Comparison of adjustment speeds in target research and development and capital investment: What did the financial crisis of 2007 change?

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Abstract

This paper investigates the dynamics of R&D and capital investment using a large sample of US firms during the period 2002-2016. A partial adjustment approach is employed with a specific focus on the impact of the financial crisis on target adjustment speed. Evidence suggests that firms have a target in both types of investment and adjust to it at varying speeds. Specifically, firms adjusted to the capital investment target faster than to R&D investment. However, firms increased the adjustment speed in R&D investment significantly during the crisis, and it has remained at similar levels during the post-crisis period. The changes in adjustment speeds can be explained by several firm-specific characteristics that are related to the ability of firms to raise internal finance.

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1. Introduction

This paper investigates the dynamic investment behavior of firms with positive research and development (R&D) expenditures. The main objective of the study is to investigate how investment dynamics differ between R&D and fixed capital investment with a focus on the speed of target adjustment. This is done using a large sample of US firms during the period 2002-2016. The sample period enables analysis of the investment decisions before, during and after the global financial crisis of 2007.

The static view of investment stemming from the traditional neoclassical theory of investment assumes that firms operate around their optimal levels, and hence, the observed investment for an average firm at any time is not far from its desired level (see, e.g., Jorgenson, 1963). This implies that when targets change and/or firms move away from their optimal investment (e.g., due to external shocks), they adjust back to their optimal one instantaneously. It is assumed that the costs of target adjustment are negligible. However, the dynamic view acknowledges that capital market imperfections are significant enough to have an impact on the adjustment process (Mueller, 2003; Bloom, Bond, & Van Reenen, 2007). It is argued that while firms desire to revert to their target investment, the desired adjustment is not completed instantly. There are delays in adjusting fully, rendering the adjustment only partial in the first instance.

In a dynamic setting, the speed of adjustment is determined by a trade-off between two types of costs, namely, the costs of reverting back to the optimal investment (adjustment costs) and the costs of being away from the optimal investment (off-target costs). Although the underlying process is similar, this study argues that the nature of this trade-off, as well as the determinants of optimal levels, change between R&D and capital investments. The ability of firms to raise finance, the cost of financing, and whether investment projects are reversible and firms can afford delaying investment expenditures are among the factors that influence the dynamics.

It is well documented in the literature that firms pursue a target investment policy and that investment targets are variant over time and across firms (Gatchev, Pulvino, & Tarhan, 2010; Dasgupta, Noe, & Wang, 2011). However, while previous research yields valuable insights into the dynamics of fixed capital investment, relatively little is known about the R&D adjustment process. More importantly, there is no prior work that specifically investigates how the speed of adjustment differs between R&D and capital investments and what determines the ability and incentives of firms to adjust to target investment levels. This paper advocates the view that the differences in adjustment speeds do not always stem from the varying adjustment costs between the two types of investment. It is argued that off-target costs are also likely to be heterogeneous across R&D and capital investments and can to some extent explain the observed differences in the adjustment dynamics of both investment targets.

Additionally, this paper investigates how the global financial crisis of 2007 affected the speeds of adjustment in target R&D and capital investment. The financial crisis imposed common exogenous shocks that adversely affected the profitability and cash flows of firms as well as their ability to raise external finance. The availability of external funds during and after the crisis was also limited, in particular for new investment projects (Campello, Graham, & Harvey, 2010; Duchin, Ozbas, & Sensoy, 2010; Bliss, Cheng, & Denis, 2015). This study provides a detailed account of how the investment adjustment behavior of firms changed during and after the recent financial crisis in comparison to the pre-crisis period. This is done in relation to both R&D and capital investments. Additionally, the study investigates the firm-specific characteristics that determine the differences in the speeds of adjustment in target levels.

The empirical analysis is conducted using a dataset that comprises 1,266 non-financial US firms during the period 2002-2016. The analysis is conducted in two stages. In the first stage, a target model and the speeds of adjustment for each type are estimated for the entire period. The estimations are then repeated separately for the pre-crisis, crisis and post-crisis periods. In the second stage, further tests are conducted to shed light on the firm-specific characteristics that are likely to explain the different adjustment speeds across R&D and capital investments. This is done by classifying firms into sub-groups using firm-specific attributes that capture the extent of financial flexibility and their ability to raise external funding. In the paper, a partial adjustment model is estimated using the generalized method of moments (GMM) estimation procedure. This estimation method helps control effectively for firm heterogeneity and potential endogeneity, while recognizing that capital market conditions may impede a firm's ability to achieve its target investment levels.

The empirical findings provide strong evidence that firms exhibit a long-term target behavior regarding both R&D and capital investment expenditures. In addition, the dynamics of investment behavior are supported - firms attempt to revert back to their optimal levels, albeit at different speeds with respect to each investment type and time period considered. It is found that the average firm in the sample adjusted to its target R&D more slowly than capital investment. Furthermore, the difference became more significant during the crisis period despite that the adjustment was faster for both types. In the aftermath of the crisis period, firms reverted to their pre-crisis adjustment speed regarding capital investment while they maintained quicker adjustment towards target R&D. Further analysis shows that the ability of firms to adjust can be explained by firms' dividend, cash holdings, leverage and stock issue/purchase decisions. The findings suggest that greater financial flexibility provides firms with higher ability to adjust, in particular to the R&D target.

This paper contributes to the literature in two important ways. First, it contributes to the strand of the literature that emphasizes the differences between R&D and capital investments (Hall, 1992; Brown & Petersen, 2015; Peters &Taylor, 2017). There is consensus in the literature that the dynamics of R&D and capital investment are different. Moreover, the target adjustment costs for R&D are greater (Brown, Fazzari, & Petersen, 2009; Li, Liu, & Xue, 2014; and Peters and Taylor, 2017). However, the analysis of this paper expands the literature by providing a comparative empirical analysis with respect to the determinants of and dynamics of R&D and capital investments. Second, the study tests explicitly the impact of the financial crisis of 2007 on the speed of adjustment of both R&D and capital investments. In doing so, the firm-characteristics that can potentially explain the differences in observed speeds of adjustment are also considered. This analysis provides additional valuable insights into the interaction between firm-specific and firm-invariant external factors.

The remainder of the paper is organized as follows. Section 2 develops the hypotheses of investment adjustment speed. Section 3 derives empirical specifications from theory and describes methodology. Section 4 illustrates preliminary data analysis. Section 5 discusses the estimation results, and Section 6 offers the conclusions.

2. Main predictions

This study argues that the speed at which firms adjust to their desired levels of investment depends on the type of investment as well as a number of firm characteristics and exogenous shocks. In this respect, two important features of the adjustment process are considered. First, it is acknowledged that firms desire to invest optimally to maximize value and hence take up all the value-increasing investment opportunities. It is hence costly to be away from optimal investment levels (i.e., off-target costs). However, it is important to note that a firm can be off-target not only by undershooting (underinvestment) but also by overshooting its investment target (overinvestment). Both sub-optimalities are assumed to be costly to firms and reduce firm value. Second, target adjustment often involves costs that are mainly determined by firm-specific as well as market-wide imperfections (i.e., adjustment costs). The relevant capital imperfections that affect the extent of adjustment costs include informational and agency problems as well as external adverse market conditions that constrain firms and make the cost of external finance greater.

The discussion above implies that being away from optimal levels for long periods are likely to have a negative impact on firm value, and hence, despite the expected significant costs of adjustment, firms would attempt to revert back to their optimal as quickly as possible. That is, the speed of adjustment is clearly determined by the firm's ability and incentives to revert to their optimal levels of investment. While the ability is related to adjustment costs, the incentives are mainly driven by off-target costs. Significant adjustment costs reduce firms' ability to adjust investment levels and hence slow the adjustment process. However, greater off-target costs, ceteris paribus, give greater incentives to change investment expenditures and are therefore expected to increase the speed of adjustment. In what follows, it is also assumed that both off-target costs and adjustment costs are significantly greater for R&D investment than capital investment.

2.1. Adjustment costs hypothesis

There are distinct characteristics of R&D investment, which can lead to significant off-target and adjustment costs. For example, R&D expenditures are mostly intangible and have lower collateral value and fetch lower values when liquidated (Hall, 1992). Furthermore, it is difficult to value R&D projects as there are usually no organized markets for them (Aboody & Lev, 2000). Even in the presence of an observed market price, it is argued that the market price cannot fully reflect all information, mainly due to asymmetric information between insiders and outsiders (Griliches, 1995). The literature argues that standard solutions provided to adverse selection problems, such as signaling, reputation acquisition and financial intermediation, are likely to fail to work for innovation intensive firms (see, e.g., Takalo & Tanayama, 2010).

Another distinct characteristic of R&D expenditures is that it comprises mainly wages, and hiring, firing and training costs of highly skilled employees. R&D costs are generally sunk, and innovation markets are segmented with oligopolistic characteristics, whereas tacit knowledge and skills of scientists make it difficult to fire them (Bloom & Van Reenen, 2002; Trushin, 2011). For the adjustment to target, installing new investment takes time and requires sunk costs, delivery lags, and learning (Cooper & Haltiwanger, 2006). Finally, R&D firms are more constrained in raising further finance, and borrowing constraints impose additional costs in adjusting investment upward. Carpenter and Petersen (2002) show that financing constraints and funding gaps arising from imperfections in capital markets affect high-tech sectors more than others. The above discussion leads to the following hypothesis.

H1: The speed of adjustment to attain the optimal level of R&D investment is lower than that for capital investment.

2.2. Off-target costs hypothesis

Compared to capital investment, R&D investments are highly firm specific and irreversible (Dixit & Pindyck, 1994; Holt, 2007) and are not easily re-deployable (Williamson, 1988). They are also greatly exposed to pre-emptive risk (threat of losing a growth option due to pre-emption), which leads to fierce competition in the R&D market (Bhattacharya & Ritter, 1983). Moreover, R&D investment opportunities are often associated with a high winner's advantage and a significant loss in market share of the losing firm. This reduces the lifetime of the firm's investment opportunities, forcing the firm to invest sooner to ensure continuing growth (Moritzen, 2015). All these features point to significant off-target costs for R&D investment and thus suggest that firms desire to adjust rapidly to their optimal levels of investment. The above arguments lead to the second hypothesis of this paper:

H2: The speed of adjustment to attain the optimal level of R&D investment is greater than that for capital investment.

2.3. Financial crisis hypothesis

In developing and testing the above predictions, this study differentiates between the periods before, during and after the recent financial crisis of 2007. Both the availability and cost of external finance are adversely affected during crises due to greater extent of market imperfections (Rafferty & Funk, 2004; Almeida, Campello, & Weisbach., 2011; Aghion, Askenazy, Berman, Cette, & Eymard, 2012; Mancusi &Vezzulli, 2014). Although both types of investment are expected to be affected adversely by the crisis, an asymmetry is expected to arise in the level of investment and the adjustment behavior of firms with respect to R&D and capital expenditures. To this end, the recent financial crisis provides a natural laboratory to study how firm-characteristics affect optimal investment and the adjustment process (Brown & Petersen, 2015).

The predictions regarding the impact of the financial crisis on R&D investment are not clear-cut. If exogenous shocks, such as financial crises, push actual R&D investment below or above target investment level, one would expect a higher speed of adjustment to re-establish target R&D investment. This is because, compared to capital investment, the expected costs of deviating from the target are higher. However, one could expect a slower speed of adjustment given the high adjustment costs of R&D investment, particularly during the crisis period when the external financing for R&D projects is more difficult to obtain.

Prior research suggests that financing constraints are more relevant to R&D than capital expenditures (see, e.g., Mulkay, Hall, & Mairesse, 2001; Czarnitzki & Hottenrott, 2011). However, Bond, Harhoff and Van Reenen (1999) claim that R&D firms are a self-selected group that face fewer financial constraints. In line with this argument, studies by Himmelberg and Petersen (1994) and Cincera (2003) imply that given the existence of significant adjustment costs for innovation investment, firms will engage in R&D activities only if they do not expect to be significantly affected by credit constraints. This paper incorporates these two opposing views.

Finally, Bernanke and Gertler (1989) find that adverse macroeconomic shocks not only hamper the functioning of financial markets but also exacerbate adverse selection and moral hazard problems. Consequently, during financial crises, firms are more likely to experience severe cash flow shortages. Moreover, Minton and Schrand (1999) show that firms do not resort to external capital markets to fully cover cash flow shortfalls, and hence, they can permanently forgo investment. This suggests that during financial crises, firms are possibly more concerned with prioritizing R&D against capital investment. Thus, during crises, off-target costs would be relatively more important than adjustment costs for R&D expenditures, implying a greater speed of adjustment. This also supports the view that capital investment is shorter term than R&D investment. Short-term investment takes relatively little time to build and therefore generates output (and liquidity) relatively quickly. However, R&D investment takes longer to complete although it contributes more to productivity growth (see Hall, 1992, Aghion & Saint-Paul, 1998, Aghion, Angeletos, Banerjee, & Manova, 2010). Consistent with these points, firms are expected to increase R&D target adjustment speed faster than capital investment during and in the aftermath of a crisis.

H3: Following the financial crisis, the speed of adjustment to attain the optimal level of R&D investment increased faster than that for capital investment.

3. Theory and empirical specification

In what follows, a motivation is provided as to the theoretical foundations of the investment models tested and the methodology used in this study.

3.1. Static model

The standard empirical specification of the neoclassical investment under perfect capital markets assumptions is given as follows:

$$INV_{i,t} = \beta_1 CF/TA_{i,t} + \beta_3 Q_{i,t} + u_{i,t} \tag{1}$$

where *INV* is the ratio of either capital expenditures to total assets (*CE/TA*) or research and development expenditures to total assets (*R&D/TA*) for firm *i* in period *t*, and *CF* and *Q* give firms' cash flows and growth opportunities, respectively. Under a frictionless model of investment, firms are assumed to have no information costs and/or sufficient internal funds to finance their desired investment levels. It is therefore predicted that only changes in growth opportunities (*Q*) have an effect on investment and internal funds (*CF*) do not influence investment levels. Accordingly, firms always achieve their desired levels of investment by maintaining optimal capital stock. In addition, in this static specification, present investment decisions are assumed to be independent of past investment decisions. It is shown that the estimated coefficients can then be biased as contemporaneous and lagged investments are expected to be positively associated (Gatchev et al., 2010).

3.2. Dynamic model

The dynamic approach taken in this study relates to the traditional Q-theory, the neoclassical theory of investment with adjustment costs function. It recognizes that markets are not frictionless, i.e., subject to informational costs, and there is an intertemporal link between current and past investment levels. It considers the investment process in two stages. In the first, firms decide on their optimal (desired) investment levels, INV^*, on the basis of relevant information available at time t. The unobservable target investment of firms, INV^*_{it}, is taken as a function of several firm-specific characteristics, K, suggested by theory, and a disturbance term ε_{it}. As explained later, K includes CF/TA and Q as well as additional control variables for each type of investment:

$$INV_{it}^{*} = \sum_{k} \beta_k x_{kit} + \varepsilon_{it} \tag{2}$$

where firms are represented by subscript i=1, ..., N, and time by t=1, ..., T .

In the second stage, firms are considered attempting to adjust their investment in order for their current investment to be close to the target ratio. This leads to the following partial adjustment:

$$(INV_{it} - INV_{i,t-1}) = \lambda(INV_{it}^{*} - INV_{i,t-1}) \tag{3}$$

where INV_{it} is the actual investment ratio in t, and hence, (INV_{it} - $INV_{i,t-1}$) and (INV^*_{it} - $INV_{i,t-1}$) can be interpreted as the actual and target changes, respectively, where only a fraction λ of the target change is achieved. It can be shown that λ is the ratio of the off-target costs, Φ, to, (Φ+Γ) where Γ is the costs of adjustment, and the cost function for adjusting investment is given as $C(K_t) = \Phi(INV_t – INV_t^*)^2 + \Gamma(INV_t - INV_{t-1})^2$. While the first term of the RHS of the cost function gives the weight of the desired change in investment, the second term presents the weight of the actual change firms can achieve.

The value of the adjustment coefficient λ lies between 0 and 1, capturing the ability and incentives of firms to adjust to their target investment levels. If λ=1, the model implies that firms are able to adjust immediately, i.e., $INV_{it} = INV^{*}_{it}$, implying zero adjustment costs. However, if λ=0, adjustment costs are so large that firms cannot change their existing investment levels, i.e., $INV_{it} = INV_{i,t-1}$. Put differently, λ gives the relative importance of each type of cost in the adjustment process. Combining (2) and (3) yields

$$INV_{it} = \gamma_0 INV_{i,t-1} + \sum_{k=1} \gamma_k x_{kit} + \alpha_i + d_t + u_{it} \tag{4}$$

where γ_0 = 1-λ, $\gamma_k = \lambda\beta_k$, and $u_{it} = \lambda\varepsilon_{it}$, and u_{it} has the same properties as ε_{it}. The positive coefficient of the lagged investment in Equation (4) provides support for the view that firms pursue a target investment policy, and they partially adjust towards an optimal investment ratio, with the estimated adjustment speed coefficient given by $\lambda = 1 - \gamma_0$. The adjustment coefficient is expected to be close to 1 if the costs of being off target are significantly higher than the costs of adjustment. Alternatively, the adjustment coefficient is expected to be close to 0 if adjustment costs are much higher than off-target costs. In all estimations, time dummies are included to control for firm-invariant time-specific effects given by d_t in Equation (4). However, α_i captures time-invariant firm-specific effects including industry effects.

3.3. Alternative investment specifications

It is acknowledged that the underlying factors that determine each type of investment are different. In what follows, a different empirical model is adopted for each investment, noting that capital and R&D investments are affected by a different set of firm-specific factors. This study estimates the following model to explain the capital investment behavior of firms.

$$CE/TA_{i,t} = \beta_1 CE/TA_{i,t-1} + \beta_2 CF/TA_{i,t} + \beta_3 Q_{i,t} + \beta_4 TD/TA_{i,t} + \beta_5 PPE/TA_{i,t} + \beta_6 DIV/TA_{i,t} + \alpha_i + d_t + u_{i,t} \tag{5}$$

In this augmented capital investment specification, in addition to the lagged capital investment ratio, *CE/TA*, cash flows ratio, *CF/TA*, and growth opportunities, *Q*, three additional firm-specific variables are incorporated. They are leverage, *TD/TA*, tangibility, *PPE/TA* and dividend payout, *DIV/TA*, ratios. How much investment firms can undertake is determined not only by their growth opportunities but also by their ability to raise external debt. The tangibility of assets in turn determines the extent to which firms can borrow. Finally, dividends are used in the literature as a proxy for the degree of financial constraints. Equity capital is less relevant for fixed capital investment, as the extent of asymmetric information regarding fixed assets is limited. It is hence not included in the capital investment specification.

However, the R&D model in this study includes similar firm characteristics to those suggested in Brown and Petersen (2009, 2011, 2015), given by the following equation:

$$R\&D/TA_{i,t} = \beta_1 R\&D/TA_{i,(t-1)} + \beta_2 CF/TA_{i,t} + \beta_3 Q_{i,t} + \beta_4 CASH/TA_{i,t} + \beta_5 SSTOCK/TA_{i,t} + \beta_6 PSTOCK/TA_{i,t} + \alpha_i + d_t + u_{i,t} \quad (6)$$

where *CASH/TA* gives cash balances, *SSTOCK/TA* is the ratio of sale of stocks, and *PSTOCK/TA* is the ratio of purchase of stocks (the definitions of the variables used in the analysis is given in Table 1). For R&D investment, the ability of firms to raise external debt is limited due to the intangible nature of R&D expenditures. It is therefore important to control in the specification for the extent to which firms can resort to internal funds (for which cash holdings serve as a proxy) and equity capital.

The main differences between the two specifications relate to the ways in which each type is financed. The findings in previous research point to significantly greater adjustment costs (Hall, Griliches, & Hausman,1986; Lach & Schankerman, 1989) associated with R&D investment. To diminish the high adjustment costs, firms decide to smooth out R&D investments over time (Himmelberg & Petersen, 1994; Hall, 2002). One way of doing this is to use cash reserves. To this end, Brown and Petersen (2011) find that firms use cash reserves to smooth their R&D expenditures. Debt is commonly viewed as not suitable for funding R&D investment due to information asymmetries, adverse selection and moral hazard problems (Hall, 2002). As equity allows more discretion, Williamson (1988) concludes that in financing R&D investment equity capital is a more appropriate source of financing than debt. The study of Brown and Petersen (2009) highlights the recently increasing role of R&D investment in comparison with capital investment and explains it with the rising importance of public equity as a source of funds. Leverage is hence excluded from the R&D specification while it is in the capital investment one. It is well established that high levels of debt lead to agency conflicts between shareholders and creditors, and hence to underinvestment (Myers, 1977) and risk-shifting (Jensen & Meckling, 1976) problems.

The empirical strategy of this paper is to estimate the above specifications for different sub-periods, where the crisis period is distinguished for the purpose of comparison with the pre-crisis and the post-crisis periods. As explained earlier, the main objective is to examine the extent to which the speed of adjustment to target changed under the influence of the financial crisis. In the following, the results for the periods 2002-2007 (pre-crisis period), 2008-2016 (crisis and post-crisis), 2008-2009 (crisis) and 2010-2016 (post-crisis) are presented.

3.4. Methodology

In line with previous studies, the GMM estimation procedure structured by Blundell and Bond (1998) is employed to estimate the dynamic model given in Equations (5) and (6) (see, e.g., Beck, Levine, & Loayza., 2000; Beck & Levine, 2004; Bond, Elston, Mairesse, & Mulkay, 2003; Brown et al, 2009). It is known that estimating a dynamic model with firm fixed effects using OLS and within-group estimates will lead to biased estimates (Nickell, 1981). Furthermore, the independent variables in Equations (5) and (6) are potentially endogenous, and therefore, there is a need to use instrumental variables. To control for the potential endogeneity problem, instruments for the explanatory variables dated only *t*-2 and *t*-3 are used in the estimations. Since earlier instruments do not yield consistent estimates for dynamic panels, they are not included among the instruments used in the estimations (see, e.g., Martinsson, 2010). The GMM estimation approach enables us not only to control for endogeneity and unobserved firm heterogeneity but also to examine the dynamic nature of the investment decision of the firms in the sample.

The consistency of the GMM estimator depends on the validity of instruments used, for which the absence of higher order serial correlation in the idiosyncratic component of the error term is crucial. To this end, first, the Hansen J-statistic of over-identifying restrictions is provided to test for the absence of correlation between the instruments and the error term. This test is distributed as a χ^2 with r-k degrees of freedom under the null hypothesis of the validity of the r instruments, where k is the number of estimated parameters. To assess the validity of instruments, two further test statistics are provided for the existence of first and second order serial correlation in the first-differenced residuals (denoted as AR1 and AR2) where the presence of a second-order correlation could render the GMM estimator inconsistent.

4. Sample selection and descriptive statistics

4.1. Sample selection

The data used in the analysis are obtained from the Worldscope database. The panel datasets for this study were created as follows. First, financial and utility firms were excluded from the sample. Second, those firm-years for which the value of capital expenditures and/or R&D expenses is equal zero are discarded. In the spirit of Brown and Petersen’s (2011) study, only firms that invest positively in R&D and capital projects are considered in this analysis. The vast majority of non-R&D firms are in industries that traditionally have little or no R&D expenditures (e.g., apparel, textiles, lumber, furniture, and printing and publishing); thus, the non-R&D sample is not useful for directly testing the importance of R&D and capital investment adjustment speed. Third, to conduct the GMM estimations, a further restriction that all firms have at least four consecutive time-series observations for all the variables included in the model is imposed. Thus, the number of consecutive years for each firm in the sample varies between 4 and 16. Finally, in an attempt to control for the impact of extreme values on the analysis, outliers are dropped by removing the values of each variable that lies outside the 1^{st} and the 99^{th} percentile range. These criteria result in an unbalanced panel of firms. By allowing firms to enter and exit the sample, the use of an unbalanced panel partially mitigates potential selection and survivor bias. This selection process yields a total of 1,266 US firms, which represent 10,865 firm-year observations for the sample period 2002-2016.

The definitions of the variables used in this study are provided in Table 1. Additionally, Table 2 gives over time industry breakdown in accordance with the Industrial Classification Benchmark of firms included in the sample. It is not surprising that more than 50 percent of firms are contained in two broad industries: industrials (2000) and technology (9000), which generally comprise high-tech firms.

- Insert Tables 1 & 2 here -

4.2. Descriptive statistics

Table 3 presents the mean and standard deviation values for the sample period and three sub-periods, namely, the pre-crisis (2002-07), the crisis (2008-09), and the post-crisis (2010-16) periods. The average values of R&D/TA and CE/TA ratios during the entire sample period are 0.058 and 0.041, respectively. Partly by construction, the average firm in the sample spent substantially more on R&D investment than on capital expenditures. The mean value for cash flow is 7.8 percent whereas a typical firm's market-to-book value is approximately 1.92. Furthermore, on average, firms have 18.2 percent of debt, 20.9 percent of collateral assets and 19.6 percent of cash reserves. Finally, the average dividend-to-assets ratio is 1.4 percent, whereas the average sale of stock by firms corresponds to 1.6 percent of total assets, the average stock purchase-to-assets ratio is 2.4 percent, suggesting that the average firm in the sample engaged more in repurchasing than issuing equity capital.

- Insert Tables 3 here -

Moving on to the differences across different sub-periods, the results reveal significant differences across the two sets of sub-periods. The average capital expenditure dropped to 4.1 percent during the crisis from its pre-crisis average of 4.3 percent. It continued to decrease in the post-crisis period, with an average of 3.9 percent. The pattern for R&D expenditures is, however, somewhat different. It increased from 5.4 percent in the pre-crisis period to 6.1 percent during the crisis period. This corresponds to an approximate 13 percent increase in R&D investment during the crisis period. It then dropped back to a level, i.e., 5.6 percent, which is slightly higher than the pre-crisis one. This provides initial support for the prediction that it is important to maintain R&D investment at times when the cost of capital is expected to be higher. However, these initial findings are not sufficient to conclude that firms also operate around their optimal investment levels and adjust to them relatively quickly.

Not surprisingly, growth opportunities, measured by Tobin's Q, also declined during the crisis period from the pre-crisis level of approximately 1.96 to 1.54 and increased again during the post-crisis to approximately 1.96, suggesting that firms had lower valuable investment opportunities during the crisis period. Importantly, the average cash flow ratio across the two periods, the pre-crisis and crisis, declined significantly from 8.2 to 6.5 and increased to 8.1 during the post-crisis period. This suggests that the ability of firms to finance their investments through internal sources decreased sharply during the crisis but reverted after the crisis back to the pre-crisis level. Furthermore, the total debt ratio dropped slightly from 17.9 in the pre-crisis to 17.3 during the crisis but increased significantly to 19.3 during the post-crisis period.

A different pattern is observed with respect to asset tangibility ratio, which decreased from 22.6 percent in the pre-crisis to 21.2 during the crisis and dropped again to 19.8 during the post-crisis period. However, the opposite is noted for firms' cash holdings, which increased from 18.4 percent in the pre-crisis to 19.1 during the crisis and to 19.6 during the post-crisis period. This corresponds to a 6.5 percent increase between the pre-crisis and post-crisis periods. Additionally, the crisis led firms to cut back on their stock issues by approximately 47 percent (from 1.9 to 1 percent). During the post-crisis period, the average stock issuance increased to 1.5 percent of total assets. In contrast, firms on average purchased more stocks during the crisis compared to the pre-crisis period, increasing the purchase-assets ratio from 2.1 percent to 2.6 percent and continued to do so in the post-crisis period by further increasing the ratio to 2.7. Similarly, firms paid higher dividends during the crisis and post-crisis periods at 1.5 percent compared to the pre-crisis level of 1.3 percent.

Overall, these findings suggest that the impact of the financial crisis on corporate investment was observed more in firms' R&D expenditures than in capital investment. Firms generally maintained their capital investment policy during and after the crisis. It is worth noting that the level of capital (R&D) investment dropped (increased) in the post-crisis period in comparison with the pre-crisis period. Furthermore, compared with the pre-crisis period, during the post-crisis period, firms' Tobin's Q, total debt, dividend payout, cash holdings and stock purchase average levels increased, whereas the levels of cash flow, tangibility and stock issue declined. On average, firms seem to have held on to their R&D investment level during the crisis period and actually invested more.

5. Results

In the following, the results are reported regarding the empirical determinants of capital expenditures (CE/TA) and R&D expenditures (R&D/TA) with a specific focus on the speed of adjustment. First, the results are provided for the entire sample period (2002-2016) and then for a set of sub-periods for comparisons between the periods 2002-2007 (pre-crisis) and 2008-2016 (crisis and post-crisis). Then, in an attempt to shed further light on the crisis period alone, the results are given separately for the periods 2008-2009 (crisis) and 2010-2016 (post-crisis).

5.1. Baseline results

To start, the baseline model given in Equations (5) and (6) are estimated for the entire period 2002-2016 for the capital and R&D investment, respectively. The results in Table 4 show that the estimated coefficient of the lagged dependent variable (L.INV) is positive and statistically significant in both specifications. Specifically, the estimated adjustment speeds for CE/TA and R&D/TA are approximately 0.66 and 0.20, respectively, for the entire period. Thus, as predicted and explained earlier, the R&D/TA adjustment speed is significantly slower than that for CE/TA, suggesting that firms can revert back to their desired levels of capital investment more quickly than R&D investment. This is in line with the first hypothesis of the paper that firms adjust to their capital investment target more quickly. If one assumes off-target costs are similar for both types of investments, this finding is then possibly due to that the adjustment costs for R&D investment are greater. However, if the adjustment costs are similar for both types of investment, it is then possible that firms adjust to their capital investment faster as the costs of being off target capital investment are greater.

- Insert Table 4 here -

As for the factors that are common to each investment type, namely, cash flows and growth opportunities, the results are mixed. While the estimated coefficient of cash flows, CF/TA is positive and significant for capital investment, the effect of cash flows on R&D investment is significant and negative. The estimated coefficient for Tobin's Q is positive but insignificant for both specifications.

Moving on to the results for the control variables for capital investment, the findings reveal that capital expenditures are lower for firms with higher levels of leverage and dividend payouts. The finding for leverage possibly suggests that greater leverage may hamper firms' ability to raise further external finance for investment purposes, and hence, high leverage firms end up investing less. However, paying dividends to shareholders may point to lower growth opportunities and hence less investment. Finally, not surprisingly, the relationship between the tangibility of assets, PPE/TA, and capital investment is positive and significant at the 1 percent level. While this is partly due to construction, as capital investment is tangible in nature, a higher tangibility ratio can be a proxy for the firm's ability to raise external debt, as the collateral value of tangible assets is greater and verifiable.

As explained earlier, the control variables for R&D investment are different. There is a positive and significant relationship between cash balances of firms and their R&D expenditures. Firms with greater flexibility, which is attained through higher cash reserves, are able to invest more in R&D projects. Moreover, the estimated coefficient of stock issue (purchase) is negative (positive) and significant in influencing R&D investment. The results provide strong evidence that firms with higher stock issues (purchases) generally have lower (higher) levels of R&D investment. Such negative (positive) results may arise from the nature of R&D projects, which are associated with greater levels of asymmetric information. The capital raised through stock issuance would hence not be employed in R&D investment.

5.2. The analysis of pre-crisis vs. crisis and post-crisis periods

Table 5 gives the estimation results for different sub-periods, comparing the pre-crisis period (2002-2007) with the crisis and post-crisis periods (2008-2016). For each sub-period, both capital and R&D models are estimated. Comparisons can be made with respect to different types of investment in the same period as well as across different periods for the same type of investment. In the following, the main focus in discussing the results will be on the estimated coefficient of the lagged dependent variable, L.INV, which can take the form of capital (CE/TA) or research and development (R&D) investment. For brevity, the findings regarding the control variables are not discussed in detail. The estimated coefficients remain similar qualitatively.

There are two main observations in relation to the speed of adjustment. First, in line with the earlier findings, the estimated speed of adjustment is greater for capital investment in both periods. Firms attempt to reach to their target levels of capital investment faster than they do for R&D investment, providing strong support for the first hypothesis that the speed of adjustment of R&D investment is lower than of capital investment. In the pre-crisis period, the estimated coefficients of adjustment speed for capital investment and R&D expenditures are 0.51 and 0.07, respectively. The latter adjustment speed suggests that firms are able to complete only 7 percent of their desired change in their R&D investment in a year. In addition to the implication that the adjustment seems to be slow, this result may also suggest that there is almost no persistency in the level of R&D expenditures in the pre-crisis period as though firms do not have a target investment R&D ratio.

- Insert Table 5 here -

Second, it is interesting to note that the speed of adjustment for both types of investments is greater during the crisis and post-crisis period. Although it does not change greatly between the two sub-periods for CE/TA, namely, from approximately 0.51 to 0.63, respectively, it increases for R&D/TA from 0.07 to approximately 0.28, suggesting that firms adjust four times faster during this period compared to the pre-crisis level.

5.3. The analysis of the crisis vs. post-crisis periods

In Table 6, further analysis is provided focusing only on the crisis and post-crisis periods, by investigating how the speed of adjustment changes between the crisis (2008-2009) and the post-crisis (2010-2016) periods. The estimated coefficient of the lagged dependent variable provides interesting insights. Specifically, during the crisis the speed of adjustment to target R&D investment (R&D/TA) is significantly greater in comparison with the results for the pre-crisis period (reported in table 5). In addition, the estimated speed of adjustment to target capital (CE/TA) investment is statistically insignificant. These findings suggest that firms are motivated to maintain their targets only with respect to R&D expenses, albeit still with a low speed. There is no meaningful target behavior for capital investment.

Following the crisis period, however, the speed of adjustment for both investments becomes statistically significant. Firms in the aftermath of the crisis seem to have returned to their target investment behavior with respect to capital investment and maintain their crisis speed of adjustment with respect to R&D. During the post-crisis period, the adjustment speeds for capital and R&D expenditures are approximately 0.55 and 0.24, respectively. As reported earlier in Table 5, the respective numbers for the pre-crisis period are 0.51 and 0.07, showing sharp increase in the R&D adjustment speed in the post-crisis period, whereas a moderate increase is observed for capital investment. These findings are in line with Hypothesis 3 of this paper, predicting that the increase in the speed of R&D investment adjustment following the impact of financial crises is greater than that for capital investment.

- Insert Table 6 here -

Taken together, the findings in Tables 5 and 6 clearly show that firms adjusted significantly faster to all their investment targets in the post-crisis period. During and following the crisis, the speed of adjustment increased significantly, albeit to a lesser extent for capital investment. These findings raise further questions as to what determines the differences in the impact of the financial crisis on the adjustment speed behavior of firms. In the following, additional analysis is provided to shed light on the likely firm-specific factors that influence the adjustment speed of different types of investment. As the observed behavior mainly relates to the post-crisis period, the results are presented only for the 2010-2016 sub-period.

- Insert Table 7 here -

In conducting the analysis, firms are divided into two sub-groups (low and high) in accordance with the median values of several financial characteristics, namely, cash flow, total debt, tangibility, dividend payout, cash holdings, stock issue, stock purchase and sales. The same investment specification is estimated in each case, but only the estimated coefficients for the lagged dependent variable are reported for brevity.

The results show that the difference in the speed of adjustment between CE/TA and R&D/TA ratios is economically significant in all estimations. Importantly, it is never greater for R&D than capital investment. Furthermore, the sub-groups in which firms adjust relatively faster to their target R&D investment are low-stock purchase, high-stock issue, low-sales, low-debt, high-cash, and low-dividend firms. Although it is difficult to provide a clear-cut interpretation of each coefficient, it seems that firms that have greater financial flexibility through, for example, higher cash balances and low levels of debt are able to adjust faster to their target levels of R&D investment. However, the highest speed of R&D target adjustment is approximately 30 percent of the desired change on annual basis.

The factors that explain the changes in the capital investment speed of adjustment are different. In contrast to R&D investment, the fastest (slowest) adjusting sub-groups of firms for capital investment are high-debt (low-debt) and low-cash (high-cash) firms. This is an interesting finding as the factors that lower the R&D adjustment speed seem to have an opposite impact on the speed of adjustment for capital investment. The findings indicate that while the higher R&D adjustment speed can be attained when firms adjust slowly in relation to their capital investment targets, the target capital investment adjustment speed does not seem to depend on how fast companies adjust to their R&D investment.

Overall, the results in Table 7 imply that the adjustment behavior of firms during the post-crisis period is not homogenous and the heterogeneity depends on several important financial characteristics. More importantly, there is an asymmetry regarding the impact of these variables on the speed of adjustment towards capital and R&D target levels. However, low-cash flow and high sales seem to work favorably for both types of investment.

6. Concluding remarks

This paper investigates the investment behavior of R&D firms with respect to both capital and R&D expenditures. This is done by conducting a dynamic panel data analysis using a sample of 1,266 non-financial US firms during the period 2002-2016. Target R&D and capital investment levels are estimated by focusing on the speed of target adjustment. The empirical analysis is conducted separately for the entire period and three sub-periods: the pre-crisis, the crisis and the post-crisis. Additional analysis is conducted to examine how various firm-specific attributes and the global financial crisis of 2007 have affected target adjustment.

The analysis provides clear evidence that firms exhibit a long-term target behavior regarding both R&D and capital investment. However, there are striking differences between the adjustment speeds to R&D and capital investment targets. Firms adjust to their capital investment target much faster than R&D target, regardless of the estimation period. Given that capital investment can be delayed and is reversible to some extent, the findings possibly suggest that the greater speed of adjustment of capital investment is due to relatively lower adjustment costs rather than greater significant off-target costs. However, this does not suggest that off-target costs are negligible. It is almost impossible to disentangle the two costs in the analysis, and hence, the results provide important insights into the relative importance of the two types of costs rather than clear-cut inferences.

As for the R&D adjustment speed, there is strong evidence that the costs of adjustment to R&D are significantly high, evidenced by low adjustment speeds. The sample of this study comprises positive R&D firms, and there is ample evidence in prior research that the costs of being away from target R&D levels are also significant due to pre-emptive risk and reduced lifetime of the firm's investment opportunities. Further analysis reveals that the R&D adjustment speed increases in the crisis and post-crisis periods. This is an interesting finding as the adjustment costs during crisis periods are normally expected to be greater due to higher cost of external finance. The results, however, show that the higher adjustment speeds for R&D firms during and after the crisis period are observed in firms with the ability to issue equity capital and those with greater cash balances.

Overall, the empirical analysis in this paper enhances the understanding of corporate investment behavior in a number of important ways and raises further research questions. First, the evidence is strong to support the view that firms differ in their efforts and ability to maintain the optimal levels of R&D and capital investment. This leads to an argument that there is further need to investigate how the two types of investment interact in determining the optimal level of total investment and the speed of target adjustment. Second, the results show that the adjustment process is not simple, and it needs to be specified more specifically. This is necessary to provide stronger insights into the dynamics of adjustment. In particular, the trade-off between the costs of adjustments and the costs of being away from target investment should be well-specified to shed further light as to the adjustment process and understand better the determinants of speed of adjustment. Third, the results with respect to the crisis period emphasize the importance of external factors in modeling corporate investment behavior. Using longer panel data to analyze the dynamics of corporate investment may conceal the changing dynamics over the period considered. Firm heterogeneity as well as time-specific effects may lead to misleading inferences unless they are controlled properly. These await future research.

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Table 1
Variables definitions

Variable	Definition	Worldscope Code [WC #]
CE/TA	The ratio of capital expenditures to total assets	[WC04601]/[WC02999]
R&D/TA	The ratio of research and development expenses to total assets	[WC01201]/[WC02999]
CF/TA	The ratio of net income before extraordinary items and preferred dividends plus depreciation, depletion and amortization to total assets	([WC01551] + [WC01151])/[WC02999]
Q	The ratio of book value of total assets minus the book value of equity plus the market value of equity to book value of total asset	([WC02999] – [WC03501] + [WC08001])/[WC02999]
TD/TA	The ratio of total debt to total assets	[WC03255]/[WC02999]
PPE/TA	The ratio of property, plant and equipment - net to total assets	[WC02501]/[WC02999]
DIV/TA	The ratio of dividend payout to total assets	[WC04551]/[WC02999]
CASH/TA	The ratio of cash and short-term investments to total assets	[WC02001]/[WC02999]
SSTOCK/TA	The ratio of sale of common and preferred stock to total assets	[WC04251]/[WC02999]
PSTOCK/TA	The ratio of purchase of common and preferred stock to total assets	[WC04751]/[WC02999]

Notes: This table provides the definitions of the main variables used in the analysis. The variables are constructed from the Worldscope database, and the respective codes are shown in the table.

Table 2

Sample distribution across industry and time

Year	1 Oil & Gas	1000 Basic Materials	2000 Industrials	3000 Consumer Goods	4000 Health Care	5000 Consumer Services	6000 Telecommu nications	9000 Technology	Total
2002	17	66	175	99	73	11	14	121	576
2003	20	69	191	105	86	14	15	144	644
2004	21	73	206	111	96	18	20	171	716
2005	23	77	221	117	104	20	20	192	774
2006	23	80	226	117	100	24	18	186	774
2007	21	78	222	125	105	25	20	194	790
2008	17	74	226	124	112	23	18	187	781
2009	16	67	216	121	114	22	15	181	752
2010	15	62	217	124	107	22	18	188	753
2011	17	65	230	135	112	24	18	197	798
2012	18	59	227	132	116	25	16	199	792
2013	15	57	224	127	107	23	15	194	762
2014	14	51	208	121	103	21	13	184	715
2015	13	50	193	116	94	18	11	170	665
2016	10	45	175	100	84	13	7	139	573

Notes: This table presents the number of firms by Industrial Classification Benchmark (ICB). The sample is constructed from publicly traded firms with coverage in the Worldscope database during 2002-2016. Firms with ICB codes from utility (7000) and financial (8000) industries are discarded. Firm-year observations are excluded if capital expenditures or R&D expenses are negative or zero. Firms without four consecutive years of observations during the period 2002-2016 are dropped.

Table 3
Descriptive statistics

	Entire period: 2002-2016	Pre-crisis period: 2002-2007	Crisis period: 2008-2009	Post Crisis period: 2010-2016
CE/TA	0.041	0.043	0.041	0.039
	-0.036	*-0.037*	*-0.034*	*-0.034*
R&D/TA	0.058	0.054	0.061	0.056
	-0.069	*-0.061*	*-0.079*	*-0.066*
CF/TA	0.078	0.082	0.065	0.081
	-0.098	*-0.092*	*-0.113*	*-0.091*
Q	1.919	1.957	1.54	1.961
	-1.111	*-1.075*	*-0.832*	*-1.141*
TD/TA	0.182	0.179	0.173	0.193
	-0.162	*-0.156*	*-0.16*	*-0.164*
PPE/TA	0.209	0.226	0.212	0.198
	-0.159	*-0.161*	*-0.157*	*-0.155*
DIV/TA	0.014	0.013	0.015	0.015
	-0.021	*-0.019*	*-0.022*	*-0.022*
CASH/TA	0.196	0.184	0.191	0.196
	-0.177	*-0.177*	*-0.173*	*-0.166*
SSTOCK/TA	0.016	0.019	0.01	0.015
	-0.044	*-0.044*	*-0.03*	*-0.043*
PSTOCK/TA	0.024	0.021	0.026	0.027
	-0.051	*-0.05*	*-0.052*	*-0.052*
Obs.	10865	3935	1198	4698
Firms	1266	716	651	762

Notes: This table presents mean and standard deviation (in parentheses and italic) values for the entire period sample, pre-crisis, crisis and post-crisis, crisis and post-crisis period samples. The sample period is 2002 to 2016. The pre-crisis period includes years 2002 to 2007 whereas the crisis and post-crisis period comprises years 2008 to 2016; the crisis period covers years 2008 and 2009, and the post-crisis period ranges from year 2010 to 2016. The t-statistic is for the difference of means between the pre-crisis and crisis and post-crisis periods as well as the difference of means between the crisis and post crisis periods. ***, **, and * indicate the t-statistic is significant at the 1%, 5%, and 10% levels, respectively. The definitions of the variables used in the analysis are provided in Table 1.

Table 4
The speed of adjustment in capital, R&D, and total investment targets during the period 2002-2016

Dep. Var.	CE/TA	R&D/TA
L.INV	0.341***	0.804***
	(0.061)	(0.050)
CF/TA	0.059***	-0.108***
	(0.018)	(0.028)
Q	0.001	0.000
	(0.001)	(0.002)
TD/TA	-0.013*	
	(0.008)	
PPE/TA	0.094***	
	(0.014)	
DIV/TA	-0.171***	
	(0.064)	
CASH/TA		0.065***
		(0.018)
SSTOCK/TA		-0.165**
		(0.064)
PSTOCK/TA		0.124***
		(0.031)
Observations	9599	9599
Firms	1266	1266
AR1 p-value	0.000	0.000
AR2 p-value	0.499	0.417
HANSEN p-value	0.201	0.465

Notes: This table presents the system GMM estimation results for the investment model in Equation (1) for all the firms in the sample during the entire period: 2002 to 2016. All regressions include time dummies. Lagged levels dated t-2 to t-3 are used as instruments for the endogenous variables. Asymptotic standard errors robust to heteroskedasticity and clustering are reported in parentheses. ***, ** and * indicate the coefficient is significant at the 1%, 5% and 10% levels, respectively. AR1 and AR2, respectively, denote tests for first-order and second-order serial correlation in the first-differenced residuals, asymptotically distributes as N(0,1) under the null of no serial correlation. The Hansen denotes a test of over-identifying restrictions, asymptotically distributed as a $\chi 2$ under the null of valid instruments. The definitions of the variables used in the analysis are provided in Table 1.

Table 5
Comparison of speeds of adjustment in capital, R&D, and total investment targets during the pre-crisis and post-crisis periods

	Pre-crisis period: 2002-2007		Crisis and post-crisis period: 2008-2016	
Dep. Var.	CE/TA	R&D/TA	CE/TA	R&D/TA
L.INV	0.493***	0.932***	0.369***	0.720***
	(0.109)	(0.070)	(0.095)	(0.115)
CF/TA	0.069**	-0.110***	0.075**	-0.101**
	(0.032)	(0.038)	(0.030)	(0.046)
Q	0.003	0.003	0.001	0.002
	(0.004)	(0.003)	(0.002)	(0.003)
TD/TA	0.019		-0.013	
	(0.027)		(0.011)	
PPE/TA	0.048		0.085***	
	(0.043)		(0.022)	
DIV/TA	-0.027		-0.234**	
	(0.140)		(0.095)	
CASH/TA		0.042**		0.098**
		(0.017)		(0.039)
SSTOCK/TA		-0.152**		-0.194**
		(0.070)		(0.091)
PSTOCK/TA		0.051		0.093
		(0.041)		(0.061)
Observations	3219	3219	5347	5347
Firms	716	716	884	884
AR1 p-value	0.000	0.000	0.000	0.000
AR2 p-value	0.078	0.416	0.448	0.818
HANSEN p-value	0.560	0.163	0.178	0.687

Notes: This table presents the system GMM estimation results for the investment model in Equation (1) for the pre-crisis (2002-2007) and the crisis and post-crisis (2008-2016) periods. Asymptotic standard errors robust to heteroskedasticity and clustering are reported in parentheses. ***, ** and * indicate coefficient is significant at the 1%, 5% and 10% levels, respectively. AR1 and AR2, respectively, denote tests for first-order and second-order serial correlation in the first-differenced residuals, asymptotically distributes as N(0,1) under the null of no serial correlation. The Hansen denotes a test of over-identifying restrictions, asymptotically distributed as a $\chi 2$ under the null of valid instruments. The definitions of the variables used in the analysis are provided in Table 1.

Table 6
Comparison of speeds of adjustment in capital, R&D, and total investment targets during the crisis and post-crisis periods

	Crisis period: 2008-2009		Post-crisis period: 2010-2016	
Dep. Var.	CE/TA	R&D/TA	CE/TA	R&D/TA
L.INV	0.203	0.716***	0.446***	0.761***
	(0.177)	(0.065)	(0.125)	(0.116)
CF/TA	0.027	-0.129	0.083**	-0.131***
	(0.045)	(0.106)	(0.041)	(0.050)
Q	-0.000	0.001	-0.001	0.002
	(0.005)	(0.007)	(0.002)	(0.004)
TD/TA	-0.023		-0.002	
	(0.034)		(0.012)	
PPE/TA	0.183***		0.072**	
	(0.047)		(0.030)	
DIV/TA	-0.144		-0.303**	
	(0.213)		(0.118)	
CASH/TA		0.035		0.083**
		(0.082)		(0.039)
SSTOCK/TA		-0.194		-0.227***
		(0.187)		(0.086)
PSTOCK/TA		0.109**		0.075
		(0.053)		(0.084)
Observations	1094	1094	3936	3936
Firms	547	547	762	762
AR1 p-value	0.010	0.002	0.000	0.000
AR2 p-value	.	.	0.190	0.815
HANSEN p-value	0.018	0.610	0.165	0.663

Notes: This table presents the system GMM estimation results for the investment model in Equation (1) for the crisis (2008-2009) and the post-crisis (2010-2016) periods. Asymptotic standard errors robust to heteroskedasticity and clustering are reported in parentheses. ***, ** and * indicate the coefficient is significant at the 1%, 5% and 10% levels, respectively. AR1 and AR2, respectively, denote tests for first-order and second-order serial correlation in the first-differenced residuals, asymptotically distributes as N(0,1) under the null of no serial correlation. The Hansen denotes a test of over-identifying restrictions, asymptotically distributed as a $\chi 2$ under the null of valid instruments. The definitions of the variables used in the analysis are provided in Table 1.

Table 7

Financial characteristics and speed of adjustment during the post-crisis period (2010-2016)

Dep. Var.	CE/TA	R&D/TA	CE/TA	R&D/TA
	Low Cash Flow Firms		High Cash Flow Firms	
L.INV	0.382***	0.759***	0.449**	0.960***
	Low Debt Firms		High Debt Firms	
L.INV	0.564***	0.742***	0.244**	1.052***
	Low Tangibility Firms		High Tangibility Firms	
L.INV	0.253	0.721***	0.339***	0.921***
	Low Dividend Firms		High Dividend Firms	
L.INV	0.359**	0.714***	0.317***	0.976***
	Low Cash Holdings Firms		High Cash Holdings Firms	
L.INV	0.281**	0.965***	0.465***	0.701***
	Low Stock Issue Firms		High Stock Issue Firms	
L.INV	0.402***	0.985***	0.424***	0.728***
	Low Stock Purchase Firms		High Stock Purchase Firms	
L.INV	0.484***	0.699***	0.435***	0.990***
	Low Sales Firms		High Sales Firms	
L.INV	0.411***	0.701***	0.367***	0.997***

Notes: This table presents the system GMM estimation results for the investment model in Equation (1) for various sub-groups of firms during the post-crisis period. Firms are classified into low and high sub-groups according to their financial characteristic ratio in relation to sample median of the respective financial characteristic ratio. The estimation period for both sub-groups is the post–crisis period (2010-2016). Asymptotic standard errors robust to heteroskedasticity and clustering are reported in parentheses. ***, ** and * indicate coefficient is significant at the 1%, 5% and 10% levels, respectively. AR1 and AR2, respectively, denote tests for first-order and second-order serial correlation in the first-differenced residuals, asymptotically distributes as N(0,1) under the null of no serial correlation. The Hansen denotes a test of over-identifying restrictions, asymptotically distributed as a $\chi 2$ under the null of valid instruments. The definitions of the variables used in the analysis are provided in Table 1.