Do Financing Constraints Matter for R&D? New Tests and Evidence*

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Abstract

Information problems and lack of collateral value should make R&D more susceptible to financing frictions than other investments, yet existing evidence on whether financing constraints limit R&D is decidedly mixed, particularly in studies of non-U.S. firms. We study a large sample of European firms and show that prior studies likely understate the impact of financing constraints on R&D because they ignore: i) firm efforts to smooth R&D with stocks of liquidity, and ii) firm use of external equity finance. We find a strong negative link between changes in cash reserves and R&D, and a large increase in the estimated impact that other financial factors (cash flow and stock issues) have on R&D when we directly control for R&D smoothing with cash reserves. Taken together, these findings offer strong evidence that financing constraints affect R&D because they cannot readily be attributed to problems controlling for investment demand. More generally, our results show how endogenous liquidity management complicates testing for financing constraints on investments with high adjustment costs. Our findings also indicate that access to equity finance matters for R&D, highlighting a causal channel through which stock market development and liberalization can promote economic growth by increasing firm-level innovative activity.

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I. Introduction

R&D is a critical input for innovation and is thus a main driver of economic growth. One key feature of R&D is that knowledge spills across firms and even countries, suggesting that socially optimal rates of R&D are likely much higher than privately optimal levels (see the survey by Hall, Mairesse and Mohnen (2009)).[1] A second important feature of R&D is susceptibility to financing constraints: for several reasons – including lack of collateral value and asymmetric information problems – R&D may face significant adverse selection and moral hazard problems, particularly for younger, smaller firms. For such firms, financing constraints can drive R&D investment considerably below the privately optimal level in a world of no financing frictions. If financing constraints are binding for a sufficient number of firms, country- and world-wide R&D levels will be depressed, leading to lower levels of growth than would be possible in a world without financing frictions.

Despite R&D's critical role in economic growth and susceptibility to financing difficulties, most research on the real effects of financing frictions focuses on fixed capital investment rather than R&D. Furthermore, evidence from the studies that do examine R&D is based almost exclusively on the sensitivity of firm-level R&D spending to the availability of internal cash flow. In these studies, the findings are decidedly mixed: a small number of studies find evidence of an internal finance-R&D link in U.S. firms (e.g., Hall (1992); Himmelberg and Petersen (1994); Brown, Fazzari and Petersen (2009)), while a number of other studies find weak evidence (at most) that finance matters for R&D, particularly those exploring continental European firms (e.g., Haroff (1998); Bond, Harhoff, and Van Reenen (2003); Mulkay, Hall and Mairesse (2001)). Since capital markets in the U.S. are at least as developed as those in Europe, the relative lack of evidence that finance matters for R&D in Europe is a puzzle, and casts doubt on whether financing frictions have a quantitatively important impact on R&D and innovation in modern

[1] R&D is now a central element of much of the vast endogenous growth literature (e.g., Romer (1990); Aghion and Howitt (1992)). For evidence on R&D spillovers across countries, see Coe, Helpman and Hoffmaister (2009).

economies. It is thus not surprising that Hall and Lerner (2010), in their review of the literature, conclude that the existing evidence on the importance of financing constraints on R&D is far from conclusive.[2]

In this study, we explore two issues, ignored in nearly all previous studies, that are potentially crucial for understanding the true impact financing constraints have on R&D. The first issue is firm use of external equity (i.e., stock issues) to finance R&D. R&D-intensive firms often have limited amounts of internally generated cash flow and little or no access to debt for financing R&D investments (given the lack of collateral value and skewed nature of returns). As a consequence, stock issues are likely the main marginal source of R&D finance for many constrained firms.[3] Furthermore, since firms appear to rely heavily on stock issues at a point in their life cycle when R&D intensity is high and cash flow is small or even negative, ignoring stock issues can lead to a downward left-out variable bias in the estimated link between R&D and cash flow. As young firms increasingly turn to stock markets for funding, there is an ever greater potential for misleading inference about the importance of financing constraints in studies that ignore stock issues.

The second issue that complicates testing for financing constraints on R&D is the fact that firms have strong incentives to keep R&D smooth because of high adjustment costs. The most plausible way for firms facing binding financing constraints to smooth R&D relative to transitory finance shocks is to build and manage internal buffer stocks of liquidity (e.g., cash reserves).[4] If firms do actively smooth R&D, then within-firm regressions that ignore endogenous liquidity management will generate downward biased estimates of the impact that financial factors have on R&D, since R&D is much less volatile in the short-run than the primary sources of finance. (This is particularly relevant in Europe, where adjustment costs for R&D may be particularly large, given labor laws.) To address this potential bias we directly

[2] See their discussion in section four.

[3] Firms with some access to external equity are still financially constrained if the supply curve for external equity is upward sloping.

[4] Several studies show theoretically that cash reserves can benefit firms facing financing frictions. In particular, Acharya, Almeida and Campello (2007) show that firms with "high hedging needs" will prefer building stocks of cash rather than debt capacity as a hedge against cash flow shortfalls. Also see Kim, Mauer and Sherman (1998) and Almeida, Campello and Weisbach (2004).

control for firm smoothing efforts by including *changes* in the firm's stock of liquid assets (cash and equivalents) in the regression specification.

To our knowledge, no previous studies explore how external finance or R&D smoothing impact testing for the presence of R&D financing constraints. One main contribution of our study is to show that accounting for firm use of external equity finance and active R&D smoothing provides a more accurate measure of whether financing constraints matter for R&D and can dramatically alter the conclusions concerning whether financing constraints are important. Our insights apply not just to R&D, but to any study that attempts to identify financing constraints on investment that is costly to adjust or is financed extensively with external funds. A second contribution of our study is to provide new tests for identifying the presence of financing constraints. Specifically, including the change in cash holdings in the R&D regression provides a sharper and more conclusive test that financing constraints influence corporate investment decisions because firms facing binding financing constraints should exhibit *both*: i) a negative within-firm link between R&D and changes in cash holdings (because reductions in cash release funds for investment), and ii) a substantial increase in the estimated impact that the *other* financial factors have on R&D when the change in cash holdings is included, revealing more of the long-run impact that access to finance has on investment. We are aware of no alternatives to binding financing constraints that can readily and simultaneously explain both of these empirical predictions. In particular, for reasons discussed in more detail in the next section, it is difficult to attribute these findings to difficulties controlling for R&D investment opportunities, a standard critique of financing constraint studies.

We study a large panel of firms across sixteen European economies for the time period 1995-2007. For the full sample, R&D investment is large (e.g., comparable to physical investment), and stock issues are, on average, substantially larger than internal cash flows for younger firms. In addition, young firms maintain very large stocks of cash and equivalents, often two to three times the size of annual R&D spending, suggesting that these firms have substantial capacity to smooth R&D in response to transitory finance shocks. Cash holdings, stock issues and R&D intensity are particularly high for young firms in the U.K. and Sweden, two countries with highly developed stock markets.

To formally explore the impact of financing constraints on R&D, we modify a dynamic structural model that Bond and Meghir (1994) develop to study fixed investment. We estimate the R&D model using a "systems" GMM estimator that accounts for unobserved firm-specific effects and allows us to address the potential endogeneity of all financial variables. We find little or no evidence that finance matters for R&D in standard specifications that include only cash flow (i.e., the estimated R&D-cash flow sensitivity is near zero), which indicates that a positive link between R&D and cash flow is not occurring simply because of poor demand controls. However, when we include stock issues, and particularly when we control for R&D smoothing by including changes in cash holdings, we find a positive, statistically significant and quantitatively important link between R&D and cash flow (as well as stock issues). More importantly for identifying binding financing constraints, the coefficient on the change in cash holdings is negative and large (in absolute value), and the coefficient estimates on the equity finance variables increase sharply when cash holdings is included in the regression. As expected, we find no evidence that access to debt has an important impact on R&D spending.

The importance of access to equity finance for R&D differs across firm types and countries. First, financial factors have by far the strongest impact on R&D in the groups of firms most likely to face binding financing constraints (e.g., younger, smaller, and lower payout firms). Second, we find a stronger link between access to finance and R&D in the U.K and Sweden (market based economies) than in France and Germany (bank based). We believe this finding reflects the fact that well-developed stock markets support many more young, entrepreneurial firms with substantial investment opportunities relative to internal funds: these firms often rely extensively on costly external equity at the margin, and thus have investment levels that are especially sensitive to finance shocks.

Several studies raise significant questions about the use of conventional investment-cash flow regressions to draw inference about the importance of financing constraints (e.g., Kaplan and Zingales (1997) and Moyen (2004)). We emphasize that our approach for evaluating the importance of financing constraints on R&D is not based on standard estimates of the investment-cash flow sensitivity (indeed, we find no evidence of an important R&D-finance link if we estimate only conventional R&D-cash flow regressions). Instead, we examine multiple tests for the presence of financing constraints and we are aware of no single alternative to the financing constraint explanation that can simultaneously rationalize our full set of findings: i) a strong positive link between R&D and the internal and external equity finance variables, ii) no significant link between R&D and debt, iii) a strong negative link between changes in cash holdings and R&D, and iv) a sharp increase in the estimated link between R&D and the equity finance variables when we control for R&D smoothing.

Our findings have a number of economic implications. First, access to equity finance appears to have a substantial impact on R&D investment. Second, corporate liquidity can have an important impact on real firm behavior: younger, smaller firms rely extensively on large cash reserves to buffer R&D from much of the transitory volatility in key sources of finance. To our knowledge, this is the first study to show that controlling for this smoothing behavior is crucial for testing for the presence and importance of financing constraints on R&D. Third, our findings highlight the importance of stock issues as a source of funds for R&D investment, and these findings indicate that stock markets are more than a "sideshow" in Europe, particularly in the countries with highly developed stock markets (Sweden and the U.K.). These findings also highlight a causal channel through which stock market development and liberalization can foster innovative activity, thereby leading to economic growth. Finally, our results suggest that better access to equity finance would significantly increase firm-level R&D intensity, a key public policy goal in a number of countries.[5]

II. Financial Factors and R&D Investment

A. Existing Evidence

For several reasons, financing frictions should matter more for R&D than for other types of investment. One reason is asymmetric information: for technical reasons, it is often difficult for outside investors to become well informed about the expected returns associated with cutting-edge R&D. This

[5] For example, higher R&D intensity is a primary focus of the 2000 Lisbon Agenda and subsequent European Councils. In 2002, the Barcelona European Council set an EU goal of investing 3% of GDP on R&D by 2010 (well above the 1.85% figure in the EU-27 in 2007).

problem is exacerbated if firms must actively maintain information asymmetries in order to appropriate the returns to R&D. A second reason is that R&D lacks collateral value, which limits the ability of firms to pledge assets, which, in theory, can overcome adverse selection and moral hazard problems (e.g., Bester (1985)). In practice, risky firms are almost always required to pledge collateral to obtain debt finance (e.g., Berger and Udell (1990)).

Compared to the vast literature testing for the presence of financing constraints on physical investment, surprisingly little research focuses on R&D.[6] Most prior studies focus on the within-firm relation between R&D spending and cash flow, and the findings are mixed. Early studies by Hall (1992) and Himmelberg and Petersen (1994) find a strong relation between R&D and cash flow for U.S. manufacturing firms. On the other hand, Bhagat and Welch (1995) report no evidence of a positive R&D-cash flow link across firms in the U.S., Canada, UK, Continental Europe and Japan, and Rauh (2006) finds no evidence that R&D responds to exogenous shocks to internal resources caused by mandatory pension contributions in a sample of U.S. firms. Harhoff (1998) finds a weak (but significant) relationship between R&D and cash flow for small and large German firms. Bond, Harhoff, and Van Reenen (2003) find that neither German firms nor U.K. firms display a correlation between the level of R&D and cash flow; they do, however, find that the level of cash flow is positively correlated with whether or not U.K. firms engage in R&D.[7] Hall, Mairesse, Branstetter and Crepon (1999), using a VAR methodology, find that R&D is much more sensitive to cash flow in U.S. firms than in French and Japanese firms. Likewise, Mulkay, Hall and Mairesse (2001) report a much stronger R&D-cash flow sensitivity for U.S. firms relative to French firms. Recent studies by Brown, Fazzari and Petersen (2009) and Brown and Petersen (2009) find a strong link between R&D and *both* internal and external equity finance for young (but not mature) publicly traded U.S. firms.

[6] Other types of intangible investment have received even less attention. For recent evidence on financing constraints for advertising, see Fee, Hadlock and Pierce (2009).

[7] One interpretation of this result, based on our findings, is that cash flow matters for R&D, but firms are so successful at smoothing R&D that there is little within-firm association between the level of R&D and cash flow.

Hall and Lerner (2010) provide a comprehensive summary of literature and conclude that it remains an open question whether financing constraints matter for R&D (see their discussion in section four). Such a conclusion is consistent with the mixed results in studies of U.S. firms and the findings of weak or no evidence of financing constraints for non-U.S (mainly European) firms. Furthermore, the relative lack of evidence on binding financing constraints in Europe is certainly a puzzle, as the U.S. is generally considered to have stronger financial markets than most economies in Europe. We now discuss possible explanations for why the evidence on financing constraints and R&D is so mixed.

B. Stock Issues as a Source of Finance

It is well known that R&D-intensive firms make relatively little use of debt finance (e.g., Hall (2002); Hall and Lerner (2010)). The likely reason is that equity has several advantages over debt for financing R&D, including: i) shareholders share in upside returns, ii) there are no collateral requirements, and iii) additional equity does not magnify problems associated with financial distress, which can be particularly costly for R&D. These advantages of equity finance, combined with limited (and frequently negative) levels of internal cash flow, suggests that external stock issues may play an important role in the financing of R&D.[8] Kim and Weisbach (2008) provide evidence suggesting that it is very important to consider stock issues in any study that explores financing constraints for R&D: in a study of 38 countries, they show that in the four years following either an IPO or an SEO, the cumulative increase in R&D spending is roughly four fold greater than the increase in fixed investment.

Public equity is, of course, not a perfect substitute for internal finance because of flotation costs and the "lemons premium" due to asymmetric information (Myers and Majluf (1984)). These frictions create a wedge between the cost of internal and external equity finance. In addition, there is evidence that the size of the wedge increases with the size of the issue, implying a rising supply curve for external

[8] This should be particularly true in countries where stock markets are sufficiently developed to give entrepreneurial firms access to public equity markets at an age when internal finance is limited relative to investment demand. We note that public equity is a compliment to venture capital (private equity) when it comes to financing R&D and innovation in young firms. The key role that venture capital plays in financing innovative activity has received a great deal of attention, but venture capital alone is almost certainly inadequate, given the short duration of VC financing and the comparatively small size of VC investment per firm (e.g., Gompers and Lerner (2006)).

finance.[9] Nevertheless, because of the very low debt levels for R&D-intensive firms and the many advantages of equity finance over debt, stock issues are plausibly a key marginal source of R&D finance, particularly for young firms.

It is the case, however, that virtually all studies of R&D and financing constraints ignore stock issues. This omission can potentially lead to the incorrect conclusion that financing frictions are unimportant for R&D for two reasons. First, studies that ignore stock issues will miss the fact that investment in R&D may be limited by access to external equity finance. Second, firms rely heavily on stock issues in the years that follow their IPO (e.g., Rajan and Zingales, 1998) and this is often a time when: i) cash flows are often low or negative, and ii) R&D intensity is high. As a consequence, failure to control for stock issues can lead to downward-biased estimates of the R&D-cash flow sensitivity.

Of importance to our study, the availability of external equity varies a great deal over time. One reason for rapid change in availability is improvement in stock markets, which has occurred in many European countries in the last few decades. For example, the average stock market value traded as a share of GDP for the countries in our sample increased from 0.42 in 1995 to 1.62 in 2007.[10] Another reason for dramatic short-run variation in availability of external equity finance is booms and busts in stock market conditions, likely due in part to mispricing, which can lead to large changes in the cost and use of public equity finance.[11] Indeed, in our sample period there is substantial variation in young-firm

[9] Financial theories predict a rising marginal cost of external equity because of adverse selection (e.g., Myers and Majluf (1984)) and evidence from Asquith and Mullins (1986) and Cornett and Tehranian (1994) is consistent with such a prediction.

[10] Data from the World Bank's Financial Development and Structure Database (Beck, Demirguc-Kunt and Levine (2000), Beck and Demirguc-Kunt (2009)).

[11] Morck, Shleifer, and Vishney (1990, p. 160) note that overpriced equity lowers the cost of capital and may allow financially constrained firms the opportunity to issue shares and increase investment. See Chen, Hong and Stein (2002), Wurgler and Zhuravskaya (2002), Kumar and Lee (2006), and Sadka and Scherbina (2007) for explanations of persistent mispricing on stock markets. Baker and Wurgler (2000) find that firms are more likely to issue equity when stock prices are high, and Loughran and Ritter (1995, p. 46) state that their "evidence is consistent with a market where firms take advantage of transitory windows of opportunity by issuing equity, when, on average, they are substantially overvalued."

use of external equity, particularly during the late 1990s and early 2000s, a period when stock prices exploded, and then collapsed, particularly for R&D-intensive firms.[12]

C. R&D Smoothing

It has long been appreciated that R&D has high adjustment costs, likely much higher than those for physical investment (e.g., see the discussion in Hall (2002)). Most R&D investment consists of wage payments to highly trained scientists, engineers, and other skilled technology workers who often require a great deal of firm-specific training. Thus, cutting R&D typically entails firing workers. If the cut in R&D is temporary – as in a response to a transitory shock to finance – then new workers need to be hired in future periods, creating additional hiring and training costs. In addition, fired R&D workers know critical proprietary information that firms do not wish to share with competitors, and the dissemination of such information could undermine the value of innovation being undertaken by the firm. Finally, labor regulations like those present in many European economies can also limit the adjustment of workers to temporary shocks.[13]

High adjustment costs suggest that firms will actively seek to maintain a relatively smooth flow of R&D spending. For firms not facing financing frictions, smoothing R&D should be straightforward, as there are multiple forms of finance that can be used to offset shocks to internal finance. However, for R&D-intensive firms facing substantial financing frictions, external finance may be extremely costly or unavailable during periods of negative shocks to internal finance. For these firms, the obvious R&D smoothing strategy is to not rely on external markets but to build and manage stocks of *internal* liquidity, which appear on the balance sheet of the firm as "cash and equivalents." (A potential alternative is to

[12] In Sweden, for example, the young-firm average stock-to-assets ratio increased by over 200% between 1999 and 2000, and then declined by 85% between 2000 and 2001. Similarly, between 1999 and 2000, young-firm stock issues increased by 42% in the U.K. and 93% in France, and then fell by 59% and 46%, respectively, the following year. In Germany, young-firm stock issues rose almost 300% between 1998 to 2000, only to fall by over 75% by 2001.The leading indexes of the UK, Germany and France experienced large swings in stock prices in the late 1990s and early 2000s. The FTSE100, DAX-index and CAC40 set all-time highs in late 1999/early 2000 and then fell 50-70% to the low in 2003.

[13] Messina and Vallanti (2007) show that firing workers in Europe is comparatively unresponsive to economic fluctuations since firms try to smooth labor reallocation over the business cycle due to regulations making such reallocation costly and time consuming.

build debt capacity for smoothing (Acharya, Almeida and Campello (2007)), but, as argued above, the equity-dependent nature of R&D makes smoothing with debt problematic.) The stock of liquidity has expanded dramatically in the last few decades and is a quantitatively large component of the balance sheets of publicly traded firms in Europe (see Table 1), giving them substantial capacity to buffer R&D from negative finance shocks.

As Hall and Lerner (2010) emphasize, active R&D smoothing complicates testing for the impact that financing constraints have on R&D. If firms aggressively smooth R&D with cash holdings, then failing to control for smoothing should lead to a substantial downward bias in the estimated link between R&D and other financial variables: the impact of short-run shocks (both positive and negative) to internal and external finance are partially offset by changes in cash holdings, dampening the short-run R&D response. This smoothing behavior can potentially explain why some studies find much stronger evidence of binding financing constraints on capital spending than on R&D (e.g, Rauh (2006)). We control for this liquidity management by including the *change* in cash holdings (or ΔCashHoldings) in our regressions. Brown and Petersen (2010) use a similar approach to show that young U.S. firms use cash reserves to smooth R&D during the volatile 1998-2002 period. We note, however, that their paper is confined to exploring how firms manage to smooth R&D; they do not discuss or explore the connections between R&D smoothing and financing constraints, or how cash holdings can be used to provide additional tests of financing constraints. We are aware of no other studies of R&D financing constraints that directly account for firm smoothing efforts.

D. Testing for Financing Constraints on R&D

The standard approach for testing for financing constraints has been to examine the cash flow sensitivity of investment (e.g., Fazzari, Hubbard and Petersen (1988)). A potential weakness of this approach is that the controls for investment demand are likely imperfect; as a consequence, because changes in financial variables correlate positively with changes in profits, cash flow may simply be capturing new information about the profitability of investment. Some recent studies (e.g., Kaplan and

Zingales (1997); Moyen (2004)) raise other questions about the use of conventional investment-cash flow regressions to draw inference about the importance of financing constraints, particularly in studies that do not address the endogeneity of cash flow or fail to control for the potential use of external finance.[14]

We emphasize that our approach for evaluating the importance of financing constraints on R&D is not subject to these critiques. We examine several predictions that provide new and more conclusive evidence on the importance of financing constraints for R&D. First, while firms that face binding financing constraints should exhibit a positive R&D-cash flow sensitivity, this link may not be apparent until we control for R&D smoothing and the use of external equity finance. (Indeed, when we follow the conventional approach, we do not find a positive cash-flow sensitivity, suggesting that imperfect controls for investment demand are not driving our results.) Second, funds from stock issues should have a positive impact on R&D investment in constrained firms, and controlling for stock issues should increase the estimated link between cash flow and R&D. Third, changes in cash holdings should have a *negative* association with R&D, as reductions in cash holdings free liquidity for R&D smoothing. Fourth, controlling for ΔCashHoldings in the regression should *raise* the coefficients on the other financial variables: if firms actively manage their cash reserves to buffer R&D from transitory finance shocks, controlling for the smoothing role of cash should *increase* the estimated impact that financial factors have on R&D, revealing the longer-run impact that access to finance has on R&D. Finally, for firms *not* facing financing frictions, the availability of cash flow and stock issues should have little impact on R&D, and there is no smoothing role for cash holdings.

[14] Kaplan and Zingales (1997) argue that it is theoretically possible for more constrained firms (i.e., firms facing a steeper external finance schedule) to display a lower investment-cash flow sensitivity than relatively less constrained firms. Bond, et al. (2003, p. 154) note that it "remains the case in [the Kaplan-Zingales] model that a firm facing no financial constraint … would display no excess sensitivity to cash flow," in which case the Kaplan-Zingales criticism does not apply. Moyen (2004) calibrates a model where firms use debt as a substitute for internal finance and uses an OLS regression on simulated data to show that positive cash flow sensitivities can be generated even if firms do not face financing frictions. The unconstrained firms in Moyen's (2004) study display cash flow sensitivities because current period debt finance is correlated with contemporaneous cash flow and debt finance is not included in the regression. We directly control for the use of external finance in the R&D regressions, and we instrument cash flow to eliminate the contemporaneous correlation between external finance and the cash flow regression variable.

Taken together, this broad set of predictions – particularly predictions three and four – provides a stronger test for the presence of R&D financing constraints. Consider, for example, the smoothing predictions for ΔCashHoldings. We emphasize that ΔCashHoldings is *positively* correlated with R&D and the financial variables, and thus should be positively correlated with investment opportunities.[15] By extension, problems measuring investment demand should also bias *upwards* the estimated coefficients on ΔCashHoldings (i.e., lead to positive coefficients). A negative coefficient on ΔCashHoldings should thus not arise simply because of inadequate demand control.[16] Equally important is the prediction that controlling for ΔCashHoldings should raise the coefficient estimates on other financial variables in the R&D regression. It is much more difficult to provide an alternative explanation (other than financing constraints) that can readily rationalize *both* a negative coefficient on ΔCashHoldings and an increase in the coefficient estimates on other financial variables when ΔCashHoldings is included in the R&D regression.

III. Estimation and Empirical Approach

We follow Brown, Fazzari and Petersen (2009) and explore the importance of financial factors for R&D by modifying an investment model that Bond and Meghir (1994) develop to study fixed investment. The Bond and Meghir (1994) approach (also used in Bond et al. (2003)) is based on the dynamic optimization "Euler condition" for imperfectly competitive firms that accumulate productive assets with a quadratic adjustment cost technology. As Bond et al. (2003, p. 153) discuss, a significant advantage of this approach is that "under the maintained structure, the model captures the influence of current expectations of future profitability on current investment decisions; and it can therefore be argued that current or lagged financial variables should not enter this specification merely as proxies for expected future profitability." Bond, Harhoff and Van Reenen (2003) note that another advantage is that the resulting empirical specification corresponds to an intuitive, dynamic R&D regression, and thus the

[15] Across all firm-years of data for the young firms in our sample, the Pearson correlation coefficient with ΔCashHoldings is 0.342 for R&D, 0.117 for capital spending and 0.058 for cash flow.
[16] Fazzari and Petersen (1993) make a similar argument in the context of smoothing fixed investment with working capital.

parameter estimates have a readily understandable interpretation even if some of the assumptions required of the underlying structural model do not strictly hold in the data.

We augment the baseline Euler specification derived under the assumption of no financing frictions with variables that measure the firm's access to both internal and external equity finance.[17] In addition, we add the *change* in cash holdings to the specification to control for the use of cash for R&D smoothing, an issue not considered in Brown, Fazzari and Petersen (2009). The resulting empirical specification is:

$$\begin{aligned} RD_{j,t} &= \beta_1 RD_{j,t-1} + \beta_2 RD^2_{j,t-1} + \beta_3 Sales_{j,t} + \beta_4 Sales_{j,t-1} + \beta_5 CashFlow_{j,t} \\ &+ \beta_6 CashFlow_{j,t-1} + \beta_7 StkIssues_{j,t} + \beta_8 StkIssues_{j,t-1} + \beta_9 \Delta CashHoldings_{j,t} \\ &+ \beta_{10} \Delta CashHoldings_{j,t-1} + d_t + \alpha_j + \nu_{j,t}. \end{aligned} \qquad (1)$$

$RD_{j,t}$ is R&D spending for firm j in period t. The expected coefficient (in the Euler condition) on lagged R&D is positive and the expected coefficient on the quadratic term is negative; the model predicts that both coefficients will slightly exceed one in absolute value. Lagged sales is in the Euler condition and has a positive coefficient under imperfect competition; we also include contemporaneous sales as an additional control for investment demand. The financial variables include contemporaneous and lagged cash flow (*CashFlow*), stock issues (*StkIssues*), and changes in cash holdings (*ΔCashHoldings*). We discuss alternative specifications, including specifications that include new debt issues, in Section VI. All regression variables are scaled by the beginning-of-period stock of firm assets.

The model includes a firm-specific effect (α_j) to control for all unobserved time-invariant determinants of R&D at the firm level, such as the technology of the firm, industry characteristics, and country-specific regulatory or institutional characteristics that are constant over the sample period. The model also includes a time-specific effect (d_t) to control for aggregate changes that could affect the demand for R&D, such as the state of the macro economy.

We estimate equation (1) for separate groups of firms based on the *a priori* likelihood they face binding financing constraints. As previously discussed, we expect a positive link between the equity

[17] A detailed derivation of the baseline estimating equation for R&D from the Euler equation is available on request.

finance variables (cash flow and stock issues) and R&D, and a negative link between changes in cash holdings and R&D, in the groups of firms most likely to be financially constrained. We also expect the predicted signs and magnitude of the lagged R&D terms from the structural model derived under the assumption of no financing constraints to hold best in the groups of firms least likely to face binding constraints. We follow the literature and use several different criteria to classify firms, including age, size, the presence of dividends and the size of the payout ratio. We make particular use of firm age, which is used to sort firms in a number of recent studies (e.g., Fee, Hadlock and Pierce (2009); and Brown, Fazzari and Petersen (2009)). Firm age is likely strongly correlated with asymmetric information problems and has the advantage of being potentially less endogenous than other splitting criteria. As we show, however, our main findings are broadly similar across the various sample splits.

We estimate equation (1) with the "system" GMM estimator developed for dynamic panel models by Arellano and Bover (1995) and Blundell and Bond (1998). This approach allows us to address the potential endogeneity of all financial variables, including stock issues and ΔCashHoldings, by jointly estimating a regression of equation (1) in differences and in levels, using lagged levels as instruments for the regression in differences and lagged differences as instruments for the regression in levels. By including the regression in *levels*, the systems estimator addresses the weak instrument problem that arises from using lagged levels of persistent explanatory variables as instruments for the regression in differences (Blundell and Bond (1998)), but it requires that an additional moment restriction hold in the data: *differences* in the right-hand side variables in equation (1) cannot be correlated with the firm-specific effect.

Our primary results use one-step GMM and rely on lagged levels dated *t*-3 and *t*-4 as instruments for the regression in differences and lagged differences dated *t*-2 for the regression in levels. The standard errors are robust to heteroskedasticity and within-firm serial correlation. As we discuss in Section VI, the estimates are similar if we use two-step GMM or employ alternative instrument sets, including starting the instruments with lagged levels dated *t*-2 and extending them to *t*-5. While lagged levels dated *t*-2 are potentially valid instruments if the error term in equation (1) is i.i.d. (Arellano and

Bond (1991)), including the *t*-2 instruments caused instrument validity problems in some of the regressions. We thus take a more conservative approach for the primary regressions and start the instrument set with lagged levels dated *t*-3, which are valid even if the error term is MA(1). To assess instrument validity we report a Hansen *J*-test of the null that the over-identifying restrictions are valid, a difference-in-Hansen test that evaluates the validity of the additional instruments required for systems estimation (i.e., the validity of the instruments used in the levels equation), and an *m2* test for second-order autocorrelation in the first-differenced residuals. These tests generally indicate no major problems with our primary instrument set, particularly in the most important specifications.

IV. Sample and Summary Statistics

A. Sample

We build the regression sample from all European firms with coverage in the Compustat Global database over the period 1995-2007. All major economies in Europe are in the sample and a list of the 16 countries (and number of firms) appears in Table 1A in the Appendix. We exclude firms outside of manufacturing (SIC 2000-3999) because most R&D takes place in manufacturing and much of the literature on the link between finance and investment focuses on this sector. We necessarily focus only on firms that report positive R&D spending, and we exclude any firm that does not have at least one string of three consecutive R&D-to-assets observations during the sample period (firms without three consecutive R&D observations would contribute no observations to the regressions). Prior to estimating the regressions we trim the 1% tails of all regression variables (the results are similar if we Winsorize instead of trim).

B. Summary Statistics

Table 1 reports summary statistics for the sample used in the regressions. We first report statistics for “all of Europe” and we then provide separate statistics for the U.K., Sweden, Germany, France and “all other Europe”, which includes the remaining 12 countries. There are two main reasons for reporting separate results for the U.K., Sweden, Germany, and France. First, these countries have the largest number of firms in the sample, with the U.K. accounting for 25.7% of the sample, followed by Germany (15.5%), France (9.6%) and Sweden (9.4%). Second, the U.K. and Sweden are leading examples of "market based" economies with strong public equity markets, while Germany and France are "bank based" economies. Focusing on these countries thus allows us to compare how financial factors impact R&D across countries with different financial systems. For each group we sort firms into "young" and "mature" based on the year the firm first appears in Compustat Global with non-missing sales. Firms who first appear after 1995 are typically recently listed firms and we classify them as "young."[18] With the exception of number of employees, all variables are scaled by beginning of year total assets.

The first column of Table 1 reports information for the full sample of 16 countries. Four numbers are particularly important. First, the R&D ratio is substantial: the mean is 0.085, which is larger than the mean physical investment ratio (0.058). (While not reported, there are other investments, such as inventories and accounts receivable, which, along with physical investment, are collectively larger than R&D). Second, the mean stock issue-to-assets ratio (0.108) is only slightly smaller than the mean cash flow ratio (0.125), showing the importance of stock issues as a source of funds. (The median value of stock issues is zero, as expected, as Table 1 reports values for pooled firm-year observations and stock issues tend to be substantial in some years and zero in others, consistent with wide swings in stock market conditions). Third, the mean of new long-term debt issues (0.015) is quite small, which is the primary reason we ignore debt in the primary regression specification. (We include debt in the regressions in Table 5 and find no effect). Fourth, the average cash holdings ratio (0.223) is well above the mean of either cash flow or stock issues, showing that firms have substantial stocks of liquidity that can potentially be used to buffer R&D from transitory shocks to finance.

Columns two and three report information for the full sample split into "young" and "mature" firms. As expected, older firms are much larger than young firms: median employment is 4,845 workers for mature firms and 479 workers for young firms. (A similar pattern exists for average workers). There

[18] In order to evaluate appropriateness of this sample split we have checked the actual year of the IPO for the Swedish sample. The average and median year of the IPO in the "young" sample is 1999 while in the "old" sample the average year of IPO is 1966.

are three other important differences between young and mature firms. First, younger firms are more R&D-intensive than older firms, which is expected for a number of reasons, including relatively greater growth opportunities for young firms. Second, stock issues are far more important for young firms: the mean of the stock issue ratio is 0.181 for young firms but only 0.025 for mature firms. The lack of stock issues for mature firms is consistent with previous findings in the literature that stock issues are used primarily in the early stage of the firm's life cycle. It is also consistent with the fact that most mature firms have large cash flows (mean of 0.143) relative to investment expenditures, suggesting that costly external equity finance is typically not required to meet investment demands. Third, unlike stock issues, debt issues are trivial for young firms. Fourth, young firms have average cash holdings ratios that are over twice as large as the cash holdings for mature firms (0.296 compared to 0.139), consistent with the fact that buffer stocks of liquidity are more important for firms likely to face financing constraints.

The remaining columns in Table 1 report separate statistics for the U.K, Sweden, Germany, France and all other Europe. The differences between younger and older firms noted above for the pooled European data are also readily apparent at the more disaggregated level. Younger firms have far fewer employees and issue far more stock (relative to size) than older firms, with the difference in the average stock ratios between younger and older firms ranging from six- to twelve-fold depending on the country. Finally, average cash holdings (per dollar of assets) are more than twice as large for young firms in all the countries.

There are some noteworthy similarities and differences across countries. First, young German and French firms are much larger than young U.K. and Swedish firms, a point we will return to when we interpret the somewhat weaker link between financial factors and R&D for German and French firms. Second, young U.K. firms are considerably more R&D intensive, rely more on stock issues, and have higher cash holdings ratios than their counterparts in Germany, France and the rest of Europe. Swedish firms fall somewhere between the U.K, Germany, France and the rest of Europe. The greater reliance on stock issues for U.K. and Swedish firms is consistent with both countries having a more "market based" financial system. It is important to point out, however, that stock issues are also quantitatively important for some young firms in Germany, France and the rest of Europe, as indicated by the substantial average stock ratios.

V. Results

A. Impact of Adding Stock Issues and Controlling for Smoothing

Table 2 reports regression results for six samples: i) all Europe, ii) U.K., iii) Sweden, iv) Germany, v) France and vi) all other Europe. For each sample, we report three regressions. We begin with a dynamic R&D regression model containing only cash flow, the standard financial variable examined in the literature. We then add stock issues to the specification and, finally, we include ΔCashHoldings. Before discussing the main findings, we note that in all regressions, the coefficient for lagged R&D is close to one (reflecting the persistence in R&D) and the coefficient on lagged R&D-squared is negative and statistically significant, but somewhat smaller in absolute value than predicted by the Euler condition (under the assumption of quadratic adjustment costs).

For the "all Europe" sample, the sum of the cash flow coefficients in the initial specification (column (1)) is near zero (-.007). Adding stock issues in the second regression results in a substantial rise in the sum of the estimated cash flow coefficients (to 0.099), but a chi-squared test continues to reject the null that the sum is statistically different from zero (p-value of 0.113). The estimated coefficients for stock issues have opposite signs and are roughly offsetting (the sum is 0.007). Of particular importance, adding ΔCashHoldings in the third regression results in a very sharp rise in the coefficients on both cash flow and stock issues: the sum of the cash flow coefficients increases to 0.220 and the sum of the stock coefficients increases to 0.171. Furthermore, both sums are now highly statistically significant (p-values of .002 or smaller). In addition, the sum of the current and lagged coefficients on ΔCashHoldings is negative, large in absolute value (-0.176) and highly significant. The point estimates on ΔCashHoldings and the impact that including this variable has on the other financial coefficients indicate that firms rely heavily on cash holdings to smooth R&D. Overall, the results are consistent with the discussion in

Section II concerning omitted variable biases from excluding stock issues and not controlling for R&D smoothing.

Columns (4)-(6) report the results for the U.K. The sum of the cash flow coefficients is negative in the initial specification (-0.050) and rises sharply with the addition of stock issues (to 0.043), but remains statistically insignificant. In column six, controlling for changes in cash holdings causes the estimated coefficients on both cash flow and stock issues to rise sharply (the sum of the cash flow coefficients is now 0.268 (p-value=0.002) and the sum of the stock coefficients is now 0.137 (p-value=0.010)), and the sum of the coefficients on ΔCashHoldings is negative, large in absolute value (-0.158) and highly significant. For Sweden (columns (7)-(9)), the pattern of results is broadly similar to the pattern for the U.K. That is, the financial coefficients are all small in regressions that exclude ΔCashHoldings (columns (7) and (8)), but increase sharply and are statistically and economically significant once ΔCashHoldings is included in the regression. Likewise, the sum of the coefficients on ΔCashHoldings is negative, quantitatively important (-0.232) and highly significant.

The pattern for Germany and France is generally similar to that of the U.K. and Sweden, except for the coefficients on cash flow in the final regression. For both Germany and France there is little or no evidence of financing constraints in the regressions that exclude ΔCashHoldings (columns (10) and (11) and columns (13) and (14)). When ΔCashHoldings is included in the regression (columns (12) and (15)) there is a large jump in the estimated coefficients on stock issues in both countries, and there is also a large jump in the sum of the cash flow coefficients for France (from -0.043 to 0.059). In addition, in both France and Germany the sum of the coefficients on ΔCashHoldings is negative and substantial (in absolute value), although not significant at conventional levels for France. For both Germany and France, however, the sum of the cash flow coefficients are positive but the values are modest (and statistically insignificant) in the final regressions.

In the rest of Europe (remaining 12 countries) there is evidence of a cash flow effect even without controlling for smoothing. When ΔCashHoldings in included in the final regression, there is a modest jump in the sum of cash flow coefficients and a doubling of the sum of coefficients for stock issues. In this final regression, the sum of the cash flow coefficients is 0.148, the sum of the stock coefficients is 0.155, and sum of the ΔCashHoldings coefficients is -0.111 and all sums are statistically significant with exception of ΔCashHoldings.

The six sets of regressions show a consistent pattern. For all Europe and the individual countries, we find evidence of a strong link between financial factors and R&D, but only when we directly control for endogenous R&D smoothing by including ΔCashHoldings in the regression. In general, the estimated impact that cash flow and stock issues have on R&D increases sharply after we control for changes in cash holdings. In all sets of regressions the coefficients on ΔCashHoldings are negative and substantial (in absolute value), further indicating that firms use buffer stocks of liquidity to smooth R&D.

B. Plausibly Constrained and Unconstrained: All Europe

In Table 3, we examine the results for all of Europe using four commonly used splits to reflect the *a priori* likelihood that firms face binding financing constraints. One split is firm age (as proxied by when a firm is first listed in Compustat Global). Young firms likely face greater asymmetric information problems and they rely heavily on external equity finance (see Table 1), suggesting that they are operating along a rising portion of the supply of finance schedule (if capital markets are imperfect). Size of firms is another commonly used split and small firms in our sample often rely heavily on external equity finance (but large firms typically do not). We consider firms to be "large" if their average level of employment over the sample period is above the 70^{th} percentile, and "small" otherwise. We also consider two splits based on dividend payouts. The sharpest split is for firms that pay precisely zero dividends. As argued in FHP (1988), firms exhausting internal finance (as proxied by the lack of dividends) are more likely to face binding financing constraints. The second payout split is based on the distribution of the net payout ratio, where net payout is equal to dividends plus stock buybacks minus stock issues. We put firms in the high payout group if their average net payout to assets ratio over the sample period is above the 70^{th} percentile; otherwise they are put in the low payout group. For ease of discussion, we refer to the new, small, no dividend and low payout groups of firms as "plausibly constrained," and the old, large, positive dividend and high payout groups as "plausibly unconstrained".

To economize on space (and to make comparisons less tedious), we report the sums of the financial coefficients in Table 3. The results are easy to summarize. For the *plausibly constrained* groups, the coefficients on lagged R&D and lagged R&D-squared are smaller (in absolute value) than predicted by the Euler condition, as expected given the condition is derived under the null of no financing constraints. More importantly, the sums of the coefficients on the financial factors are always large (in absolute value) and statistically significant. For example for the *plausibly constrained* group, the sum of cash flow coefficients ranges from 0.218 for low payout firms to 0.318 for zero dividend firms. The sums of the financial coefficients in Table 3 are generally larger than the sums of the coefficients for the all Europe sample in Table 2, which is expected, given that the results in Table 2 are pooled across constrained and unconstrained firms.

For the *plausibly unconstrained* groups, the coefficients on lagged R&D and lagged R&D-squared are consistent with the predictions from the structural model derived under the assumption of no financing constraints (see the discussion of equation 1) for all splits except positive dividend firms. In addition, sums of the coefficients for the financial factors are quantitatively small and generally statistically insignificant, and are always far smaller than the sums of the coefficients for the *plausibly constrained* groups. In particular, for both large and high payout firms, none of the financial factors are statistically significant; for the positive dividend firms the only significant financial factor (at the 10% level) is ΔCashHoldings. Further, among the *plausibly unconstrained* firms the largest significant sum of cash flow coefficients is only 0.061 (for mature firms). These small and insignificant coefficients are important, as Bond et al. (2003) argue that heterogeneity tests are most convincing when the plausibly unconstrained group displays no evidence of financing constraints.

We also repeat (but do not report) the exercise in Table 2, where the regressions progress from one financial factor (cash flow) to all three financial factors. For the *plausibly constrained* group, we get exactly the same pattern of results as reported in Table 2: adding stock issues impacts the cash flow coefficients, but the largest impact arises from adding ΔCashHoldings to the regressions. For the *plausibly unconstrained* groups, adding stock issues makes relatively little difference (consistent with the small stock issue figures in the summary statistics for mature firms) and the impact of adding ΔCashHoldings is quantitatively small. Thus, the findings in Table 3 support the basic findings in Table 2: adding stock issues and controlling for smoothing is important for assessing the presence of financing constraints for R&D.

C. Sample Splits for Individual Countries

We extend the exercise in Table 3 to individual countries. To save space, we report the results for two different splits: age (reported in Panel A) and payout level (reported in Panel B). The results are similar for size and presence of a dividend. Once again, we sum the financial coefficients and we report the corresponding chi-squared tests below the sum. We also leave out lagged R&D and sales to conserve space. Test statistics are reported at the bottom of each panel.[19]

Panel A shows strong financial effects for young firms in the U.K., Sweden, Germany and all other Europe. For each grouping, the financial coefficients are generally quantitatively large (in absolute value) and statistically significant. The sum of the cash flow coefficients is particularly large in the U.K. (0.345). Evidence of a link between financial factors and R&D for young-firms is weakest in France, where the sum of the cash flow coefficients is statistically significant but relatively small (0.058) and there is little evidence of a stock issue-R&D link. For old firms, the coefficients on all of the financial variables are quantitatively small and generally insignificant everywhere except Germany. In Germany, old firms have significant sums for all financial variables, although the coefficients are smaller than those for young firms.

Panel B indicates strong financial effects on R&D for the low payout firms in the U.K., Sweden, "all other Europe" and Germany (with the exception of the relatively small and insignificant cash flow

[19] In several of the country level splits we have a small number of firms relative to the number of instruments generated by our estimation approach. The instrument validity tests are less reliable in this setting, as evidenced by the implausibly high *p*-values generated by the *J*-test. See Bowsher (2002).

sum for Germany). In France, financial factors are stronger in the low payout firms than in both high payout firms and the young firms in Panel A, but only the coefficients on stock issues are statistically significant at conventional levels. High payout firms in the U.K., Sweden, France and "all other Europe" have quantitatively small, and generally insignificant, coefficients on the three financial variables. Germany remains the exception, where the stock issue and ΔCashHoldings coefficients are sizable and statistically significant.

Thus, for the U.K., Sweden and "all other Europe", the findings in Table 4 line up very closely with the findings in Table 3 (all Europe). That is, there are quantitatively large and typically significant sums of coefficients on all financial variables in the *plausibly constrained* groupings, and small and generally insignificant coefficients for the *plausibly unconstrained* groupings. This is reassuring, as the U.K., Sweden and "all other Europe" constitute approximately 75% of the total sample. In France the evidence is mixed and depends on how the *plausibly constrained* groupings are constructed. For Germany, there is strong evidence of a stock effect and R&D smoothing, and more limited evidence of a cash flow effect, but differences between the *plausibly constrained* and *plausibly unconstrained* groupings are often not that large (although the differences in the coefficients across the sample splits do generally go in the expected direction).

VI. Robustness

The findings we present above are robust to a number of alternative specifications and estimation approaches. We present two of the most important checks in Table 5. First, in columns (1)-(4), we adjust the instrument set to include lagged levels dated *t*-2 to *t*-4 and lagged differences dated *t*-1. For the plausibly constrained firms, we continue to find a strong positive link between the equity finance variables and R&D, and a strong negative link between ΔCashHoldings and R&D, though the difference-in-Hansen test indicates potential problems with instrument validity in the young-firm regression. For mature and high payout firms, the estimates on the lagged R&D terms are consistent with the predictions of the structural model and the financial effects are small and generally insignificant. In particular, the coefficients on ΔCashHoldings for mature firms remain negative with the alternative instrument set (as in Table 3) but are smaller in magnitude and no longer statistically significant.

Second, in columns (5)-(8), we include current and lagged values of new long-term debt issues in equation (1) and recover similar (or stronger) coefficient estimates on the key financial variables. In addition, unlike cash flow and stock issues, the estimated coefficient on new debt issues is negative but insignificant for constrained firms and approximately zero for unconstrained firms. These results are consistent with arguments that debt is poorly suited for funding R&D and further highlight the importance of stock market development and the availability of equity finance for funding innovative activity.

We explore a number of other robustness checks that are available on request. We find similar financial effects on R&D if we replace current and lagged sales in equation (1) with sales growth and the market-to-book ratio, two commonly used controls for investment demand. Our findings are also similar if we use alternative data transformations (forward orthogonal deviations instead of first differences) or rely on two-step GMM with Windmeijer (2005) corrected standard errors.

VII. Interpretation and Implications

A. Testing for Financing Constraints on R&D

Our paper provides new insights into testing for whether financing constraints matter for R&D. First, ignoring stock issues and R&D smoothing with cash holdings can result in sharp downward biases in the estimated link between R&D and cash flow, potentially leading to an incorrect assessment of the importance of financing constraints in studies that look only at the standard R&D-cash flow sensitivity. (We show, in fact, that firms we believe face substantial financing frictions can exhibit essentially no R&D-cash flow relation if we ignore stock issues and R&D smoothing.) Second, we provide new tests for the presence of financing constraints. We are aware of no alternatives to the financing constraint explanation that can rationalize our full set of findings: i) a strong positive link between R&D and both internal and external equity finance, ii) no significant link between R&D and debt, iii) a strong negative link between changes in cash holdings and R&D, iv) a sharp increase in the estimated link between R&D

and the equity finance variables when we control for R&D smoothing, and v) substantial estimates on the financial factors and evidence of active liquidity management to smooth R&D primarily for firms which are *a priori* most likely to face binding financing constraints.

B. Financing Constraints across Countries

Several studies rely on a comparison of investment-finance sensitivities across countries to draw inference about the relative importance of binding financing frictions (e.g., Bond et. al. (2003)). One possible interpretation of our findings is that R&D financing constraints are more severe in the market-based economies of the U.K. and Sweden than the bank-based systems in Germany and France. We think this need not be the case. Rather, we believe these findings reflect the fact that market-based financial systems tend to have better-developed stock markets, and better stock markets generate more young publicly traded firms at a stage in their life cycle when internal finance is low and costly external finance is used extensively to fund R&D investment. The summary statistics in Table 1 show that “young” U.K. and Swedish firms are much smaller and have lower cash flow ratios than “young” German or French firms, almost surely because “young” firms in the U.K and Sweden went public at an earlier stage of development.[20] The link between finance and investment may be strongest in countries with well developed stock markets precisely because strong stock markets support a larger number of firms that are highly dependent on external finance and thus have investment that is especially sensitive to internal and external finance shocks. Thus, our approach is useful for identifying the presence of financing constraints within a country (or group of countries), but it may not identify the *relative* importance of financing constraints across countries.

Hall and Lerner (2010, p. 23) note that an alternative explanation for stronger financial effects in market-based financial systems is that “firms are more sensitive to demand signals in thick financial equity markets.” For several reasons, we believe that a “financing constraint” explanation is more consistent with our set of findings than a “demand-side” explanation. First, when we follow the standard

[20] Vandemaele (2003) reports a median age of 28 years for French firms going public, while Ljungqvist (1997) reports a median age of 52 for German IPOs in the period 1970-1990, compared to 7 years for the U.S.

practice of regressing R&D and cash flow (with no other financial variables) we obtain quantitatively small and insignificant cash flow coefficients in countries with financially thick markets (including the U.K. and Sweden), which is inconsistent with a "demand-side" explanation. Second, when we include ΔCashHoldings to control for R&D smoothing, financial effects are present in the U.K. and Sweden only for the plausibly constrained firms (see Table 4). If demand signals drive R&D-finance sensitivities, then R&D and finance correlations should be present for *all firm types*, regardless of the likelihood they face binding financing constraints. Third, our new evidence on R&D smoothing with cash holdings is not consistent with a "demand signals" explanation. As we note above, ΔCashHoldings is positively correlated with the other financial variables, and hence with demand shocks, so if demand shocks cause positive coefficients on other financial variables, they should lead to a positive coefficient on ΔCashHoldings. Furthermore, suppose that firms did respond to positive demand signals by drawing down cash holdings (potentially causing a negative coefficient on ΔCashHoldings for reasons other than smoothing). If this were the case, then *excluding* ΔCashHoldings from the R&D regression would *increase* (rather than decrease) the coefficient estimates on the other financial variables: excluding a source of finance that allows firms to increase investment in response to positive demand signals will bias upwards the coefficient estimates on the other financial variables. We instead find exactly the opposite: excluding ΔCashHoldings *reduces* the estimated link between R&D and the other financial variables, indicating that firms manage cash reserves to keep R&D smooth relative to transitory finance shocks.

C. Access to Public Equity and R&D Intensity

R&D intensity has long been lower in the EU than in the U.S., and the main reason is lower business R&D intensity in the EU.[21] (We note, however, that Sweden's R&D intensity is well above that of the U.S.). The lower levels of R&D in Europe were a key subject of the Lisbon European Council (2000) and the Barcelona European Council (2002), which recommended an R&D goal for the EU of 3%

[21] For example, over the period 2000-2005, R&D spending by businesses averaged 1.2% of GDP in the EU-15 compared to 1.9% in the U.S. (Uppenberg (2009)). Furthermore, Uppenberg shows that the lower level of business R&D investment in Europe is due to lower R&D intensity at the sectoral level, and is *not* due to different sectoral specialization.

of GDP by 2010 (compared to 1.85% for the EU-27 in 2007). Our findings suggest that better access to finance should lead to higher levels of R&D; however, it is better access to equity finance that matters, not better access to debt. A straightforward way to raise *internal* equity finance (e.g., cash flow) is to lower corporate income taxes (and substantial efforts have been made in the EU in this regard in recent years). There are also policies that can increase access to *external* equity finance. Straightforward policy initiatives include efforts to improve accounting standards and craft regulations that permit firms to list on equity markets at an earlier age (perhaps even before they are profitable). For example, beginning in the 1980s, Sweden removed many restrictions in their financial markets, which led to a 20-fold increase in the transaction volume on their stock exchange between 1980-1990 (Englund (1990)).[22] Other policy initiatives involve strengthening investor protection, which appears to be strongly associated with improved access to equity finance (e.g., La Porta et al. (1997, Tables IV and VI)).

There are currently large differences in stock market development *within* Europe, suggesting considerable scope for improving access to public equity in Europe. To illustrate, consider some facts highlighting the differences between the market-based economies of the U.K and Sweden and the bank-based economies of France and Germany. First, based on the number of IPOs reported in Loughran, Ritter and Rydqvist (1994, updated in 2009), the U.K. and Sweden had three to four times as many IPOs as Germany and France in recent decades, after adjusting for the size of the economy.[23] Second, the total number of publicly listed firms is three to four times larger in the U.K. and Sweden compared to Germany and France (after adjusting for size of the economy). Third, the ratio of stock market value traded to GDP is much greater in the U.K. and Sweden (3.79 and 2.18) than in Germany and France (1.02 and 1.33).[24] Fourth, based on the total proceeds from initial public offerings and seasoned equity offerings over 1990

[22] One change was allowing foreigners to purchase stock on Swedish exchanges. As in the U.S., Swedish banks are restricted from owning equity in non-financial firms (see ISA Report (2008, p. 52)), which has increased the transparency of publicly traded firms in Sweden and reduced the possibility of a given firm becoming dependent on a single bank for the provision of funds. Before this restriction, Sweden resembled Germany with corporate groups centering on a bank, and it was the bank that re-allocated resources among the different branches of the group. Sweden was also a pioneer in Europe in electronic stock market trading.

[23] This is consistent with the evidence in La Porta et al. (1997) that countries with a Scandinavian legal system have far more IPOs (per capita) than countries with a French or German legal system.

[24] Statistics on the number of listed firms (per 10 thousand population) and stock market value traded to GDP comes from Beck, Demigruc-Kunt and Levine (2000) and Beck and Demigruc-Kunt (2009).

to 2003 reported in Kim and Weisbach (2008), the level of public equity raised (adjusted for size of the economy) is more than twice as high in the U.K. and Sweden than in Germany and France.[25]

Our summary statistics are consistent with the differences noted above for these four countries: young U.K. and Swedish firms have considerably higher average stock issues than young German and French firms. Furthermore, as expected, young firms in the U.K. and Sweden also have substantially higher R&D intensities.[26]

VIII. Conclusions

Determining whether financing constraints matter for R&D is important for identifying the causal connections between finance and economic growth and for understanding key issues in corporate finance, including how financing frictions influence real activity and why firms build large stocks of liquidity. While there are strong theoretical reasons to suspect that financing constraints should matter for R&D, a number of prior studies find weak evidence (at most) that financing constraints have a quantitatively important impact on R&D. Utilizing a broad sample of European firms, we also find little or no evidence that finance matters for R&D if we look only at the R&D-cash flow sensitivity, consistent with the approach in most studies of finance and R&D. However, when we expand the analysis to include stock issues as a source of funds and changes in cash holdings to control for endogenous R&D smoothing, our findings show that access to equity finance matters a great deal for R&D, particularly in firms most likely to face binding financing constraints. The main reason for this reversal of results is resolving an

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[25] In addition, a recent study by Groh et al. (2009) shows that the U.K. and Sweden have by far the most developed venture capital markets in Europe, while Germany and France have comparatively little VC finance. This provides useful evidence on the nature of stock market development across the countries, since it is important for a country to have a deep and liquid stock market in order to give private equity investors attractive exit possibilities (Groh et al. (2009)). In addition, the presence of a vibrant VC market appears to be very important for speeding up the process of getting young firms to a stage where they can go public (e.g., Gompers and Lerner (2006)).

[26] Sweden has the highest R&D intensity in the EU, with business R&D spending over 3.0%, 2.5 times the EU-15 average. Germany and France are well below Sweden, and the UK is below all three countries. The lower *aggregate* number in the UK is due composition: manufacturing is the sector responsible for most of R&D spending but UK manufacturing is below the EU average and well below countries like Germany. For example, in 2005, manufacturing accounted for only 13.6 percent of GDP in the UK compared with 23.2 percent in Germany. Within individual sectors, however, the UK's R&D intensity compares favorably with France and Germany (see Uppenberg, 2009).

important left out variable problem: firms facing financing frictions have strong incentives to build and utilize stocks of liquidity to keep the flow of R&D spending relatively smooth in the face of transitory finance shocks. Focusing on R&D smoothing with stocks of liquidity also allows us to introduce new tests for the presence of financing constraints that avoid the problems associated with previous efforts to identify financing constraints.

Our results indicate that better access to equity finance can substantially increase R&D investment, which has long been a key public policy goal in the EU and several other countries. In particular, we show that stock markets are much more than a "sideshow" when it comes to financing R&D, which helps explain the very high R&D-intensities of young publicly traded firms in countries such as the U.K. and Sweden. More generally, our study provides new micro-level evidence that is useful for understanding the positive link between economic growth and broad measures of stock market development and liberalization documented in studies like Levine and Zervos (1998), Beck and Levine (2002) and Bekaert, Harvey and Lundblad (2005): public stock markets can foster economic growth by directly funding the innovative activity of young, entrepreneurial firms.

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Table 1a: Sample Statistics

The sample is constructed from European manufacturing firms (SIC codes 20-39) with coverage in the Compustat Global database during 1995-2007. The sample consists only of R&D reporting firms that have at least one string of three consecutive R&D observations. All variables except employees are scaled by beginning-of-period total assets. Firms are classified as young if the first year Compustat reports non-missing sales is after 1995. All other Europe includes firms from all countries except the UK, Sweden, France and Germany. Outliers in all variables are trimmed at the 1% level.

		All Europe			U.K.			Sweden		
		Full	Young	Mature	Full	Young	Mature	Full	Young	Mature
Employees	Mean	10607.575	3161.684	17875.277	1755.940	761.116	2669.109	10653.737	859.855	26108.303
	Median	1570.000	479.000	4845.000	582.500	202.000	1477.000	610.000	215.000	14335.000
Capex	Mean	0.058	0.056	0.060	0.051	0.050	0.053	0.046	0.043	0.052
	Median	0.045	0.037	0.051	0.038	0.032	0.043	0.035	0.027	0.048
R&D	Mean	0.085	0.120	0.044	0.115	0.170	0.049	0.097	0.129	0.036
	Median	0.041	0.062	0.029	0.051	0.095	0.028	0.038	0.078	0.025
Sales	Mean	1.068	0.987	1.161	1.000	0.841	1.190	1.046	1.040	1.058
	Median	1.060	0.972	1.113	1.047	0.781	1.152	1.020	1.033	1.002
CashFlow	Mean	0.125	0.109	0.143	0.098	0.066	0.134	0.094	0.062	0.154
	Median	0.129	0.122	0.134	0.114	0.086	0.130	0.128	0.099	0.148
StkIssues	Mean	0.108	0.181	0.025	0.209	0.338	0.054	0.114	0.163	0.011
	Median	0.000	0.000	0.000	0.002	0.006	0.001	0.000	0.000	0.000
DbtIssues	Mean	0.015	0.014	0.016	0.011	0.010	0.011	0.019	0.014	0.029
	Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
CashHoldings	Mean	0.223	0.296	0.139	0.294	0.393	0.177	0.234	0.297	0.108
	Median	0.114	0.151	0.091	0.152	0.232	0.106	0.124	0.159	0.068
Firms		746	467	279	192	122	70	70	52	18

Table 1b: Sample Statistics

The sample is constructed from European manufacturing firms (SIC codes 20-39) with coverage in the Compustat Global database during 1995-2007. The sample consists only of R&D reporting firms that have at least one string of three consecutive R&D observations. All variables except employees are scaled by beginning-of-period total assets. Firms are classified as young if the first year Compustat reports non-missing sales is after 1995. All other Europe includes firms from all countries except the UK, Sweden, France and Germany. Outliers in all variables are trimmed at the 1% level.

		Germany			France			All Other Europe		
		Full	Young	Mature	Full	Young	Mature	Full	Young	Mature
Employees	Mean	14869.127	2574.144	28894.706	28399.528	10281.184	39073.902	9489.839	4024.526	14752.579
	Median	2130.000	570.000	8430.000	6250.000	515.000	12730.000	2180.000	800.000	5330.000
Capex	Mean	0.067	0.062	0.073	0.059	0.052	0.064	0.062	0.063	0.060
	Median	0.049	0.039	0.059	0.052	0.036	0.061	0.047	0.045	0.049
R&D	Mean	0.074	0.098	0.042	0.069	0.103	0.042	0.072	0.097	0.044
	Median	0.051	0.069	0.034	0.031	0.043	0.027	0.035	0.046	0.028
Sales	Mean	1.154	1.038	1.296	1.045	0.966	1.101	1.089	1.052	1.130
	Median	1.139	1.031	1.260	1.048	0.958	1.093	1.045	1.002	1.067
CashFlow	Mean	0.137	0.130	0.147	0.120	0.112	0.127	0.145	0.142	0.149
	Median	0.139	0.144	0.136	0.115	0.100	0.123	0.135	0.135	0.135
StkIssues	Mean	0.076	0.129	0.011	0.059	0.126	0.011	0.067	0.112	0.019
	Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DbtIssues	Mean	0.013	0.008	0.019	0.009	0.003	0.014	0.018	0.020	0.016
	Median	0.000	-0.001	0.000	-0.001	-0.002	-0.001	0.000	0.000	-0.001
CashHoldings	Mean	0.192	0.265	0.104	0.177	0.265	0.115	0.200	0.253	0.143
	Median	0.100	0.153	0.067	0.098	0.120	0.092	0.108	0.125	0.095
Firms		116	74	42	72	37	35	296	182	114

Table 2a: Dynamic R&D Regressions

Estimation is by systems GMM with lagged levels dated *t*-3 to *t*-4 used as instruments for the equation in differences and lagged differences dated *t*-2 used as instruments for the equation in levels. Fixed firm and time effects are included in all regressions. The sample is described in Table 1. Outliers in all regression variables are trimmed at the 1% level. Standard errors are robust to heteroskedasticity and with-in firm serial correlation.

Dependent Variable: $(R\&D)_t$

	All Europe			U.K.			Sweden		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
$(R\&D)_{t-1}$	1.223	1.095	0.931	1.355	1.292	1.055	1.045	1.096	1.035
	(0.246)	*(0.200)*	*(0.123)*	*(0.407)*	*(0.274)*	*(0.132)*	*(0.106)*	*(0.096)*	*(0.086)*
$(R\&D)_{t-1}^2$	-0.874	-0.613	-0.538	-0.923	-0.698	-0.626	-0.637	-0.498	-0.555
	(0.351)	*(0.219)*	*(0.150)*	*(0.515)*	*(0.278)*	*(0.173)*	*(0.296)*	*(0.169)*	*(0.136)*
$(Sales)_t$	0.070	0.009	0.025	0.054	-0.015	-0.016	0.046	0.018	0.014
	(0.029)	*(0.025)*	*(0.025)*	*(0.033)*	*(0.024)*	*(0.024)*	*(0.019)*	*(0.015)*	*(0.014)*
$(Sales)_{t-1}$	-0.079	-0.054	-0.059	-0.086	-0.035	-0.038	-0.057	-0.032	-0.027
	(0.022)	*(0.021)*	*(0.020)*	*(0.027)*	*(0.025)*	*(0.022)*	*(0.015)*	*(0.014)*	*(0.012)*
$(CashFlow)_t$	-0.110	0.071	0.129	-0.078	0.125	0.227	-0.003	0.047	0.106
	(0.094)	*(0.051)*	*(0.045)*	*(0.118)*	*(0.069)*	*(0.058)*	*(0.052)*	*(0.031)*	*(0.044)*
$(CashFlow)_{t-1}$	0.103	0.028	0.091	0.028	-0.082	0.041	0.045	-0.032	0.020
	(0.063)	*(0.053)*	*(0.053)*	*(0.063)*	*(0.087)*	*(0.058)*	*(0.052)*	*(0.031)*	*(0.030)*
$(StkIssues)_t$		0.095	0.229		0.097	0.198		0.051	0.150
		(0.019)	*(0.048)*		*(0.022)*	*(0.053)*		*(0.016)*	*(0.027)*
$(StkIssues)_{t-1}$		-0.088	-0.058		-0.085	-0.061		-0.065	0.011
		(0.024)	*(0.030)*		*(0.027)*	*(0.026)*		*(0.015)*	*(0.031)*
$(\Delta CashHoldings)_t$			-0.148			-0.136			-0.136
			(0.046)			*(0.056)*			*(0.031)*
$(\Delta CashHoldings)_{t-1}$			-0.028			-0.022			-0.096
			(0.037)			*(0.038)*			*(0.031)*
Sum CashFlow (p-value)	0.918	0.113	0.001	0.685	0.598	0.002	0.227	0.544	0.003
Sum StkIssues (p-value)		0.822	0.002		0.747	0.010		0.550	0.001
Sum ΔCashHoldings (p-value)			0.002			0.024			0.000
m2	0.69	-0.75	-0.12	0.24	-1.68	-1.19	1.03	0.17	-0.16
J-test (p-value)	0.403	0.331	0.273	0.295	0.190	0.382	0.999	1.000	1.000
Diff-Hansen (p-value)	0.582	0.528	0.076	0.476	0.088	0.286	1.000	1.000	1.000
Observations	4240	4001	3940	985	926	895	490	474	462
Firms	746	737	726	192	191	183	70	70	70

Table 2b: Dynamic R&D Regressions

Estimation is by systems GMM with lagged levels dated *t*-3 to *t*-4 used as instruments for the equation in differences and lagged differences dated *t*-2 used as instruments for the equation in levels. Fixed firm and time effects are included in all regressions. The sample is described in Table 1. Outliers in all regression variables are trimmed at the 1% level. Standard errors are robust to heteroskedasticity and with-in firm serial correlation.

Dependent Variable: $(R\&D)_t$

	Germany			France			All Other Europe		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$(R\&D)_{t-1}$	1.365	0.936	0.861	1.295	1.197	1.059	1.278	1.049	1.055
	(0.278)	*(0.133)*	*(0.119)*	*(0.141)*	*(0.077)*	*(0.106)*	*(0.156)*	*(0.186)*	*(0.163)*
$(R\&D)_{t-1}^2$	-1.415	-0.127	-0.215	-1.001	-0.807	-0.825	-0.957	-0.668	-0.701
	(0.454)	*(0.268)*	*(0.194)*	*(0.410)*	*(0.303)*	*(0.326)*	*(0.186)*	*(0.175)*	*(0.154)*
$(Sales)_t$	0.026	0.011	0.015	0.049	0.034	0.034	0.027	0.015	0.039
	(0.019)	*(0.015)*	*(0.013)*	*(0.022)*	*(0.011)*	*(0.010)*	*(0.030)*	*(0.016)*	*(0.020)*
$(Sales)_{t-1}$	-0.038	-0.031	-0.024	-0.096	-0.058	-0.050	-0.058	-0.051	-0.059
	(0.015)	*(0.014)*	*(0.012)*	*(0.028)*	*(0.012)*	*(0.009)*	*(0.028)*	*(0.025)*	*(0.022)*
$(CashFlow)_t$	0.065	0.065	0.084	0.079	0.003	0.070	0.062	0.143	0.145
	(0.062)	*(0.044)*	*(0.036)*	*(0.121)*	*(0.040)*	*(0.052)*	*(0.078)*	*(0.057)*	*(0.047)*
$(CashFlow)_{t-1}$	-0.039	-0.044	-0.035	-0.040	-0.046	-0.011	0.082	-0.032	0.003
	(0.047)	*(0.032)*	*(0.031)*	*(0.089)*	*(0.074)*	*(0.050)*	*(0.105)*	*(0.069)*	*(0.063)*
$(StkIssues)_t$		0.099	0.184		0.097	0.136		0.157	0.181
		(0.029)	*(0.031)*		*(0.017)*	*(0.050)*		*(0.036)*	*(0.055)*
$(StkIssues)_{t-1}$		-0.090	-0.031		-0.031	0.042		-0.077	-0.026
		(0.033)	*(0.024)*		*(0.033)*	*(0.054)*		*(0.047)*	*(0.047)*
$(\Delta CashHoldings)_t$			-0.108			-0.061			-0.054
			(0.035)			*(0.058)*			*(0.060)*
$(\Delta CashHoldings)_{t-1}$			-0.053			-0.065			-0.057
			(0.033)			*(0.047)*			*(0.039)*
Sum CashFlow (p-value)	0.694	0.652	0.133	0.612	0.568	0.142	0.048	0.140	0.020
Sum StkIssues (p-value)		0.882	0.000		0.120	0.043		0.120	0.040
Sum ΔCashHoldings (p-value)			0.006			0.155			0.194
M2	1.62	0.13	0.61	1.84	-0.27	-0.99	-1.14	1.11	0.06
J-test (p-value)	0.649	0.971	1.000	0.999	1.000	1.000	0.039	0.531	0.450
Diff-Hansen (p-value)	0.884	1.000	1.000	1.000	1.000	1.000	0.006	0.586	0.201
Observations	664	637	634	391	374	371	1710	1590	1578
Firms	116	115	115	72	72	71	296	289	287

Table 3: Sample Splits All Europe

Estimation is by systems GMM with lagged levels dated *t*-3 to *t*-4 used as instruments for the equation in differences and lagged differences dated *t*-2 used as instruments for the equation in levels. Fixed firm and time effects are included in all regressions. The sample is described in Table 1. Outliers in all regression variables are trimmed at the 1% level. Standard errors are robust to heteroskedasticity and with-in firm serial correlation.

Dependent Variable: $(R\&D)_t$

	Young	Mature	Small	Large	No Dividend	Dividend	Low Payout	High Payout
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(R\&D)_{t-1}$	0.950	1.061	0.925	1.141	0.936	0.989	0.951	1.123
	(0.143)	*(0.081)*	*(0.134)*	*(0.125)*	*(0.145)*	*(0.110)*	*(0.132)*	*(0.132)*
$(R\&D)_{t-1}^2$	-0.544	-1.330	-0.513	-1.350	-0.610	-0.326	-0.555	-1.495
	(0.163)	*(0.177)*	*(0.165)*	*(0.166)*	*(0.151)*	*(0.208)*	*(0.151)*	*(0.620)*
$(Sales)_t$	0.030	0.029	0.008	0.034	0.017	0.026	0.018	0.038
	(0.027)	*(0.011)*	*(0.026)*	*(0.007)*	*(0.024)*	*(0.015)*	*(0.022)*	*(0.009)*
$(Sales)_{t-1}$	-0.064	-0.039	-0.046	-0.033	-0.080	-0.039	-0.050	-0.037
	(0.022)	*(0.009)*	*(0.020)*	*(0.005)*	*(0.022)*	*(0.011)*	*(0.019)*	*(0.009)*
Sum CashFlow	0.275	0.061	0.251	0.052	0.318	0.034	0.217	0.061
(p-value)	*0.000*	*0.026*	*0.000*	*0.296*	*0.000*	*0.254*	*0.004*	*0.144*
Sum StkIssues	0.219	0.076	0.184	0.000	0.231	0.045	0.179	-0.043
(p-value)	*0.000*	*0.032*	*0.001*	*0.995*	*0.000*	*0.428*	*0.002*	*0.424*
Sum ΔCashHoldings	-0.261	-0.095	-0.206	-0.043	-0.256	-0.106	-0.191	0.004
(p-value)	*0.000*	*0.025*	*0.001*	*0.489*	*0.000*	*0.067*	*0.002*	*0.928*
m2	0.33	-1.10	0.04	-0.96	0.59	-0.38	0.23	-0.62
J-test (p-value)	0.355	0.200	0.228	0.562	0.701	0.735	0.074	0.477
Diff-Hansen (p-value)	0.569	0.232	0.054	0.228	0.907	0.118	0.011	0.328
Observations	2040	1900	2631	1309	992	2948	2843	1097
Firms	449	277	537	189	229	497	546	180

Table 4: Sample Splits by Country

Estimation is by systems GMM with lagged levels dated *t*-3 to *t*-4 used as instruments for the equation in differences and lagged differences dated *t*-2 used as instruments for the equation in levels. Fixed firm and time effects are included in all regressions. The sample is described in Table 1. Outliers in all regression variables are trimmed at the 1% level. Standard errors are robust to heteroskedasticity and with-in firm serial correlation.

	U.K.		**Sweden**		**Germany**		**France**		**All Other Europe**	
Panel A: Sample Split Based on Age										
	Young	**Mature**	**Young**	**Mature**	**Young**	**Mature**	**Young**	**Mature**	**Young**	**Mature**
Sum CashFlow	0.344	-0.003	0.145	0.014	0.093	0.067	0.058	0.002	0.174	0.053
(p-value)	*0.000*	*0.863*	*0.002*	*0.375*	*0.006*	*0.004*	*0.008*	*0.833*	*0.011*	*0.075*
Sum StkIssues	0.159	0.033	0.161	-0.029	0.157	0.080	0.041	-0.034	0.148	-0.034
(p-value)	*0.017*	*0.189*	*0.003*	*0.492*	*0.000*	*0.035*	*0.413*	*0.426*	*0.054*	*0.346*
Sum ΔCashHoldings	-0.185	-0.034	-0.239	-0.015	-0.170	-0.114	-0.042	0.037	-0.104	-0.014
(p-value)	*0.030*	*0.450*	*0.000*	*0.331*	*0.006*	*0.000*	*0.313*	*0.155*	*0.247*	*0.718*
m2	-1.09	-0.89	-0.08	0.17	0.36	2.01	-0.70	-1.06	-0.06	0.03
J-test (p-value)	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.533	1.000
Diff-Hansen (p-value)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.137	1.000
Observations	448	447	288	174	352	282	156	215	796	782
Firms	114	69	52	18	73	42	36	35	174	113

Panel B: Sample Split Based on Payout										
	Low Pay	**High Pay**	**Low Pay**	**High Pay**	**Low Pay**	**High Pay**	**Low Pay**	**High Pay**	**Low Pay**	**High Pay**
Sum CashFlow	0.223	0.015	0.124	-0.002	0.051	0.016	0.069	-0.026	0.151	0.079
(p-value)	*0.001*	*0.355*	*0.003*	*0.812*	*0.128*	*0.501*	*0.131*	*0.272*	*0.047*	*0.074*
Sum StkIssues	0.116	-0.055	0.152	0.009	0.145	0.177	0.176	0.044	0.133	0.027
(p-value)	*0.016*	*0.000*	*0.001*	*0.853*	*0.002*	*0.017*	*0.034*	*0.524*	*0.108*	*0.673*
Sum ΔCashHoldings	-0.127	0.044	-0.224	-0.044	-0.139	-0.122	-0.126	-0.018	-0.106	-0.003
(p-value)	*0.036*	*0.070*	*0.000*	*0.006*	*0.030*	*0.000*	*0.147*	*0.793*	*0.232*	*0.911*
m2	-1.23	0.13	-0.04	0.39	0.64	1.10	-1.00	0.86	0.40	-0.86
J-test (p-value)	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.467	1.000
Diff-Hansen (p-value)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.272	1.000
Observations	610	285	307	155	543	91	304	67	1079	499
Firms	134	49	48	22	100	15	59	12	205	82

Table 5: Alternative Estimates: Pooled Sample

Estimation is by systems GMM on the full Europe sample described in Table 1. Fixed firm and time effects are included in all regressions. The sample is described in Table 1. Outliers in all regression variables are trimmed at the 1% level. Standard errors are robust to heteroskedasticity and with-in firm serial correlation.

Dependent Variable: $(R\&D)_t$

	***t*-2 to *t*-4 instruments**				**Add New Debt Issues**			
	Young	**Mature**	**Low Pay**	**High Pay**	**Young**	**Mature**	**Low Pay**	**High Pay**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$(R\&D)_{t-1}$	0.815	1.118	0.838	1.050	0.840	1.347	0.871	1.052
	(0.114)	*(0.047)*	*(0.108)*	*(0.122)*	*(0.131)*	*(0.154)*	*(0.123)*	*(0.110)*
$(R\&D)_{t-1}^2$	-0.501	-1.310	-0.562	-1.216	-0.437	-2.781	-0.458	-0.988
	(0.136)	*(0.066)*	*(0.135)*	*(0.530)*	*(0.158)*	*(0.753)*	*(0.156)*	*(0.436)*
$(Sales)_t$	-0.001	0.032	-0.005	0.032	0.003	0.025	-0.008	0.029
	(0.021)	*(0.009)*	*(0.017)*	*(0.008)*	*(0.024)*	*(0.006)*	*(0.020)*	*(0.009)*
$(Sales)_{t-1}$	-0.041	-0.032	-0.034	-0.033	-0.044	-0.034	-0.027	-0.033
	(0.015)	*(0.006)*	*(0.011)*	*(0.006)*	*(0.019)*	*(0.007)*	*(0.017)*	*(0.008)*
Sum CashFlow	0.205	0.031	0.180	0.080	0.251	0.029	0.211	0.030
(p-value)	*0.000*	*0.055*	*0.000*	*0.010*	*0.000*	*0.152*	*0.000*	*0.310*
Sum StkIssues	0.183	0.046	0.176	-0.024	0.232	0.083	0.187	-0.083
(p-value)	*0.000*	*0.048*	*0.000*	*0.476*	*0.000*	*0.016*	*0.000*	*0.042*
Sum ΔCashHoldings	-0.209	-0.037	-0.194	0.017	-0.253	-0.100	-0.188	0.004
(p-value)	*0.000*	*0.280*	*0.000*	*0.634*	*0.000*	*0.017*	*0.000*	*0.920*
Sum NewDebt					-0.075	0.016	-0.062	0.003
(p-value)					*0.446*	*0.513*	*0.405*	*0.942*
m2	-0.82	-0.50	-0.50	-1.22	-1.22	-1.20	-1.11	-0.14
J-test (p-value)	0.154	0.281	0.153	0.991	0.575	0.502	0.231	0.536
Diff-Hansen (p-value)	0.045	0.619	0.373	1.000	0.899	0.515	0.413	0.287
Observations	2040	1900	2843	1097	1949	1867	2737	1097
Firms	449	277	546	180	440	277	537	180

Table A1: Firm and Observation Count by Country

Table A1 reports the number of firms and observations from each country in the sample. The count is based on the number of firms and observations each country contributes to the baseline regression that includes only cash flow. The number of observations declines slightly as additional financial variables are included in the specification.

	Firms	Observations
UK	192	985
Germany	116	664
France	72	391
Sweden	70	490
Switzerland	66	429
Finland	51	347
Denmark	28	175
Turkey	27	120
Netherlands	26	175
Belgium	23	121
Norway	20	81
Greece	16	73
Italy	14	46
Ireland	11	82
Austria	11	55
Spain	3	6
	746	4240