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Karine T. Borri, Carlos Martins-Filho, Aquiles E.G. Kalatzis

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Exploring nonlinearities between investment and internal funds: evidence of the U-shaped investment curve

Karine T. Borri[a], Carlos Martins-Filho[b], Aquiles E. G. Kalatzis[a,*]

[a]*Department of Production Engineering, School of Engineering of São Carlos, University of São Paulo, EESC—USP, Brazil*
[b]*Department of Economics, University of Colorado at Boulder, USA*

Abstract

We provide new empirical evidence of the relationship between the availability of internal funds and firms' investment. By employing a semi-parametric fixed effect model, we estimate a U-shaped curve relating investment and internal funds. Our results highlight the importance of allowing for nonlinearities when modeling changes in internal funds and investment, and show that R&D expenses play a critical role on firms' investment under financial constraints.

Keywords: Investment decision, Financial Constraints, Semi-parametric model, R&D investment
JEL Classification Code: C5; C14; G3

1. Introduction

The relation between firms' investment decisions and the availability of internal funds has been the subject of an important and extensive debate. The original viewpoint, first presented in the seminal work of Fazzari et al. (1988), is that financial factors matter to firms' investment decisions in imperfect capital markets.

The gap between external financing cost and firms' internal funds supports the idea of financing hierarchy disseminated by Myers and Majluf (1984), especially for firms facing high levels of financial constraints. Based on this hypothesis, several empirical studies[1] show that investment decisions of firms identified as more financially constrained are more sensitive to available internal funding (usually measured by cash flow).

However, Kaplan and Zingales (1997), Cleary (1999), Povel and Raith (2001) and Allayannis and Mozumdar (2004) challenge the generality of this conclusion. These papers provide both theoretical and empirical evidence that this differential in investment-cash flow sensitivity is not a valid measure of financial constraint. According to Allayannis and Mozumdar (2004), this divergence of results is due to firms with high financial distress, for which investment may not respond to an increase in internal funds in a monotonic and positive way.

Cleary et al. (2007) argue that a firm's optimal investment is, actually, an U-shaped function of its internal funds by empirically employing a spline regression for quantiles. For groups of firms with positive cash flow they obtain a positive coefficient for internal funds, but a negative coefficient for firms with negative cash flow.

In this paper, we make several contributions to this debate. First, using a semi-parametric fixed effect model and series estimator proposed in Baltagi and Li (2002), we provide new empirical evidence on the functional relationship between firms' investment and cash flow. Our model relaxes the usual linearity assumption, allowing for an entirely flexible functional form. Using the results of our estimation we extend prior works and contribute to the literature by providing new evidence on the relationship between investment and firms' cash flow under financial constraints. We do so not only by allowing this relationship to be more realistically modeled by a smooth function, but *also* by dividing the sample at a critical threshold, thereby providing evidence that R&D expenditures play a crucial role in explaining why firms with negative cash flow have high investment rate.

Second, our results add to the interpretations and findings proposed by previous empirical work, contributing to a better understanding of the conflicting results in the literature regarding positive and negative investment-cash flow sensitivity, and the puzzle in interpreting the cash flow significance as a financial constraint.

*Corresponding author
Email address: aquiles@sc.usp.br (Aquiles E. G. Kalatzis)

[1]See, e.g., Hubbard (1998), Stein (2003) and Carpenter and Guariglia (2008).

Third, we also contribute to the corporate finance debate on information asymmetry versus managerial discretion in a context of financial constraint with contradictory empirical findings. Our results suggest that firms with stronger financial positions can also have high investment-cash flow sensitivity but they can't be considered financially constrained. The interpretation is based on agency cost theory, which argues that excess of free cash flow may be used in a wasteful way and to managers' advantage. (Jensen, 1986).

We find that a large share of firms have a negative relationship between internal funds and investment. As firms with negative cash flow show good investment opportunities in comparison to those firms with positive cash flow, they continue to invest even when cash flow is negative. However, a higher cost of external resources may arise mainly from the uncertainty and higher risk of default associated with a higher rate of R&D expenditures rather than to maintain their scale of investment. As far we know, this conjecture did not emerge in prior work that found an U-shape relationship between internal funds and firm's investment.[2] We emphasize that our conclusions are based solely on our regression results suggesting no casual relationships.

Our findings also suggest that although financial constraints are essential for the implementation of new projects, it improves the efficient allocation of capital by reducing cash flow, which enforces the managers to be more efficient, especially when dealing with R&D expenditures.

2. Data and empirical approach

Our sample, from Compustat Global database, over the period 2010-2018, contains data from three European countries (France, Germany and Great-Britain), comprising an unbalanced panel with 18,681 observations from 2,901 listed firms.

To explore nonlinearities in the relation between internal funds and investment, we modify the traditional investment model in Fazzari et al. (1988) by considering cash flow as a non-parametric component in the model:

$$\frac{I_{it}}{K_{i,t-1}} = \alpha_i + \gamma_t + f\Big(\frac{CF_{it}}{K_{i,t-1}}\Big) + \beta_1 \frac{D_{it}}{K_{i,t-1}} + \beta_2 Q_{it} + \beta_3 Size_{it} + \epsilon_{it} \quad (1)$$

where $I_{it} = K_{it} - K_{it-1}$ is the investment of firm i during year t; K_{it} is capital stock, measured by property plant and equipment; CF_{it} is firm´s cash flow; D_{it} is the long term debt; Q_{it} is the Tobin's Q; $Size_{it}$ is the firm's size, measured by the natural logarithm of total assets; α_i is a firm-specific effect; γ_t is the country specific effect; and ϵ_{it} is an error term.

To estimate the model in equation (1), we adopt Baltagi and Li (2002)'s assumptions and estimation procedure for a partially linear semi-parametric panel data model with fixed effects. As in their paper, we take the number of time periods T to be fixed and let the number of firms $n \to \infty$ for asymptotically valid inference.

3. Results and discussion

Our semi-parametric fixed effect model allow us to obtain estimates of the global parameters (β_1, β_2 and β_3) and a graph of pointwise estimates of f.

Table 1 gives estimates of β_1, β_2 and β_3. Column (1) gives estimates of a fixed effect linear model using the entire sample, while in columns (2) and (3), only firms with negative and positive cash flow were used, respectively. Column (4) shows the estimated β's associated with the semi-parametric fixed effect model in equation (1). We find a positive and significant parameter for debt, Tobin's Q and size. These control variables have a positive impact on the firm's investment decisions, with a quite higher magnitude for firms with negative cash flow for size and Tobin's Q variables.

Table 1: Regression results

	Fixed-effect			PLR
	(1)	(2)	(3)	(4)
(CF/K)	0.030***	-0.11***	0.097***	-
	(0.002)	(0.010)	(0.003)	-
(D/K)	0.032***	0.024***	0.031***	0.041***
	(0.001)	(0.003)	(0.002)	(0.002)
Q	0.81*	1.57*	0.89***	1.77***
	(0.314)	(0.833)	(0.318)	(0.421)
$Size$	0.12***	0.17***	0.10***	0.33***
	(0.007)	(0.017)	(0.009)	(0.013)
Obs.	18681	4668	14010	15630
R^2	0.080	0.091	0.139	0.1568

Results of the estimation of the partial linear model (PLR) coefficients using Baltagi and Li (2002)'s estimator for a semi-parametric model with fixed effects. Robust Standard errors are reported in parenthesis. The superscripts ***, **, and * denote statistical significance at the 1%,5%, and 10% levels, respectively. The variables were winsorized at 5th and 95th percentile of their pooled distribution across all firm-years.

Turning our analysis to the non-parametric component, Figure 1 presents the shape of the estimated relation between investment and internal funds with 95% pointwise confident

[2] See Allayannis and Mozumdar (2004), Cleary et al. (2007) and Guariglia (2008).

bands. We observe a clear U-shaped curve, with a positive slope for firms with positive internal funds, and a negative slope between investment and internal funds when cash flow is negative.

Our approach provides an additional explanation for the divergent findings in the literature regarding a positive and negative investment-cash flow sensitivity. One explanation goes in the same direction as that found in Cleary et al. (2007), in which firms that are not able to maintain their scale of investment, and reduce their investment by decreasing the negative level of cash flow. With a smaller scale of investment, firms do not need new financing and, therefore, will not incur additional costs to maintain investment.

An interesting aspect here is that firms with negative cash flow show good investment opportunities, with similar value of Tobin's Q, sales growth and investment rate in comparison to those firms with positive cash flow. This suggests that firms that have good investment opportunities continue to invest even with a negative cash flow. On the other hand, to maintain high investment levels and to respond to investment opportunities, firms need to borrow, thus increasing the cost of greater financing and facing a higher risk of default. To avoid higher costs and a high risk of default, firms reduce their investment, and improve their cash flow management. Also, as pointed out by Guariglia (2008), the firm's strategy to avoid higher borrowing with increasing repayment costs and higher risk of default would be to link lower cash flow to lower investments.

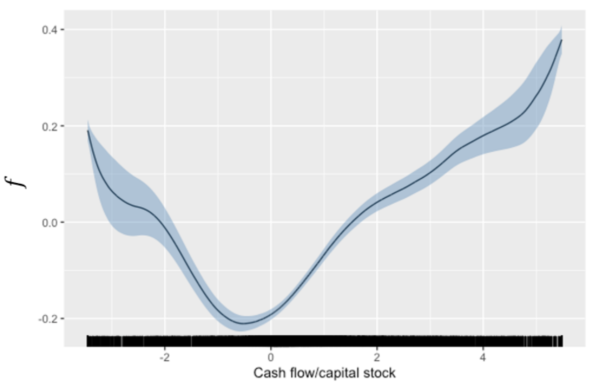

Figure 1: Estimated linear prediction of investment as a function of cash flow with 95% pointwise confidence bands.

Another compelling finding is that there is no difference on the parameters' significance between financially constrained and unconstrained firms. To further examine this issue for firms with negative and positive cash flow, we split the sample according to the critical threshold suggested by the estimated semi-parametric function in Figure 1. Table 2 presents the values for the mean and standard deviation of the financial characteristics of firms with negative and positive cash flow, separately.

Table 2: Summary statistics

	Negative CF		Positive CF	
	Mean	SD	Mean	SD
Investments	0.073	0.505	0.090	0.362
Cash flow	-2.109	1.409	1.393	1.743
Debt	2.164	4.080	2.447	4.177
Size	3.353	1.784	5.117	2.412
Dividends	29.26	76.34	53.71	109.35
Sales Growth	0.09	0.39	0.10	0.24
Tobin's Q	1.004	0.014	1.006	0.017
Capex	10.44	47.02	56.43	120.58
Leverage	0.490	0.923	0.687	0.943
R&D	4.24	5.70	1.87	4.08
ROA	-0.247	0.185	0.013	0.134
ROE	-0.359	0.391	0.048	0.226
Cash holdings	0.232	0.241	0.182	0.193
Age	8.010	4.158	8.618	5.022
WW Index	-0.183	0.093	-0.306	0.097
SA Index	-0.371	0.391	-0.632	0.346
Obs.	5177		15,722	

Mean and standard deviation for firms with negative and positive cash flow. The variables were winsorized at 5th and 95th percentile of their pooled distribution across all firm-years. The variables Investments, Cash flow, Debt and R&D are scaled by firm´s capital

By looking at characteristics and financial indicators of firms with negative cash flow, we observe that they are smaller, pay less dividends, have lower capital expenditures, lower leverage, negative profitability (ROA and ROE), and most interestingly, their level of R&D investment by capital is much higher than for firms with positive cash flow. They also have higher cash holdings, which according to the literature suggests that financially constrained firms need to stock more cash as a precautionary motive to avoid future opportunities losses.

Even though, consistent with our regression results, there is evidence that firms with negative cash flow are financially constrained, this does not necessarily mean that feasible investments will be undertaken only on a sufficiently large scale to generate high revenues. In particular, we observe that firms with negative cash flow have higher R&D expenses by capital (4.54), while firms with positive cash flow have a much lower value (1.87). Therefore, the higher risk of default is not only associated with high levels of investment, but mainly associated with higher investment in R&D. The significant attention of the extant literature on capital investments tends to shift the attention from the essential role that financing has on R&D expenditures in relation to investment-cash flow sensitivity.

In addition to the claims of Cleary et al. (2007) and Guariglia (2008) - that argue that firms with negative cash flow are dominated by the revenue effect and the effect of high investment scale - our most important finding is that for firms with negative cash flow, the dominant effect, consistent with our regression, may be related to the raising of external funds to maintain high rates of R&D expenses.

This finding suggests that besides internal shortfalls, these firms are investing heavily in innovation projects, which may worsen the financing gap due to agency problems, asymmetric information and uncertainty (Hall, 2002). Furthermore, since R&D projects are typically more uncertain regarding return and payback time, external financing becomes even more crucial. The long time needed for the implementation of an innovation project since its conception will also lead to a higher adjustment cost associated with R&D investments (Brown and Petersen, 2011).

According to these results, policymakers could be mindful of easier access to finance, particularly for firms with negative cash flow and high R&D expenditures, given their higher risk of default. This aspect plays an important role on firm's investment and in a country's economic growth, given that these firms have not only high levels of R&D expenditures but also a large scale of investment in physical capital.

4. Conclusions

This paper sheds light on the extensive discussion concerning the connection between investment and the availability of internal funds. Although the shape of this relation has already been suggested in previous works, there are two notable contributions of our results compared to those studies.

First, by allowing for a nonparametric relation between investment and cash flow and, considering the effect on firms' financial constraints, we provide an important explanation to the conflicting empirical literature when finding a U-shape curve that drives the firm's investment decisions based on the level of internal funds.

Second, by exploring the financial characteristics of firms with negative cash flow, as revealed by the estimated nonparametric function, our results suggest that a high level of R&D expenditures, coupled with high risk premium, is more important than the investment scale or the revenue effect, in contrast to the case of firms with positive cash flow, and in agreement with conclusions found in the extant literature.

Overall, our results clarify that applying more realistic assumptions is fundamental for a better understanding the relationship between changes in internal funds and investment. The evidence suggest that different dimensions and scale of financial constraint with different criteria may provide conflicting results. It is worth highlighting that the investment-cash flow sensitivity is indeed non-monotonic, and although the dependence of investment on cash flow is significant for both firms with negative and positive cash flows, only firms with negative cash flow can be considered as financially constrained.

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- R&D is crucial to explain why firms with negative cash flow have high investment rate
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