Adjustment Costs and Financial Frictions

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Abstract

We develop a simple theoretical model of investment under the assumption that financial frictions generate adjustment costs different from those of industrial origin that are normally discussed in the literature. We identify several restrictions that are used to test the model and estimate it using aggregate data for the United States. We find strong evidence that adjustment costs on external finance are significant. We then investigate whether the availability of external finance affects investment of non-financial corporations. We find that a strong relationship holds between financial flows and investment. Shocks to investment have a persistent impact on external finance, whereas the impact on investment of external finance shocks is less persistent.

JEL classification: E22;

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1 Introduction

This paper provides a simple theoretical framework describing the links between investment, internal finance, and external finance. The model is developed on the assumption that a fixed share of the financial resources generated by industrial corporations is paid out to shareholders as dividends, while the remaining is used to finance investment, or alternatively is discretionally paid out when expected returns from investment opportunities are poor. Expected returns on investment, as captured by Tobin's q, being forward-looking, are not necessarily always in line with generated cash flows, so that the optimal desired investment may require an amount of financial resources larger than the quantity available, which has to be obtained from external sources. External finance is costly, particularly if a substantial amount of resources has to be gathered in a short period of time. As such, it is raised only to fill the gaps between desired levels of investment and internally generated funds available. In this framework the dynamic properties of financial flows play an important role in the dynamics of investment, since financial costs induce industrial firms to smooth investment over time not only to minimize adjustment cost on the stock of capital, but also to minimize the cost of adjusting the stock of external finance.

The standard approach followed to investigate the relevance of financial frictions on investment relies on the use of micro-level data, on the ground that different classes of industrial firms are likely to face different financial constraints. Implicit in this approach is the belief that macro-level data provide little information content, since the behavior of individual firms is averaged out in the process of aggregation. The literature so far has obtained important results, using panel data estimates. In particular, it is now well established that cash flows have strong explanatory power beyond average q in investment regressions, a finding usually interpreted as evidence of the relevance of the financing constraints facing firms. However, this evidence has been challenged by a number of studies which show that cash flows may be significant in investment regressions even in the absence of financial frictions.[1]

Recent works on the role of financial constraints, however, such as Jermann and

[1] See, for instance, Abel and Eberly (2011), Gomes (2001), and Hayashi and Inoue (1991).

Quadrini (2012), make use of aggregate data to exploit the availability of long time-series and to study the dynamic properties of investment, average q, and cash flows. These dynamics are important, as all these series are extremely persistent. We follow a similar approach by studying quarterly data from the Flow of Funds Financial Accounts of the United States, focussing on figures for non-financial corporations, over a long time span covering the period 1952 - 2013. We depart from Jermann and Quadrini (2012) by choosing data for non-financial corporations instead of non-financial businesses, to work with a relatively homogeneous aggregate, as investment from non-financial corporations represents 87 percent of the total. These data allow us to derive a new set of insights not available under the traditional approach. We find, in fact, that financial frictions are strongly significant even in spite of the aggregation issues and for an aggregate where large firms, in principle subject to weaker financial constraints, play an overwhelming role. Our evidence thus complements the results obtained in the literature based on panel data. In contrast with most of the existing literature, we test the relevance of financial frictions in the environment that *a priori* is expected to be more challenging. A finding that these frictions are significant is thus quite robust.

The following charts provide a visual insight of the above stylized facts. Fig. 1 displays a four periods moving average for the series of dividends distributed and the series of internally generated financial flows. Fig. 2 depicts the series of internally generated financial flows and investment whereas Fig. 3 sets out the series for the external finance raised together with investment.[2] The three diagrams show that the series under scrutiny strongly co-move over time. For instance, their pairwise correlations calculate, respectively, to 0.70, 0.55 and 0.61.[3]

The distinctive feature of our model is the specification of a functional form for the financing constraints, so that it becomes possible to study the dynamic properties

[2] All the above series are expressed as a percentage of the book value of capital and they are taken from the Flow of Funds Accounts of the United States for non-financial corporations.

[3] The correlation of 0.70 would be higher for annual data. In fact, the volatility of dividends around the year 2005 was a quickly reverted, temporary phenomenon that does not emerge on annual figures.

Figure 1: Internally generated financial flows (solid line, scale on left-hand side) and dividends (dotted line, scale on right-hand side).

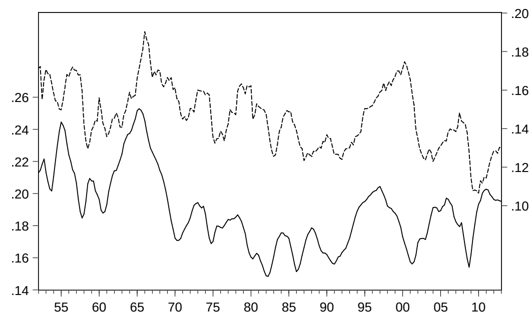

Figure 2: Internally generated financial flows (solid line, scale on left-hand side) and investment (dotted line, scale on right-hand side).

of the variables involved.[4] More specifically, we argue that when the cost of external finance is convex because of information costs, it generates additional adjustment costs on the stock of capital, on top of those usually assumed. Moreover, we introduce a simple dynamic dimension in the specification of cash-flows. The model thus generates a reduced form solution that explicitly incorporates a dynamic structure. Our empirical results strongly support this modelling strategy, as the lags predicted by the model are strongly significant. Moreover, the model suggests that, in presence of frictions of

[4]Gomes (2001) has introduced costly financing for firms in a general equilibrium framework, but leaving the model as general as possible, and imposing restrictive assumptions in the calibration process. A similar strategy allows to analyze the impact of financial constraints on firms returns, and it emerges that financially constrained firms have larger stock returns (see Gomes et al. (2006) and Whited and Wu (2006)).

Figure 3: Investment (solid line, scale on left-hand side) and external finance (dotted line, scale on right-hand side).

financial origin, a pattern of empirical results similar to the one usually found in the literature can be obtained even if adjustment costs on the stock of capital are zero. We carry out the empirical analysis by means of OLS and instrumental variables (IV) estimations, and Vector Auto-Regression (VAR) techniques, obtaining strong evidence that adjustment costs on external finance are statistically significant. We find that the dynamics of cash flows and that of investment are strictly interdependent, while external flows of finance and investment are only contemporaneously correlated. At the same time, though, we obtain a strong neutrality result, as we find that external finance is driven by investment, but investment is never significantly constrained by the availability of external finance.

The paper is organized as follows: Section 2 presents a survey of the literature, Section 3 develops the theoretical model of investment. Section 4 describes the dataset and the econometric approach used. Section 5 comments on the empirical results and Section 6 presents our conclusions.

2 The literature

Fumio Hayashi has shown that in presence of constant returns to scale and competitive markets, the marginal productivity of investment is equal to the average productivity, and it is measured by the ratio between the value of the liabilities of the firm and the replacement cost of capital, i.e. the Tobin's q. Under these conditions, Tobin's theory can be empirically tested, since the value of average q can be derived from the market prices of securities. The existing empirical evidence, however, has provided weak support for the theory. Bernanke et al. (1988), for example, suggest that the empirical performance of q regressions is no better than that of standard accelerator models. Moreover, the extremely small values usually found for the coefficient of the average q when this last is regressed on investment, imply extremely large values for the parameters of the adjustment cost function, which are highly implausible.[5] However, Whited (1994) suggests that in presence of technological shocks, the small coefficients for average q do not necessarily imply implausible large adjustment costs. Schaller (1990), and Gordon (1992) have instead explained the above evidence as the result of an aggregation bias. Moreover, Hayashi and Inoue (1991) suggest that most empirical studies erroneously treat the average q as an exogenous process, and the lack of a proper treatment of the serial correlation of truly exogenous shocks in the estimation procedures generates a downward bias in the empirical estimates.

Other scholars have challenged the theory from different angles. Studies based on micro data, such as Blundell et al. (1992) for the U.K., and Fazzari et al. (1988), or Gilchrist and Himmelberg (1995), for the U.S., indicate that, contrary to the predictions of the theory, average q is only one of several significant explanatory variables for investment, and other variables like output, profits, or cash flows have stronger explanatory power. This finding has also been interpreted as evidence of the relevance of the financing constraints facing firms. More specifically, several of these studies, such as Fazzari et al. (1988), Hubbard et al. (1995), or Gilchrist and Himmelberg (1995), find that investment is driven by internal funds in the case of classes of firms assumed *a priori* to face financing constraints.[6] Also this evidence, however, has been questioned: Hayashi and Inoue (1991) suggest that when the endogeneity of the marginal q is properly modelled, cash flows may be significant in investment regressions, even in the absence of financial frictions, while Abel and Eberly (2011) have developed a model where investment is positively related to cash flows even in the absence of both financ-

[5] See, for instance, Hall (2001).

[6] Hubbard (1998) provides an extensive survey of this literature.

ing constraints and convex adjustment costs. Gomes (2001) develops and calibrates a model with financial frictions, finding that cash flows are not always significant. The significance of cash flows in investment regression is thus not necessarily associated with the non-neutrality of financial variables. Jermann and Quadrini (2012), on the contrary, calibrate a business cycle model were financial frictions are relevant, finding that shocks of financial nature can explain the cyclical behavior of macroeconomic variables during the crisis beginning in late 2009.

An alternative strand of the literature attempts to rehabilitate the theory by showing that its poor empirical performance is due to the fact that average q is a poor proxy for marginal q. Several studies, in fact, provide evidence that measurement error severely biases the coefficient attached to average q, inducing as a result the poor sensitivity found in the empirical estimates. The measurement error problem may be produced by different factors, such as the relevance of intangible assets and human capital, and deviations of the market value of the capital stock from its intrinsic value. Although some papers that have explicitly addressed the effect of measurement errors, such as Blundell et al. (1992) and Gilchrist and Himmelberg (1995), have reasserted the findings of a significant role for internal funds, other studies, such as Erickson and Whited (2000), and Gomes (2001) suggest that measurement errors can generate most of the problems affecting empirical q models. In presence of measurement errors, in fact, OLS estimates for the mismeasured regressor are biased toward zero. The empirical evidence provided by Erickson and Whited (2000, 2006), supports the thesis that the measurement error is large, and that it can explain both the small values of the parameters attached to average q and the large values of those of cash flows.[7] Lamont and Stein (2006) challenge this interpretation, since they find that investment is equally sensitive to aggregate stock returns and values of q than to firm level measures of the same variables, while equity issuance is considerably more sensitive to the aggregate variables than the firm level ones. They argue, in fact, that measurement error in idiosyncratic measures of q cannot explain the sensitivity of investment to aggregate measure of q.

[7] See also Cummins et al. (2006).

3 The model

We explicitly introduce the cost of external finance in a standard investment model, by assuming that investment can be financed either internally, using current cash-flows, or externally, issuing shares or debt. Thus, over time, the firm must satisfy the following constraint:

$$P_t^I I_t = EF_t + \alpha NCF_t, \tag{1}$$

where $NCF_t = P_t^Y F(K_t, N_t) - w_t N_t$ defines current cash-flows, α is the share of cash flows that is not distributed to liability holders, I_t is real investment, K_t is the stock of capital, N_t and w_t are, respectively, the quantity and price of variable inputs, P_t^Y the price of the output and P_t^I the price of investment goods, EF_t is the flow of external finance, and $F(K_t, N_t)$ is a standard production function.[8] The expression above can be rewritten in real terms as:

$$I_t = E_t + \alpha CF_t = E_t + \alpha[R_t F(K_t, N_t) - W_t N_t], \tag{2}$$

where $E_t = EF_t/P_t^I$, $R_t = P_t^Y/P_t^I$, and $W_t = w_t/P_t^I$.

Following Froot and Stein (1998), it is now quite standard to assume that the recourse to external finance is costly, and that such cost is convex.[9] In conditions of imperfect information this is the case for debt, since bankruptcy risk rises with the amount of outstanding debt. Moreover, it is now well established that the demand curve for newly issued shares is downward sloping, because markets assume that insiders issue shares only when the market overprices them. As a consequence, the cost of equity issuance is also convex.[10]

[8] We assume that a fixed share $(1 - \alpha)$ of cash flows is distributed to shareholders (see, e.g., Brav et al. (2005)). This is clearly a rough simplification, but we want to abstract from the problem of the optimal dividend setting policy. Our empirical results, however, are not significantly influenced by the inclusion or omission of dividends from our explanatory variables.

[9] See also Kashyap and Stein (1995) and Stein (1998).

[10] The empirical evidence available suggests that large issues must imply a heavy discount, that is related to the size of the placement. See Asquith and Mullins (1986) and Gilchrist et al. (2005).

This standard framework implies that financial constrains are always or nearly always binding, and it seems more adequate to describe the condition of small firms. However, it does not seem adequate to describe large firms in the US, since they normally hold very large buffers of liquid securities. Moreover, industrial firms typically have access to bank credit through commitment loans, nowadays representing by far the largest share of commercial and industrial lending.

Given our focus on corporate business, we describe the cost for external finance as linear, but we introduce the further assumption that information costs generate adjustment costs, whose size is related to the ratio between the amount of external finance required during a time period, and the book value of the existing stock of capital. The value of existing capital, in fact, provides the collateral for the new finance raised, limiting potential losses in case of defaults, and its size is critical for the risk profile that outside investors face. The convexity of the external finance cost function implicitly generates adjustment costs on capital different from those usually assumed (based on frictions of real origin). It is more expensive to finance a rapid increase of the capital stock, rather than small and smooth incremental investment projects. External investors, in fact, because of uncertainty, prefer to spread the disbursement over time rather than undertaking a lump-sum installment. In this way they properly price the option value of time, since by waiting they can choose to invest only if the actual realizations of the stochastic processes involved are favorable and generate the expected increase in cash flows.[11] As risk rises with the amount of new finance required during a period of time, the cost of external finance surges because external investors need a premium to give up their option. In contrast with the standard hypothesis regarding information costs, frictions of this nature are likely to be relevant independently of the size of the firm.

In any other aspect, the model presents features in line with the standard literature. In particular, we assume constant returns to scale to capital and labour input in the production function. Assuming linear costs for external finance, the Lagrangian of the

[11]The investor providing external finance faces the same kind of problem of the industrial investor facing the real-option problem discussed in great detail by Dixit and Pindyck (1994).

problem is the following:

$$\ell = \sum_{t=0}^{\infty} \beta^t \Big\{ \Big[P_t^Y \Big(F(K_t, N_t) - \psi(I_t, K_t) - \phi(E_t, K_t) \Big) - W_t N_t - P_t^I I_t - P_t^E E_t \Big] + \\ -\lambda_t \Big[K_t - K_{t-1}(1-\delta) - I_t \Big] - \mu_t \Big[E_t - I_t + \alpha \Big(R_t F(K_t, N_t) - W_t N_t \Big) \Big] \Big\}, \quad (3)$$

where $\psi(I_t, K_t)$ and $\phi(E_t, K_t)$ are the adjustment cost functions and P_t^E is the nominal cost of external finance.

The first order conditions for investment and external finance are:

$$\frac{\partial \ell}{\partial I_{t+j}} = \beta^{t+j} \Big[- P_{t+j}^I - P_{t+j}^Y \psi'(I_{t+j}) + \lambda_{t+j} + \mu_{t+j} \Big] = 0, \quad (4)$$

$$\frac{\partial \ell}{\partial E_{t+j}} = \beta^{t+j} \Big[- P_{t+j}^Y \phi'(E_{t+j}) - P_{t+j}^E - \mu_{t+j} \Big] = 0. \quad (5)$$

Rearranging Eq. (5), we obtain that the Lagrange multiplier μ_{t+j} must be equal to the marginal cost of external finance, or the marginal benefits of cash payouts. Replacing this expression in Eq. (4), we obtain:

$$P_{t+j}^I + P_{t+j}^E + P_{t+j}^Y \psi'(I_{t+j}) + P_{t+j}^Y \phi'(E_{t+j}) = \lambda_{t+j}. \quad (6)$$

The above relationship implies that the value of the capital (the shadow value of investment) must be equal to the marginal industrial adjustment cost plus the marginal adjustment cost of external finance. Hayashi (1982) has shown that the marginal and average Tobin's q are equal when returns to scale are constant. When this is the case, the parameter λ_{t+j}, measuring the marginal increase in value of the stock of capital, becomes equal to the Tobin's q: $(S_{t+j} + B_{t+j})/K_{t+j}$ where S_{t+j} and B_{t+j} measure, respectively, the value of equity and debt of the firm. Specifying the adjustment cost functions $\psi(I_t, K_t)$ and $\phi(E_t, K_t)$, it becomes possible to express Eq. (6) in terms of observable variables. In order to obtain the equality of the marginal and average Tobin's q, both these functions must be linearly homogeneous, respectively in investment and capital, and in external finance and capital.[12] We also assume that markets are competitive and returns to scale are constant, as in the zero-rent economy described by Hall (2001).

When these conditions hold, the first derivatives of the cost functions are linear, respectively, in the ratios I_t/K_t and E_t/K_t. Eq. (6), therefore, becomes:

$$P^I_{t+j} + P^E_{t+j} + P^Y_{t+j}\alpha\frac{I_{t+j}}{K_{t+j}} + P^Y_{t+j}\gamma\frac{E_{t+j}}{K_{t+j}} + P^Y_{t+j}k = \lambda_{t+j}, \qquad (7)$$

where k is a constant. From Eq. (7) we obtain the expression for the measure of the average q that we construct:

$$Qn_{t+j} = \frac{\lambda_{t+j} - P^I_{t+j} - P^E_{t+j}}{P^Y_{t+j}} = \frac{\frac{S_{t+j}+B_{t+j}}{K_{t+j}} - P^I_{t+j} - P^E_{t+j}}{P^Y_{t+j}} = \alpha\frac{I_{t+j}}{K_{t+j}} + \gamma\frac{E_{t+j}}{K_{t+j}} + k. \qquad (8)$$

This is the standard expression showing the return of the investment of a dollar in additional capital of the firm, as used extensively in the literature following Hayashi (1982).[13] We only obtain an extra term in external finance that implies a further correction to the empirical measure of Tobin's q on top of the standard one given by the ratio between investment and output deflators. We use alternative specifications for the cost of external finance, but in any case the correction introduced does not have strong impact on the stochastic properties of Qn_{t+j}. The cost of finance reduces the average level of the series by about 10 percent during the period 1979-1981 when interest rates peaked and by a lower amount in any other period, and it increases the variance of Qn_{t+j}, albeit marginally.

Since the model does not impose any restriction on external finance, the sign of coefficient γ may become negative. When this is the case, the value of Qn_{t+j} rises when discretionary payouts on top of dividends, largely carried out through share repurchases, are larger than financial resources raised in the market.

The solution of the model does not imply a unique causal relationship: external

[12] A widely used specification of such a function is $\psi(I_t, K_t) = (\alpha/2)(I_t/K_t - v)I_t$, as in Hubbard et al. (1995). Analogously, we define the adjustment cost function for external finance as $\phi(E_t, K_t) = (\gamma/2)(E_t/K_t - w)E_t$.

[13] See, for a recent example, Cummins et al. (2006).

finance may act as a constraint for investment, so that the former expression can be solved for the investment ratio, or alternatively the amount of external finance raised can be studied as the dependent variable:

$$\frac{I_{t+j}}{K_{t+j}} = a_0 + a_1 Qn_{t+j} + a_2 \frac{E_{t+j}}{K_{t+j}} \tag{9}$$

or

$$\frac{E_{t+j}}{K_{t+j}} = b_0 + b_1 Qn_{t+j} + b_2 \frac{I_{t+j}}{K_{t+j}}. \tag{10}$$

The standard relationship between Q and investment, however, could be produced by either the usual industrial adjustment costs, or the financial ones. Importantly, the last relationship would hold even if the adjustment costs $\psi(I_t, K_t)$ were insignificant. In this case, the term I_{t+j}/K_{t+j} would disappear from Eq. (8), and, as a consequence, Eq. (9) should be solved for external finance, as external finance only would be linked to Qn_{t+j}. However, external finance is linked to investment through the financing constraint. After substituting in Eq. (9) the value of E_{t+j} from Eq. (2), we obtain:

$$\frac{I_{t+j}}{K_{t+j}} = c_0 + c_1 Qn_{t+j} + c_2 \frac{CF_{t+j}}{K_{t+j}}. \tag{11}$$

It is thus difficult to test if the standard finding of a strongly significant value of Qn_{t+j} in the regression is due to the relevance of frictions of industrial or financial origin. However, the coefficients a_1 and a_2 in Eq. (9) are simultaneously significant only when both types of adjustment costs play a role. On the contrary, a finding that the coefficient c_1 in Eq. (11) is not significant might in principle indicate that frictions of industrial origin are not important.

An obvious extension of the model implies the assumption that investment expenditure is financed out of both current and past retained cash flows:

$$I_t = E_t + \sum_{i=0}^{n} \alpha CF_{t-i}. \tag{12}$$

Past cash flows, when positive, generate a stock of liquid securities that the firm can use at will as a source of finance; when negative they produce a stock of debt that must be serviced by means of current cash flows.[14] Given that past cash flows are predetermined variables, the first order conditions remain unaffected but the baseline relationships of Eqs. (9) - (11) change substantially. In the simplest case, when we assume $n = 2$ and a constant value for α, we can rewrite the constraint as:

$$I_t = E_t + \alpha CF_t + \alpha CF_{t-1} I_{t-1} = E_{t-1} + \alpha CF_{t-1} + \alpha CF_{t-2}, \tag{13}$$

and thus, by substituting backward we obtain:

$$I_t = E_t + \alpha CF_t + I_{t-1} - E_{t-1} - \alpha CF_{t-2}, \tag{14}$$

or

$$E_t = I_t - \alpha CF_t - I_{t-1} + E_{t-1} + \alpha CF_{t-2}. \tag{15}$$

As a result, the values of $P_t^I I_t$ and EF_t can be expressed as a function of their current and lagged values, plus the current value of cash flows. This simple modification of the model would imply the relevance of lagged values of cash flows in Eq. (11) and the persistence of the series in Eq. (9) and (10). These last equations become, respectively:

$$\begin{aligned} \frac{I_{t+j}}{K_{t+j}} = a_0 + a_1 Qn_{t+j} + a_2 \frac{CF_{t+j}}{K_{t+j}} + \sum_{i=0}^{n} a_{i+3} \frac{E_{t+j-i}}{K_{t+j-i}} + \\ + \sum_{k=1}^{n} a_{n+3+k} \frac{I_{t+j-k}}{K_{t+j-k}} + a_{2n+4} \frac{CF_{t+j-n-1}}{K_{t+j-n-1}} \end{aligned} \tag{16}$$

$$\begin{aligned} \frac{E_{t+j}}{K_{t+j}} = b_0 + b_1 Qn_{t+j} + b_2 \frac{CF_{t+j}}{K_{t+j}} + \sum_{i=1}^{n} b_{i+2} \frac{E_{t+j-i}}{K_{t+j-i}} + \\ + \sum_{k=0}^{n} b_{n+3+k} \frac{I_{t+j-i}}{K_{t+j-i}} + b_{2n+4} \frac{CF_{t+j-n-1}}{K_{t+j-n-1}}. \end{aligned} \tag{17}$$

[14] We leave unexplained the choice between holding a buffer and running debt, which largely depends on the volatility of cash flows. At the firm or industry level this assumption may be over-restrictive since there is substantial variability both intra-industry and inter-industry in the degree of leverage. However, the assumption is more acceptable when dealing with aggregate data, since the degree of leverage is in this case quite persistent.

Given the specification of Eq. (12) the lag structure of external finance and investment should be the same. A finding that values of cash flows are significant, together with the lagged values of the dependent variable in Eqs. (16) and (17), would confirm that financial frictions are relevant. Similarly, a finding that external finance and investment remain significant in the investment and external finance regressions, after controlling for the dynamics of the variables, would provide support for our modelling strategy.

4 Dataset and Estimation Technique

We use quarterly aggregate data for non-financial corporations of the US spanning from 1952:Q1 to 2013:Q1, provided by the Flow of Funds Accounts maintained by the Federal Reserve Board. The deflators applied to the series under scrutiny are taken from the NIPA dataset of the Bureau of Economic Analysis.

The series INV is the ratio between real investment and stock of capital. Real investment is calculated as the ratio between "Gross Fixed Investment of Non-Financial Corporate Businesses" and the "Price Deflator of Fixed Investment". Real capital is constructed by capitalizing forward real investment with an annual depreciation rate of 10 percent and with initial value (virtually irrelevant) taken from Robert E. Hall's dataset.[15] The standard Tobin's q is computed as the ratio between the "Value of All Securities" minus "Inventories" and the replacement cost of capital, the latter computed as the real stock of capital times the "Price Deflator of Fixed Investment". The Tobin's q is then corrected multiplying it by the ratio between "Price Deflator of Fixed Investment" and "Price Deflator of Personal Consumption". Qn is then constructed by subtracting from the series previously generated the real yield on BAA corporate bonds, as a proxy for the cost of external finance. An alternative version is also computed by subtracting yields on AAA corporate bonds. Yields are deflated by using the inflation rate obtained from the "Price Deflator of Fixed Investment". INFLOWS is calculated as the ratio between "Credit and Equity Market Instruments" and the

[15] See Hall's web page at http://www.stanford.edu/ rehall/.

replacement cost of capital. "Credit and Equity Market Instruments" measures the net availability of new funds as the sum of net new equity issues and credit market instrument flows. CASH is calculated as the ratio between the book value of internal funds plus net dividends paid, and the replacement cost of capital. The book value of internal funds is obtained by adding the capital consumption allowance (consumption of fixed capital plus capital consumption adjustment) to profits before tax, and by subtracting taxes on corporate income and net dividends. The marginal productivity of capital MPK is computed as the ratio between net operating surplus and replacement cost of capital.[16]

The empirical evaluation of the theoretical model set out in Section 2 is carried out by means of OLS linear regressions. The same regressions are estimated by means of IV when the Hausman test provides evidence of endogeneity. When we find evidence of serial correlation or heteroscedasticity in the residuals we make use of the Continuously Updated Estimator (CUE), a GMM estimator proposed by Hansen et al. (1996). Although the CUE provides no asymptotic efficiency gains over two-step GMM and IV, recent research suggests that its finite sample performance may be superior.[17] Moreover, these estimators are robust to the presence of serial correlation in the residuals.

We then analyze the dynamic properties of the same model by employing standard VARs, in order to account for the possible endogeneity among the variables. A further advantage of VARs is that they yield valid estimates even though some of the variables under scrutiny are non-stationary, as long as the system as a whole remains stable.[18] This is a relevant feature of our analysis, as some of the variables considered are stationary (such as investment or the different variables measuring financial flows)

[16]Values for net operating surplus are obtained from the NIPA database (table 1.14, line 24).

[17]As discussed in Baum et al. (2007).

[18]More specifically, Sims et al. (1990) have shown that in VAR models which contain both stationary and non-stationary series, the coefficients of stationary regressors will have normal asymptotic distributions while those of integrated regressors will have non-normal asymptotic distributions, and Granger causality tests with non standard limiting distributions (see also Canova (2007), Hamilton (1994) and Lütkepohl (1993)). The stability of the VAR, in turn, is evaluated by computing the associated eigenvalues and checking that they fall within the unit circle.

whereas others, Qn and CASH in particular, are not. As suggested by Gonzalo and Pitarakis (2004) we employ the Akaike Information criterion (AIC) to determine the lag length of our VARs.[19] Throughout the paper all the impulse response functions are generated using the Generalized Impulses Procedure, as described in Pesaran and Shin (1997).[20]

We estimate the VAR models without first-differencing the non-stationary variables. The inclusion of these variables in levels, in fact, does not affect the overall stability of our VAR specifications and the reliability of the empirical estimates. The stationarity of the residuals originated by the estimated VAR models suggests that the specifications adopted are indeed stable. When we proceed to the interpretation of the impulse-response functions and Granger causality tests, the issue of non-stationarity in some variables must be taken into account, insofar some standard inferential results cannot be applied. Conventional Granger causality tests are, in fact, no longer valid when an I(1) variable is used as a regressor. In this situation though, Lutkepohl and Kratzig (2004) show that the causality tests can be performed by estimating a VAR specification with an additional lag, and by conducting a Wald test in which the last adjunct lag is neglected.[21] The only problem with this procedure is that, because of the redundant parameters, it is not fully efficient. Nevertheless, given the length of our database, and a large number of degrees of freedom, this should not represent a problem. A further important advantage of our dataset is that it should be subject to small measurement error, since the flow of funds data cover the whole population of U.S. firms. This is particularly relevant in Granger causality analysis, since error in variables can generate spurious causality.[22]

We introduce two dummy variables for the quarters 1979:Q3 and 1980:Q1. In the first quarter the adoption of the new operating procedures by the FED produced a sharp reduction of commercial paper issuance that was entirely reversed two quarters

[19]These authors have shown that for VAR models that include three or more variables the AIC becomes, by far, the best performing lag length criterion. Moreover, alternative criteria such as the Schwarz and Hannan-Quinn deliver very similar results.

[20]Different procedures for the impulse responses yield outcomes that are virtually identical.

[21]See also Dolado and Lutkepohl (1996).

[22]See Sargent (1987).

afterwards. Moreover, we introduce a seasonal dummy for the third quarter of the year that turns out to be always significant for all the variables. We test for the introduction of a deterministic trend, and it turns out to be not significant.

Finally, we carry out a number of different robustness checks. Firstly, we re-estimate linear regressions and VARs with an alternative specification of the Tobin's q obtained by using yields on AAA corporate bonds. Secondly, we carry out empirical estimates of linear regressions for a shorter period spanning from 1952:Q1 to 2007:Q1. Thirdly, we supplement our baseline VARs with either yield spreads or growth rates in oil prices. The former is calculated as the difference between yields on 10-year government bonds and 3-month T-Bills whereas the latter is computed as relative annual changes in WTI oil prices.[23] However, none of these modified specifications has any significant impact on our results.

5 Results

5.1 Contemporaneous regressions

The empirical estimates of Eqs. (9), (10), and (11) are reported in Table 1. For each equation we report both the OLS and IV estimates, as the Hausman tests provide evidence of endogeneity between INFLOWS, INV, Qn, and CASH. The choice of the instruments is dictated by the logical assumptions of the model. We use lagged values of dividends and marginal productivity of capital. Dividends are a natural candidate as they are set by a fixed rule, exogenous by definition, and while the current value is strictly correlated to current cash flows, lagged values are presumably uncorrelated with current investment and INFLOWS, whose amount is set in a forward looking way on the basis of the expected productivity of capital as captured by Qn. But the current value of securities is correlated with current and past values of dividends, to the extent that profit margins of industrial firms are persistent. Similarly, while current values of MPK are likely to be closely correlated with all the variables of the model, past values should not directly explain neither INV nor INFLOWS. On the contrary,

[23] These series are taken from the FRED database at the Federal Reserve Bank of St. Louis.

since the endogeneity between INV and INFLOWS is driven by the persistence of the series when past cash flows are used to finance investment, past values of MPK should capture these dynamics.

We find that the instruments we use, i.e. first and second lag of dividends and MPK, are not correlated with the error processes as the Hansen tests fail to reject the null at standard significance levels. The above instruments are not weakly identified, as both the Kleibergen-Paap Wald and LR statistics soundly reject the null. Moreover, they are strongly correlated with the endogenous regressors, as the Stock and Yogo rk Wald statistic strongly rejects the null.[24] Since we find evidence of serial correlation in the residuals, we make use of the CUE estimator which is robust to departures from the assumption of iid disturbance terms.[25]

The estimation of the investment relationship of Eq. (9) indicates that both Qn and INFLOWS are statistically significant at the 1 percent level, and both the coefficients have positive sign as predicted by the model. The statistical significance of the coefficient attached to INFLOWS suggests that financial frictions are relevant. The results do not change substantially between the OLS and IV estimations, although both coefficients are larger in the latter case, and Hausman tests (not reported) indicate that all variables are endogenous. Diagnostic tests show that the residuals are serially correlated and heteroscedastic.

The empirical estimates of Eq. (10) show that both Qn and INV are statistically significant at the 1 percent level. The strongly significant and positive coefficient for INV suggests that external finance flows are driven by investment needs. However, the negative sign of the Qn coefficient indicates that external finance is unlikely to represent a constraint for investment, as net inflows decline when expected returns from investment are higher. Since negative values of INFLOWS represent payouts to liability holders, as for example share repurchases, it is not surprising to find such a negative correlation. But endogeneity problems make it difficult to establish clear causal relationships. Although the results do not change much between the OLS and IV estimations, also in this case values are larger, in absolute values, for the IV

[24]See Baum et al. (2007).

[25]The Cumby-Huizinga test statistic suggests, in fact, that residuals are serially correlated.

estimates. Also in this case, diagnostic tests suggest the presence of serial correlation and heteroscedasticity in the residuals.

The estimates of Eq. (11) show that CASH is strongly significant and positive, whereas Qn remains significant in the IV regression only, but the sign becomes negative. In this case, however, the Hansen test of over identifying restrictions is strongly rejected, so that the instruments are not independent from the error process, and the estimates are unreliable. The problem cannot be easily solved by means of other instruments as it seems likely that lagged values of cash flows and investment are mutually interconnected, so the dynamic structure of the problem must be properly identified. We then explore the possibility that lagged values of cash flows explain

Table 1: OLS and IV empirical estimates of Eqs. (9), (10) and (11).

$INV_t = a_0 + a_1 Qn_t + a_2 INFLOWS_t + \eta_t$				OLS
a_0	a_1	a_2	R^2	
0.131	0.011	0.313	0.44	
(95.51)	(5.340)	(12.81)		
$Q(4)^{\dagger} = 345$ (0.000)	$Q(8)^{\dagger} = 440$ (0.000)	$Q(12)^{\dagger} = 450$ (0.000)	$W^{\flat} = 1.990$ (0.080)	
$INV_t = a_0 + a_1 Qn_t + a_2 INFLOWS_t + \eta_t$				IV
a_0	a_1	a_2	R^2	
0.011	0.028	0.641	0.98	
(28.17)	(5.071)	(8.080)		
$K-P^{\ddagger} = 32.79$ (0.000)	$S-Y^{\S} = 10.79$ (4.720)	$H^{\maltese} = 0.156$ (0.930)	$C-H^{\pounds} = 4.420$ (0.036)	
$INFLOWS_t = b_0 + b_1 Qn_t + b_2 INV_t + \eta_t$				OLS
b_0	b_1	b_2	R^2	
-0.143	-0.013	1.290	0.40	
(-9.781)	(-3.260)	(12.81)		
$Q(4)^{\dagger} = 131$ (0.000)	$Q(8)^{\dagger} = 181$ (0.000)	$Q(12)^{\dagger} = 199$ (0.000)	$W^{\flat} = 1.490$ (0.190)	
$INFLOWS_t = b_0 + b_1 Qn_t + b_2 INV_t + \eta_t$				IV
b_0	b_1	b_2	R^2	
-0.177	-0.044	1.560	0.73	
(-6.370)	(-5.571)	(8.071)		
$K-P^{\ddagger} = 50.60$ (0.000)	$S-Y^{\S} = 30.39$ (4.720)	$H^{\maltese} = 0.156$ (0.930)	$C-H^{\pounds} = 6.330$ (0.012)	
$INV_t = c_0 + c_1 Qn_t + c_2 CASH_t + \eta_t$				OLS
c_0	c_1	c_2	R^2	
0.078	0.003	0.357	0.31	
(10.79)	(1.310)	(9.251)		
$Q(4)^{\dagger} = 679.1$ (0.000)	$Q(8)^{\dagger} = 905.3$ (0.000)	$Q(12)^{\dagger} = 963$ (0.000)	$W^{\flat} = 3.940$ (0.000)	
$INV_t = c_0 + c_1 Qn_t + c_2 CASH_t + \eta_t$				IV
c_0	c_1	c_2	R^2	
0.015	-0.029	0.720	0.98	
(1.041)	(-4.180)	(9.221)		
$K-P^{\ddagger} = 43.32$ (0.000)	$S-Y^{\S} = 17.94$ (4.720)	$H^{\maltese} = 17.66$ (0.000)	$C-H^{\pounds} = 8.910$ (0.003)	

Notes: Sample period spans from 1952:Q1 to 2013:Q1. T-statistics in parenthesis. R^2 computed as 1-(sum of squared error/sum of squares deviation).
† Portmanteau test for the null of no serial correlation up to lags lags 4, 8 and 12. P-values in parenthesis.
♭ White test for the null of no heteroscedasticity. P-values in parenthesis.
‡ Underidentification test: Kleibergen-Paap rk LM statistic. P-values in parenthesis.
§ Weak identification test: Kleibergen-Paap rk Wald F statistic, Stock-Yogo weak identification test critical values at 10% maximal LIML size in parenthesis.
✠ Hansen J-statistic (overidentification test of all instruments). P-values in parenthesis.
£ Cumby-Huizinga test for the null of residuals non-autocorrelated at order 1. P-values in parenthesis.

investment. The empirical estimates of Eqs. (16) and (17) are set out in Table 2. Standard diagnostic tests suggest that the residuals are free from serial correlation but not from heteroscedasticity. However, given the large number of degrees of freedom, heteroscedasticity should not plague the consistency of the estimators. The simplest dynamic model, built under the assumption that cash flows from two periods contribute to finance investment, generates results that are virtually identical to the ones reported. We add two more lags of the dependent variable to clean the residuals, but they do not alter the picture.

Once past values of INV are included in the investment regression, as predicted by the model, both CASH and Qn are statistically significant. Similarly, INFLOWS remains strongly significant, so that the findings that frictions of financial nature are relevant are confirmed also in the dynamic framework. The OLS and IV regressions provide very similar results. In the IV regressions we treat CASH and INFLOWS as endogenous, as suggested by the Hausman test.

We then estimate Eq. (17) by means of OLS, as we find no evidence of endogeneity when lags of the dependent variable are added as explanatory variables. We find that Qn has no impact whatsoever on INFLOWS, while both current and lagged values of CASH are significant. INV remains strongly significant, so that the introduction of the dynamic dimension does not alter the basic implication of the model, namely that the net financial inflows, or net payout to liability holders, are driven by the relative magnitude of cash flows and investment needs.

As a robustness check we estimate Eqs. (16) and (17) for a shorter period, until 2007:Q1, to exclude the period encompassing the financial crisis. The results for Eqs. (16) are very similar to those for the entire sample, the only difference is that the coefficients of Qn and CASH become marginally larger and more significant, while that of INFLOWS becomes marginally smaller. The results for Eqs. (17) remain very similar for most of the variables, with the exception of CASH that becomes not significant. The pattern of results previously obtained survives even when the two regressions are estimated over two smaller samples which span from 1952:Q1 to 1972:Q4, and from 1973:Q1 to 2013:Q1. The only relevant differences is that Qn is not significant in the investment regressions for any of the two subsamples. Moreover, when Eq. (17) are estimated on the first subsample CASH becomes not significant whereas Qn takes positive and significant values. Qn becomes negative but not significant in the second subsample, indicating that the zero coefficient for the whole sample is the result of different regimes occurring over the two periods, and it can be explained with the increased relevance that share repurchases have assumed in the recent decades as a tool to remunerate shareholders.[26] Overall these robustness checks further confirm that financial frictions are relevant, while the importance of the industrial adjustment costs is probably often overstated because in standard q regression the former are not modelled, so that the latter appear to be responsible for all the frictions present in the data.[27] We thus have strong evidence that financial frictions play a very important

Table 2: OLS and IV empirical estimates of Eqs. (16) and (17).

$INV_t = a_0 + a_1 Qn_t + a_2 CASH_t + a_3 INFLOWS + a_4 INV_{-1} + a_5 INV_{-2} + \eta_t$							OLS		
a_0	a_1	a_2	a_3	a_4	a_5	R^2			
0.006	0.001	0.070	0.043	1.060	-0.210	0.95			
(2.360)	(2.051)	(5.841)	(4.760)	(17.67)	(-3.810)				
$Q(4)^{\dagger} = 3.560$ (0.471)		$Q(8)^{\dagger} = 7.601$ (0.470)		$Q(12)^{\dagger} = 18.95$ (0.090)		$W^{\flat} = 2.810$ (0.000)			
$INV_t = a_0 + a_1 Qn_t + a_2 CASH_t + a_3 INFLOWS + a_4 INV_{-1} + a_5 INV_{-2} + \eta_t$							IV		
a_0	a_1	a_2	a_3	a_4	a_5	R^2			
-0.009	0.001	0.054	0.059	1.080	-0.231	0.99			
(2.980)	(1.951)	(4.310)	(3.581)	(12.41)	(-2.780)				
$K - P^{\ddagger} = 23.12$ (0.000)		$S - Y^{\S} = 6.651$ (4.060)		$H^{\maltese} = 6.341$ (0.171)		$C - H^{\pounds} = 5.730$ (0.021)			
$INFLOWS_t = b_0 + b_1 Qn_t + b_2 CASH_t + b_3 INV + b_4 CASH_{t-1} + \sum_{i=1}^{4} b_{i+4} INFLOWS_{t-i} + \eta_t$									
b_0	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	R^2
-0.053	0.0002	0.555	0.381	-0.504	0.303	0.161	0.060	0.184	0.57
(-3.001)	(0.051)	(2.711)	(2.352)	(-2.330)	(4.691)	(2.352)	(0.890)	(2.851)	
$Q(4)^{\dagger} = 0.301$ (0.990)		$Q(8)^{\dagger} = 9.022$ (0.341)		$Q(12)^{\dagger} = 915.3$ (0.220)		$W^{\flat} = 1.981$ (0.000)			

Notes: Sample period spans from 1952:Q1 to 2013:Q1. T-statistics in parenthesis. R^2 computed as 1-(sum of squared error/sum of squares deviation).
† Portmanteau test for the null of no serial correlation up to lags lags 4, 8 and 12. P-values in parenthesis.
♭ White test for the null of no heteroscedasticity. P-values in parenthesis.
‡ Underidentification test: Kleibergen-Paap rk LM statistic. P-values in parenthesis.
§ Weak identification test: Kleibergen-Paap rk Wald F statistic, Stock-Yogo weak identification test critical values at 10% maximal LIML size in parenthesis.
✠ Hansen J-statistic (overidentification test of all instruments). P-values in parenthesis.
£ Cumby-Huizinga test for the null of residuals non-autocorrelated at order 1. P-values in parenthesis.

role in explaining investment. This result holds at the aggregate level even when we make use of a dataset that excludes non-corporate investment, and after controlling for the recent periods of financial distress.

[26] These results are not reported but available from the authors upon request.
[27] These results are in line with Hall (2004) and Groth and Khan (2010).

The empirical results of this section, however, must be interpreted with caution as there is evidence of non stationarity for both the Qn and CASH series. Thus, we proceed in the analysis by making use of VARs which account for non stationarity in some of the variables included, and enable a proper treatment of causal relationships. We carry out the analysis by estimating several VAR specifications and by imposing as little theoretical structure as possible.[28]

5.2 VAR analysis

We begin our analysis with the specification of Eq. (9), so that our initial VAR consists of the variables Qn, INV and INFLOWS. Empirical results are displayed in Table 3. The upper panel reports Granger causality tests while the lower panel sets out a number of diagnostic tests for the null of no serial correlation and heteroscedasticity in the residuals. Granger causality tests highlight that the null that Qn does not granger-cause INV or INFLOWS is rejected at standard significance levels in both cases. The causality is stronger in the case of INV, where the null is rejected at the one percent level. We find evidence that INFLOWS granger-cause Qn at the 10 percent level, while the null that INV does not granger-causes Qn and that INFLOWS does not granger-cause INV cannot be rejected at standard significance levels.

Fig. 4 reports the impulse response functions that are statistically significant. As expected, the response of INV to Qn is positive and strongly significant. It is more surprising though that the response of investment is extremely slow. This last, in fact, is initially small and not statistically significant, and it peaks only after two years. This explains why basic static models perform badly. The response of INFLOWS to Qn shocks is very similar, although the impact is somewhat anticipated with respect to that on INV. XXX On the contrary, the response of Qn to INFLOWS shocks is negative and significant after four quarters. This last result suggests that when net inflows decline, for instance because of share repurchases, expected returns from investment tend to increase. This finding supports the previous evidence based on regression

[28]This section is inspired by the remarks of Christopher A. Sims in his discussion of Morck et al. (1990).

analysis that external finance is unlikely to represent a constraint for investment. XXX Finally, the response of INFLOWS to INV shocks is positive but only marginally significant, suggesting that external finance responds to investment innovations (as the contemporaneous regressions have highlighted), but the persistence of the impact is rather limited.

Finally, we decompose the variance of the three variables. It is important to notice that the results we obtain are not affected by the ordering among the variables, suggesting that contemporaneous relationships do not play a predominant role. Qn innovations explain a large and statistically significant share of the forecasting error variance of INV (19.3 percent after 4 quarters and 37.6 percent after 8 quarters) and INFLOWS (7.6 percent after 4 quarters and 13.3 percent after 8 quarters). The forecasting error variance of Qn, on the contrary, is explained by INFLOWS at horizons as long as 16 quarters.

We find no evidence that external finance is a relevant constraint on investment, as INFLOWS do not granger-cause INV at any level of significance, while they explain only a small and not significant percentage of the forecasting variance of INV. On the contrary, our results highlight that positive shocks to INV generate a positive and significant impact on INFLOWS at horizons as short as 2 quarters.

Both Liung-Box and LM tests reported in the lower panel of Table 3 fail to reject the null no serial correlation in the residuals of the estimated VAR model, whereas the White test soundly rejects the null of homoscedasticity. All in all, the above statistics suggest that the model is reasonably well specified.

We then partition our sample in two subperiods which span from 1952:Q1 to 2006:Q4, and from 1992:Q1 to 2013:Q1 in order to isolate the impact of the 2007-2010 Crisis. Both Granger causality tests and variance decompositions for the estimated VARs are reported in Tables 3 and 4. The pattern of results we obtain is very similar to that previously set out for the entire sample. The only difference is that for the most recent subperiod INV granger-causes INFLOWS, even though at the 10 percent level only. Both the impulse response (not reported) and variance decomposition support the above result. For instance, the share of variance of INFLOWS explained by INV more than doubles when the Crisis is included.[29] The diagnostic statistics suggest that the VAR models estimated on the restricted samples are reasonably well specified.

We carry out a number of different robustness checks. We begin by re-estimating the VAR specification with an alternative definition of Qn constructed by using yields on AAA corporate bonds. We then supplement the same VAR model with series for the yield spread and WTI oil price.[30] For these specifications we compute Granger causality tests, impulse response functions and variance decompositions and we obtain pattern of results very similar to the baseline model reported in Table 3 and Fig. 4 for the entire sample. All in all, the inclusion of alternative specification of Qn as well as of business cycle indicators such as yield spreads and oil price does not modify the dynamic relationship among Qn, INV and INFLOWS.[31]

5.2.1 Is the market a sideshow?

So far, we have found strong evidence that current values of cash flows are important predictors of industrial investment, and that when included in investment regressions, they make current values of Qn smaller and less significant. There is, nevertheless, no reason to assume a unique causal relationship running from Qn to investment, since the neoclassical theory of investment also implies that investment affects the current and future productivity of capital, and thus the value of Qn.

Furthermore, given that the value of Qn is largely dependent on market valuations of equities, if markets are efficient, Qn has to be forward-looking. It is thus possible that Qn is simply a forward-looking indicator of the returns on investment. To explore this hypothesis, in this section we estimate a VAR with Qn, CASH, and INV.[32]

[29] The share of variance after 8 quarters is 16.05 for the subperiod 1992:Q1-2013:Q1 which halves for the subperiod 1952:Q1-2006:Q4 as well as for the entire sample.

[30] More specifically, we compute annual returns on WTI oil price for the period 1974:Q1-2013:Q1 as in the period pre-1974 the series shows little variability.

[31] Both Ljiung-Box and LM statistics applied to the residuals originated by the three alternative VARs fail to reject the null of no serial correlation at standard significance levels, whereas White tests indicate the presence of heteroscedasticity. Empirical results are not reported to save space but are available from the authors.

[32] We exclude INFLOWS to increase the power of the tests used. Also in this case, the inclusion in our VAR model of I(1) variables does not impair the stability of the model itself. The eigenvalues of the system fall within the unit circle and the residuals turn out to be stationary.

Table 3: Granger causality tests among Qn, INV and INFLOWS.

	1952:Q1-2013:Q1			1952:Q1-2006:Q4			1992:Q1-2013:Q1		
	Qn	INV	INFLOWS	Qn	INV	INFLOWS	Qn	INV	INFLOWS
Qn	–	0.000	0.051	–	0.000	0.092	–	0.000	0.072
INV	0.307	–	0.242	0.189	–	0.167	0.127	–	0.072
INFLOWS	0.072	0.606	–	0.075	0.655	–	0.051	0.336	–
Q(6)[†]		14.43 (0.700)			14.34 (0.707)			19.03 (0.389)	
Q(12)[†]		74.62 (0.311)			86.46 (0.117)			72.38 (0.465)	
LM(6)[‡]		3.373 (0.947)			4.549 (0.872)			6.732 (0.664)	
LM(12)[‡]		9.519 (0.391)			13.15 (0.156)			9.155 (0.423)	
W[♭]		236.9 (0.000)			225.1 (0.002)			165.4 (0.287)	
R^2	0.92	0.95	0.58	0.93	0.94	0.52	0.86	0.98	0.50
Obs	241	241	241	216	216	216	85	85	85

Notes: The upper panel reports the p-values of the Wald test for the null hypothesis that $x_{1,t}$ does not granger-cause $x_{2,t}$ (see Dolado and Lütkepohl (1996)). The "dependent" variables $x_{2,t}$ are reported in the first row while the "explanatory" variables $x_{1,t}$ appear in the first column of the panel. Lag length (AIC) are 4 for the full sample and for the subsamples 1952:Q1-2006:Q4 and 1992:Q1-2013:Q1. The lower panel reports the following diagnostic statistics:

[†] Portmanteau test for the null of no serial correlation up to lag 6 and 12. P-values in parenthesis.

[‡] LM test for the null no serial correlation at lag 6 and 12. P-values in parenthesis.

[♭] White test for the null of no heteroscedasticity. P-values in parenthesis.

Table 4: Forecasting error decomposition for Qn, INV and INFLOWS.

		1952:Q1-2013:Q1			1952:Q1-2006:Q4			1992:Q1-2013:Q1		
T		Qn	INV	INFLOWS	Qn	INV	INFLOWS	Qn	INV	INFLOWS
2	Qn	99.77	0.186	0.042	98.87	0.849	0.276	90.20	8.86	0.936
	INV	4.634	95.01	0.359	3.758	96.11	0.132	7.008	90.97	2.020
	INFLOWS	4.511	5.869	89.61	3.745	6.048	90.20	19.74	3.062	76.72
4	Qn	97.76	0.886	1.354	95.48	2.245	2.265	77.81	20.68	2.671
	INV	19.32	79.77	0.904	16.97	82.47	0.557	18.73	80.05	1.209
	INFLOWS	7.604	8.101	84.29	6.130	7.729	86.13	19.22	9.998	70.77
8	Qn	89.25	1.091	9.654	85.43	2.173	12.38	55.07	41.24	3.679
	INV	37.62	61.38	0.986	34.78	64.67	0.537	27.29	72.07	0.626
	INFLOWS	13.38	8.288	78.32	10.83	7.962	81.20	20.63	16.05	63.31
16	Qn	74.76	0.929	24.31	70.01	1.506	28.47	48.36	48.03	3.603
	INV	45.18	52.38	2.429	42.67	53.94	3.388	24.45	74.69	0.789
	INFLOWS	15.40	8.091	76.56	13.14	7.704	79.23	20.64	17.30	62.09

Notes: Proportion of forecasting error variance at horizons 2, 4, 8 and 16 quarters. The "dependent" variables are reported in the first column while the "explanatory" variables appear in the first row of the table. For each panel the figures reported in the columns sum up to 100 percent.

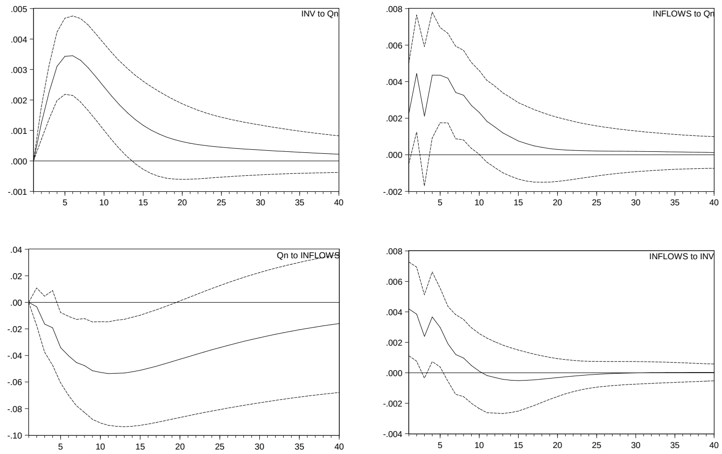

Figure 4: Impulse response functions of INV to one S.D. Qn innovations, of INFLOWS to Qn, of Qn to INFLOWS, and of INFLOWS to INV.

We find that the null that Qn and CASH (separately) do not granger-cause INV can be rejected at the 1 percent level. The impulse response functions of Fig.5 indicate that INV responds positively to both CASH and Qn shocks, with the former response which is slightly weaker than the latter. The variance decomposition confirms that Qn has a stronger explanatory power for INV than CASH. For instance, Qn innovations explain 30.1 percent of the forecasting error variance of INV after 8 quarters whereas CASH innovations explain about 9 percent.

Similarly, the null that INV does not granger-cause either CASH or Qn is strongly rejected. As expected, in fact, the impulse response functions of Fig.5 indicate that a positive INV shock generates negative responses of both CASH and Qn that are significant and highly persistent. The impact of the decreased MPK due to a larger investment is strong and persistent on both the current cash flows and expected profitability, in line with the basic neoclassical theory. Likewise, INV explains sizeable portions of the forecasting error variance of both CASH and Qn, as the figures set out in Table 6 suggest.[33]

Together with the evidence that CASH and Qn are endogenous with respect to

[33] We have chosen to have Qn first in the Choleski decomposition, followed by CASH. Also in this case the ordering chosen does not substantially affect the results.

INV, these findings strongly support the hypothesis that the Tobin's q is a leading indicator of the expected future profitability. As a consequence, market prices of securities play only a minor role in investment decisions. On the contrary, the delayed response to CASH shocks may be understood if industrial firms are heavily dependent on past cash flows to finance investment projects, and a peak response after a year and a half does not seem implausible.

Both Liung-Box and LM tests reported in the lower panel of Table 5 fail to reject the null of no serial correlation in the residuals at the 5 percent level, whereas the White test rejects the null of homoscedasticity. All in all, the above statistics suggest that the also in this case the estimated model is reasonably well specified.

We then estimate the same VAR model for the subperiods 1952:Q1-2006:Q4 and 1992:Q1-2013:Q1. Both granger causality tests and variance decompositions are reported in Tables 5 and 6. In this case the pattern of results obtained for the two subsamples is quite different. In fact, for the most recent subperiod the null that INV does not granger-cause Qn and CASH cannot be rejected at standard significance levels. Moreover, also the causality relationship from Qn to CASH vanishes. Both the impulse responses and variance decomposition support the above evidence.[34] For instance, the share of variability of CASH explained by INV decreases by more than 80 percent between the first and second subsample.

To check the robustness of our results we re-estimate the baseline VAR by replacing and supplementing it with the same series previously considered. For the three specifications under scrutiny we compute Granger causality tests, impulse response functions and variance decompositions and we obtain pattern of results very similar to the baseline model reported in Table 5 and Fig. 5 for the entire sample. All in all, also in this case the alternative specifications considered do not modify the dynamic relationship among Qn, INV and INFLOWS.[35]

[34] Impulse response functions for the two subperiods are not reported but available from the authors upon request.

[35] Both Ljiung-Box and LM statistics applied to the residuals originated by the three alternative VARs fail to reject the null of no serial correlation and the White tests fail to reject the null of homoscedasticity at standard significance levels. Empirical results for the supplemented VARs are not reported to save space but are available from the authors.

Table 5: Granger causality tests among Qn, CASH and INFLOWS.

	1952:Q1-2013:Q1			1952:Q1-2006:Q4			1992:Q1-2013:Q1		
	Qn	CASH	INV	Qn	CASH	INV	Qn	CASH	INV
Qn	–	0.001	0.000	–	0.001	0.000	–	0.356	0.000
CASH	0.508	–	0.013	0.163	–	0.017	0.979	–	0.000
INV	0.058	0.000	–	0.008	0.000	–	0.981	0.779	–
Q(6)†		28.06 (0.061)			19.44 (0.364)			49.10 (0.071)	
Q(12)†		89.72 (0.077)			75.33 (0.371)			121.2 (0.016)	
LM(6)‡		9.400 (0.401)			8.109 (0.523)			12.10 (0.207)	
LM(12)‡		9.967 (0.353)			5.481 (0.790)			14.22 (0.114)	
W♭		206.9 (0.022)			221.3 (0.004)			92.56 (0.245)	
R^2	0.93	0.94	0.95	0.94	0.93	0.94	0.83	0.84	0.98
Obs	241	241	241	216	216	216	85	85	85

Notes: The upper panel reports the p-values of the Wald test for the null hypothesis that $x_{1,t}$ does not granger-cause $x_{2,t}$ (see Dolado and Lütkepohl (1996)). The "dependent" variables $x_{2,t}$ are reported in the first row while the "explanatory" variables $x_{1,t}$ appear in the first column of the panel. Lag length (AIC) are respectively 4 for the full sample, 4 for the subsample 1952:Q1-2006:Q4, and 2 for the subsample 1992:Q1-2013:Q1. The lower panel reports the following diagnostic statistics:

† Portmanteau test for the null of no serial correlation up to lag 6 and 12. P-values in parenthesis.

‡ LM test for the null no serial correlation at lag 6 and 12. P-values in parenthesis.

♭ White test for the null of no heteroscedasticity. P-values in parenthesis.

Table 6: Forecasting error decomposition for Qn, CASH and INV.

T		1952:Q1-2013:Q1			1952:Q1-2006:Q4			1992:Q1-2013:Q1		
		Qn	CASH	INV	Qn	CASH	INV	Qn	CASH	INV
	Qn	99.06	0.051	0.891	96.50	0.163	3.347	95.14	0.053	4.814
2	CASH	2.27	87.46	10.27	1.045	87.45	11.52	4.634	93.91	1.452
	INV	3.932	1.183	94.89	2.741	0.737	96.53	10.71	5.814	83.48
	Qn	95.38	0.083	4.545	89.26	0.312	10.43	91.87	2.431	5.691
4	CASH	8.615	84.63	6.775	5.613	87.08	7.312	6.823	92.23	0.955
	INV	16.13	3.205	80.67	12.80	3.864	83.34	32.41	18.59	49.00
	Qn	89.43	2.131	8.443	79.54	4.012	16.45	81.46	12.73	5.816
8	CASH	6.601	75.39	18.01	4.172	78.50	17.33	6.183	91.40	2.426
	INV	30.08	8.762	61.16	23.08	16.011	60.91	40.72	35.60	23.68
	Qn	72.77	10.64	16.59	58.28	16.37	25.35	71.88	23.03	5.093
16	CASH	4.601	64.60	30.79	2.881	69.35	27.77	14.01	79.74	6.254
	INV	30.42	20.03	49.55	19.81	34.44	45.74	35.81	47.95	16.24

Notes: Proportion of forecasting error variance at horizons 2, 4, 8 and 16 quarters. The "dependent" variables are reported in the first column while the "explanatory" variables appear in the first row of the table. For each panel the figures reported in the columns sum up to 100 percent.

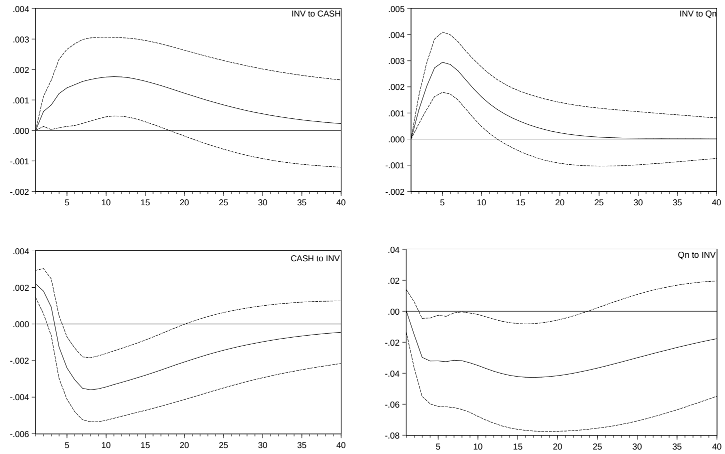

Figure 5: Impulse response functions of INV to one S.D. CASH innovations, of INV to Qn, of CASH to INV, of Qn to INV.

6 Conclusions

The theoretical model that we have developed identifies useful restrictions that we exploit to test whether external finance generates a different type of adjustment costs on top of those on the stock of capital which are standard in the literature. We find strong evidence that adjustment costs on external finance are significant, and produce an impact on the behavior of aggregate investment that is similar to that of standard adjustment costs of industrial origin.

We also find that the dynamic properties of aggregate investment can be largely explained by those of cash flows, indicating that financial constraints bind. More specifically, our results suggest that aggregate investment is mainly driven by current and past cash flows. This result is well documented in the literature, and it is supported by the evidence that small businesses have a limited access to security markets because of information costs. In spite of the aggregation issues, we find that these dynamics are not specific of small firms only, but they hold also for the aggregate investment of non-financial corporations. As a corollary of this result, it is normally suggested that since at least some firms are financially constrained, they would invest more if they could benefit from easier access to external sources of finance. We find some limited support for this implication. Although we find that flows of external funds impact on aggregate investment, and vice-versa in the current period, the effect of investment on external finance is far stronger than the opposite. Moreover, when analyzing the dynamic properties of the variables it emerges that financial flows are driven by aggregate investment, while the impact of financial flows on investment is not persistent.

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