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R&D Investment and Internal Finance: The Cash Flow Effect

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Abstract

This paper investigates the effect of financial constraints on R&D investments for firms in Denmark. Evidence is found that firms' internal funds are important in explaining R&D investments, indicating that R&D intensive firms are financially constrained. The effect of cash flow on R&D is stronger both for smaller firms and for firms with low debt relative to assets. Furthermore, this effect is also present after controlling for cash flow's role as a predictor of future profitability.

Keywords: R&D, cash flow, internal finance, financial constraints
JEL classification: G32, O32

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1. Introduction

It is often argued that there is too little investment in R&D. The main reason for this is that much of the ideas and knowledge created by R&D is non-rival; its use by one firm does not preclude its use by another. Firms may then be unable to fully appropriate the gains from their investment, which then leads to underinvestment.

However, there may also be another reason why firm investment is suboptimal. Both the nature of R&D investments and information problems may affect the access to and the cost of external funding. As a result, R&D investments may be affected by a number of factors.

An extensive literature[1] has examined the presence of financial constraints on investment in fixed capital, most often by examining whether cash flow affects investment. A lesser number[2] have also considered the role of cash flow on R&D investment. The majority of this work has been on U.S. data. However, consideration of these issues in other countries is interesting both in their own right and also in comparison with U.S. results. Financial systems and relationships between firms and banks vary considerably from country to country.

Examining R&D investment as opposed to physical investment is interesting, given that the two types of investment differ in a number of important ways. First, since a large portion of R&D expenditure is wages and salaries, and the output is mainly knowledge and ideas, R&D is difficult to collateralize. Second, much of the knowledge created is tacit; the firm's knowledge base sits with its researchers, and in order to maintain it, the firm must keep their staff employed. This implies that there are high adjustment costs for R&D, which also motivates the smoothing of R&D spending. Third, the returns to R&D investment are much more uncertain than fixed capital investment.

The objective of this paper is to examine the role of financial factors on R&D investments in Danish firms. The main question this paper examines is whether evidence can be found of financial constraints on R&D investments. If firm borrowing is constrained then R&D expenditures will be dependent on firms' own cash flow. Thus, cash flow's ability to explain R&D investments provides evidence of financial constraints. However, cash flow may also function as an indicator of future profitability, which suggests that cash flow may help explain R&D investments simply because it forecasts future earnings, and not due to financial constraints.

Hence, in addition to examining the effect of cash flow on R&D investments, it is equally important to be able to differentiate between these two interpretations. I will address this issue in two ways.

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[1] Examples are Fazzari et al. (1988), Gilchrist and Himmelberg (1995).
[2] Among them, Hao and Jaffe (1993), Himmelberg and Petersen (1994), Hall (1992), Mulkay et al. (2001), Boughaes et al. (2003). A review of literature on the financing of R&D can be found in Hall (2002).

First, following Fazzari et al. (1988) and Hao and Jaffe (1993), I consider subsets of the sample that, a priori, are more likely to be subject to financial constraints. If cash flow effects are stronger for these subsets, then this provides evidence that at least part of cash flow effects on R&D investment are due to financial constraints.

Second, I use a simplified approach to that used to examine capital investment in Gilchrist and Himmelberg (1995), in which I construct an estimate of expected future profitability, "Expected Q", controlling for, among other things, cash flow's predictive power for future earnings. This makes it possible to distinguish between the two interpretations. A finding that cash flow still helps to explain R&D investments after controlling for its ability to forecast future earnings provides strong evidence for the presence of financial constraints.

An additional financial factor that may affect R&D investments is the firm's market value. Due to information asymmetries and potential shortsightedness of investors, the market may value R&D differently than the firm itself. In this case, R&D investments may be influenced by managers' perceptions of how the market will respond. Chung and Wright (1998) find that R&D only has a positive effect on market value if Tobin's Q is "high" (greater than one). The role of market value in R&D investments can be examined by considering subsets of the sample in terms of their average values of Tobin's Q.

I examine these questions using a panel of Danish firms. The dataset draws on a comprehensive database, compiled by the Danish Centre for Studies in Research and Research Policy, on R&D activities for Danish firms from 1989 to 2001. This data has then been combined with accounting and stock market data for all non-financial firms listed on the Copenhagen Stock Exchange[3].

I find in general that cash flow has a positive, significant effect on R&D investments. Furthermore, when subsets are considered that, a priori, are more likely to be subject to credit market imperfections, this effect is stronger (i.e. the coefficient on cash flow increases.) This is the case both when small firms are considered and for firms with low levels of debt. In addition, when Expected Q is used instead of Tobin's Q in the regressions, cash flow still has a significant effect on R&D investments, in particular for small and low debt firms. These results give a strong indication that cash flow's effect on R&D reflects the presence of credit market imperfections.

The remainder of the paper is as follows. Section 2 discusses theoretical motivations for financial constraints, and their economic implications. Section 3 contains the empirical analysis, in which I discuss the data, the methods used, and the empirical results. Section 4 concludes.

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[3] Annual account data is from the Account Database from the Copenhagen Business School. Stock market data is obtained from the Danish Stock Database from the Center of Analytical Finance at the Aarhus School of Business. A more detailed description of the R&D data is given in the appendix.

2. Information problems and credit market imperfections

According to the Miller-Modigliani (1958) theorem, optimal levels of investment should be indifferent to capital structure. Though, economic theory on information problems offers a number of reasons why this may not be the case. This literature suggests that information problems may lead investors to restrict financing for R&D investments.

R&D may be characterized by problems of asymmetric information[4]. The firm has better information on the likelihood of success and nature of the project than the investor. The investor may then have difficulties in determining which projects are most promising. Additionally, reducing information problems in this case is problematic since firms are reluctant to give more information on their research due to strategic considerations.

Myers and Majluf (1984) argue that managers' inside information on the value of investment projects will make them reluctant to seek external finance, instead relying on internal funds.

As with other types of investment, external financing creates problems of moral hazard[5]; due to limited liability, firms may be willing to take on greater risk than otherwise when projects are financed by external funds. These problems are potentially greater for R&D, given that R&D is very difficult to collateralize.

R&D investments may also be affected by the firm's market value, or by expectations of how R&D will affect the firm's market value. Due to information asymmetries, investors may value R&D investments differently than management. Additionally, investors may be more shortsighted. If an R&D investment is not expected to have a positive impact on market value in the short run, then firms may invest less in R&D.

2.1. Economic implications

Credit market imperfections can affect outcomes both in the long run and over the business cycle. For example, if imperfections result in higher capital costs, then long run levels of R&D investment will be lower than otherwise. Imperfections may also magnify the effects of shocks, as demonstrated by e.g. Bernanke and Gertler (1989) and Bernanke et al. (1999), via what they term as the "financial accelerator mechanism". Additionally, given that high adjustment costs are associated with R&D, changes in R&D investment that are necessitated by financial constraints may be particularly costly. Concerns about these costs may lead to a shift in the firm's focus towards short term results at the expense of longer term objectives.

[4] Classical references are Akerlof (1970) and Stiglitz and Weiss (1981).
[5] See, e.g. Holmstrom and Tirole (1997) and Townsend (1979).

3. Empirical analysis

The objective of this analysis is to examine whether firms' R&D investments are financially constrained. An indication that this is the case is evidence that firms' internal funds are an important determinant of R&D investments. However, as noted above, the finding that firms' cash flow helps explain R&D investment can be interpreted in two ways:

- The effect of cash flow on R&D investment is due to firms' limited access to external finance.
- R&D investment's positive association with cash flow is not due to financial constraints, but is instead due to cash flow's role as a predictor of firms' investment opportunities.

Hence, having found a 'cash flow effect', it is equally important to identify the role of cash flow in affecting R&D investment.

The standard approach draws on the Tobin's Q theory of investment. Q, the ratio of the market value of the capital stock to its replacement cost, reflects the future profitability of investments. If Q is greater than one, then the marginal return to investment is greater than its cost, leading to increased investment. Given that Tobin's Q is theoretically a sufficient statistic[6] for the profitability of investment, any additional effects of cash flow after controlling for Q are argued to be due to financial constraints.

However, concerns with respect to the quality of empirical approximations of Tobin's Q raise questions on this approach. The standard empirical measure of Q is the ratio of the market value to the book value of total assets. If this is a poor proxy of the theoretical measure of Q, then cash flow effects can be argued to supplement the empirical measure of Q as a predictor of future investment opportunities.

I will address this issue in two ways. First, I will consider subsamples of the data set. If cash flow effects are stronger for firms that, a priori, are considered likely to be subject to financial constraints, then this provides evidence that cash flow effects reflect financial constraints. Second, I will attempt to control for cash flow's ability to forecast future profitability by estimating the expected value of Q using cash flow, sales, and other variables. If cash flow still affects R&D investment after controlling for its effect on expectations of future profitability, then this provides evidence of the presence of financial constraints.

[6] See Hayashi (1982).

3.1. The empirical model

The empirical model that I will use here is:

$$\frac{RD_{it}}{TA_{it}} = \beta_0 + \beta_1 Q_{it} + \beta_2 \frac{CF_{it}}{TA_{it}} + \beta_3 \frac{S_{it}}{TA_{it}} + e_{it} \quad (1)$$

where RD_{it} is R&D investment for firm i in period t, *TA* is the book value of total assets, Q is an empirical measure of Tobin's Q, *CF* is cash flow, *S* is sales, and *e* is an error term. *Q* and *TA* are values at the beginning of the period, while *CF, RD*, and *S* are values during the period. As indicated in (1), cash flow, sales, and R&D are normalized by total assets.

Q is defined as the ratio of the market value to the book value of the firms total assets[7]. As discussed above, Q is included to capture the effect of future investment opportunities on R&D investments. This specification borrows from literature of financial constraints for fixed investment (see the references listed above), however this specification is equally applicable for R&D investments, in particular since the measure for Q uses the total market value for the firm. Firm sales, or net turnover, are also included as an indicator of future profitability.

Cash flow is the amount of internal funds the firm has available for R&D investment during the period[8]. Cash flow is intended to capture the effects of internal financing on R&D investments, though, as discussed above, it may also function as a predictor of future profitability.

The dataset comprises firms listed on the Copenhagen Stock Exchange over the period, 1989-2001. In order to focus on firms that are active in research and development, only firms with average R&D expenditures greater than one percent of the market value of equity are included. This yields an unbalanced panel consisting of 53 firms with a total of 337 observations. Table 1 shows some summary statistics for the sample.

[7] Q is calculated as the market value of equity plus the book value of long term debt, divided by the book value of total assets.
[8] More precisely, cash flow is defined as operating income *before* R&D expenditures, plus liquid assets.

Table 1. Summary statistics

Variable	Mean	Standard Deviation
Market capitalization[a]	3078	9245
Book value of total assets[a]	2980	5615
R&D investments[b]	0.046	0.066
Tobin's Q[b]	1.296	1.496
Long term debt[b]	0.149	0.098
Cash Flow[b]	0.302	0.216

[a] In millions of DKK.
[b] Normalized by the book value of total assets. Tobin's Q and cash flow as defined above.

The choice of estimation method should consider two potential sources of bias: individual firm effects and the correlation of explanatory variables with the error term. For example, a shock to R&D investments may also be assumed to affect cash flow and sales. The potential correlation between current variables and the error term argues for the use of Generalized Method of Moments as an estimation method. However, the small size of this sample and the large variation in the number of observations for each individual firm makes this approach problematic. An alternative instrument variables method, such as Two Stage Least Squares, may give very imprecise estimates if the instruments used are weak (i.e. low correlation with the variables to be instrumented). This was indeed what was found to be the case for the sample here. Standard errors were so large that all variables were insignificant.

Instead, this paper will estimate the model using a fixed effects estimation method[9]. This allows for individual firm effects, but does not control for potential bias with the explanatory variables. As a control, the model was also estimated using the Hausman-Taylor instrumental variables approach[10]. These results were fairly similar to those with fixed effects, giving an indication that the fixed effects estimates are fairly reliable. The results using the Hausman-Taylor approach are included in the appendix for comparison.

Table 2 shows the results for estimation of the model using the fixed effects method. The model is estimated for the full sample and for subsets of firms that, a priori, may be considered likely to be constrained. Small firms can be considered more likely to suffer from the information problems that cause credit market imperfections and may be more dependent on banks for external financing[11]. Additionally, firms that are financially constrained may be expected to have lower levels of debt.

[9] Mulkay et al. (2001) also use a fixed effects estimator for similar reasons.
[10] See Hausman and Taylor (1981).
[11] Where as larger firms, for example, may be able to issue their own bonds.

The model is also estimated using an estimate of expected future profitability, 'Expected Q'. In constructing this estimate, I regress future values of Tobin's Q on current values of Q, cash flow, sales, long term debt and R&D, and then save the predicted values. Expected Q (EQ) then incorporates, among other things, cash flow's ability to forecast expected future earnings.

Consider first the regressions with Tobin's Q. In the full sample, all variables are positive and significant. For the subsets of 'a priori constrained' firms, the effect of cash flow on R&D investment is stronger. For both small firms and those with low debt, the coefficient for cash flow increases both in size and significance.

Next consider the regressions with Expected Q, where EQ incorporates the effect of cash flow, sales and Q on the next period's value of Q. For the full sample, the coefficient of cash flow falls both in size and significance. However, cash flow still helps to explain R&D investments. In addition, when considering 'constrained' firms, the coefficient for cash flow is much larger.

The results here then provide strong support for the presence of financial constraints for R&D investments. Cash flow has a significant effect on R&D investments, even after controlling for its effect on expected future profitability.

Highly R&D intensive firms may be considered riskier investments. This could then imply that financial constraints are greater for these firms. Results are mixed here. The coefficient for cash flow is only moderately higher using Tobin's Q and for Expected Q it is insignificant.

Chung and Wright (1998) find that R&D investments only affect firms' market value for high levels of Q. Motivated by this, Table 1 also includes regressions for firms with, respectively, high and low values of Q. For high Q, the effect of cash flow is weaker than for the full sample, and is insignificant when Expected Q is used. Firms with a high value of Q have strong expectations of high profitability. This may provide them with greater access to external finance.

For low Q, none of the variables are significant when using Tobin's Q. Only cash flow has a semblance of an effect (p value of 0.1765). Using instead Expected Q, cash flow has a strong, significant effect while the coefficient on EQ has a negative sign. The latter is difficult to interpret, but could reflect attempts (via R&D investments) to reverse declines in market value.

Table 2. Regression results

	Cash Flow	Q	EQ	Sales	Constant	No. obs.	df	(adj) R^2
Dependent variable: R&D investment								
Full	0.0344* (0.0120)	0.0042* (0.0020)		0.0081* (0.0049)	0.020* (0.0049)	337	272	0.828
Full	0.0238** (0.0129)		0.0165* (0.0064)	0.0088* (0.0038)	0.0075 (0.0081)	337	272	0.830
Small	0.0707* (0.0235)	0.0098* (0.0040)		-0.0014 (0.0100)	0.0249* (0.0121)	175	133	0.822
Small	0.0465** (0.0252)		0.0388* (0.0124)	0.0003 (0.0099)	-0.0007 (0.0165)	175	133	0.827
Low debt	0.0613* (0.0242)	0.0037 (0.0028)		0.0053 (0.0060)	0.0310* (0.0089)	151	114	0.832
Low debt	0.0505* (0.0252)		0.0159** (0.0087)	0.0060 (0.0060)	0.0141 (0.0146)	151	114	0.834
High Q	0.0349** (0.0171)	0.0043** (0.0025)		0.0089** (0.0054)	0.0292* (0.0076)	185	142	0.826
High Q	0.0235 (0.0183)		0.0174** (0.0080)	0.0097** (0.0054)	0.0112 (0.0131)	185	142	0.828
Low Q	0.0229 (0.0168)	-0.0085 (0.0086)		-0.0011 (0.0055)	0.0297* (0.0088)	152	118	0.739
Low Q	0.0523* (0.0252)		-.0449** (0.0259)	-0.0023 (0.0055)	0.0532* (0.0179)	152	118	0.743
High R&D	0.0429* (0.0213)	0.0046 (0.0030)		0.0160 (0.0183)	0.0384* (0.0179)	151	113	0.798
High R&D	0.0309 (0.0225)		0.0187* (0.0094)	0.0165 (0.0182)	0.0173 (0.0224)	151	113	0.801

Estimation method: fixed effects (Least Squares with Dummy Variables), using both firm and time dummies (coefficients for fixed effects not shown. Heteroskedasticity consistent standard errors are in parentheses. A '*' indicates significance at the 5% level, and a '**' indicates significance at the 10% level. Cash flow is operating income before R&D expenses, plus liquid assets. Q is an empirical measure of Tobin's Q, equal to the market value of common equity plus the book value of long term debt, divided by the book value of total assets. EQ is Expected Q in the next period, based on current values of cash flow, sales, long term debt, Q and R&D. Cash flow, R&D investment and sales normalized by the book value of total assets.

Full is the entire sample. Small is all firms with average sales less than one billion DKK. Low Debt consists of firms with average long term debt (relative to total assets) less than the sample median. High (Low) Q are firms with average Q greater (less) than the sample median value. High R&D is firms with an average R&D to Sales ratio greater than median.

4. Conclusion

This paper has investigated the presence of financial constraints for R&D investments using the 'Tobin's Q approach'. I have examined whether cash flow helps to explain R&D investment when Tobin's Q is used as a measure of future investment opportunities. I have used two approaches to overcome problems that empirical measures of Tobin's Q may not be adequate proxies for the theoretical measure: by considering subsets of 'constrained firms', and by controlling for cash flow's ability to predict future profitability. I find strong evidence that financial constraints play an important role in determining the size of R&D investments. These results are based on R&D intensive firms that are publicly traded. Though, there is good reason to believe that financial restrictions may be even greater for smaller firms. These results are also qualitatively similar to studies using US data. However, due to the fact that model specifications are not the same, a straightforward comparison of quantitative estimates is not feasible.

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Appendix

A. R&D data for non-financial firms on the Copenhagen Stock Exchange

This section describes the compilation of R&D data for non-financial firms listed on the Copenhagen Stock Exchange. The data is taken from the Danish Institute for Studies in Research and Research Policy's (AFSK) database for private sector R&D. The data is gathered and compiled in accordance with the definitions and guidelines of the OECD's Frascati Manual.

The majority of the firms listed consist of more than one company or own a number of subsidiaries. In order to ensure to the greatest degree possible that all R&D data is registered for each firm, the database was checked for R&D data both at the overall concern level and for their subsidiaries. If R&D expenditures were reported at the concern level then these were used as total R&D expenditures. If not, then R&D was calculated as the sum of R&D expenditures for its subsidiaries (times percent ownership).

There are also a group of firms that have not reported any R&D statistics. In these cases, their annual reports were examined. If R&D expenditures were reported in their annual reports, then these numbers were used. In the case where firms did not report any statistics to AFSK, nor were there any R&D expenditures listed on their annual reports, then these data were considered as missing. Note though, that the definitions used by each individual firm in their annual reports may not be exactly the same as those used by AFSK. However, given the somewhat limited size of the sample here, it was considered best to include them.

The R&D database at AFSK contains data for every other year from 1989 to 1997 and annually from 1997 onwards. For the years missing between 1989 and 1997 (i.e. 1990, 1992, 1994 and 1996), R&D data was interpolated from years before and after. Additionally, the database for listed firms was checked for missing values. These missing values were then estimated. However, if more than two years were missing from the sample (among those years where data was gathered) then the firm was removed from the sample.

B. Additional regression results

Table 3. Results using the Hausman – Taylor Instrument Variables approach

	Cash Flow	Q	EQ	Sales	Constant	obs.
Full	0.0509*	0.0067*		0.0043	0.0203**	337
	(0.0116)	(0.0019)		(0.0037)	(0.0120)	
Full	0.0352*		0.0272*	0.0054	0.0128	337
	(0.0128)		(0.0064)	(0.0037)	(0.0126)	
Small	0.0763*	0.0119*		-0.0077	0.0384*	175
	(0.0224)	(0.0037)		(0.0098)	(0.0191)	
Small	0.0493*		0.0466*	-0.0052	0.0266	175
	(0.0252)		(0.0125)	(0.0099)	(0.0203)	
Low Debt	0.0960*	0.0052**		-0.0016	0.0404	151
	(0.0238)	(0.0027)		(0.0058)	(0.0277)	
Low Debt	0.0845*		0.0225*	-0.0009	0.0328	151
	(0.0249)		(0.0088)	(0.0059)	(0.0286)	
High Q	0.0606*	0.0067*		0.0030	0.0291	185
	(0.0167)	(0.0024)		(0.0052)	(0.0228)	
High Q	0.0454*		0.0274*	0.0040	0.0207	185
	(0.0180)		(0.0081)	(0.0052)	(0.0238)	
Low Q	0.0198	-0.0011		-0.0047	0.0142	152
	(0.0155)	(0.0081)		(0.0051)	(0.0094)	
Low Q	0.0480**		-0.0375	-0.0059	0.0270**	152
	(0.0268)		(0.0307)	(0.0053)	(0.0154)	
High R&D	0.0675*	0.0065*		-0.0079	0.0666**	151
	(0.0207)	(0.0029)		(0.0160)	(0.0347)	
High R&D	0.0530*		0.0263*	-0.0062	0.0593**	151
	(0.0222)		(0.0095)	(0.0162)	(0.0357)	

Time and sector dummies included in the regressions. Regressions performed under the assumption that sales and cash flow may be correlated with the error term (and were thus instrumented), while Q is strictly exogenous.