a positive cash flow sensitivity of cash, while unconstrained firms' cash savings are not systematically related to cash flows. Sufi (2009), using a panel of US firms, also shows that the cash sensitivity of cash is higher for constrained firms, defined as the lack of access to a line of bank credit. Khurana et al. (2006), using data from several countries, find that the sensitivity of cash holdings to cash flows decreases with financial development. Similar findings are reported by Baum, Schäfer & Talavera (2008) as they point out the importance of countries' financial systems in that relationship.

2.2. Effects of Expected Investment Opportunities on Liquidity

Although researchers seek to show that firms' cash holdings will be related to their investment opportunities, there is no consensus on how to capture those effects. Traditionally, researchers use Tobin's Q as a measure of future investment opportunities of firms, yet Erickson & Whited (2000) raise several warnings to those who follow this route. Most recently, Riddick & Whited (2009), after correcting for measurement error associated with Tobin's Q, estimate negative propensities to save out of cash flow, overturning the results of Almeida et al. (2004). Furthermore, researchers (e.g., Opler et al.

(1999)) generally incorporate firms' current investment expenditures in empirical models to capture the impact of investment opportunities on cash holding behavior. However, empirical models that use current investment expenditures does not necessarily capture the effect of future investment. In a recent paper Baum et al. (2009) study firms' leverage decisions by employing not current but realized future values of the level of capital investment. Assuming that managers form rational expectations, this measure can be considered as an unbiased forecast of future investment.

While asserting the importance of expected investment opportunities, few researchers distinguish how different types of investment affect corporate liquidity. Notably, Almeida & Campello (2007) claims that accumulation of tangible assets could attract more external financing as tangibility increases the value that could be pledged as collateral and captured by creditors in case of bankruptcy. Along these lines, we could distinguish two extreme cases: R&D investment and physical capital investment. As discussed above, the former may be considered to be investment in intangible capital, which has a substantially higher marginal cost of external financing because of its limited pledgability. Additionally, the returns from R&D investment are more uncertain, which might lead to greater asymmetric information and more serious problems of moral hazard Hall (2002).

In our study, in contrast to the available literature, we use changes in the actual future fixed capital and R&D investment expenditures to capture the movements in firms' liquidity behavior while considering the impact of financial frictions.

3. Empirical Implementation

3.1. Test Design

To quantify the motivation for firms' liquid asset holdings we use a variant of an empirical specification proposed by earlier researchers. The main difference in our approach is the introduction of two types of investment, fixed capital and R&D, rather than merely focusing on fixed capital investment. Second, we investigate the effect of changes in investment expenditures rather than the level. Finally, we include the lagged dependent variable into our specification to control for the persistence of cash holdings. Our baseline model takes the following form:

$$\begin{aligned} \Delta Cash_{it} &= \alpha_0 + \alpha_1 \Delta Cash_{i,t-1} + \alpha_2 CashFlow_{it} + \alpha_3 \Delta RD_{i,t+1} \\ &+ \alpha_4 \Delta FixInv_{i,t+1} + \alpha_5 \Delta ShortDebt_{it} + \alpha_6 \Delta NWC_{it} \\ &+ \mu_i + \tau_t + \epsilon_{it} \end{aligned} \tag{1}$$

where i indexes the firm, t the year, $\Delta Cash$ is a ratio of change in cash and short term investment to beginning-of-period total assets $((Cash_t - Cash_{t-1})/TA_{t-1})$, and $CashFlow$ is defined as income before extraordinary items plus depreciation, normalized by total assets. The key coefficients of interest, α_3 and α_4, determine the response of liquid assets' holdings to changes in *actual future* R&D, ΔRD, and fixed capital investment, Δ $FixInv$, respectively.[7] Additionally, the decision to hold cash crucially depends on changes in net working capital (ΔNWC) and changes in short term debt ($\Delta ShortDebt$), which could be considered as cash substitutes. These two firm-specific characteristics are normalized by beginning-of-period total assets (TA_{t-1}). The firm and year-specific effects are denoted by μ and τ, respectively. Finally, ϵ is an idiosyncratic error term.

While allowing for differences between R&D and fixed investment's effects on corporate liquidity, Equation (1) does not allow us to explore variations of the cash–investment sensitivity between financially constrained and unconstrained firms. To investigate this issue as well as the differential impact of cash flow between constrained and unconstrained firms, we specify an extended model in which cash flow and future fixed capital and R&D investment expenditures are interacted with a vector of size or dividend payout categories:

$$\Delta Cash_{it} = \alpha_0 + \alpha_1 \Delta Cash_{i,t-1} + [CashFlow_{it} \times TYPE_{it}]\, \eta + [\Delta RD_{i,t+1} \times TYPE_{it}]\, \gamma_1$$

$$
\begin{aligned}
&+ \quad [\Delta FixInv_{i,t+1} \times TYPE_{it}]\,\gamma_2 + \alpha_5 \Delta ShortDebt_{it} + \alpha_6 \Delta NWC_{it} \qquad (2)\\
&+ \quad \mu_i + \tau_t + \epsilon_{it}
\end{aligned}
$$

where $TYPE_{it}$ is a vector of either three size categories or two dividend groups. The indicators of firm size are defined as follows. We compute average book value of total assets per year by country separately. Then, we assign the top and bottom quartiles to large and small firms, respectively, while the two intermediate quartiles constitute medium size firms. The dividend categorization is based on a zero *versus* non-zero dividend payout ratio per year. Hence, for each type of categorization, firms are allowed to transit among groups year by year.

3.2. Data

In our empirical investigation we use manufacturing firm-level data extracted from S&P's Global COMPUSTAT database which reports accounting information on large corporations. Although this dataset covers a number of countries, we constrain our investigation to three advanced economies: the US, UK and Germany. This is mainly due to data availability so that we may construct a sample from a set of countries which have similar accounting standards as we investigate the impact of different financial market characteristics on firms' liquidity management. These countries allow us to have a reasonably large sample which is essential to satisfy the asymptotic properties of the GMM-System estimator.

In total, our sample is an unbalanced panel of about 32,000 manufacturing firm-year observations over the period from 1991–2006.[8] Prior to estimating our models we apply a number of sample selection criteria which roughly follow Almeida et al. (2004). First, we retain companies which have not undergone substantial changes in their composition during the sample period (e.g., participation in a merger, acquisition or substantial divestment). As these phenomena are not observable in the data, we calculate the growth rate of each firm's total assets and sales, and trim the annual distribution of these growth rates exceeding 100%.[9] Second, we remove all firms that have fewer than three observations over the time span. Third, the top and bottom 1% observations of all firm-specific variables are denoted as missing. Finally, we drop all those companies that have cash flow-to-assets ratio lower than -0.5 (-50%) for at least three years. The screened US sample is the largest and consists of 17,813 observations pertaining to 2,006 companies. The German and UK screened samples consist of 2,306 (352 firms) and 3,202 (505 firms) firm-years' data, respectively.

Descriptive statistics for the firm-year observations entering the analysis are presented in Table 1. As anticipated, there are considerable variations in liquidity ratios across countries. The highest average liquidity ratio (14%) is maintained by US companies, while the lowest (9%) is found for companies headquartered in Germany. Importantly, Table 1 shows that those US companies that are involved in R&D invest almost as much in R&D as in fixed capital, while UK firms have a smaller R&D to asset ratio and German firms have the smallest. This information suggests that US firms which are heavily involved in R&D expenditures should have a higher sensitivity in their cash holding behavior than UK or German firms. We should also note that German firms maintain the highest fixed investment rates and the highest short-term debt among the three countries.

Table 2 presents information on the distribution of firms by size and dividend categories for the US, UK and Germany. As noted above, individual firm-years are categorized on these two dimensions, so that a given firm may be classified as small in one year and medium in another, or switch from non-dividend to dividend status. This is particularly important with respect to the secular trend in dividend payout ratios in the US, where during the sample period a very sizable fraction of firms were observed paying zero dividends. This has been explained by unfavorable treatment of dividend income in US tax law, and firms' resulting strategies of buying back equity to generate greater capital gains income for their shareholders. In any event, the classification of US firms as financially constrained based on dividend payout ratios should be considered with some caution.

Although there is some overlap among firms across the size and dividend payout ratio classifications, it is far from complete. Panel A of the table suggests that half of the US firm-year observations in our sample do not pay dividends. Panels B and C report considerably smaller numbers of observations for Germany (18%) and the UK (5%), respectively. Interestingly, most of the small and medium size firms in the US do not pay dividends, whereas the opposite is true when we look at the small and medium companies in Germany and the UK. Finally, we see that in all three countries, large companies are more likely to pay dividends.

Next, we present information on the basic descriptive statistics of the key variables by firm size and dividend payout ratios. Table 3 gives the basic descriptive statistics for levels of the key variables by size categories. There are a few similarities as well as several notable differences among the firms across the three countries. As expected, firms in each size category maintain quite different levels of liquidity in all countries. On average, small firms hold more cash than do their large counterparts, perhaps reflecting that they have constrained access to external funds. In contrast, mixed evidence is observed for the R&D expenditures-to-total assets ratio. Interestingly, US and UK small companies have the highest level of R&D activity in comparison to their larger counterparts, while the opposite is observed for German firms. It also turns out that small US firms have the highest liquidity ratio and the lowest short-term debt ratio across all countries in the sample, while German firms have the highest short-term debt ratio, perhaps reflecting their reliance on bank finance. For all countries, firms have roughly similar fixed investment-to-asset ratios across different firm size categories.

Table 4 reports the descriptive statistics when we classify firms with respect to their dividend payout ratio. In general, we observe sizable differences in firms' cash holdings between dividend paying and non-dividend paying firms for the US and UK. Dividend-paying firms in the US and UK hold significantly less cash on average than do their non-dividend paying counterparts, while the opposite is observed for German companies. For all three countries we also note that non-dividend paying firms have a higher R&D-to-asset ratio than their dividend-paying counterparts, but the fixed investment-to-asset ratio is higher for dividend-paying firms. Finally, while the short-term debt ratio is similar across the US firms, this ratio is lower for dividend-paying companies in the UK and Germany.

4. Empirical Results

Prior to presenting our findings it is useful to note that all models are estimated with the two-step GMM System dynamic panel data (DPD) estimator, which combines equations in differences of the variables with equations in levels of the variables. Individual firm fixed effects are removed by using a first difference transformation. The reliability of our econometric methodology depends crucially on the validity of the instruments, which can be evaluated with the Sargan–Hansen J test of overidentifying restrictions, asymptotically distributed as χ^2 in the number of restrictions. A rejection of the null hypothesis that instruments are orthogonal to errors would indicate that the estimates are not consistent. We also present test statistics for second-order serial correlation in the error process. In a dynamic panel data context, we expect first order serial correlation, but should not be able to detect second-order serial correlation if the instruments are appropriately uncorrelated with the errors. Our instrument set has been chosen to ensure that the orthogonality conditions are satisfied. Most importantly, second lags of changes in *actual future* R&D, ΔRD, and fixed investment, $\Delta FixInv$ have not been included. In each of the models presented below, the J statistic for overidentifying restrictions and the Arellano–Bond AR(2) tests show that our instruments are appropriate and no second order serial correlation is detected, respectively. Hence, we do not make additional comments on those aspects of the models.

4.1. The Basic Regression Model

We begin our investigation, as defined in Equation (1), by implementing a dynamic model for each country to explore the effects of cash flow, lagged change in cash holding, change in future R&D and fixed capital investment expenditures, and changes in non-cash net working capital and short-term debt ratios on firms' cash holding behavior. Our premise is that cash flow and future R&D and fixed investment expenditures should have positive and significant coefficients. We also expect that the impact of increases in R&D expenditures should be greater than that of increases in fixed capital investment expenditures, as explained earlier. The coefficients of changes in the non-cash net working capital and short-term debt ratios are expected to be negative. We also expect that the impact of R&D expenditures would be most significant for the US firms as the data show that US firms are more heavily engaged in R&D activities.

Table 5 presents the results for the dynamic model given in Equation (1). The change in future fixed investment expenditures is positive for the US and UK, negative for Germany, but insignificant for all countries. This evidence could be explained by the pledgeability of investments in physical capital. Bester (1985) argues that that collateral can be used as a signalling mechanism to distinguish between high-risk and low-risk borrowers. In contrast, R&D capital has limited collateral value, and firms are likely to accumulate liquid assets to finance this type of investment. Table 5 suggests that the effect of the change in future R&D expenditures is positive and significant (at the 1% level for US and at the 5% level for UK and German firms). This observation implies that firms increase their current cash holdings in anticipation of next period's R&D expenditures. Furthermore, firms accumulate more cash for future R&D expenditures than for future fixed investment expenditures, as captured by the relative magnitudes of their coefficients. The tests of equality of $\gamma_{\Delta RD}$ and $\gamma_{\Delta FixInv}$ coefficients yields p-values of less than 0.10, unambiguously rejecting the null of equal coefficients.

The coefficient of cash flow is positive for all countries and significant for both US and UK firms at the 1% level, and Germany at the 10% level. Although the German coefficient cannot be distinguished from those of the UK or US, the magnitudes of the point estimates imply that firms are likely to be more financially constrained in market based economies, in accordance with the findings of Baum, Schäfer & Talavera (2008). This result is also in line with Bond et al. (2003) who show that UK firms exhibit a higher fixed investment–cash flow sensitivity than their German counterparts, which they explain by differences in financial systems. The coefficient on the lagged dependent variable for all countries is significant and negative, implying that firms have a target level of cash holdings and adjust their liquidity to achieve their target. As earlier research has shown, changes in the non-cash net working capital ratio possess negative and significant coefficients for US and UK firms, while it is insignificant for the German firms. Finally, we find that the change in the short-term debt ratio has a negative and significant effect on savings only for UK and US firms.

4.2. The Augmented Regression Model

The next two set of results given in Tables 6 and 7 present our findings for Equation (2) where we investigate the effect of these factors on firms' savings for different size and dividend categories, respectively. Each table depicts six models (two per country) where columns 2, 4 and 6 implement Equation (2) fully, while columns 1, 3 and 5 only differentiate the impact of size on firms' cash flows.

4.2.1. Firms' Savings and the Role of Firm Size

Table 6 presents our results for Equation (2) where we investigate the effect of the factors we discuss above on firms' savings for different size categories. Comparing results from this table with that of Table 5, we see that the lagged dependent variable and the changes in non-cash net working capital and short-term debt ratios have similar significance and effects on firms' saving. Columns 1, 3 and 5 of Table 6 present our results where we allow cash flow to have a differential effect on savings across size categories.

We note that small firms contribute to their savings more than their larger counterparts do as their cash flow increases. In line with earlier research, cash flow has the smallest effect on large firms' saving behavior across all three countries. Although the differences between these effects' magnitudes across size categories are generally not statistically significant, the point estimates clearly suggest the greater importance of cash flow for smaller firms.

Having analyzed the impact of cash flow across different size categories, we next consider the effects of R&D and fixed capital expenditure on the saving behavior of firms as firm size is allowed to change. Table 6 reveals that future capital investment expenditures only affect US firms' saving. Furthermore, we find that US small firms' response to an increase in future capital investment expenditures is the greatest, followed by those of medium firms and large firms. For the UK and Germany, we do not observe significant differences across size groups. However, when we concentrate on the effects of future R&D expenditures, we see similar and sizable differences in saving behavior of firms for all countries.[10] In particular, we find that small firms' future R&D expenditures have a significant and larger impact on firms' savings compared to those of their larger or medium-size counterparts. This means that large firms in these countries augment their savings less than do their smaller counterparts in response to an increase in future R&D expenditures. These results imply that constrained firms tend to save more in comparison to unconstrained firms, with future R&D expenditures emerging as an important factor that induces firms to adjust their cash holdings. However, the difference in saving behavior of firms with respect to the impact on R&D expenditures between medium and large firms is not significant.

4.2.2. Firms' Savings and the Role of Dividend Payments

Table 7 presents our regression results when we investigate firms' liquidity behavor across dividend-paying *versus* non-dividend paying firms. In all models, the coefficient of the lagged dependent variable is negative and significant, indicating that firms adjust their savings to achieve their optimal cash-to-asset ratio. The significance and sign of changes in the non-cash net working capital and short-term debt ratios are unchanged: negative and significant for US and UK firms but insignificant or marginally significant for German firms. When we inspect the effect of dividend payout policy across firms, as depicted in columns 1 and 5, we see that non-dividend-paying US and UK firms increase their savings more than dividend-paying counterparts. In columns 3 and 4, which present the results for German firms, dividend policy does not have an effect on firms' liquidity behavior.

Next we concentrate on the effects of fixed capital investment and R&D expenditures. In contrast to the earlier set of results presented in Table 6, when we split the two samples with respect to the dividend payout ratio, we see no differential effect of future fixed investment expenditures on saving behavior across firms. In the case of R&D expenditures, we see that US and UK firms that do not pay dividends augment their savings while dividend-paying firms do not change their saving behavior in response to future R&D expenditures. For Germany, we find no difference across the two groups. This outcome could be explained by specific features of the German financial system, in which banks' monitoring and long-term customer relationships may reduce the need for dividends as signals of the firm's financial stability Goergen et al. (2005).

Overall, our findings highlight the importance of the impact of changes in future R&D investment on the optimal level of a firm's cash buffer. R&D expenditures lead to accumulation of intangible capital which cannot be pledged as collateral. This reinforces the degree of financial obstacles faced by financially constrained firms. In particular, small and non-dividend paying firms substantially increase their cash holdings prior to increasing R&D expenditures. Furthermore, this evidence is somewhat less relevant for German companies, operating in a bank-based financial environment.

5. Conclusions

In this paper we empirically examine the factors that lead to firms' accumulation or decumulation of cash reserves while considering the role of market imperfections. In doing so, we specifically consider the impact of future fixed capital and R&D expenditures on constrained and unconstrained firms. The differential impact of future fixed investment and R&D expenditures is based on the observation that R&D investment lead to accumulation of intangible assets, which have limited collateral value. We investigate this relationship using data from three advanced economies: the US, UK and Germany. Hence our results can shed light on the differences and similarities across market-based *versus* bank-based financial systems. Last but not least, in contrast to much of the literature that investigates cash holding behavior, we implement a dynamic framework to consider the potential impact of adjustment and transaction costs which may prevent firms from achieving their target cash holding levels instantaneously.

To carry out our investigation, we use panels of quoted manufacturing firms obtained from Global COMPUSTAT for the US, UK and Germany over 1991–2006. To capture the impact of market imperfections, we consider sample categorizations based on size and dividend payout ratios. Our analysis reveals that firms in each economy augment their cash holdings more vigorously when they plan additional future R&D expenditures than they do for planned increases in fixed capital investment expenditures. Scrutinizing the data in more detail, we find that this behavior is particularly prominent among small firms and non-dividend paying firms that are heavily involved in R&D activities. Also, similar to the earlier literature, we show that the cash flow sensitivity of cash is higher for constrained firms with respect to their larger counterparts in the US and the UK, whereas this difference is substantially smaller in Germany.

From the policy perspective, it is hard to underestimate the importance of technology-producing mechanisms for knowledge-based economies. However, our study reveals that

R&D-intensive companies are more likely to be financially constrained than their less technological counterparts as they must maintain their liquidity. Substantial asymmetric information, moral hazard, and lack of collateral lead to credit rationing by financial intermediaries and market participants. Furthermore, while policy makers have already taken steps to support knowledge-producing companies, the gap between private and social returns on R&D investment remains sizable. Therefore, the efficiency of current R&D-promoting actions, such as subsidies, tax allowances, and venture capital incubators should be reevaluated.

Our findings are unique in light of previous studies, which have not shown such diverse and significant effects. In contrast to the cash holding literature, we show that future R&D investment has an economically significant effect on firms' liquidity behavior. However, there are a number of problems and criticisms still remaining. In a world of increasing global financial markets the distinctions between US, UK and German companies might be dubious. While we examine effects of expected R&D on liquidity, we cannot explain why (largely export-oriented) German firms have much lower R&D ratios than do their US and UK counterparts. This phenomenon could be linked to differential skills and human capital accumulation among these three countries. Further exploration along these lines could shed considerable light on the effects of current and expected investment opportunities on firms' cash holdings when investigating factors affecting their liquidity behavior.

Notes

[1]As Hall & Lerner (2009) stress (p. 5), this is perhaps the most important distinguishing characteristic of R&D investment, and leads to firms smoothing R&D spending over time to retain their skilled human capital.

[2]Among the few exceptions are investigations by Ozkan & Ozkan (2004) and Baum, Caglayan, Stephan & Talavera (2008), but they consider the *level* of cash holdings, not cash accumulation, in their studies.

[3]In contrast, Foley et al. (2007) suggest that tax considerations might provide incentives for large companies to hoard large amounts of cash.

[4]For instance, see Miller & Orr (1966) who show that firms hold liquid assets as a result of the presence of brokerage costs involved in raising funds.

[5]See Kaplan & Zingales (1997), Kaplan & Zingales (2000), Fazzari et al. (2000), and Erickson & Whited (2000) for more along these lines.

[6]Pinkowitz & Williamson (2001) report similar findings for firms in Germany and Japan in addition to those in the US.

[7]We define $\Delta RD_{t+1} = (RD_{t+1} - RD_t)/TA_t$ and $\Delta FixInv_{t+1} = (Inv_{t+1} - Inv_t)/TA_t$.

[8]A firm is considered in the manufacturing sector if its two-digit US Standard Industrial Classification (SIC) code is in the 20–39 range. The database provides this code for non-US firms as well.

[9]We experimented with a more restrictive definition and received quantitatively similar results.

[10]The results of formal tests of equality of investment coefficients follow patterns of testing $\gamma_{\Delta RD}$ and $\gamma_{\Delta FixInv}$ as reported in Table 5.

References

Almeida, H. & Campello, M. (2007), 'Financial constraints, asset tangibility, and corporate investment', *Review of Financial Studies* **20**(5), 1429–1460.

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

Baum, C. F., Caglayan, M., Stephan, A. & Talavera, O. (2008), 'Uncertainty determinants of corporate liquidity', *Economic Modelling* **25**(5), 833–849.

Baum, C. F., Schäfer, D. & Talavera, O. (2008), The impact of financial structure on firms' financial constraints: A cross-country analysis, Boston College Working Papers in Economics 690, Boston College Department of Economics.

Baum, C. F., Stephan, A. & Talavera, O. (2009), 'The effects of uncertainty on the leverage of nonfinancial firms', *Economic Inquiry* **47**(2), 216–225.

Bester, H. (1985), 'Screening vs. rationing in credit markets with imperfect information', *American Economic Review* **75**(4), 850–55.

Blundell, R. & Bond, S. (1998), 'Initial conditions and moment restrictions in dynamic panel data models', *Journal of Econometrics* **87**, 115–143.

Bond, S., Harhoff, D. & Reenen, J. V. (2003), Investment, R&D and financial constraints in Britain and Germany, CEP Discussion Papers dp0595, Centre for Economic Performance, LSE.

Dittmar, A. & Mahrt-Smith, J. (2007), 'Corporate governance and the value of cash holdings', *Journal of Financial Economics* **83**(3), 599–634.

Erickson, T. & Whited, T. M. (2000), 'Measurement error and the relationship between investment and q', *Journal of Political Economy* **108**(5), 1027–1057.

Faulkender, M. & Wang, R. (2006), 'Corporate financial policy and the value of cash', *Journal of Finance* **61**(4), 1957–1990.

Fazzari, S., Hubbard, R. G. & Petersen, B. C. (1988), 'Financing constraints and corporate investment', *Brookings Papers on Economic Activity* **19**(2), 141–195.

Fazzari, S. M., Hubbard, R. G. & Petersen, B. C. (2000), 'Investment-cash flow sensitivities are useful: A comment on Kaplan and Zingales', *The Quarterly Journal of Economics* **115**(2), 695–705.

Foley, C. F., Hartzell, J. C., Titman, S. & Twite, G. (2007), 'Why do firms hold so much cash? A tax-based explanation', *Journal of Financial Economics* **86**(3), 579–607.

Goergen, M., Renneboog, L. & da Silva, L. C. (2005), 'When do German firms change their dividends?', *Journal of Corporate Finance* **11**(1-2), 375 – 399.

Hall, B. H. (2002), 'The financing of research and development', *Oxford Review of Economic Policy* **18**(1), 35–51.

Hall, B. H. & Lerner, J. (2009), The financing of r&d and innovation, NBER Working Papers 15325, National Bureau of Economic Research, Inc.

Harford, J., Mansi, S. A. & Maxwell, W. F. (2008), 'Corporate governance and firm cash holdings', *Journal of Financial Economics* **87**(3), 535–555.

Kaplan, S. N. & Zingales, L. (1997), 'Do investment-cash flow sensitivities provide useful measures of financing constraints', *Quarterly Journal of Economics* **107**(1), 196–215.

Kaplan, S. N. & Zingales, L. (2000), 'Investment-cash flow sensitivities are not valid measures of financing constraints', *The Quarterly Journal of Economics* **115**(2), 707–712.

Keynes, J. M. (1936), *The general theory of employment, interest and money*, London, Harcourt Brace.

Khurana, I. K., Martin, X. & Pereira, R. (2006), 'Financial development and the cash flow sensitivity of cash', *Journal of Financial and Quantitative Analysis* **41**(4), 787–807.

Kim, Chang-Soo, D. C. M. & Sherman, A. E. (1998), 'The determinants of corporate liquidity: Theory and evidence', *Journal of Financial and Quantitative Analysis* **33**, 335–359.

Miller, M. H. & Orr, D. (1966), 'A model of the demand for money by firms', *The Quarterly Journal of Economics* **80**(3), 413–435.

Modigliani, F. & Miller, M. (1958), 'The cost of capital, corporate finance, and the theory of investment', *American Economic Review* **48**(3), 261–297.

Myers, S. C. (1984), 'The capital structure puzzle', *Journal of Finance* **39**(3), 575–92.

Myers, S. C. & Majluf, N. S. (1984), 'Corporate financing and investment decisions when firms have information that investors do not have', *Journal of Financial Economics* **13**, 187–221.

Opler, T., Pinkowitz, L., Stulz, R. & Williamson, R. (1999), 'The determinants and implications of cash holdings', *Journal of Financial Economics* **52**, 3–46.

Ozkan, A. & Ozkan, N. (2004), 'Corporate cash holdings: An empirical investigation of UK companies', *Journal of Banking and Finance* **28**, 2103–2134.

Pinkowitz, L. & Williamson, R. (2001), 'Bank power and cash holdings: Evidence from japan', *Review of Financial Studies* **14**(4), 1059–82.

Pinkowitz, L. & Williamson, R. (2007), 'What is the market value of a dollar of corporate cash?', *Journal of Applied Corporate Finance* **19**(3), 74–81.

Riddick, L. A. & Whited, T. M. (2009), 'The corporate propensity to save', *Journal of Finance* **64**(4), 1729–1766.

Sufi, A. (2009), 'Bank lines of credit in corporate finance: An empirical analysis', *Review of Financial Studies* **22**(3), 1057–1088.

Table 1: Descriptive statistics: All Firms, 1991–2006

Panel A: US				
Variable	μ	σ	Median	N
Cash	0.144	0.176	0.070	17,813
Cash Flow	0.067	0.127	0.089	17,813
R&D	0.048	0.077	0.019	17,813
Fixed Investment	0.052	0.041	0.042	17,813
Short Term Debt	0.024	0.054	0.000	17,813
Δ Cash	0.015	0.109	0.002	17,813
Δ RD	0.005	0.035	0.000	17,813
Δ Fixed Investment	0.005	0.040	0.002	17,813
Δ Net Working Capital	0.011	0.098	0.008	17,813
Δ Short Term Debt	0.001	0.043	0.000	17,813
Panel B: Germany				
Variable	μ	σ	Median	N
Cash	0.086	0.101	0.049	2,306
Cash Flow	0.080	0.096	0.087	2,306
R&D	0.013	0.035	0.000	2,306
Fixed Investment	0.068	0.049	0.058	2,306
Short Term Debt	0.109	0.111	0.068	2,306
Δ Cash	-0.003	0.067	-0.001	2,306
Δ RD	0.000	0.019	0.000	2,306
Δ Fixed Investment	-0.002	0.047	-0.002	2,306
Δ Net Working Capital	-0.008	0.106	-0.001	2,306
Δ Short Term Debt	0.000	0.073	0.000	2,306
Panel C: UK				
Variable	μ	σ	Median	N
Cash	0.113	0.134	0.071	3,202
Cash Flow	0.077	0.119	0.097	3,202
R&D	0.020	0.054	0.000	3,202
Fixed Investment	0.060	0.044	0.051	3,202
Short Term Debt	0.073	0.083	0.045	3,202
Δ Cash	0.004	0.084	0.000	3,202
Δ RD	0.001	0.020	0.000	3,202
Δ Fixed Investment	0.003	0.049	0.000	3,202
Δ Net Working Capital	0.001	0.088	0.002	3,202
Δ Short Term Debt	0.001	0.067	0.000	3,202

Note: All figures are calculated as a ratio to the firm's total assets. μ and σ represent mean and standard deviation respectively. N is the number of firm-years.

Table 2: Tabulation of Size and Dividend Payout Subsamples

	Small	Medium	Large	Total
Panel A: US				
No Dividends	2,883 (16%)	4,899 (28%)	1,141 (6%)	8,923 (50%)
Dividends	797 (5%)	4,455 (25%)	3,638 (20%)	8,890 (50%)
Total	3,680 (21%)	9,354 (52%)	4,779 (23%)	17,813 (100%)
Panel B: Germany				
No Dividends	78 (5%)	158 (10%)	53 (3%)	289 (18%)
Dividends	194 (12%)	654 (41%)	448 (28%)	1,296 (82%)
Total	272 (17%)	812 (51%)	501 (31%)	1,585 (100%)
Panel C: UK				
No Dividends	74 (3%)	55 (2%)	15 (1%)	144 (5%)
Dividends	536 (18%)	1,533 (52%)	741 (25%)	2,810 (95%)
Total	610 (21%)	1,588 (54%)	756 (26%)	2,954 (100%)

Note: Number of firm-years in each category is reported.

Table 3: Descriptive statistics: Size categories

Panel A: US						
	Small		Medium		Large	
Variable	μ	σ	μ	σ	μ	σ
Cash	0.205	0.216	0.149	0.176	0.088	0.113
Cash Flow	0.013	0.183	0.075	0.114	0.094	0.074
R&D	0.085	0.120	0.042	0.063	0.033	0.045
Fixed Investment	0.045	0.044	0.053	0.041	0.056	0.037
Short Term Debt	0.032	0.075	0.018	0.048	0.027	0.045
Panel B: Germany						
	Small		Medium		Large	
Variable	μ	σ	μ	σ	μ	σ
Cash	0.096	0.124	0.076	0.089	0.096	0.102
Cash Flow	0.055	0.142	0.081	0.088	0.097	0.056
R&D	0.010	0.043	0.008	0.026	0.025	0.040
Fixed Investment	0.067	0.060	0.067	0.048	0.071	0.040
Short Term Debt	0.126	0.132	0.116	0.118	0.083	0.076
Panel C: UK						
	Small		Medium		Large	
Variable	μ	σ	μ	σ	μ	σ
Cash	0.127	0.168	0.112	0.133	0.103	0.092
Cash Flow	0.044	0.158	0.085	0.113	0.091	0.075
R&D	0.030	0.080	0.019	0.047	0.014	0.026
Fixed Investment	0.057	0.047	0.064	0.046	0.056	0.032
Short Term Debt	0.084	0.104	0.071	0.077	0.067	0.068

Note: All figures are calculated as a ratio to the firm's total assets. μ and σ represent mean and standard deviation respectively.

Table 4: Descriptive statistics: Dividend categories

Panel A: US				
	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.195	0.206	0.094	0.120
Cash Flow	0.034	0.155	0.100	0.076
R&D	0.072	0.096	0.025	0.038
Fixed Investment	0.049	0.043	0.055	0.037
Short Term Debt	0.023	0.063	0.024	0.044
Panel B: Germany				
	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.071	0.096	0.091	0.096
Cash Flow	0.011	0.127	0.109	0.057
R&D	0.016	0.058	0.013	0.030
Fixed Investment	0.050	0.040	0.076	0.049
Short Term Debt	0.140	0.130	0.097	0.098
Panel C: UK				
	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.202	0.241	0.104	0.113
Cash Flow	-0.094	0.196	0.097	0.086
R&D	0.093	0.145	0.013	0.027
Fixed Investment	0.038	0.036	0.062	0.044
Short Term Debt	0.091	0.122	0.069	0.073

Note: All figures are calculated as a ratio to the firm's total assets. μ and σ represent mean and standard deviation respectively.

Table 5: Robust two-step GMM estimates of $\Delta Cash$

	US	Germany	UK
	(1)	(2)	(3)
ΔCash$_{t-1}$	-0.127***	-0.206**	-0.163***
	(0.048)	(0.085)	(0.059)
Cash Flow$_t$	0.208***	0.139*	0.197***
	(0.041)	(0.082)	(0.047)
ΔRD$_{t+1}$	0.920***	0.616**	0.545**
	(0.246)	(0.241)	(0.271)
ΔFix. Investment$_{t+1}$	0.182	-0.071	0.108
	(0.134)	(0.120)	(0.103)
ΔNWC$_t$	-0.338***	-0.030	-0.346***
	(0.080)	(0.047)	(0.093)
ΔShort Term Debt$_t$	-0.203*	0.018	-0.306***
	(0.121)	(0.095)	(0.090)
Firm-years	17,813	2,306	3,202
Firms	2,006	352	505
J	209.706	108.635	310.319
J pvalue	0.112	0.519	0.725
AR(2)	-1.366	-1.104	0.043
AR(2) pvalue	0.172	0.270	0.965
Test $\gamma_{\Delta RD} = \gamma_{\Delta FixInv}$, pvalue	0.009	0.013	0.073

Notes: Two-step GMM-SYS estimates of $\Delta Cash$ are reported. Time fixed effects are included in all specifications. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Robust two-step GMM estimates: Size interactions

	US		Germany		UK	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔCash$_{t-1}$	-0.071*	-0.098**	-0.165**	-0.133**	-0.233***	-0.203***
	(0.043)	(0.042)	(0.065)	(0.059)	(0.059)	(0.076)
Small × CF$_t$	0.209***	0.191***	0.185*	0.202***	0.142***	0.185**
	(0.045)	(0.047)	(0.097)	(0.065)	(0.051)	(0.073)
Medium × CF$_t$	0.171***	0.152***	0.126**	0.183***	0.209***	0.249***
	(0.039)	(0.055)	(0.060)	(0.056)	(0.072)	(0.081)
Large × CF$_t$	0.076	0.027	0.080	0.136**	0.090	0.129
	(0.089)	(0.051)	(0.094)	(0.060)	(0.071)	(0.120)
ΔRD$_{t+1}$	0.464**		0.371*		0.412*	
	(0.185)		(0.200)		(0.219)	
ΔFix. Investment$_{t+1}$	0.359***		-0.069		-0.017	
	(0.130)		(0.103)		(0.102)	
ΔNWC$_t$	-0.289***	-0.302***	-0.037	-0.073	-0.316***	-0.349***
	(0.061)	(0.060)	(0.063)	(0.050)	(0.073)	(0.095)
ΔShort Term Debt$_t$	-0.167*	-0.227**	-0.001	0.024	-0.263***	-0.285***
	(0.092)	(0.091)	(0.084)	(0.068)	(0.072)	(0.110)
Small × ΔRD$_{t+1}$		0.510**		0.636*		0.889**
		(0.210)		(0.348)		(0.432)
Medium × ΔRD$_{t+1}$		0.338		0.080		0.019
		(0.275)		(0.188)		(0.837)
Large × ΔRD$_{t+1}$		0.676		-0.028		-0.239
		(0.493)		(0.199)		(0.448)
Small × ΔInv$_{t+1}$		0.346*		-0.003		0.252
		(0.180)		(0.113)		(0.201)
Medium × ΔInv$_{t+1}$		-0.125		0.178		0.223
		(0.158)		(0.111)		(0.198)
Large × ΔInv$_{t+1}$		0.221		0.075		-0.442
		(0.136)		(0.208)		(0.445)
Firm-years	17,813	17,813	2,306	2,306	3,202	3,202
Firms	2,006	2,006	352	352	505	505
J	363.345	524.516	171.063	293.772	446.868	161.801
J pvalue	0.155	0.150	0.484	1.000	0.810	0.857
AR(2)	-0.766	-1.385	-0.817	-0.519	-0.977	-0.480
AR(2) pvalue	0.443	0.166	0.414	0.604	0.329	0.631

Notes: Two-step GMM-SYS estimates of $\Delta Cash$ are reported. Time fixed effects are included in all specifications. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Robust two-step GMM estimates: Dividend payout interactions

	US		Germany		UK	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔCash_{t-1}	-0.096*	-0.108**	-0.112*	-0.153*	-0.175***	-0.125*
	(0.050)	(0.055)	(0.067)	(0.090)	(0.052)	(0.068)
No Div × CF_t	0.184***	0.250***	0.017	0.056	0.108	0.304*
	(0.042)	(0.045)	(0.107)	(0.124)	(0.101)	(0.182)
Div × CF_t	-0.008	-0.046	0.075	0.122	0.062	0.141
	(0.110)	(0.093)	(0.109)	(0.086)	(0.093)	(0.128)
ΔRD_{t+1}	0.489*		0.457*		0.614**	
	(0.259)		(0.248)		(0.294)	
$\Delta\text{Fix. Investment}_{t+1}$	0.085		-0.107		0.085	
	(0.140)		(0.118)		(0.148)	
ΔNWC_t	-0.401***	-0.437***	-0.038	-0.137*	-0.310**	-0.429**
	(0.092)	(0.100)	(0.068)	(0.081)	(0.124)	(0.215)
$\Delta\text{Short Term Debt}_t$	-0.291**	-0.096	0.019	-0.120*	-0.271***	-0.366*
	(0.135)	(0.158)	(0.074)	(0.064)	(0.103)	(0.217)
No Div × ΔRD_{t+1}		0.741***		0.247		0.535***
		(0.271)		(0.427)		(0.179)
Div × ΔRD_{t+1}		-0.168		0.297		0.133
		(1.141)		(0.226)		(0.382)
No Div × ΔInv_{t+1}		0.241		-0.023		2.021*
		(0.179)		(0.247)		(1.224)
Div × ΔFInv_{t+1}		0.028		0.095		0.324*
		(0.388)		(0.126)		(0.177)
Firm-years	17,813	17,813	1,585	1,585	2,954	2,954
Firms	2,006	2,006	288	288	486	486
J	177.437	120.804	98.725	64.453	203.787	149.920
J pvalue	0.151	0.890	0.912	1.000	0.511	0.705
AR(2)	-1.026	-0.759	-1.497	-1.559	-1.166	-0.585
AR(2) pvalue	0.305	0.448	0.134	0.119	0.244	0.558

Notes: Two-step GMM-SYS estimates of $\Delta Cash$ are reported. Time fixed effects are included in all specifications. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$