UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 10/03

Investment, irreversibility, and financing constraints in transition economies

Alessandra Guariglia
(*Durham University*)

John Tsoukalas
(*University of Nottingham*)

Serafeim Tsoukas
(*University of Nottingham*)

April 2010

Investment, irreversibility, and financing constraints in transition economies

by

Alessandra Guariglia
(*Durham University*)

John Tsoukalas
(*University of Nottingham*)

and

Serafeim Tsoukas
(*University of Nottingham*)

Abstract

Using a panel of 4223 Bulgarian, Czech, Polish, and Romanian firms, over the period 1998-2005, we show that financially constrained firms likely to face irreversibility constraints exhibit low and insignificant sensitivities of investment to cash flow. These firms typically use their cash flow to accumulate cash instead of investing. Our findings provide a new explanation for why some financially constrained firms may exhibit low investment-cash flow sensitivities. Specifically, controlling for investment irreversibility may matter for the interpretation of these sensitivities.

JEL classification: D21; E22; E32; G31.

Keywords: Investment; Irreversibility; Cash flow; Cash accumulation; Capital market imperfections

Acknowledgements

Corresponding Author: Alessandra Guariglia; Email:alessandra.guariglia@durham.ac.uk.
We have received helpful comments from Michael Bleaney and seminar participants at the 2010 Royal Economic Society, University of Surrey. Serafeim Tsoukas gratefully acknowledges support from the Economic and Social Research Council, grant PTA-026-27-1790. Any remaining errors are our own.

1. Introduction

A large body of empirical work has established the significance of financial variables in influencing firm level investment. In this work, measures of internal finance are found to be important determinants of investment even after controlling for investment opportunities (see Schiantarelli, 1995; Hubbard, 1998; and Bond and Van Reenen, 2007, for surveys). For example, within an augmented Q model, Fazzari et al. (1988) find that the sensitivity of investment to cash flow is much higher for firms which are a priori expected to be liquidity constrained. This finding has proven remarkably robust: it has been reported in a variety of datasets, different countries, and time periods. Accordingly, investment cash flows sensitivities have been interpreted as evidence of capital market imperfections that disturb firms' investment from the frictionless neoclassical benchmark. An important challenge to this interpretation came from Kaplan and Zingales (1997), who focused on the sub-sample of firms classified as liquidity constrained by Fazzari et al. (1988) and concluded that higher sensitivities of investment to cash flow cannot be interpreted as evidence that firms are more financially constrained. A heated debate followed the publication of Kaplan and Zingales' (1997) article (Fazzari et al., 2000; Kaplan and Zingales, 2000; Clearly, 1999; Guariglia, 2008 and so on) [1].

With very few exceptions, however, empirical studies on investment typically neglect the potential effects of investment irreversibility when testing for the capital market imperfections hypothesis. In this paper we argue that investment irreversibility may mute the response of investment to cash flow even for firms one would expect should exhibit a significant response, i.e. firms that face binding constraints on external finance. The failure to control for irreversibility may therefore adversely affect the inference based on investment cash flow sensitivities.

Investment is irreversible when capital goods are firm or industry specific: in this case, expenditures on capital goods constitute unrecoverable sunk costs. However, even in the absence of capital specificity, investment may be at least partially irreversible if the purchase price of capital goods exceeds the resale price, or if

[1] Other authors claim that investment-cash flow sensitivities are not good proxies for the presence of financing constraints, as cash flow typically picks up the effect of investment opportunities not properly accounted for by Tobin's Q (Cummins et al, 2006; Bond et al, 2004). Yet, D'Espallier and Guariglia (2009) show that the investment opportunity bias is not a serious problem for unlisted firms.

disinvesting entails significant fixed costs. Theoretical work on investment under uncertainty has analyzed the impact of irreversibility on firm investment (see Abel and Eberly, 1994; Bertola and Caballero, 1994; and Dixit and Pindyck, 1994, among others). The key fundamental insight of this work is that irreversibility may generate a "reluctance to invest" or equivalently a "wait and see" approach: a forward looking firm may prefer to wait for the arrival of more information than to undertake a costly action with uncertain consequences. This "wait and see" approach in turn implies that some firms may choose to suspend profitable investment projects. It is therefore entirely possible that in the context of an augmented *Q* equation --the main empirical specification in the literature that aims to test for the importance of financing constraints-- cash flow may be found insignificant as a determinant of investment. In this case however, the unresponsiveness of investment cannot be interpreted as evidence against the importance of financing constraints; rather, it is a direct consequence of behavior induced by irreversibility.

The purpose of our study is to provide, for the first time, a systematic empirical analysis of the effects of both irreversibility and financing constraints on firm level investment, focusing on the interactions between these constraints. To this end, we analyze the investment behavior of 4223 firms from four transition economies (Bulgaria, the Czech Republic, Poland, and Romania). Our sample is an ideal setting to test for the importance of financial and irreversibility constraints because the economic environment in these countries is such that both constraints are likely to be relevant for a large fraction of firms[2]. To the best of our knowledge, no paper in the literature has addressed the issue of irreversibility constraints in the context of transition economies.

We estimate investment equations as a function of Tobin's *Q* and cash flow, similar to those in Konings et al. (2003). Building on Konings et al. (2003) and Scaramozzino (1997), we then differentiate firms into more and less likely to face irreversibility constraints, with the aim of empirically assessing the extent to which firms with different degrees of investment irreversibility exhibit different investment-cash flow sensitivities.

[2] Budina et al. (2000), Konings et al. (2003), Perotti and Vesnaver (2004), Rizov (2004) and others document that financing constraints are prevalent in these economies. Moreover, second hand markets of capital goods are poorly developed in transition economies (Fox and Haller, 2006).

We find that investment is sensitive to cash flow only for firms that are less likely to face irreversibility constraints. In contrast, despite significant financing constraints, investment is unresponsive to cash flow variations for those firms more likely to be characterized by investment irreversibility. Based on these findings we suggest that irreversibility may confound the effect of financing constraints, thus limiting the inference on the existence and importance of financing constraints that can be drawn from investment cash flow sensitivities.[3]

We also provide an answer to the following related question: how do firms, likely to face irreversibility constraints, respond to cash flow innovations? Based on a formal argument that we illustrate in section 3, we hypothesize that firms may accumulate cash instead of investing. This may happen because firms prefer to save the extra cash to protect against adverse future industry conditions or because this additional savings may help them to relax future financing constraints. To test this hypothesis, we formulate an equation a-la Almeida et al. (2004) and find that firms with irreversible capital display strong sensitivities of cash accumulation to cash flow.

Our results suggest that irreversibility constraints can be seen as a new explanation for why, in some cases, firms facing financing constraints may exhibit low or insignificant sensitivities of investment to cash flow. They also carry significant policy implications. Considering that in the process of restructuring private sector enterprises in transition economies, firm investment is the main decision taken at the microeconomic level, policies that aim to stimulate investment through relaxation of financing constraints may not be successful in achieving the desired effect. In particular, tax incentives or other policies aiming to increase available internal resources for investment may have limited success for firms with irreversible capital. Our results indicate that firms may behave cautiously and respond to these incentives by saving the extra cash.

The paper proceeds as follows. In section 2, we provide an economic background for our analysis. Section 3 presents some theoretical considerations, aimed at motivating our empirical analysis. Section 4 illustrates our baseline specifications and estimation methodology. Section 5 describes our dataset and illustrates our sample separation criteria identifying firms more and less likely to face irreversible

[3] Interestingly, and consistent with our findings, Caggese (2007a) shows that, in a simulated model, investment regressions based on variable (reversible) as opposed to fixed capital have more power in testing for financing constraints.

constraints. Section 6 presents our main empirical results and some robustness tests, and section 7 concludes.

2. Economic background

Very little work in the literature combines both irreversibility and financing constraints. Most of this work is theoretical. For instance, Holt (2003) constructs a model in which he examines how firms' investment and dividend policies interact under irreversibility and financial constraints. He notes that firms characterized by highly irreversible prospective investment find it more difficult to obtain external finance, as lenders would be more reluctant to lend to them.

Bayer (2006) presents a model of investment that incorporates both constraints and finds a non-linear pattern of short term investment in the UK, consistent with the predictions of his model. Holt (2007) develops a model of investment under financial frictions and irreversibility, and finds that irreversibility exacerbates the effects of current financing constraints. Caggese (2007b) presents a model with fixed investment and inventories in which the irreversibility and financing constraints interact, and their effects amplify each other.

To the best of our knowledge, Scaramozzino (1997) is the only paper which provides an empirical analysis of the interaction between the two constraints. Using data for UK listed firms, he estimates a simple *Q*-model of investment on various categories of firms, and finds that this model only performs well for firms that face neither financing, nor irreversibility constraints. Although Scaramozzino (1997) shows that cash flow attracts a positive and significant coefficient for all groups of firms except the fully unconstrained ones, he does not provide clear predictions on how this variable should affect the investment at firms facing different degrees of investment irreversibility.

3. Theoretical considerations

In order to build some intuition on the role of non-convex adjustment costs, irreversibility, and financing constraints for the behavior of firms' investment and cash accumulation, we add an irreversibility constraint to the simple (partial equilibrium) theoretical model developed by Whited (2006).

Within this model, the firm uses capital to produce output. The period revenue function is given by $\pi(k,z)$, where k denotes the capital stock and z represents a stochastic disturbance that combines productivity and demand shocks. This revenue function is continuous and concave, due to either decreasing returns to scale or market power. It can be thought of as a reduced form production function that has maximized out the variable factors of production.

It is assumed that the firm purchases and sells capital at a price of one and incurs a scale dependent fixed cost, *ck* whenever investment is not equal to zero. This type of adjustment cost is a parsimonious and simple way to capture the non-convexities that exist at the firm level. The evolution of the capital stock is given by $k' = (1-\delta)k + I$, where I denotes gross investment, δ is the depreciation rate, and a prime denotes next period values.

The firm saves an amount m via a risk free one period bond that earns an interest rate r. As in Whited (2006), we assume that the firm cannot issue debt, i.e. $m \geq 0$. We then add a new further assumption to Whited's (2006) model. Specifically, we assume that the firm faces significant costs when disinvesting. This can be captured parsimoniously with a strict irreversibility constraint, $I \geq 0$.

To model costly external finance, we follow Whited (2006) and use the approach developed by Gomes (2001). Specifically we assume that the firm incurs a premium for external finance whenever desired investment exceeds internal resources. We define the excess of desired investment over internal resources as, $e(k,k',m,m'z) = k' - (1-\delta)k - \pi(k,z) + ck - m(1+r) + m'$. We then specify a financing cost function, $\phi(e)$, where $\phi(e) = 0$ if $e(k,k',m,m'z) \leq 0$ and $\phi(e) > 0$ if $e(k,k',m,m'z) > 0$. We further assume $\phi_e(e) > 0$, where $\phi_e(e)$ denotes the first order derivative of $\phi(e)$.

The firm chooses *k'* and *m'* each period to maximize the present discounted value of future cash flows. Let $V(k,m,z)$ denote the value function of the firm. In the case in which the firm invests, this function satisfies the following equation:

$$\begin{aligned} V(k,m,z) = \max\{&\pi(k,z) + m(1+r) - m' - (k' - (1-\delta)k) - ck - \phi(e(k,k',m,m'z)) \\ &+ \lambda\left(k' - (1-\delta)k\right) + \theta m' + \frac{1}{1+r} E_t V\left(k',m',z'\right)\} \end{aligned} \qquad (1)$$

where r denotes the market interest rate, used for discounting future cash flows, λ is the Kuhn-Tucker multiplier associated with the irreversibility constraint on investment, and θ is the Langrage multiplier associated with the constraint on savings. The expectations operator is taken with respect to the information set at time t, which includes the shock z.

The first order necessary condition for optimal investment is given by:

$$1 = \frac{1}{(1+r)(1+\phi_e(e)-\lambda)} E_t\{(1+\phi_{e'}(e'))(\pi_{k'}(k',z')+(1-\delta)-c)-\lambda'(1-\delta)\} \tag{2}$$

where $\pi_{k'}$ denotes the derivative of π with respect to k'. The left hand side of this optimality condition represents the cost (in terms of reduction in dividends) of investing an additional unit of capital, while the right hand side represents the benefit (in terms of increase in the expected future discounted firm value) of this additional investment. The optimality condition can be used to illustrate several important points. First, when the firm is using external finance, the effective discount rate for future cash flows rises $(\phi_e(e)>0)$, effectively pushing the profitability threshold for investment projects higher. As Whited (2006) demonstrates in simulation results, this in effect imposes an additional adjustment cost on capital and may therefore adversely affect the timing of investment, i.e. firms may suspend investment.

Second, the presence of fixed capital adjustment costs, reduces future cash flows by the constant c, and hence also reduces the attractiveness of investment. In this case, we should expect the firm to only undertake investment projects that are expected to yield high revenue (e.g. those projects with higher z'), so that the firm can expect to recover the fixed cost.

The irreversibility constraint generates a similar retarding effect on investment. Let us assume for simplicity that this constraint does not bind in the current period, but is expected to bind in the future (i.e. let $\lambda = 0, \lambda' > 0$). In this case, a very low value of future marginal profitability (which may result from a low z' value) implies that the firm may want to get rid of capital in the future, a very costly action. The firm takes into account this possibility and thus optimally chooses a level of investment lower than it would have been without this constraint in effect (in an extreme case, the firm would not invest at all). This illustrates the well known “reluctance to invest” effect of irreversibility.

Both fixed capital adjustment costs and irreversibility can therefore adversely affect the inter-temporal allocation of investment either by raising the threshold levels of profitability or by inducing a cautious approach when investing. As shown by Whited (2006), optimal capital accumulation follows in this case an intermittent pattern with infrequent adjustment (i.e. a two sided (*S*,*s*) rule), where there is a large range of inactivity. This discussion has an obvious implication: for some firms, investment may be unresponsive to a rise in internal funds because they operate in the range of inactivity of the capital accumulation rule.[4]

The insights offered by our model lead to a natural question: if investment is delayed or suspended as a result of the considerations above, how do firms respond to innovations in cash flow? In the simple framework presented above there are two options: either distribute the extra cash to owners (for instance in the form of dividends) or save it as cash. Whited (2006) shows that firms follow a bang-bang policy with respect to savings: they save as much as possible in periods in which there is no investment. Thus cash flow innovations are hoarded as savings. Firms then use these savings for investment in periods in which they choose to invest. We should therefore expect firms with no investment activity to rapidly accumulate cash and use it in the periods they invest. The intuition follows from the costly external finance assumption: because raising external finance is costly, firms that do not invest, accumulate as much cash as possible in order to reduce future reliance on external finance. Thus optimal investment activity is directly linked (via the budget constraint) with the accumulation of financial resources by firms. This is a useful insight we exploit in the empirical tests we design below.

The implications of our model can thus be summarized as follows. First, investment may be unresponsive to cash flow innovations, due to non-convex capital adjustment costs and irreversibility. Second, cash accumulation may be prevalent in periods in which firms do not invest.[5] In the sections that follow, we undertake an empirical analysis of firm level investment using the implications of this model as a guide for choosing our empirical specifications.

[4] Pratap (2003) uses a similar reasoning-based on non-convex adjustment costs-to explain why firms facing significant liquidity constraints may exhibit very little sensitivity of investment to cash flow.
[5] This prediction is also consistent with Riddick and Whited (2009) who show that there should be a positive sensitivity of savings to cash flow for firms with intermittent investment due to fixed capital adjustment costs.

4. Baseline specifications and estimation methodology

4.1 Baseline specifications: As in Konings et al. (2003), we initially estimate an equation of the following type:

$$\frac{I_{it}}{K_{it-1}} = \alpha_0 + \alpha_1 \frac{Q_{it}}{K_{it-1}} + \alpha_2 \frac{CF_{it}}{K_{it-1}} + \varepsilon_{it} \quad (3)$$

where I_{it} denotes firm *i*'s investment at time *t* and CF_{it} , its cash flow. Q_{it} represents Tobin's *Q*, which is included in our specification to control for investment opportunities[6]. Tobin's *Q* is typically defined as the market value of the firm over the replacement value of its capital stock. As most of the firms in our sample are not listed on the stock market, we are unable to assess their market value. Hence, we control for investment opportunities in two different ways. First, following Konings et al. (2003) and Bakucks et al. (2009), we use the firm's sales growth, instead of *Q*, as a proxy for the firm's future profitability. Second, we include time dummies interacted with industry dummies in all our specification. As discussed in Brown et al. (2009), Brown and Petersen (2009), and Duchin et al. (2010), since these dummies account for all time-varying demand shocks at the industry level, their inclusion represents an indirect way to control for investment opportunities or more general demand factors.

The error term in Equation (3), ε_{it}, comprises a firm-specific time-invariant component, encompassing all time-invariant firm characteristics likely to influence investment, as well as the time-invariant component of the measurement error affecting any of the regression variables; a time-specific component accounting for possible business cycle effects; and an idiosyncratic component. We control for the firm-specific time-invariant component of the error term by estimating our equation in first-differences, and for the time-specific component by including time dummies (in

[6] See the Appendix for precise definitions of all our variables.

addition to the time dummies interacted with industry dummies) in all our specifications.

When constraints on the availability of external finance bind -- a very likely situation in transition economies (de Haas, 2001)[7] -- firms can only pursue profitable investment projects using internal funds. Costly external finance may thus retard investment spending if firms do not have adequate internal funds to undertake this spending. We therefore expect a positive and significant investment-cash flow sensitivity (i.e. a positive and significant α_2 coefficient in Equation 3).

However, as we have explained in section 3, this may no longer be the case when we explicitly consider irreversibility. In fact, in the presence of innovations to cash flow, firms facing irreversibility constraints may act cautiously and put aside the extra cash as a future buffer, instead of investing. This cautious behavior will be more likely to obtain in environments characterized by high levels of uncertainty, such as the transition economies that we focus on (Susjan and Redek, 2008)[8]. In order to verify whether this is the case, we undertake two additional tests. The first consists in estimating the following specification, where IRR_i is a dummy equal to 1 if firm i faces irreversible investment over the sample period, and 0 otherwise[9].

$$\frac{I_{it}}{K_{it-1}} = \alpha_0 + \alpha_1 \frac{Q_{it}}{K_{it-1}} + \alpha_{21} \frac{CF_{it}}{K_{it-1}} * IRR_i + \alpha_{22} \frac{CF_{it}}{K_{it-1}} * (1 - IRR_i) + \varepsilon_{it} \tag{4}$$

If our hypothesis were true, we would expect cash flow not to significantly affect investment at firms characterized by relatively high levels of capital irreversibility, while it would still affect the investment of firms with low levels of capital irreversibility. Hence, we would expect α_{21} to be poorly determined, and only α_{22} to be statistically significant.

Our second test of the hypothesis according to which, in the presence of innovations to cash flow, firms facing irreversibility constraints act cautiously and put

[7] Also see Arellano et al. (2009) who provide compelling evidence that financial markets are poorly developed in transition economies: they document that over the period 2000-2004, the ratio of private credit to GDP was equal to 37%, 22%, and 11%, respectively in the Czech Republic, Bulgaria, and Romania; while it was equal to 143% in the UK, 143% in the Netherlands, and 87% in France.

[8] This is because the level of cautiousness in investment typically rises with uncertainty. See Bloom et al. (2007) for an illustration of this argument and an application using firm level UK data.

[9] Details on how this dummy is constructed are provided in the next section.

aside extra cash as a buffer instead of investing is focused on the estimation of the following model, similar to Almeida et al.'s (2004), which relates the firm's accumulation of cash to total assets ratio (*ΔCash*$_{it}$*/Total Assets*$_{i(t-1)}$) to its cash flow to assets ratio, Tobin's *Q* (proxied by sales growth), and size (measured by the logarithm of its total assets)[10]:

$$\frac{\Delta Cash_{it}}{TotalAssets_{it-1}} = \beta_0 + \beta_1 \frac{Q_{it}}{TotalAssets_{it-1}} + \beta_2 \frac{CF_{it}}{TotalAssets_{it-1}} + \beta_3 SIZE_{it-1} + \eta_{it} \qquad (5)$$

Size is included in this model to capture potential economies of scale in cash management. As suggested by Almeida et al. (2004) and Khurana (2006), a positive and precisely determined propensity to save cash out of cash flow can be interpreted as an indication of the presence of financing constraints in our sample. Specifically, forward looking firms may accumulate cash in order to relax future financing constraints. Thus cash accumulation may be an indicator of the presence of financing constraints, as constrained firms save cash to hedge the fluctuations in their cash flow. In addition to the above, firms may engage in cash hoarding due to precautionary motives[11]. This may arise, for example, when there are concerns about future survival prospects, and may be a relevant motive when market conditions change swiftly as in the economies we focus on, where a host of structural and market reforms were (and still are) under way during the sample period[12].

With reference to the formalization we provided in section 3, we next test whether, as predicted by the model, firms with irreversible capital tend to accumulate cash at a relatively faster pace compared to firms with reversible capital, in response

[10]Pal and Ferrando (2006), Khurana (2006), and Riddick and Whited (2009) estimate similar equations, which include a variety of additional regressors.

[11] See Han and Qiu (2007) for a careful analysis of the precautionary motive for a firm's cash holdings.

[12] An imperfect indicator for the relevance of the precautionary motive is the high risk of bankruptcy characterizing transition economies compared to Western economies. Transition economies are characterized by significantly higher corporate failure rates: according to our dataset, failure rates in Poland, the Czech Republic, and Bulgaria are respectively 5.5%, 2.3%, and 2.6%, compared to only 1.5% in the UK (Bridges and Guariglia, 2008).

to innovations to cash flow. To this end, we interact our cash flow variable in Equation (5) with the IRR_{it} dummy, which leads to the following equation:

$$\frac{\Delta Cash_{it}}{TotalAssets_{it-1}} = \beta_0 + \beta_1 \frac{Q_{it}}{TotalAssets_{it-1}} + \beta_{21} \frac{CF_{it}}{TotalAssets_{it-1}} * IRR_i + \beta_{22} \frac{CF_{it}}{TotalAssets_{it-1}} * (1 - IRR_i) + \beta_3 SIZE_{it-1} + \eta_{it} \quad (6)$$

We expect firms characterized by high degrees of irreversibility to display higher sensitivities of cash accumulation to cash flow, compared to firms with low degrees of irreversibility. The coefficient β_{21} should therefore be larger than β_{22}.

4.2 Estimation methodology: All equations are estimated in first-differences, to control for firm-specific, time-invariant effects. Given the possible endogeneity of our regressors, we use a system Generalized Method of Moments (GMM) approach (Arellano and Bover, 1995; Blundell and Bond, 1998). This estimator combines in a system the relevant equation in first differences and in levels. It makes use of values of the regressors lagged twice or more as instruments in the differenced equation, and of differences of the regressors lagged once in the levels equation. The system GMM estimator is preferred to the simple first-difference GMM estimator when instruments are likely to be weak (Blundell and Bond, 1998).

To evaluate whether our instruments are legitimate and our model is correctly specified, we use the Sargan test (also known as *J* test), which is a test for overidentifying restrictions, and the test for second-order serial correlation of the residuals in the differenced equation (*m2*). Under the null of instrument validity, the former test is asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters. The *m2* test is asymptotically distributed as a standard normal under the null of no second-order serial correlation of the differenced residuals, and provides a check on the specification of the model and legitimacy of variables dated *t*-2 as instruments in the differenced equation[13].

[13] If the un-differenced error terms are *i.i.d.*, then the differenced residuals should display first-order, but not second-order serial correlation. Note that neither the Sargan nor the *m2* tests allow to discriminate between bad instruments and model specification.

5. Data and summary statistics

5.1 Data: Our data set is drawn from the annual accounting reports taken from the *AMADEUS* database, published by Bureau Van Dijk Electronic Publishing (*BvDEP*). The database includes balance sheet and profit and loss information for over 11 million public and private companies in 41 European countries over the period 1998-2005. Our focus is on the four transition economies also studied by Konings et al. (2003): Bulgaria, the Czech Republic, Poland and Romania[14].

The sample we choose to work with is particularly well suited for assessing the interaction between irreversibility and financing constraints. As we document below the economies we focus on, are characterized by high levels of uncertainty compared to developed economies and have poorly developed credit markets and limited resale markets for used capital (Fox and Haller, 2006). These considerations serve to illustrate that financial and irreversibility constraints are expected to be particularly severe in these economies.

De Haas (2001) and Arellano et al. (2009) document that capital markets are poorly developed in transition economies. Specifically, Arellano et al. (2009) measure financial development with the level of private credit to GDP and order the 22 countries in their sample according to this measure. They find that Romania (whose level of private credit to GDP is 11%) ranks last, while Bulgaria (with 22%) ranks nineteenth, and the Czech Republic (with 37%) ranks sixteenth[15]. For comparison, Denmark, which ranks first, has a percentage of private credit to GDP of 147%.

The level of firm specific and aggregate uncertainty is also considerably higher in these economies compared with a developed economy like the US. We document this in two ways. First, following Bloom (2009), we compute the inter-quartile range of the cross sectional spread of firm level sales in our sample as a measure of firm level uncertainty. We obtain a value equal to 0.37 for Bulgaria, 0.25 for Czech Republic, 0.31 for Poland, and 0.40 for Romania. In contrast, the corresponding measure for the US is only 0.15. Second, we compute the standard deviation of GDP growth as a

[14] We have only selected firms that have unconsolidated accounts: this ensures that the majority of the firms in our dataset are relatively small. Moreover, it avoids the double counting of firms belonging to groups, which would be included in the dataset if firms with consolidated accounts were also part of it.

[15] Note that Poland is not included in the set of countries analyzed by Arellano et al. (2009) but has a similar low domestic bank credit to GDP ratio (Mueller and Peev, 2007). All statistics reported by Arellano et al. (2009) refer to the year 2005. De Haas (2001) reports similar statistics for an earlier period.

measure of macroeconomic volatility or more loosely of aggregate uncertainty. The values we obtain are also considerably higher in transition economies compared to the US: they are equal to 1.53 for Bulgaria, 1.62 for the Czech Republic, 1.41 for Poland, 2.75 for Romania, but only to 1.3 for the US. This high level of uncertainty combined with the fact that transition economies are characterized by very thin secondary markets for capital equipment (Fox and Heller, 2006) suggests that irreversibility is likely to be a very important factor in these countries, and thus expected to significantly affect firms' investment behavior.

We drop observations with negative sales, as well as observations with negative total assets. Firms that do not have complete records on our main regression variables are also dropped. To control for the potential influence of outliers, we exclude observations in the one percent tails for each of our regression variables. Finally, we drop all firms with less than 5 years of consecutive observations. Our final panel, which is unbalanced, covers 462 firms for Bulgaria (corresponding to 2314 observations), 1539 firms for the Czech Republic (corresponding to 7757 observations), 1208 firms for Poland (corresponding to 5629 observations), and 1014 firms for Romania (corresponding to 4656 observations)[16]. The majority of these firms are unlisted, and hence particularly likely to face financing constraints (Guariglia, 2008).

5.2 Sample separation criteria: Following Leahy and Whited (1996) and Drakos and Goulas (2006), we initially partition our firms into more and less likely to face irreversibility constraints based on the time-series variance of their labor to capital ratio. Specifically, we classify a firm *i* as facing a relatively high (low) degree of irreversibility if the variance of its labor to capital ratio over the period considered falls in the bottom (top) half of the distribution of the ratios of all firms belonging to the same industry as firm *i*. The rationale for this classification is that a greater variability in a firm's labor to capital ratio highlights greater ability to substitute labor for capital, and suggests a lower degree of irreversibility of the firm's capital stock.

As a robustness test, we use two additional sample separation criteria. First, following Chirinko and Schaller (2009), we classify firms on the basis of the average depreciation to capital ratios of the industry in which they operate. In particular, we

[16] See the Appendix for information about the structure of our panels.

classify a firm as being more (less) likely to face a high degree of irreversibility if this ratio is below (above) the median depreciation rate over all industries. This classification is motivated by the fact that, in addition to selling capital, firms can reduce their capital stock through depreciation. As noted by Chirinko and Schaller (2009), in industries with low depreciation rates, this recourse is sharply limited, which can be seen as further evidence of the importance of irreversibility.

Second, we follow the criterion proposed by Scaramozzino (1997), which consists in classifying firm *i* as facing a higher degree of irreversibility in year *t* if its investment to capital ratio falls below the median ratio of all firms operating in the same industry a firm *i* in year *t.* The rationale behind this classification is that irreversibility constraints may reduce the attractiveness of investing in capital equipment. In all cases, we construct a dummy variable, $IRR_{i(t)}$, which is equal to 1 if firm *i* faces irreversible investment (at time *t*), and 0 otherwise[17].

5.3 Summary statistics: Table 1A presents descriptive statistics of all variables used in our investment models for the entire sample. Table 1B provides similar statistics for the variables used in our cash models. The investment to capital ratio ranges from a minimum of 17.2% in Romania, to a maximum of 31.9% in Bulgaria. These rates are much higher than those characterizing Western European countries. For instance, focusing on the period 1978-89, Bond et al. (2003) report investment to capital rates of 12.5% in Belgium, 11.1% in France, 12.2% in Germany, and 11.7% in the UK. The high investment rates in transition economies can be justified in the light of the fact that firms operating in these countries need to invest heavily in order to modernize their obsolete capital stock and acquire competitiveness in the global economy (Lizal and Svejnar, 2002).

The cash flow to capital ratios range from 24.3% in Bulgaria to 35.2% in Poland, and are in line with those reported by Bayraktar et al. (2005) for Germany[18]. The cash to assets ratio ranges from 5.9% in Romania to 7.2% in the Czech Republic. These numbers are lower than those reported by Almeida et al. (2004) for US firms, which range from 8-9% for unconstrained firms to 15% for their constrained counterparts,

[17] Note that only our last measure of irreversibility is time-varying. All our results were robust to constructing a time-invariant measure of irreversibility based on firms' average investment to capital ratios.

[18] Our figures are not directly comparable with those reported in Bond et al. (2003), due to slight differences in cash flow definitions.

but are in line with those reported by Kalcheva and Lins (2007) for countries such as Spain and Portugal[19]. Finally, the cash accumulation to assets ratios range from 0.1% for Romania to 1.0% for Bulgaria.

Table 2 reports descriptive statistics of the variables used in our investment models, respectively for firms assumed to face higher and lower degrees of irreversibility on the basis of the variance of their labor to capital ratios. It is interesting to note that the real capital stock is always significantly higher for firms with irreversible investment, compared to those with reversible investment. For the former, the values range from 33.5 (thousands of Euros) for Romania to 113.8 for the Czech Republic, whereas for the latter, they range from 7.6 for Romania to 28.2 for the Czech Republic, with all differences being statistically significant. This can be explained considering that irreversible capital consists mainly of land and buildings, while reversible capital consists of computers, telecom equipment and so on.

With the exception of Romania, the investment to capital ratio is always lower for those firms more likely to face a higher degree of irreversibility. For instance, for Bulgaria, the investment to capital ratio of firms with reversible investment is 41.0%, while the corresponding figure for firms with irreversible investment is 25.6%. The difference between these two figures is statistically significant, as is the corresponding difference for Poland and the Czech Republic. This may be a consequence of the higher capital stock characterizing firms with irreversible investment. Alternatively, it may suggest that firms more likely to face irreversibility constraints may be more reluctant to invest.

Firms more likely to face a higher degree of investment irreversibility display lower cash flow to capital ratios. Specifically the average cash flow to capital ratio of firms with irreversible capital in Bulgaria is 21.3% compared to 27.9% for firms with reversible capital. The corresponding figures for the Czech Republic are 22.0% versus 32.9%; for Poland, 29.1% versus 41.6%; and for Romania, 29.6% versus 39.3%. All these differences are statistically significant.

Finally, firms more likely to face irreversibility constraints also exhibit low sales growth to capital ratios: these range from 23.5% for the Czech Republic to 33.7% in the case of Poland. The corresponding figures for firms with reversible investment range from 49.5% for the Czech Republic to 68.1% for Bulgaria.

[19] Note that our ratios are not perfectly comparable to theirs as we divide cash holdings by total assets, while they divide them by net assets (i.e. total assets net of cash).

In summary, irreversibility seems to be associated not only with lower investment rates, but also with lower cash flow rates and lower sales growth.

Table 3 reports summary statistics for the variables used in our cash models, for firms facing higher and lower degrees of irreversibility. In line with the statistics reported in Table 2, we can see that firms with a higher degree of irreversibility are typically larger than their counterparts with reversible capital, in terms of real assets. Specifically, for firms with irreversible investment, real assets range from 71.0 (thousands of Euros) for Romania to 211.7 for the Czech Republic, while the corresponding figures for firms with reversible capital range from 17.8 for Romania to 72.2 for Poland. Furthermore, firms more likely to face irreversibility constraints have lower cash to assets ratios. Specifically, Bulgarian firms with irreversible capital hold on average 4.6% of their total assets in the form of cash and marketable securities, while their counterparts with reversible capital hold 8.8%. Corresponding figures for the Czech Republic are 6.2% versus 8.2%; for Poland, 5.1% versus 6.0%, and for Romania 4.3% versus 6.0%. All these differences are statistically significant. These findings are probably due to the fact that, as discussed above, firms characterized by irreversible investment have significantly higher total assets than their counterparts with reversible investment. Figures for real cash holdings for firms with irreversible capital are in fact higher than those for firms with reversible capital: in the case of the former, they range from 3.0 for Romania to 10.3 for the Czech Republic, while in the case of the latter, they are considerably lower and range from 1.17 for Romania to 5.0 for the Czech Republic.

Finally, the figures for the cash accumulation to assets ratios of irreversible capital firms are 0.5%, 0.6%, 0.8%, and 0.1%, respectively for Bulgaria, the Czech Republic, Poland, and Romania. The corresponding figures for firms with reversible investment in the four countries are 1.5%, 0.6%, 0.9%, and 0%. No clear pattern emerges regarding the magnitudes of these ratios across firms with reversible and irreversible capital.

In the sections that follow, we analyze the links between investment and cash flow, on the one hand; and cash accumulation and cash flow, on the other, within a formal regression analysis framework, which also controls for other factors.

6. Empirical results

6.1 Baseline models: Table 4A presents estimates of Equation (3) for our four countries. The cash flow coefficients are positive and statistically significant for all countries. In terms of magnitudes, these coefficients range from 0.36 for Romania to 0.96 for Bulgaria. These coefficients suggest that the elasticity of investment to cash flow, evaluated at sample means, is 0.73 for Bulgaria and 0.71 for Romania. In other words, a 10% increase in cash flow implies a 7.3% and 7.1% increase in investment for Bulgarian and Romanian firms respectively. The elasticities for the Czech Republic and Poland are 0.47 and 0.53, respectively. These results suggest that firms in all four transition countries suffer from significant financing constraints. Konings et al. (2003) reached a similar conclusion for Poland and the Czech Republic, but did not find evidence of financing constraints for Bulgaria and Romania. The difference between our results and theirs may be due to the fact that their sample covers a much earlier time period (1994-1999). It is therefore possible that Bulgaria and Romania still faced soft budget constraints at the start of their transition process, while in most recent years, they have been converging towards the markets economy model. This interpretation is in line with Mueller and Peev (2007) who document that soft budget constraints in Central and Eastern Europe have been hardened over the 1999-2003 period.

Table 4B presents the estimates of our baseline cash accumulation model. In line with Almeida et al. (2004) and Pal and Ferrando (2006), all four countries exhibit positive sensitivities of cash accumulation to cash flow, which confirms that they all suffer from liquidity constraints. The coefficients on cash flow range from 0.096 for Bulgaria to 0.118 for the Czech Republic. These findings are economically important: the elasticities of cash with respect to cash flow, evaluated at sample means, are 1.07 and 1.99 for Bulgaria and the Czech Republic respectively. Thus a 10% increase in firms' cash flow is associated with a 10.7% and 19.9% increase in cash accumulation for Bulgarian and Czech firms. The elasticities for Poland and Romania are 1.25 and 1.49, respectively. The cash flow sensitivities of cash for our four transition economies are higher in magnitude compared to the sensitivities obtained by Almeida et al. (2004) for the US. Considering the relatively low level of financial development characterizing transition economies in comparison with the US (de Haas, 2001; Arellano et al., 2009), and considering that financial development reduces the costs of external funds and eases firms' financing constraints, this result is consistent with Khurana et al.'s (2006) finding that the cash flow sensitivity of cash is higher for countries characterized by lower financial development. In both Tables 4A and 4B, the Sargan test statistics are insignificant at the conventional 5% level, and in most cases the *m2* test does not highlight problems with our instruments.

6.2 Differentiating firms according to the degree of investment irreversibility:

One issue with the estimates reported in Tables 4A and 4B, is that they do not differentiate the effects of cash flow on investment and cash accumulation of firms facing different degrees of investment irreversibility. Yet, as discussed in section 3, it is possible that firms with irreversible investment are less likely to invest and more likely to accumulate cash as a consequence of innovations in cash flow, than their counterparts with reversible investment.

To further investigate this issue, estimates of Equation (4) are presented in Table 5A. In both tables, we control for irreversibility using the variance of each firm's labor to capital ratios over the period considered. We can see that it is only those firms characterized by relatively low degrees of irreversibility, which exhibit positive and significant sensitivities of investment to cash flow. Investment at firms with relatively high degrees of irreversibility is always unresponsive to cash flow. The largest coefficient for firms with reversible capital is observed for Bulgaria (1.13), which indicates that the elasticity of investment with respect to cash flow, evaluated at sample means, is 0.45. The cash flow coefficients for firms with reversible capital in the Czech Republic, Poland, and Romania are respectively 0.39, 0.38, and 0.33. The corresponding elasticities are 0.19, 0.29 and 0.39.

For comparison, in the last column of Table 5A, we report the estimates of Equation (4) based on 8,852 UK firms[20]. Considering that the UK is characterized by a much lower degree of financing constraints and a much lower degree of uncertainty compared to transition economies, we do not expect the same results to hold. We can in fact see that it is those firms with irreversibile capital, which display the highest investment-cash flow sensitivities (0.50 compared to 0.11 for firms with reversible

[20] Data for UK firms are also drawn from the *AMADEUS* database.

capital). Yet, the difference between these two coefficients is not statistically significant[21].

These findings are in line with our prediction according to which, in economies characterized by high levels of uncertainty and a high degree of financing constraints such as transition economies, firms characterized by a high degree of irreversibility may be reluctant to further increase their investment spending following increases in cash flow[22]. Irreversibility constraints may therefore contribute to reducing the investment cash flow sensitivities even for firms that are likely to face binding liquidity constraints. Consequently, they limit the usefulness of such regressions as tests for the financing constraints hypothesis. This result highlights that researchers should properly control for the presence of irreversible capital when attempting to interpret investment-cash flow sensitivities. Importantly, it also suggests that policies aimed at promoting investment (e.g. tax incentives) may be inadequate to achieve the desired outcome if a significant fraction of firms is likely to face irreversibility constraints.

Table 5B reports estimates of our cash accumulation equation (Equation 6). Here, in accordance with the prediction of section 3, cash flow coefficients are only significant for those firms with irreversible capital. They range from values of 0.10 for Poland to 0.38 for the Czech Republic. The elasticities evaluated at sample means suggest that increasing cash flow by 10% leads to a 7.75% and 33.8% rise in cash accumulation for Poland and the Czech Republic respectively. In line with the model's intuition, these estimates suggest firms with irreversible capital prefer to accumulate cash, rather than to accumulate more fixed productive assets. In contrast, the last column of Table 5B shows that there is no statistically significant difference in the cash-cash flow sensitivities reported for UK firms[23]. The comparison of our transition economies with the UK highlights the relevance of irreversibility constraints in the former, but not the latter. In both Tables 5A and 5B, the Sargan and *m2* tests do not highlight significant problems with the choice of our instruments and the specification of our model.

---

[21] An *F*-test for the equality of the cash flow coefficients for firms characterized by more and less reversible investment delivers in fact a *p*-value of 0.12.

[22] As firms characterized by irreversible investment are typically larger than those with reversible investment (Table 3), one could argue that the irreversibility dummy simply captures a size effect. Yet, all our results were robust to controlling for size in the regressions.

[23] An *F*-test for the equality of the cash flow coefficients for firms characterized by more and less reversible investment delivers in fact a *p*-value of 0.81

Tables 6A and 6B report the investment and cash regressions, when firms are divided into more and less likely to face irreversibility, based on their industries' depreciation rates. Once again, the regressions of the former group indicate that for Bulgaria, Poland, and Romania, investment is sensitive to cash flow only for those firms with reversible capital (Table 6A). For the Czech Republic, the cash flow coefficient is significant for both firms with reversible and irreversible capital, but considerably larger for the former. Focusing on the cash regressions (Table 6B), we can see that it is those firms with irreversible capital that display the highest sensitivities of cash to cash flow. Yet, the relevant coefficient is only statistically significant for the Czech Republic and Romania.

Finally, Tables 7A and 7B present estimates of Equations (4) and (6) respectively, when the irreversibility dummy is constructed based on the firms' investment to capital ratios. Once again, only firms with reversible capital exhibit positive and significant sensitivities of investment to cash flow. Furthermore, firms with irreversible capital in Bulgaria, Romania, and the Czech Republic, all display positive and precisely determined sensitivities of cash to cash flow. In the case of the Czech Republic, also firms with reversible capital exhibit a positive sensitivity. Yet, this sensitivity is lower in magnitude compared to that of firms with irreversible capital. In the case of Poland, both types of firms have insignificant cash to cash flow sensitivities.

In summary, regardless of the way in which we partition firms into more and less likely to face irreversibility constraints, our results suggest that in transition economies, firms likely to face irreversibility of capital will be reluctant to invest, but will prefer to channel additional internal funds to accumulate cash instead. On the other hand, firms characterized by reversible capital will typically invest out of extra cash flow, as predicted by the financing constraints literature. It is therefore possible that the insignificant or low investment-cash flow sensitivities reported in previous work (such as Kaplan and Zingales, 1997; Cleary, 1999; and Cummins et al., 2006) may be due to irreversibility constraints faced by these firms, and not accounted for in their models.

7. Conclusions

We have used a panel of 4223 mainly unlisted firms from four transition economies (Bulgaria, the Czech Republic, Poland and Romania) to study the interactions between financing and irreversibility constraints. When estimating an investment equation for the whole sample neglecting irreversibility, we found evidence of high investment-cash flow sensitivities, suggesting that financing constraints are binding in transition economies. Yet, when we controlled for irreversibility we found that, even though both are expected to face the same degree of financing constraints, firms with reversible capital exhibit a significant response of investment to cash flow, while firms with irreversible capital exhibit a non significant response. Furthermore, firms with irreversible capital exhibit high sensitivities of cash accumulation to cash flow. These results, which are robust to measuring irreversibility in different ways, suggest that irreversibility confounds the effects of financing constraints in empirical investment equations, adversely affecting the inference based on investment cash flow sensitivities. Hence, irreversibility constraints can be seen as a new explanation for why in some cases, firms facing financing constraints may exhibit low and insignificant sensitivities of investment to cash flow.

Our findings have two implications. First, researchers who aim at testing the presence of capital markets imperfections should carefully try to assess the likely impact of irreversibility before making any inferences based on investment-cash flow sensitivities. Second, policies that aim to stimulate investment through the relaxation of financing constraints may not be successful in achieving the desired effect. Specifically, tax incentives or other policies aimed at increasing available internal resources for investment may have limited success for firms with irreversible capital.

Appendix

Definitions of the variables used

Total assets: sum of the firm's fixed and current assets, where fixed assets include tangible fixed assets, intangible fixed assets, and other fixed assets; and current assets include inventories, accounts receivable, and other current assets.

Cash flow: net income plus depreciation.

Cash: cash and equivalents.

Fixed investment: difference between the book value of tangible fixed assets (which include land and buildings; fixtures and fittings; and plant and vehicles) of end of year *t* and end of year *t*-1, plus depreciation of year *t*.

Capital stock: tangible fixed assets.

Q: Tobin's *Q* proxied by the firm's sales growth.

Sales: firm's total sales (including domestic and overseas sales).

Deflators: all variables are deflated using the GDP deflator for the relevant country.

Structure of the unbalanced panel

I. Bulgaria

Number of obs. per firm	Number of observations	Percent	Cumulative
5	238	10.29	10.29
6	353	15.25	25.54
7	444	19.19	44.73
8	1,279	55.27	100.00
Total	2,314	100.00	

II. Czech Republic

Number of obs. per firm	Number of observations	Percent	Cumulative
5	956	12.37	12.37
6	1380	17.78	30.15
7	1591	20.50	50.65
8	3830	49.35	100.00
Total	7,757	100.00	

III. Poland

Number of obs. per firm	Number of observations	Percent	Cumulative
5	788	14.00	14.00
6	883	15.69	29.69
7	1,035	18.39	48.07
8	2,923	51.93	100.00
Total	5,629	100.00	

IV. Romania

Number of obs. per firm	Number of observations	Percent	Cumulative
5	311	6.68	6.68
6	422	9.06	15.74
7	656	14.09	29.83
8	3,267	70.17	100.00
Total	4,656	100.00	

References

Abel, A. And J. Eberly (1999). "The effects of irreversibility and uncertainty on capital accumulation." *Journal of Monetary Economics*, 44, 339–377.

Almeida, H., Campello, M., and M. Weisbach (2004). "The cash flow sensitivity of cash." *Journal of Finance*, 59, 1777-1804.

Arellano, C., Bai, Y., and J. Zhang (2009). "Firm dynamics and financial development." National Bureau of Economic Research Working Paper No. 15193.

Arellano, M. and O. Bover (1995). "Another look at the instrumental-variable estimation of error-components models." *Journal of Econometrics*, 68, 29-52.

Bakucs, L., Ferto, I., and J. Fogarasi (2009). "Investment and financial constraints in Hungarian agriculture." *Economics Letters*, 3, 122-24.

Bayer, C. (2006). "Investment dynamics with fixed capital adjustment cost and capital market imperfections." *Journal of Monetary Economics*, 53, 1909-1947.

Bayraktar, N., Sakellaris, P., and P. Vermeulen (2005). "Real versus financial frictions to capital investment". European Central Bank Working Paper No. 659.

Bertola, G., and R.J. Caballero (1994). "Irreversibility and Aggregate Investment." *Review of Economic Studies*, 61, 223-246.

Bloom, N. and S. Bond and J. Van Reenen (2007). "Uncertainty and investment dynamics." *Review of Economic Studies*, 74, 391-415.

Bloom, N. (2009). "The impact of uncertainty shocks." *Econometrica*, 77, 623-685.

Blundell, R. and S. Bond (1998). "Initial conditions and moment restrictions in dynamic panel data models." *Journal of Econometrics*, 87, 115-43.

Bond, S., Elston, J., Mairesse, J., Mulkay, B. (2003). "Financial factors and investment in Belgium, France, Germany, and the United Kingdom: a comparison using company panel data." *Review of Economics and Statistics,* 85, 153-65.

Bond, S., Klemm, A., Newton-Smith, R., Syed, M., and G. Vlieghe (2004). "The roles of expected profitability, Tobin's *Q* and cash flow in econometric models of company investment." Working Paper No. 04/12. Institute for Fiscal Studies.

Bond, S. and J. Van Reenen (2007). Microeconometric models of investment and employment. In J. Heckman and E. Leamer (eds.), *Handbook of Econometrics*, Vol. 6, Edn 1, Chapter 65. North Holland: Elsevier, pp. 4417–98.

Bridges, S. and A. Guariglia (2008). "Financial constraints, global engagement, and firm survival in the United Kingdom: evidence from micro data." *Scottish Journal of Political Economy,* 55, 444-464.

Brown, J., Fazzari, S., and B. Petersen (2009). "Financing innovation and growth: cash flow, external equity and the 1990s R&D boom." *Journal of Finance*, 64, 1, 151-85.

Brown. J. and B. Petersen (2009). "Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments." *Journal of Banking and Finance,* 33, 971-84.

Budina, N., Garretsen, H., and E. de Jong (2000). "Liquidity constraints and investment in transition economies. The case of Bulgaria." *Economics of Transition*, 8, 453-75.

Bulan, L. (2005). "Real options, irreversible investment and firm uncertainty: new evidence from U.S. firms." *Review of Financial Economics* 14 (3–4), 255–279.

Caballero, R. (1991). "On the sign of the investment-uncertainty relationship." *American Economic Review*, 81, 279-88.

Caballero, R. (1999). "Aggregate investment". In: Taylor, J.B., Woodford, M. (Eds.), *Handbook of Macroeconomics*. Elsevier, Amsterdam, 813–862.

Caggese, A. (2007a). "Testing financing constraints on Firm Investment using variable capital." *Journal of Financial Economics*, 86, 683-723.

Caggese, A. (2007b). "Financing constraints, irreversibility, and investment dynamics." *Journal of Monetary Economics*, 54, 2102-2130.

Chirinko, R. and H. Schaller (2009). "The irreversibility premium." *Journal of Monetary Economics,* 56, 390-408.

Cleary, S. (1999). "The relationship between firm investment and financial status." *Journal of Finance,* 54, 673-92.

Cummins, J., Hasset, K., and S. Oliner, (2006). "Investment behavior, observable expectations, and internal funds." *American Economic Review*, 96, 796–810.

D'Espallier, B. and A. Guariglia (2009). "Does the investment opportunities bias affect the investment-cash flow sensitivities of unlisted SMEs?" *Mimeograph*, Durham University**.**

De Haas, R. (2001). "Financial development and economic growth in transition economies: a survey of the theoretical and empirical literature." *Mimeograph,* De Nederlandsche Bank.

Dixit, A. and R. Pindyck (1994). *Investment under uncertainty*. Princeton University Press, Princeton NJ (USA).

Drakos, K. and E. Goulas (2006). "Investment and conditional uncertainty: the role of market power, irreversibility, and returns-to-scale." *Economics Letters*, 93, 169-175.

Duchin, R., Ozbas, O., and B. Sensoy (2010). "Costly external finance, corporate investment, and the subprime mortgage credit crisis." *Journal of Financial Economics* (forthcoming).

Fazzari, S., Hubbard, R., and B., Petersen (1988). "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity*, 141-195.

Fazzari, S., Hubbard, G., and B. Petersen (2000). "Investment - cash flow sensitivities are useful: a comment on Kaplan and Zingales." *Quarterly Journal of Economics*, 115, 695-705.

Fox, M. and M. Heller (2006). "Corporate governance lessons from transition economy reforms." Princeton University Press, Princeton NJ (USA).

Gomes, J. (2001). "Financing investment" *American Economic Review*, 91, 1263-1285.

Guariglia, A. (2008). "Internal financial constraints, external financial constraints and investment choice: Evidence from a panel of UK firms." *Journal of Banking and Finance,* 32, 1795-1809.

Guiso, L. and G. Parigi (1999). "Investment and demand uncertainty". *Quarterly Journal of Economics,* 114, 185–227.

Han, S. and J. Qiu (2007). "Corporate precautionary cash holdings." *Journal of Corporate Finance*, 13, 43-57.

Holt, R. (2003). "Investment and dividends under irreversibility and financial constraints." *Journal of Economic Dynamics and Control*, 27, 467–502.

Holt, R. "Investment, irreversibility and financial imperfections: the rush to invest and the option to wait." *Economics Bulletin*, 5, 1-10.

Hubbard, G. (1998). "Capital market imperfections and investment." *Journal of Economic Literature*, 35, 193-225.

Kalcheva, I. and K. Lins (2007). "International evidence on cash holdings and expected managerial agency problems." *Review of Financial Studies*, 4, 1087-1112.

Kaplan, S. and L. Zingales (1997). "Do investment-cash flow sensitivities provide useful measures of financing constraints?" *Quarterly Journal of Economics,* 112, 169–215.

Kaplan, S. and L. Zingales (2000). "Investment - cash flow sensitivities are not valid measures of financing constraints." *Quarterly Journal of Economics*, 115 (2), 707-12

Khurana, I., R. Pereira, and X. Marin (2006). "Financial development and the cash flow sensitivity of cash." *Journal of Financial and Quantitative Analysis*, 41, 357-80.

Konings, J., Rizov, M., and H. Vandenbussche (2003). "Investment and financial constraints in transition economies: micro evidence from Poland, the Czech Republic, Bulgaria, and Romania." *Economic Letters*, 78, 253-58.

Leahy, J. and T. Whited (1996). "The effect of uncertainty on investment: some stylized facts". *Journal of Money, Credit and Banking*, 28, 64–83.

Lizal, L. and J. Svejnar (2002). "Investment, credit rationing, and the soft budget constraint: evidence from Czech panel data." *Review of Economics and Statistics*, 84, 353-70.

Mueller, D. and E. Peev (2007). "Corporate governance and investment in Central and Eastern Europe." *Journal of Comparative Economics*, 35, 414-37.

Pal, R. and A. Ferrando (2006). "Financing constraints and firms' cash policy in the Euro area." European Central Bank Working Paper No. 642.

Perotti, E. and L. Vesnaver (2004). "Enterprise finance and investment in listed Hungarian firms." *Journal of Comparative Economics*, 32, 73-87.

Pindyck, R. (1993). "A note on competitive investment under uncertainty." *American Economic Review*, 83, 273-277.

Pratap, S. (2003). "Do adjustment costs explain investment-cash flow insensitivity?" *Journal of Economic Dynamics and Control*, 27, 1993-2006.

Riddick, L. And T. Whited (2009). "The corporate propensity to save." *Journal of Finance*, 64, 4, 1729-66.

Rizov, M. (2004). "Firm investment in transition." *Economics of Transition*, 12, 721-46.

Scaramozzino, P. (1997). "Investment irreversibility and finance constraints." *Oxford Bulletin of Economics and Statistics*, 59, 89–108.

Schiantarelli, F. (1995). "Financial constraints and investment: methodological issues and international evidence." *Oxford Review of Economic Policy* 12, 70-89.

Susjan, A. And T. Redek (2008). "Uncertainty and growth in transition economies." *Review of Social Economy*, 66, 209-34.

Tsyplakov, S. (2008). "Investment frictions and leverage dynamics." *Journal of Financial Economics,* 89, 423-43.

Whited, T. (2006). "External finance constraints and the intertemporal pattern of intermittent investment." *Journal of Financial Economics*, 81, 467-502.

TABLE 1A: Summary statistics: baseline investment model

	Bulgaria	Czech Republic	Poland	Romania
I/K	0.318	0.223	0.263	0.172
	(.540)	(.278)	(.346)	(0.648)
Q/K	0.446	0.357	0.467	0.033
	(1.391)	(1.039)	(1.501)	(1.385)
Cash Flow/K	0.243	0.271	0.352	0.346
	(0.290)	(0.321)	(0.441)	(0.571)
K	34.801	73.565	60.825	19.917
	(64.075)	(127.977)	(98.248)	(41.448)
Observations	2314	7757	5629	4656

Note: I represents the firm's real investment; *K*, its real capital stock (expressed in thousands of euros); and *Q*, Tobin's *Q*, proxied by the firm's sales growth. The numbers in this Table are means, with standard deviations in parentheses. See the Appendix for precise definitions of all variables.

TABLE 1B: Summary statistics: baseline cash model

	Bulgaria	Czech Republic	Poland	Romania
Cash/A	0.065	0.071	0.063	0.059
	(0.098)	(0.087)	(0.087)	(0.085)
∆*Cash/A*	0.009	0.006	0.008	0.0008
	(0.068)	(0.052)	(0.052)	(0.061)
Q/A	0.181	0.130	0.163	0.019
	(0.533)	(0.328)	(0.482)	(0.491)
Cash Flow/A	0.107	0.105	0.129	0.132
	(0.107)	(0.090)	(0.122)	(0.174)
Cash	2.855	8.124	7.177	1.936
	(8.188)	(23.241)	(19.855)	(5.938)
A	69.664	145.795	130.862	43.107
	(114.922)	(222.750)	(192.222)	(82.657)
Observations	2310	7747	5600	4651

Note: A represents the firm's real total real assets (expressed in thousands of euros); and *Q*, Tobin's *Q*, proxied by the firm's sales growth. *Cash* represents real cash holdings, expressed in thousands of euros. The numbers in this Table are means, with standard deviations in parentheses. See the Appendix for precise definitions of all variables.

TABLE 2: Summary statistics for the investment model: controlling for irreversibility with the variance of the labor to capital ratio

	Bulgaria		Diff.	**Czech Republic**		Diff.	**Poland**		Diff.	**Romania**		Diff.
	IRR=1	*IRR*=0		*IRR*=1	*IRR*=0		*IRR*=1	*IRR*=0		*IRR*=1	*IRR*=0	
I/K	0.256	0.410	0.00	0.186	0.265	0.00	0.226	0.300	0.00	0.210	0.167	0.03
	(0.458)	(0.642)		(0.217)	(0.330)		(0.306)	(0.377)		(0.688)	(0.675)	
Q/K	0.252	0.681	0.00	0.235	0.494	0.00	0.337	0.605	0.00	0.257	0.677	0.00
	(0.982)	(1.737)		(0.707)	(1.304)		(1.081)	(1.830)		(1.055)	(1.818)	
Cash Flow/K	0.213	0.279	0.00	0.220	0.3294	0.00	0.2914	0.416	0.00	0.295	0.393	0.00
	(0.266)	(0.313)		(0.209)	(0.405)		(0.336)	(0.524)		(0.525)	(0.607)	
K	53.175	12.721	0.00	113.835	28.170	0.00	91.920	27.742	0.00	33.467	7.612	0.09
	(79.738)	(22.541)		(157.623)	(54.296)		(122.668)	(42.992)		(55.057)	(14.411)	
Observations	1269	1045		4113	3644		2940	2689		2216	2440	

Note : *IRR* is a dummy variable equal to 1 if the firm faces irreversible investment, and 0 otherwise. More specifically, it takes the value 1 for firm *i* if the variance of firm *i*'s labor to capital ratio over the period considered falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i*, and 0 otherwise. *I* represents the firm's real investment; *K*, its real capital stock (expressed in thousands of euros); and *Q*, Tobin's *Q*, proxied by the firm's sales growth. The numbers in this Table are means, with standard deviations in parentheses. See the Appendix for precise definitions of all variables. Diff. is the *p*-value of the test statistic for the equality of means.

TABLE 3: Summary statistics for the cash model: controlling for irreversibility with the variance of the labor to capital ratio

	Bulgaria		Diff.	**Czech Republic**		Diff.	**Poland**		Diff.	**Romania**		Diff.
	IRR=1	*IRR*=0		*IRR*=1	*IRR*=0		*IRR*=1	*IRR*=0		*IRR*=1	*IRR*=0	
Cash/A	0.046	0.088	0.00	0.062	0.082	0.00	0.051	0.060	0.00	0.043	0.060	0.00
	(0.071)	(0.120)		(0.078)	(0.094)		(0.080)	(0.089)		(0.064)	(0.095)	
Δ *Cash/A*	0.005	0.0149	0.00	0.006	0.006	0.72	0.008	0.009	0.87	0.001	-0.001	0.14
	(0.053)	(0.082)		(0.047)	(0.057)		(0.051)	(0.053)		(0.054)	(0.067)	
Q/A	0.111	0.262	0.00	0.110	0.152	0.00	0.146	0.181	0.05	0.110	0.260	0.00
	(0.40)	(0.645)		(0.285)	(0.370)		(0.416)	(0.542)		(0.401)	(0.641)	
Cash flow/A	0.097	0.120	0.00	0.106	0.103	0.08	0.129	0.130	0.81	0.117	0.147	0.00
	(0.102)	(0.113)		(0.088)	(0.091)		(0.118)	(0.125)		(0.163)	(0.182)	
A	102.63	30.061	0.00	211.729	71.612	0.00	186.165	72.174	0.00	70.988	17.777	0.00
	(138.230)	(57.025)		(267.436)	(120.719)		(236.562)	(101.597)		(108.267)	(32.321)	
Cash	3.860	1.652	0.00	10.283	4.965	0.00	9.346	4.001	0.00	3.008	1.171	0.00
	(9.746)	(5.921)		(24.931)	(17.650)		(26.748)	(10.018)		(8.153)	(2.786)	
Observations	1261	1049		4105	3642		2896	2704		2214	2437	

Note: IRR is a dummy variable equal to 1 if the firm faces irreversible investment, and 0 otherwise. More specifically, it takes the value 1 for firm *i* if the variance of firm *i*'s labor to capital ratio over the period considered falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i*, and 0 otherwise. *A* represents the firm's real total real assets (expressed in thousands of euros); and *Q*, Tobin's *Q*, proxied by the firm's sales growth. *Cash* represents real cash holdings, expressed in thousands of euros. The numbers in this Table are means, with standard deviations in parentheses. See the Appendix for precise definitions of all variables. Diff. is the *p*-value of the test statistic for the equality of means.

Table 4A: Baseline investment model

	Bulgaria	**Czech Republic**	**Poland**	**Romania**
Q/K	0.236**	0.002	-0.010	0.193***
	(0.10)	(0.03)	(0.03)	(0.06)
Cash flow/K	0.960***	0.391***	0.400***	0.356***
	(0.35)	(0.09)	(0.09)	(0.12)
Observations	2314	7757	5629	4656
Firms	462	1539	1208	1014
m2	0.534	0.341	0.701	0.644
Sargan	0.188	0.129	0.123	0.316

Notes: All specifications were estimated using a GMM system estimator. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in all columns are *Q/K* and *Cash flow/K* lagged twice or more. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. Also see Notes to Table 1A. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 4B: Baseline cash model

	Bulgaria	**Czech Republic**	**Poland**	**Romania**
Q/A	0.008	0.003	0.001	-0.005
	(0.02)	(0.01)	(0.00)	(0.01)
Size	0.016	-0.006	0.002	0.008
	(0.01)	(0.01)	(0.00)	(0.01)
Cash flow/A	0.096*	0.118***	0.085***	0.097**
	(0.05)	(0.03)	(0.02)	(0.05)
Observations	2310	7747	5600	4651
Firms	462	1539	1207	1014
m2	0.426	0.320	0.560	0.00
Sargan	0.620	0.05	0.283	0.05

Notes: All specifications were estimated using a GMM system estimator. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroskedasticity. Instruments in all columns are *Q/A, Size* (measured as the log of the firm's real assets), and *Cash flow/A* lagged twice or more. Time dummies and time dummies interacted with industry dummies were always included in the instrument set. The *J* statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument alidity. *m2* is a test for second-order serial correlation in the first-differenced residuals, asymptotically distributed as N(0,1) under the null of no serial correlation. Also see Notes to Table 1B. * indicates significance at the 10% level. ** indicates significance at the 5% level. *** indicates significance at the 1% level.

Table 5A: Investment model controlling for irreversibility with the variance of the labor to capital ratio

	Bulgaria	Czech Republic	Poland	Romania	UK
Q/K	0.142*	0.008	-0.012	0.229***	-0.0001
	(0.08)	(0.03)	(0.02)	(0.08)	(0.002)
*(Cash flow/K)**IRR*	0.243	0.180	0.179	0.144	0.497**
	(0.31)	(0.14)	(0.12)	(0.19)	(0.23)
*(Cash flow/K)**(1-IRR)*	1.135***	0.386***	0.383***	0.331*	0.108**
	(0.41)	(0.11)	(0.08)	(0.19)	(0.05)
Observations	2314	7757	5629	4656	8852
Firms	462	1539	1208	1014	2794
m2	0.858	0.359	0.585	0.633	0.040
Sargan	0.129	0.057	0.169	0.198	0.748

Note: See Notes to Tables 1A and 4A. *IRR* is a dummy which takes the value 1 for firm *i* if the variance of firm *i*'s labor to capital ratio over the period considered falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i*, and 0 otherwise.

TABLE 5B: Cash model controlling for irreversibility with the variance of the labor to capital ratio

	Bulgaria	Czech Republic	Poland	Romania	UK
Q/A	0.037	0.032	-0.009	0.0001	-0.025
	(0.03)	(0.04)	(0.01)	(0.01)	(0.01)
Size	0.020	-0.001	0.002	0.008	0.038**
	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)
*(Cash flow/A)**IRR*	0.230*	0.375*	0.101*	0.106**	0.381***
	(0.12)	(0.19)	(0.06)	(0.05)	(0.14)
*(Cash flow/A)**(1-IRR)*	-0.126	0.261	-0.037	0.074	0.335***
	(0.12)	(0.19)	(0.08)	(0.05)	(0.13)
Observations	2310	7747	5600	4651	10519
Firms	462	1539	1207	1014	2729
m2	0.338	0.382	0.626	0.00	0.643
Sargan	0.572	0.867	0.936	0.259	0.178

Note: See Notes to Tables 1B and 4B. *IRR* is a dummy which takes the value 1 for firm *i* if the variance of firm *i*'s labor to capital ratio over the period considered falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i*, and 0 otherwise.

TABLE 6A: Investment model controlling for irreversibility with industry-level depreciation rates

	Bulgaria	Czech Republic	Poland	Romania
Q/K	0.188*	0.005	0.017	0.213***
	(0.09)	(0.03)	(0.03)	(0.07)
(Cash flow/K)*IRR	-0.433	0.144*	0.202	0.205
	(0.44)	(0.08)	(0.17)	(0.26)
(Cash flow/K)*(1-IRR)	0.778*	0.758*	0.651**	0.632***
	(0.45)	(0.45)	(0.29)	(0.13)
Observations	2314	7757	5629	4656
Firms	462	1539	1208	1014
m2	0.535	0.475	0.478	0.637
Sargan	0.520	0.154	0.034	0.491

Note: See Notes to Tables 1A and 4A. *IRR* is a dummy which takes the value 1 for firm *i* if the average depreciation to capital ratios of the industry firm *i* operates in is below the median depreciation rate over all industries, and 0 otherwise.

TABLE 6B: Cash model controlling for irreversibility with industry-level depreciation rates

	Bulgaria	Czech Republic	Poland	Romania
Q/A	0.041	0.034	0.017	0.001
	(0.02)	(0.02)	(0.01)	(0.01)
Size	0.062*	-0.001	0.011	0.011
	(0.03)	(0.01)	(0.009)	(0.01)
(Cash flow/A)*IRR	0.306	0.309*	0.128	0.165***
	(0.55)	(0.17)	(0.08)	(0.05)
(Cash flow/A)*(1-IRR)	0.218	0.139	0.066	0.061
	(0.25)	(0.14)	(0.11)	(0.06)
Observations	2310	7747	5600	4651
Firms	462	1539	1207	1014
m2	0.378	0.753	0.575	0.001
Sargan	0.216	0.717	0.883	0.483

Note: See Notes to Tables 1B and 4B. *IRR* is a dummy which takes the value 1 for firm *i* if the average depreciation to capital ratios of the industry firm *i* operates in is below the median depreciation rate over all industries, and 0 otherwise.

TABLE 7A: Investment model controlling for irreversibility with *I/K*

	Bulgaria	Czech Republic	Poland	Romania
Q/K	0.030	0.003	0.027	0.174***
	(0.08)	(0.03)	(0.02)	(0.06)
(Cash flow/K)*IRR	-0.541	-0.207	-0.106	0.014
	(0.39)	(0.31)	(0.09)	(0.23)
(Cash flow/K)*(1-IRR)	0.714***	0.546***	0.471***	0.424***
	(0.21)	(0.11)	(0.08)	(0.15)
Observations	2314	7757	5629	4656
Firms	462	1539	1208	1014
m2	0.874	0.836	0.907	0.967
Sargan	0.190	0.390	0.03	0.251

Note: See Notes to Tables 1A and 4A. *IRR* is a dummy which takes the value 1 for firm *i* in year *t* if firm *i*'s investment to capital ratio in year *t* falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i* in year *t*, and 0 otherwise.

TABLE 7B: Cash model controlling for irreversibility with *I/K*

	Bulgaria	Czech Republic	Poland	Romania
Q/A	0.028	0.008	-0.017	0.008
	(0.03)	(0.02)	(0.01)	(0.01)
Size	0.019	0.017	0.016***	0.006
	(0.01)	(0.02)	(0.01)	(0.005)
(Cash flow/A)*IRR	0.340***	0.309*	0.032	0.158**
	(0.11)	(0.17)	(0.05)	(0.07)
(Cash flow/A)*(1-IRR)	0.140	0.297*	0.010	-0.002
	(0.09)	(0.15)	(0.04)	(0.05)
Observations	2310	7747	5600	4651
Firms	462	1539	1207	1014
m2	0.532	0.370	0.554	0.00
Sargan	0.886	0.887	0.825	0.146

Note: See Notes to Tables 1B and 4B. *IRR* is a dummy which takes the value 1 for firm *i* in year *t* if firm *i*'s investment to capital ratio in year *t* falls in the bottom half of the distribution of the ratios of all firms belonging to the same industry as firm *i* in year *t*, and 0 otherwise.