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

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Abstract

The paper explores factors that lead to accumulation or decumulation of firms' cash reserves. In particular, we empirically examine whether additional future fixed capital and R&D investment expenditures induce firms to change their liquidity ratio 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 adjustments to cash holdings when they plan additional future R&D rather than fixed capital investment expenditures. This behavior is particularly prevalent among financially constrained 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 all three countries. (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 as 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 business opportunities.

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 particular, we focus on the effects of future investment expenditures. Although we are not the first to investigate the relation between investment and cash holding behavior of firms, our study differs from the rest of the literature on several grounds. An inspection of the literature shows that researchers have recognized the significance of current and future investment plans for liquidity management, yet there seems to be little consensus on how to capture those effects. For instance, some researchers use current investment expenditures or reported investment plans, while others use Tobin's Q to proxy future investment opportunities of the firm. However, all of these strategies have their drawbacks, as we later discuss. In this paper, we examine the effect of one-period-ahead additional investment expenditures on firms' liquidity management behavior. We reason that a rational manager who plans to expand her firm's investment in the next period would take measures to improve the liquid assets of the company so that the project could be realized despite the potential effects of external or internal financial constraints.

In such circumstances we should observe that firm's cash holdings will increase.

Our second objective is to examine which type of future investment, fixed capital *versus* R&D expenditures, would lead to a higher accumulation of cash buffer stocks. We conjecture that an increase in 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 of firms that mainly invest in physical capital, as the latter firms may pledge their fixed investment as collateral. As most of a firm's R&D capital stock is represented by human capital, it would be much more difficult to temporarily reduce R&D expenditures without losing much of the specialized human capital to other companies.[2] Therefore, companies that carry out sizable R&D activities are more likely to face greater obstacles in accessing external financing in comparison to those firms that invest in pledgeable physical assets. In the presence of financial frictions, this will require firms to hoard more cash should they plan to increase their R&D expenditures. Another reason linking expansion in R&D activities to those firms' increase in cash holdings is the fact that R&D expenditures have a lengthy and highly uncertain payback.

To test our hypothesis, 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 1989–2007 period. We employ the Dynamic Panel Data System-GMM estimator of Blundell & Bond (1998) to allow for the possible endogeneity of the explanatory variables. Our approach considers

[2] As Hall & Lerner (2009) stress (p. 5), a multi-year purchase of machinery could be rescheduled in the face of financial exigiencies, but it would be much more difficult to temporarily reduce R&D expenditures. They indicate that 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.

how changes in future investment expenditures may lead to changes in firms' liquidity. In contrast to other studies (e.g., Almeida et al. (2004), Ozkan & Ozkan (2004) and Baum et al. (2008)) that consider the level of cash holdings, we consider firms' cash accumulation and decumulation. In estimating our models, we take into account firm-level fixed effects and time effects as well as other firm-specific factors. As the impact of additional investment expenditures may differ across categories of firms due to the presence of financial frictions, we consider three sample categorizations based on firms' size, their dividend payout ratio and their dividend status.

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 in the case of future fixed capital investment. Scrutinizing the data in more detail, we find that this behavior is particularly prevalent among the so-called 'financially constrained' firms (firms that are small in size, have a low payout ratio, or pay no dividends) 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 all three countries.

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

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

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. For instance, many firms have imperfect access to external funds and they cannot borrow sizable sums on short notice: particularly when firms experience shortfalls in their cash flow. In such circumstances, even if a lender is willing to extend external credit, it is likely that the premium will be high. In this context, pecking order theory maintains that in the presence of financial frictions, firms follow a financial hierarchy, firms first tap into cheaper internal sources of funds followed by more expensive alternatives in financing their activities (see Myers (1984) and 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 that is built upon the seminal work of Fazzari et al. (1988) helps us to appreciate why internal funds for the 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 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 funds. Although there are some challenges with respect to 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 unconstrained firms.[5]

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[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 &

Given the developments in the literature on fixed investment behavior of firms and financial frictions, several researchers implement those methodologies 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] Almeida et al. (2004) provide evidence that constrained firms have a positive cash flow sensitivity of cash, while unconstrained firms' cash balance adjustments are not systematically related to cash flows. Sufi (2009), using a panel of US firms, also shows that the cash flow 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. In a related study, Faulkender & Wang (2006) and Pinkowitz & Williamson (2007) present evidence that the value of cash is higher for constrained firms than for unconstrained firms.[7]

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. Researchers (e.g., Opler et al. (1999)) often 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

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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]There is also active research that relates the value of cash to corporate governance. For instance 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.

do not necessarily capture the effect of future investment. Other studies (e.g., Lamont (2000)) have used firms' investment plans, which more closely address the notion that capital expenditures are largely determined for a multiperiod horizon. However, data on investment plans is very limited.

Perhaps the most common approach in the literature is the use of Tobin's Q as a measure of future investment opportunities of firms, although Erickson & Whited (2000) raise several warnings about this strategy. For instance, Riddick & Whited (2009), after correcting for measurement error associated with Tobin's Q, estimate negative propensities to save out of cash flow. Almeida et al. (2004) replace the standard Q measure in their basic regressions model with the average growth of investment over two periods to capture the impact of current and future investment opportunities on cash holdings.[8] In a similar vein, Baum et al. (2009) study firms' leverage decisions by employing not current, but realized future values of the level of capital investment. We follow a similar approach in this study.

While acknowledging the importance of expected investment opportunities, few researchers distinguish how different types of investment affect corporate liquidity. As we have discussed above, one type of investment leads to the accumulation of pledgeable assets, whereas another type such as R&D may not. We expect that a firm that increases its non-pledgeable investment activities would hold more liquid assets than a similar firm whose assets may readily be pledged as collateral. Notably, Almeida & Campello (2007) claim that accumulation of pledgeable assets supports more borrowing and hence more capital expenditures.[9]

In our case, we investigate the impact of two types of firms' future investment activity

[8] Time 0 investment opportunities are measured as $(I_2 + I_1)/2I_0$.

[9] Almeida & Campello (2007) define tangibility as a function of receivables, inventories and capital stock. They also use a proxy to measure how easily lenders can liquidate the firm and another proxy based on product type (durable/nondurable) of each firm.

on the accumulation of cash holdings: R&D investment *versus* investment in physical capital. As discussed in the introduction, the former may be considered as intangible capital investment, which has a substantially higher marginal cost of external financing because of its limited pledgeability. Another reason linking expansion in R&D activities to those firms' increase in cash holdings is the fact that R&D expenditures have a lengthy and highly uncertain payback. A firm which is engaged in R&D activity may not realize any benefit in the near future, and may indeed never receive a meaningful return on that investment. This increases the uncertainty surrounding the firm's cash flows and working capital. As Hall (2002) points out, the more uncertain returns from R&D investment might lead to greater asymmetric information and more serious problems of moral hazard, rendering borrowing a costly option. Therefore, one would expect that firms planning to expand their R&D activities would increase their liquid assets in comparison to other firms which only plan to increase their fixed capital.

3. Empirical Implementation

3.1. Test Design

To quantify the motivation for firms' liquid asset holdings, we use a variant of an empirical specification which is often employed in the literature. The main difference in our approach is the introduction of two types of investment, fixed capital and R&D, rather than merely focusing on the role of fixed capital investment. Second, we investigate the effect of changes in investment expenditures rather than the level. In doing so we would like to capture the impact of actual changes in investment patterns on the accumulation or decumulation of cash holdings. If the firm changes either sort of future investment by a sizable amount, we expect to find a concomitant change in the firm's 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 the 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, also normalized by total assets. The key coefficients of interest are α_3 and α_4, which determine the response of liquid assets' holdings to changes in *actual future* R&D, ΔRD, and fixed capital investment, $\Delta FixInv$, respectively.[10] 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 also 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.

We allow for dynamics in the adjustment of cash holdings, as the firm's managers (unbeknownst to the econometrician) may have a multi-year investment plan in place that may imply several years' adjustments to their liquidity ratio. Taking this into account, we believe it is wise to allow the data to indicate whether dynamics in the changes of the liquidity ratio should play a role in the model.

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–future investment sensitivity between financially constrained and unconstrained firms. To investigate this issue as well as the differential impact of cash flow between constrained

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

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 firm categories.

The first categorization is based on firm size, given the widespread use of size as a proxy for financial constraints in the literature. For each firm, we compute average book value of total assets per year. We assign the top and bottom quartiles to large and small firms, respectively, while the two intermediate quartiles constitute medium size firms. The second category is based on the level of the dividend payout ratio. The payout categorization is based on the ratio of common share dividend and stock repurchases to total operating income, using the same three quartile-based categories. The third categorization is dichotomous, considering whether the dividend payout ratio is positive or zero. There are disagreements in the empirical literature on the use of the dividend payout ratio (or the presence or absence of dividends) as a proxy for financial constraints. This is all the more important in a cross-country setting with different institutional factors. Thus, for robustness, we use two alternative measures based on the firm's dividend policy.

Our augmented model takes the form

$$\begin{aligned}\Delta Cash_{it} &= \alpha_0 + \alpha_1 \Delta Cash_{i,t-1} + [CashFlow_{it} \times TYPE_{it}]\,\eta + [\Delta RD_{i,t+1} \times TYPE_{it}]\,\gamma_1 \\ &+ [\Delta FixInv_{i,t+1} \times TYPE_{it}]\,\gamma_2 + \alpha_5 \Delta ShortDebt_{it} + \alpha_6 \Delta NWC_{it} \\ &+ \mu_i + \tau_t + \epsilon_{it}\end{aligned} \tag{2}$$

where $TYPE_{it}$ is a vector of dummies capturing one of the categorizations of firms as more or less likely to face financial constraints.

We do not run separate regression analyses for each of these groups, but we rather examine a single model where we interact the category indicators with cash flow and changes of future investment. This approach allows us to properly conduct a test of coefficients' stability over these categories of firms. This strategy also allows firms to transition among categories, year by year, rather than categorizing them once and for all.

To estimate equations (1) and (2) we must take into account the endogeneity of financial and investment decisions. In particular, including the lagged dependent variable as an explanatory variable renders a fixed effects estimator biased and inconsistent (see Nickell (1981)). To overcome this difficulty previous researchers relied heavily on using various GMM-family estimators (e.g. IV or 2SLS). However, quite often the choice of instruments in those settings requires very careful justification. To address this critique, we employ the Dynamic Panel Data (DPD) estimator that proposes an appropriate set of instruments by construction. All our models are estimated with the two-step GMM-System 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 the error process 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.

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.[11] 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 consists of an unbalanced panel of about 32,000 manufacturing firm-year observations over the period from 1989–2007.[12] 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%.[13] 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 winsorized. Missing values of R&D expenditures are replaced with zeros. Finally, we drop all those companies that have cash flow-to-assets ratio lower than −0.5 (−50%) for at least three years to remove those

[11] Unfortunately for many countries the dataset do not provide information on R&D expenditures for firms. For instance although the dataset provides information on a large sample of firms for Japan, data on R&D are not available.

[12] 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.

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

companies in financial distress.[14] 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. All data items are transferred into US dollars and CPI adjusted.

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 (14.4%) is maintained by US companies, while the lowest (8.6%) 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 provides the distribution of firms by size and dividend payout ratio categories for the US, UK and Germany. Panel A shows that about 80% of the small US firms are classified as low payout whereas a third of the medium and a fifth of the large US firms are registered as low payout. In the case of Germany, half of the small firms are registered as low payout, yet approximately 20% of the medium and large firms are too in the low payout firm category. Similar observations are valid for the UK firms except that only 10% of the large firms are classified as low payout firms.

Table 3 presents information on the distribution of firms by size and dividend status (positive vs. zero dividends) for the three countries. As noted above, individual firm-years are categorized on these two dimensions, so that a given firm may be classified

[14]There companies are likely to be in financial distress. In total, 104 firms have been removed.

as small in one year and medium in another, or switch from non-dividend-paying to dividend-paying status. This is particularly important with respect to the secular trend in firms' dividend policy 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. Panel A of the table suggests that almost half of the US firm-year observations in our sample do not pay dividends. Panels B and C report that there is considerably smaller numbers of observations for Germany (15%) and the UK (5%), respectively. Interestingly, most of the small firms in the US do not pay dividends, whereas in Germany and the UK most of the firms pay dividends regardless of their size.

Next, we present information on the basic descriptive statistics of the key variables by firm size and dividend status.[15] Table 4 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.

[15]For brevity, we do not provide an equivalent table for the dividend payout ratio.

Table 5 reports the descriptive statistics when we classify firms with respect to their dividend status. 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 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

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, with the impact of increases in R&D expenditures 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. The impact of R&D expenditures are likely to be most significant for the US firms as the data show that US firms are more heavily engaged in R&D activities.

Table 6 presents the results for the dynamic model given in Equation (1). The change in future fixed investment expenditures is positive for all countries but it is only significant for the US at the 5% level. That is an increase in fixed investment behavior does not necessarily lead to a significant change in cash holdings. This evidence could be explained by the pledgeability of investments in physical capital. Bester (1985) argues that collateral can be used as a signaling mechanism to distinguish between high-risk and low-risk borrowers. In contrast, R&D capital has limited collateral value and it is a riskier investment type. We expect that those firms that are planning to increase their R&D investment expenditures are likely to accumulate liquid assets to finance this type of investment. We find support for this conjecture. Table 6 provides evidence that the effect of the change in future R&D expenditures leads to a positive and significant increase in liquidity (at the 1% level for US and Germany and at the 5% level for the UK). This observation implies that firms increase their current cash holdings in anticipation of next period's R&D expenditures. Furthermore, given the results we can say that 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.

In Table 6 the coefficient on the lagged dependent variable for all countries is significant and negative, implying that dynamics of the cash adjustment process are important. Interestingly, our coefficient estimates are very similar to those reported on a firm level by Opler et al. (1999) from their Eqn. 1, a pure autoregressive model of the change in the cash/assets ratio. They find a median coefficient of -0.242 at the firm level.[16] The table also shows that an increase in cash flow leads to an accumulation of cash for all countries, as its coefficient is positive and significant for all three countries at the 1% level. As earlier research has shown, changes in the non-cash net working capital ratio possess negative and significant coefficients for all countries. Finally, we find that

[16] Opler et al. (1999), in their full models, include last period's deviation from a target cash ratio as an explanatory factor, using several definitions of the target cash ratio. As we are not testing the 'static tradeoff' model, we do not include this complication in our dynamic specification.

the change in the short-term debt ratio has a negative and significant effect on cash accumulation for UK firms, but an insignificant effect in the US and Germany.

4.2. The Augmented Regression Model

The results given in Tables 7, 8 and 9 present our findings for Equation (2) where we model firms' adjustment of their cash balances for different size, dividend and payout 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 each category on firms' cash flows.

4.2.1. Firms' Liquidity and the Role of Firm Size

Table 7 presents our results for Equation (2) for different firm size categories. Comparing results from this table with that of Table 6, we see that the lagged dependent variable and the changes in non-cash net working capital ratios have similar significance and effects on firms' adjustments of their liquidity. Columns 1, 3 and 5 of Table 7 present our results where we allow only cash flow to have a differential effect on the liquidity ratio across size categories. Columns 2, 4 and 6 present our results where we allow both cash flow and future R&D and fixed investment to have a differential effect on firms' liquidity across size categories. Our results show that small firms contribute to their liquidity more than their larger counterparts do as their cash flow increases. In line with the earlier research, cash flow has a small and insignificant effect on large firms' liquidity 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 examined the impact of cash flow across different size categories, we next consider the effects of R&D and fixed capital expenditure on the liquidity behavior of firms as firm size is allowed to change for the same set of models. Columns 1, 3, and 5 of the table show that future capital investment expenditures only affect US firms' liquidity at the 1% level while the effect is insignificant for the other countries. In contrast, future change in R&D affects liquidity in all three countries positively and significantly: at the 5% level for US firms and 10% level for UK and German firms.

We next allow the impact of the change in R&D and fixed investment to differ across different categories along with that of cash flow. Inspecting the results given in columns 2, 4 and 6, we see that only US small firms' liquidity responds to an increase in future capital investment expenditures. When we consider the effects of future R&D expenditures, we find that small firms' future R&D expenditures have a significant and large impact on firms' liquidity, yet we find no such effect for medium or large firms. This means that medium and large firms do not significantly increase their liquidity in response to an increase in future R&D expenditures. Financially 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.

4.2.2. Firms' Liquidity and the Dividend Payout Ratio

Our second categorization is based on firms' payout ratios. This categorization allows us to generate three groups of firms, with low, medium and high dividend payout ratios. We follow this approach due to the observation that most German and UK firms pay dividends while some of these may be in fact financially constrained. Hence, inspection of German and UK firms using this categorization may help us to understand the effects of the changes in future R&D and fixed investment activities. The disadvantage of this route is that we will allocate some of the non-dividend paying US firms, which are generally considered by researchers as financially constrained, to another category. Hence, we would expect that when evaluating results for US firms that low and medium payout firms in the US would have similar characteristics.

Table 8 presents our regression results when we investigate firms' liquidity behavior categorizing the firms with respect to their dividend payout ratio. In line with our earlier results, the coefficient of the lagged dependent variable is negative and significant. Also, the significance and sign of changes in the non-cash net working capital and short-term debt ratios are unchanged. We also observe that while cash flow for low and medium payout firms has a positive and significant effect on liquidity the impact of cash flow on those firms that are in the large payout category, although positive, is insignificant.

When we inspect the impact of a change in future fixed investment on liquidity we find that the effect is positive for all countries for those countries in the low payout group yet significant only for the US and the UK. In all cases, changes in future capital investment does not lead to an increase in firms' liquidity for medium and high payout firms. When we examine the impact of a change in future R&D expenditure, we find that low payout firms increase liquidity in all countries. In the US, firms that are in the medium payout category also increase their liquidity. As discussed earlier, an increase in future R&D investment induces financially constrained firms to increase their liquidity. While similar behavior is observed for those firms that increase their fixed capital investment, the evidence is not as broad as in the case of R&D investment, and the size of the impact on liquidity is always smaller than that of a change in future R&D investment.

4.2.3. Firms' Liquidity and Dividend Status

Table 9 presents our regression results when we investigate firms' liquidity behavior comparing dividend-paying with non-dividend-paying firms. In all models, the coefficient of the lagged dependent variable is negative and significant, indicating that dynamics play an important role in this relationship. The significance and sign of changes in the non-cash net working capital and short-term debt ratios are unchanged: non-cash net working capital is negative and significant for US and UK firms but insignificant for German firms, while the short-term debt ratio is negative for all cases but significant only for UK firms (see column 5). When we inspect the effect of cash flow for dividend-paying *versus* non-dividend-paying firms, we see that non-dividend-paying US firms increase their liquidity significantly in comparison to their dividend-paying counterparts. For the case of UK and German firms we find no difference across dividend paying and non-dividend paying firms, as an increase in their cash flow leads to an increase in their liquidity.

Next we concentrate on the effects of fixed capital investment and R&D expenditures. In contrast to the results presented in Table 7, when we categorize the firms between dividend-paying and non-dividend paying firms, we see no differential effect of future fixed investment expenditures on either type of firms' liquidity behavior. However, when we inspect the impact of an increase in future R&D expenditures, we see that non-dividend-paying firms augment their liquidity, while dividend-paying firms do not significantly change their liquidity behavior. This pattern holds for firms in all three economies, supporting the claim that an increase in future R&D expenditures leads to an increase in financially constrained firms' liquidity.

5. Conclusions

In this paper we empirically examine the factors that affect the accumulation or decumulation of cash reserves of firms using data from three advanced economies: the US, UK and Germany. Our investigation specifically considers the impact of future fixed capital and R&D expenditures on firms' liquidity behavior. Although one can expect that an increase in either type of investment will lead to an improvement in firms' cash holdings, we conjecture that the effect of R&D expenditures on firms' cash holdings should be stronger based on the observation that R&D investment leads to accumulation of intangible assets and yields highly uncertain returns. As a result, asymmetric information problems weigh more heavily in the case of R&D investment in comparison to investment in fixed capital, rendering R&D activity more dependent on internal resources.

To carry out our investigation, we use panels of quoted manufacturing firms obtained from Global COMPUSTAT for the US, UK and Germany over 1989–2007. The empirical models implement a dynamic framework to allow the adjustment of cash balances to reflect the many unobserved factors that may be associated with firms' multi-year investment plans for both fixed capital and R&D expenditures. We also consider the impact of market imperfections resulting in financial constraints by categorizing firms based on size, dividend payout ratio and dividend status. Our analysis reveals that firms in each country augment their cash holdings more vigorously in response to additional future R&D expenditures than they do for increases in future fixed capital investment. Scrutinizing the data in more detail, we find that this behavior is particularly prominent among firms more likely to be financially constrained: small, low-payout firms and those who do not pay dividends. In line with the earlier literature, we also show that the cash flow sensitivity of cash is higher for constrained firms with respect to their larger counterparts in all three countries.

From the policy perspective, it is hard to underestimate the importance of technology-producing mechanisms for knowledge-based economies. Our study reveals that companies that plan to increase their R&D activities would increase their cash buffers, implying their need for internally generated funds. This observation holds for all countries in our dataset. In that sense, our findings are unique in light of previous studies, which have not shown such diverse and significant effects. In particular we show that future R&D investment has an economically significant effect on firms' liquidity behavior, and that this effect is much larger than that related to future fixed investment.

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Table 1: Descriptive statistics: All Firms, 1989–2007

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, NWC	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, NWC	-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, NWC	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 Dividend Payout Ratio and Size Subsamples

	Small	Medium	Large	Total
Panel A: US				
Low Payout	2,567	3,976	909	7,095
Medium Payout	593	3,106	1,710	5,409
High Payout	520	2,272	2,160	4,952
Total	3,680	9,354	4,779	17,813
Panel B: Germany				
Low Payout	242	295	146	683
Medium Payout	156	547	266	969
High Payout	68	309	277	654
Total	466	1,151	689	2,306
Panel C: UK				
Low Payout	317	378	87	782
Medium Payout	287	928	352	1,567
High Payout	136	361	356	853
Total	740	1,667	795	3,202

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

Table 3: Tabulation of Size and Dividend Status Subsamples

	Small	Medium	Large	Total
Panel A: US				
No Dividends	2,485	3,774	836	7,095
Dividends	1,195	5,580	3,943	10,718
Total	3,680	9,354	4,779	17,813
Panel B: Germany				
No Dividends	77	173	55	305
Dividends	389	978	634	2,001
Total	466	1,151	689	2,306
Panel C: UK				
No Dividends	83	61	18	162
Dividends	657	1,606	777	3,040
Total	740	1,667	795	3,202

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

Table 4: Descriptive statistics: Firm 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 5: Descriptive statistics: Dividend Status categories

Panel A: US

	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.194	0.212	0.111	0.139
Cash Flow	0.010	0.165	0.105	0.071
R&D	0.078	0.104	0.029	0.042
Fixed Investment	0.048	0.044	0.055	0.038
Short Term Debt	0.026	0.068	0.022	0.043

Panel B: Germany

	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.069	0.093	0.088	0.102
Cash Flow	0.013	0.124	0.091	0.086
R&D	0.017	0.057	0.013	0.031
Fixed Investment	0.049	0.040	0.071	0.049
Short Term Debt	0.143	0.131	0.103	0.107

Panel C: UK

	No Dividends		Dividends	
Variable	μ	σ	μ	σ
Cash	0.191	0.232	0.109	0.125
Cash Flow	-0.093	0.190	0.086	0.107
R&D	0.086	0.139	0.017	0.042
Fixed Investment	0.038	0.035	0.061	0.044
Short Term Debt	0.091	0.118	0.072	0.080

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

Table 6: Robust two-step GMM estimates of $\Delta Cash$

	US	Germany	UK
	(1)	(2)	(3)
ΔCash$_{t-1}$	-0.089**	-0.195***	-0.207***
	(0.038)	(0.049)	(0.071)
Cash Flow$_t$	0.246***	0.269***	0.126**
	(0.039)	(0.055)	(0.055)
ΔRD$_{t+1}$	0.671***	0.511***	0.856**
	(0.184)	(0.190)	(0.404)
ΔFix. Investment$_{t+1}$	0.219**	0.088	0.056
	(0.107)	(0.072)	(0.164)
ΔNWC$_t$	-0.247***	-0.121***	-0.323***
	(0.063)	(0.044)	(0.100)
ΔShort Term Debt$_t$	-0.100	0.008	-0.326***
	(0.090)	(0.065)	(0.102)
Firm-years	17,813	2,306	3,202
Firms	2,006	352	505
J	337.669	312.251	213.486
J pvalue	0.162	0.987	0.536
AR(2) pvalue	0.251	0.238	0.705
Test $\gamma_{\Delta RD} = \gamma_{\Delta FixInv}$, pvalue	0.040	0.033	0.064

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: Firm 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 $\times$ 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 $\times$ CF$_t$	0.171***	0.152***	0.126**	0.183***	0.209***	0.249***
	(0.039)	(0.055)	(0.060)	(0.055)	(0.072)	(0.081)
Large $\times$ 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 $\times$ ΔRD$_{t+1}$		0.510**		0.636*		0.889**
		(0.210)		(0.349)		(0.432)
Medium $\times$ ΔRD$_{t+1}$		0.338		0.080		0.019
		(0.275)		(0.189)		(0.837)
Large $\times$ ΔRD$_{t+1}$		0.676		-0.028		-0.239
		(0.493)		(0.199)		(0.448)
Small $\times$ ΔFInv$_{t+1}$		0.346*		-0.003		0.252
		(0.180)		(0.113)		(0.201)
Medium $\times$ ΔFInv$_{t+1}$		-0.125		0.178		0.223
		(0.158)		(0.111)		(0.198)
Large $\times$ ΔFInv$_{t+1}$		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) 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 8: Robust two-step GMM estimates: Dividend Payout Ratio interactions

	US		Germany		UK	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔCash_{t-1}	-0.098**	-0.102***	-0.225***	-0.222***	-0.269***	-0.203***
	(0.041)	(0.038)	(0.055)	(0.045)	(0.050)	(0.041)
Low Payout × CF_t	0.164***	0.206***	0.377***	0.276***	0.133**	0.102*
	(0.045)	(0.037)	(0.091)	(0.078)	(0.063)	(0.061)
Medium Payout × CF_t	0.203***	0.017	0.212***	0.118**	0.267***	0.256***
	(0.053)	(0.083)	(0.073)	(0.053)	(0.081)	(0.072)
High Payout × CF_t	0.023	-0.136	0.192**	0.157	0.137	0.164
	(0.044)	(0.084)	(0.094)	(0.098)	(0.089)	(0.107)
ΔRD_{t+1}	0.503***		0.374***		0.493*	
	(0.194)		(0.140)		(0.268)	
$\Delta\text{Fix. Investment}_{t+1}$	0.263**		0.007		0.088	
	(0.109)		(0.069)		(0.109)	
ΔNWC_t	-0.249***	-0.271***	-0.086*	-0.029	-0.208***	-0.297***
	(0.055)	(0.058)	(0.045)	(0.041)	(0.080)	(0.071)
$\Delta\text{Short Term Debt}_t$	-0.171*	-0.139*	-0.003	-0.035	-0.237***	-0.326***
	(0.094)	(0.083)	(0.072)	(0.055)	(0.074)	(0.078)
Low Payout × ΔRD_{t+1}		0.512***		0.654*		0.845**
		(0.190)		(0.394)		(0.355)
Medium Payout × ΔRD_{t+1}		1.383**		0.133		-0.131
		(0.587)		(0.199)		(0.407)
High Payout × ΔRD_{t+1}		0.776		-0.306		0.629
		(0.570)		(0.791)		(0.417)
Low Payout × ΔFInv_{t+1}		0.363**		0.185		0.341***
		(0.167)		(0.165)		(0.126)
Medium Payout × ΔFInv_{t+1}		-0.058		-0.028		-0.010
		(0.176)		(0.091)		(0.176)
High Payout × ΔFInv_{t+1}		0.069		-0.093		0.212
		(0.200)		(0.137)		(0.229)
Firm-years	17,813	17,813	2,306	2,306	3,202	3,202
Firms	2,006	2,006	352	352	505	505
J	359.825	449.795	311.949	280.121	415.413	447.795
J pvalue	0.117	0.169	0.601	0.801	0.660	0.720
AR(2) pvalue	0.166	0.217	0.190	0.111	0.171	0.608

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 9: Robust two-step GMM estimates: Dividend Status interactions

	US		Germany		UK	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔCash_{t-1}	-0.081*	-0.125**	-0.193***	-0.211***	-0.256***	-0.190**
	(0.042)	(0.062)	(0.049)	(0.056)	(0.055)	(0.092)
No Div $\times$ CF_t	0.193***	0.191***	0.258***	0.253**	0.214*	0.158*
	(0.038)	(0.048)	(0.091)	(0.112)	(0.122)	(0.094)
Div $\times$ CF_t	0.117***	-0.089	0.215***	0.222**	0.167***	0.086
	(0.040)	(0.090)	(0.070)	(0.094)	(0.064)	(0.077)
ΔRD_{t+1}	0.533***		0.475**		0.574*	
	(0.177)		(0.192)		(0.333)	
$\Delta\text{Fix. Investment}_{t+1}$	0.217**		0.081		0.039	
	(0.109)		(0.081)		(0.091)	
ΔNWC_t	-0.220***	-0.372***	-0.155***	-0.050	-0.404***	-0.248
	(0.057)	(0.113)	(0.050)	(0.046)	(0.079)	(0.178)
$\Delta\text{Short Term Debt}_t$	-0.134	-0.073	-0.073	-0.030	-0.403***	-0.210
	(0.095)	(0.160)	(0.052)	(0.075)	(0.088)	(0.197)
No Div $\times$ ΔRD_{t+1}		0.525**		1.766***		1.115***
		(0.263)		(0.650)		(0.357)
Div $\times$ ΔRD_{t+1}		1.018		0.001		-1.576
		(0.643)		(0.306)		(1.182)
No Div $\times$ ΔFInv_{t+1}		0.376		-0.501		0.940
		(0.231)		(0.398)		(0.644)
Div $\times$ ΔFInv_{t+1}		0.140		0.025		0.260
		(0.205)		(0.085)		(0.182)
Firm-years	17,813	17,813	2,306	2,306	3,202	3,202
Firms	2,006	2,006	352	352	505	505
J	353.093	128.674	288.255	150.975	294.859	37.902
J pvalue	0.145	0.884	0.997	0.850	0.749	0.796
AR(2) pvalue	0.300	0.273	0.298	0.236	0.192	0.583

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