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How and when do firms adjust their investments toward targets?

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How and when do firms adjust their investments toward targets?

October 26, 2015

Abstract

Due to adjustment costs, firms' only partially adjust toward desired investment levels. By exploiting unique survey data on firms' desired investments, we examine how and when firms adjust their investments toward stated plans (targets). More precisely, we examine how financing costs due to asymmetric information, disruption costs, and costs due to asset irreversibility influence firms' adjustment costs and thus adjustment behavior. We find that firms with sufficient cash flows to finance all desired investments adjust significantly faster toward targets than firms with insufficient cash flows. Moreover, firms with either minor investment targets, a large fraction of desired replacement investments or low asset irreversibility adjust within shorter time compared to firms with major investment plans, capacity expansion targets or high asset irreversibility, respectively. Finally, although several prior studies find that the financial crisis of 2008 and 2009 reduced firms' realized investment spending, our results indicate that firms' speed of adjustment toward target investments was not influenced by the crisis.

JEL classification: D92; E22; G31; G32.

Keywords: Investment behavior, Partial adjustment, Adjustment costs, Survey data, Financial crisis.

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1 Introduction

From economic theory, we know that in a world without frictions, firms would always maintain their optimal capital stock and undertake all desired investments (Jorgenson, 1967; Gould, 1968; Hay, 1970). As markets are, however, subject to frictions, the implementation and completion of firms' investments entail additional costs. Therefore, firms face a trade-off between the costs of having a suboptimal level of investments and the costs of adjusting toward desired investment levels. The speed with which firms reverse deviations from target investments depends on the cost of adjusting toward targets. With zero adjustment costs, firms should never deviate from their targets. With infinitely high adjustment costs, firms should never move towards their targets.

In this paper, we determine the impact of adjustment costs on firms' investment behavior by applying standard partial adjustment models to estimate firms' speed of adjustment toward target investments. More precisely, we exploit unique data on firms' investment realizations from financial statements and on firms' stated investment plans from the Ifo Investment Survey. Both accounting and survey data are available for about 400 German manufacturing firms from 2004 to 2013. We consider stated investment plans as firms' desired target investments and estimate the speed of adjustment with which firms adjust their actual investments toward stated targets. To the best of our knowledge, this is the first study to determine how fast firms adjust toward stated targets by estimating partial adjustment models. We find that due to adjustment costs, firms only partially adjust toward target investments and need approximately one year to close half the gap between a typical firm's realized and desired investment spending.

Moreover, as economic theory suggests a number of factors determining adjustment costs, such as financing costs (Whited, 2006), disruption costs (Hamermesh and Pfann, 1996; Cooper and Haltiwanger, 2006), and costs due to asset irreversibility (Dixit and Pindyck, 1994; Caballero and Engel, 1999), we examine the impact of each factor on firms' adjustment costs and thus adjustment behavior. By identifying major sources of adjustment costs and deriving possible factors influencing these costs, we further show why models assuming adjustment to be costless and immediate are flawed. Our results indicate

that there are differences in adjustment behavior across our sample of manufacturing firms. For instance, we find that firms with sufficient cash flows adjust significantly faster toward targets than firms with insufficient cash flows. Moreover, firms with either minor investment targets or a large fraction of desired replacement investments adjust within shorter time compared to firms with major investment plans or capacity expansion targets, respectively. We further find that firms with a high degree of asset irreversibility adjust slower toward targets than firms with a low degree of asset irreversibility. We provide several tests which confirm the robustness of our results.

Beside the adjustment costs which arise out of firms' environment, adjustment costs might also be the result of external shocks. For example, changes in government support for investments, changes in firms' corporate tax rates or amortization rules or changes in the overall economic situation might lead to revisions in firms' optimal capital stock (Hamermesh and Pfann, 1996). We therefore examine how shocks to the overall economic situation influence firms' adjustment behavior. More precisely, we study the consequences of the recent financial crisis of 2008 and 2009 on firms' adjustment behavior. Although the recent financial crisis reduced firms' realized investment spending, firms' speed of adjustment toward target investments did not respond to the financial crisis. We propose several explanations for our findings.

In this paper, we explore how and when firms adjust toward target investments. Understanding firms' adjustment behavior is important for several reasons. First, by estimating firms' speed of adjustment toward targets, we are able to indirectly quantify firms' adjustment costs, as a low speed of adjustment indicates high adjustment costs and fast adjustment toward targets indicates low adjustment costs. Second, beside examining firms' adjustment behavior toward stated targets, we are capable of identifying factors influencing firms' adjustment behavior. In doing so, we are able to specify firms facing lower adjustment costs and are thus better able to adjust toward targets. Finally, we find that deviations between realized and planned investments (investment gaps) are meaningful in an economic sense. More precisely, we find that annual average investment gaps, which are defined as the difference between non-scaled planned and non-scaled realized

investments, correspond to approx. 0.536 billion Euros. This complies to about one third of average realized investments.¹ These figures seem even more impressive if we consider that we only aggregate investment gaps for a very small fraction of manufacturing firms in West Germany (less than 1% of the total manufacturing industry). Given its economic significance, we hence want to examine which firms deviate most from stated targets and how fast do firms adjust toward targets.

Our paper is related to several strands of literature. Our paper builds on the literature examining the nature of adjustment costs of capital stock. While most of the investment literature refers to standard neoclassical models with convex adjustment costs (Jorgenson, 1967; Fazzari et al., 1988), more recent literature propose investment models which account for investment irreversibility and non-convexities in adjustment costs (Abel and Eberly, 1996; Doms and Dunne, 1998; Caballero and Engel, 1999; Cooper et al., 1999; Cooper and Haltiwanger, 2006). In these models firms invest only when capital stock is sufficiently far from the desired level, otherwise firms remain inactive to avoid lump-sum costs associated with investments. Cooper and Haltiwanger (2006), for instance, find that models accounting for irreversibility and non-convexity are best able to explain observed investment patterns characterized by investment spikes and periods of inaction when exploring plant-level data from U.S. manufacturing firms over the sample period 1972 to 1988. However, Cooper and Haltiwanger (2006) also show that a model with only convex adjustment costs fits aggregate data reasonably well.

Our study further relates to prior literature examining the impact of firms' adjustment costs on investment behavior. For instance, Whited (2006) can show that external financing constraints entail additional costs of adjusting firms' capital stock, thereby leading to delays between episodes of intense investments.

Our paper extends prior literature examining investments' adjustment costs, as prior studies mainly examine investment adjustment costs on an aggregate basis (Levin et al., 2005; Cooper and Haltiwanger, 2006) or on an industry-level basis (Groth and Khan,

¹If we simply sum up investment gaps over all firm-year observations for the entire sample period from 2004 to 2013, we obtain accumulated investment gaps of approx. 4.28 billion Euros which corresponds to an annual average gap of 0.536 billion Euros.

2010). Groth and Khan (2010), for instance, provide estimates on the magnitude of adjustment costs for 18 U.S. manufacturing industries. More precisely, Groth and Khan (2010) estimate industry-specific adjustment cost parameters over the sample period 1949 to 2000 by using generalized methods of moments estimators. The results of Groth and Khan (2010) indicate that adjustment costs are rather small, which coincide with the findings of Hall (2004). When comparing their industry estimates to adjustment cost estimates based on aggregate data as provided by Levin et al. (2005), they find substantial differences. The authors conclude that due to aggregation bias, estimates based on aggregate models have to be treated with caution.

In contrast to Hall (2004) and Groth and Khan (2010), we do not want to estimate the magnitude of adjustment costs. Instead, we determine how and when firms adjust toward targets. We hence estimate firms' speed of adjustment toward targets and thereby analyze which firms are best able to adjust toward stated targets. Since firms' speed of adjustment reflects the degree of adjustment costs, we only indirectly measure firms' costs of adjustment. More precisely, we can only infer from firms' speed of adjustment the magnitude of firms' adjustment costs. This paper thus contributes to the literature examining adjustment costs, but sheds some new light to this discussion, since we focus on firms' speed of adjustment toward targets by studying micro level data. To the best of our knowledge there is no other study which examines the speed of adjustment by taking into account stated targets from micro level data.

Finally, our study is related to prior studies examining data on investment plans. Due to limited data availability, there are only few studies which examine data on investment plans and realizations (Friend and Bronfenbrenner, 1950; Modigliani and Weingartner, 1958; Foss and Natrella, 1960; Guiso and Parigi, 1999; Lamont, 2000; Glaser et al., 2013; Gennaioli et al., 2015). Lamont (2000), for instance, examines survey data on aggregate actual and planned investments conducted by the U.S. Department of Commerce for the time period 1947-1994. By univariately regressing the growth rate of actual investments on the growth rate of planned investments, he finds a high congruency between actual and planned investment growth rates. A more recent study analyzing quarterly data

on investment plans and realizations from several business-units of a multinational conglomerate over the sample period 2002 to 2006 is Glaser et al. (2013). In contrast to the results of Lamont (2000) the authors find systematic divergences between investment plans and actual investments. They claim that differences arise as business-unit managers systematically build a cushion into their capital budgets.

In a broader sense, our paper is also related to prior literature on firms' capital structure. Several papers examine firms' adjustment behavior by estimating firms' speed of adjustment toward target leverage and by determining the factors influencing firms' speed of adjustment. For details see e.g., Frank and Goyal (2003) Flannery and Rangan (2006), Byoun (2008), Elsas and Florysiak (2011) and Faulkender et al. (2012).

The outline of this study is as follows: In Section 2, we present a standard partial adjustment model for firms' investments and describe factors influencing firms adjustment costs and thus adjustment behavior. Section 3 describes the data used, explains the econometric methodology and presents summary statistics. The results and robustness tests are presented in Section 4. The impact of the financial crisis on firms' adjustment behavior is examined in Section 5. Section 6 concludes.

2 Partial adjustment toward target investments

In a world without frictions, firms would always maintain their desired capital stock. Due to adjustment costs, however, firms only partially adjust toward target values. To examine how and when firms adjust toward target values, we show in Section 2.1 how a standard partial adjustment model derived for firms' optimal capital stock can be applied to firms' investment behavior. Since adjustment costs explain firms' partial adjustment behavior, we further describe in Section 2.2 possible factors determining adjustment costs. In doing so, we develop four hypotheses about the factors influencing firms' adjustment costs which will be tested in the empirical part of our paper (Section 4).

2.1 A partial adjustment model for firms' investments

One fundamental assumption of standard theory of investments is that for each firm an optimal capital stock K_t^* exists which maximizes the value of equity owned by shareholders (Jorgenson, 1963, 1971). Under the assumption of no adjustment costs, every firm would thus choose a capital stock level which corresponds to firms' desired capital stock K_t^* .

However, if adjustment of capital stock is costly, actual observed capital stock K_t will deviate from desired capital stock K_t^* . In the presence of adjustment costs, firms thus have to decide to what extent to adjust toward desired capital stock. In doing so, firms take into account the costs associated with deviating from optimum and the costs of adjusting toward optimum. By assuming both cost parts to be quadratic and additive², firms' cost function for adjusting capital stock can be expressed as

$$C(K_t) = \nu(K_t - K_t^*)^2 + \mu(K_t - K_{t-1})^2, \quad (1)$$

where the parameters ν and μ ($\nu, \mu > 0$) indicate the magnitude of the respective cost part. K_t denotes firms' actual observed capital stock in t , K_{t-1} denotes firms' realized capital stock at time $t-1$ and desired capital stock is K_t^* . Since firms aim to choose K_t in a way which minimizes firms' costs, we derive the first-order condition of Equation (1) with respect to firms' capital stock

$$\frac{\partial C(K_t)}{\partial K_t} = 2\nu(K_t - K_t^*) + 2\mu(K_t - K_{t-1}) \stackrel{!}{=} 0, \quad (2)$$

and solve for K_t

$$K_t = \frac{\nu}{\nu + \mu} K_t^* + \frac{\mu}{\nu + \mu} K_{t-1}. \quad (3)$$

²This assumption is standard in the literature, see, e.g., Gould (1968), Nickell (1975), Fazzari et al. (1988) or Ratti et al. (2008). For instance, the basic idea of the Q theory is to solve the dynamic optimization problem of a firm with convex costs of capital adjustment Cooper and Ejarque (2001). Although several prior studies show that assuming convex adjustment costs contradicts observable investment patterns (Caballero and Engel, 1999; Cooper and Haltiwanger, 2006; Whited, 2006), Hall (2004) can show that biases from specification errors in adjustment costs (estimating convex adjustment costs technology in the presence of nonconvex costs) are relatively small. Moreover, Cooper and Haltiwanger (2006) show that a model with only convex adjustment costs fits aggregate data reasonably well. By assuming convex cost function, we implicitly assume that the faster the firm adjusts its capital stock toward targets the higher will be the costs.

By substituting $\nu/(\nu + \mu)$ by λ and $\mu/(\nu + \mu)$ by $(1 - \lambda)$, we obtain

$$K_t = \lambda K_t^* + (1 - \lambda)K_{t-1}, \quad (4)$$

which can be transformed into a standard partial adjustment model for firms' capital stock

$$K_t - K_{t-1} = \lambda(K_t^* - K_{t-1}). \quad (5)$$

Equation (5) indicates that due to adjustment costs, firms close only a fraction λ of the gap between actual and desired capital stock levels each year. Accordingly, λ measures the speed of adjustment with which firms reach their optimal target values. λ can take values between zero and one, whereas values close to one indicate low adjustment costs and thus faster rate of adjustment of capital stock. The closer the value of λ is to zero, the larger are the implied costs of adjustment and the slower is firms' rate of adjustment of capital stock.

Since data on firms' capital stock or net investments are often not available or difficult to obtain, we relate firms' capital stock to firms gross investments. As standard in the literature (Jorgenson, 1963), we assume that firms' gross investments correspond to firms' change in capital stock plus replacement investments (depreciation of last year's capital stock)

$$I_t = K_t - K_{t-1} + \delta K_{t-1}. \quad (6)$$

I_t reflects firms' gross investments and δ corresponds to firms' fixed depreciation rate ($0 < \delta < 1$). By applying the lag operator L to Equation (6), we derive an expression for firms' capital stock (K_t) in relation to firms' investments³

$$K_t = \frac{1}{1 - (1 - \delta)L} I_t. \quad (7)$$

Analogously, expressions for firms' capital stock in period $t-1$ (K_{t-1}) and for firms' optimal capital stock (K_t^*) can be derived. By substituting Equation (7) and the corresponding

³By lag operator, we understand the following relation: $L_{z_t}^K = z_{t-k}$, for $k = \dots, -1, 0, 1, 2, \dots$

expressions for K_{t-1} and K_t^* into Equation (4), we obtain a partial adjustment model for firms' investments

$$I_t - I_{t-1} = \lambda(I_t^* + I_{t-1}). \quad (8)$$

Where I_{t-1} reflects firms' realized investments in $t-1$, I_t^* reflects firms' desired investment spending and I_t indicates firms investment spending as of t . From Equation (8) it follows that firms' adjustment behavior toward desired gross investments corresponds to firms' adjustment behavior toward desired capital stock (Equation (5)). Accordingly, we can use standard partial adjustment models derived for firms' capital stock on firms' gross investments. Partial adjustment models are thus not only applicable to stock values but also to flow values. For our empirical analyses, we will estimate Equation (8) to determine firms' speed of adjustment toward target investments. Estimates for λ then enable us to draw conclusions on the importance of adjustment costs for private firms' investments. While estimates of λ close to zero indicate a low speed of adjustment and thus high adjustment costs, estimates close to one indicate immediate adjustment and thus low adjustment costs.

2.2 Stylized facts on adjustment costs and hypotheses development

In general, adjustment costs contain all costs associated with the sale, purchase, or productive implementation of new capital goods above the basic price of these new goods. Accordingly, if a firm installs a new machine, this installation will entail, beside the costs of buying the machine, several other costs (Cooper and Haltiwanger, 2006; Hamermesh and Pfann, 1996).⁴ In the following, we briefly discuss the main sources of adjustment costs. We do this for two reasons. First, by identifying major sources of adjustment costs, we show why models assuming adjustment to be costless and immediate are flawed. Second, understanding the sources of adjustment costs enable us to identify factors influencing these costs. In the following, we therefore briefly recap prior economic theory which suggests financing costs due to asymmetric information, disruption costs, and costs due

⁴For a detailed description on capital adjustment costs, see e.g., Hamermesh and Pfann (1996).

to asset irreversibility as key sources of adjustment costs.

2.2.1 Adjustment costs arising from informational asymmetries

If firms buy new capital goods, they can either use internal or external sources of funds to finance capital stock adjustments. In a world with perfect capital markets, the costs for both sources of funds will be equal. As capital markets are, however, imperfect, informational asymmetries will drive a wedge between the costs of internal and external financing sources (Jensen and Meckling, 1976; Myers and Majluf, 1984). Accordingly, informational asymmetries entail adjustment costs in terms of financing costs if firms with insufficient internal funds are forced to raise expensive external funds to finance new capital goods. Whited (2006), for instance, shows that external financing constraints entail additional costs of adjusting firms' capital stock and thereby increases the delay between episodes of intense investments. We should therefore observe that firms with cash flows greater or equal to target investments (firms with sufficient cash flows to finance planned investment projects) face lower adjustment costs and hence adjust faster toward investment targets than firms which have to raise (expensive) external financing. This leads to our first hypothesis:

*H1: Firms with sufficient cash flows adjust faster toward target investments than firms with insufficient cash flows.*⁵

2.2.2 Adjustment costs resulting from disruptions in production

According to Cooper and Haltiwanger (2006), the costs of adjusting capital stock reflect a variety of interrelated factors which are difficult to measure, as most of these costs are implicit. For instance, if a firm has to reallocate production across machines during the installation of a new capital good, input from current production has to be shifted away which might lead to a decrease in firms' output (Hamermesh and Pfann, 1996). Hence, the installation of new capital goods entails adjustment costs in terms of

⁵Alternatively, we could test whether financially constrained firms adjust more slowly toward target investment than unconstrained firms, as constrained firms face higher adjustment costs due to difficulties in obtaining external financing. We will test the influence of financing constraints in our robustness tests.

disruption costs if firms' production output and efficiency decreases during installation. According to Hamermesh and Pfann (1996) and Cooper and Haltiwanger (2006), disruption costs might also occur after installation, if workforce's tasks have to be restructured or training of workers how to use the new machine is necessary. Obviously, especially major investment projects (in terms of firms' total assets) which comprise the construction of a new production site or the installation of highly specialized -and thus expensive- machines will entail high disruption costs. The reason is that these major projects often lead to reorganizations of production lines or require special trainings to workers. Consequently, we expect that firms with major investment plans adjust slower toward targets, as major projects are more likely to entail costly production disruptions. Our second hypothesis thus is:

H2: Firms with major investment plans adjust slower toward stated targets than firms with minor investment plans.

Beside firms' decisions on the magnitude and on the type of financing of target investments, firms have to decide on the purpose of investments. In general, firms can either choose to increase capital stock by undertaking investments into capacity expansions or firms can replace existing capital stock by undertaking replacement investments. Following Feldstein and Foot (1971) who argue that expansion investments induce more profit losses, we claim that investments into capacity expansions entail higher disruption costs compared to replacement investments. This is reasonable as capacity expansions often include the introduction of new products which cause changes in production processes or require time-consuming training of workers. In contrast, the implementation of replacement investments entails lower disruption costs, as replacement investments often only substitute older machines for which functionality and area of application is clear. Accordingly, production lines most often do not change when old machines are replaced and workers do not need special training. Moreover, replacement investments often have to be undertaken by the firm to ensure production. Firms planning to undertake replacement investments are thus especially keen on undertaking these investments as otherwise

production might be endangered.⁶ Thus, our third hypothesis to be tested is

H3: Firms planning to undertake replacement investments adjust more quickly toward targets than firms planning to undertake investments into capacity expansion.

2.2.3 Adjustment costs due to asset irreversibility

If firms plan to undertake investments, they will also take into account costs of asset irreversibility (Dixit and Pindyck, 1994; Bertola and Caballero, 1994; Caballero and Engel, 1999). Asset irreversibility hereby indicates that due to the lack of a secondary market for used capital goods, many firms will hesitate before buying new equipment, especially if future outlook is uncertain. Several studies provide evidence that the degree of asset irreversibility crucially depends on firms' capital specificity at the industry level (Dixit and Pindyck, 1994; Chirinko and Schaller, 2009). Hence, it will be either impossible or quite expensive for firms to reverse an investment project if new capital goods are rather specialized or specific to the industry. For instance, Chirinko and Schaller (2009) find evidence that firms operating in industries with limited resale markets have to pay an irreversibility premium which is significantly different from zero. We therefore argue that adjustment costs are higher for firms with highly specialized equipment. Our last hypothesis to be tested is

H4: Firms facing a high degree of asset irreversibility adjust more slowly toward targets than firms facing a low degree of asset irreversibility.

3 Empirical implementation

To study firms' adjustment behavior toward stated investment plans, we examine unique panel data on large, private manufacturing firms in Germany. We provide a brief overview on our data in Section 3.1. In Section 3.2, we describe our estimation equation

⁶Even if firms' adjustment costs for replacement investments are not lower than the ones for capacity expansions, we can argue that the costs for not adjusting (for not undertaking replacement investments and taking the risk to endanger production) are at least higher than for adjusting.

and the construction of relevant variables. We discuss the employed econometric methods in Section 3.3 and present summary statistics in Section 3.4.

3.1 Data

For our empirical analyses, we combine information from two main sources: the ifo Investment Survey, which is conducted by the ifo Institute, and the accounting databases from either Bureau van Dijk's Amadeus (Amadeus) or Bisnode. Both survey and accounting data sources are described in detail in Appendix A.

The main purpose of the ifo Investment Survey is to provide information on firms' investment behavior. The survey has been conducted on private manufacturing firms in West Germany every fall (September/October) of a year since 1964, whereas managers mainly belonging to the higher management of a firm's controlling or finance department are polled (Abberger et al., 2009). In detail, managers have been asked about realized investment spending since fall 1964 and about factors influencing firms' investment behavior since 1989. Since fall 2004, the survey also asks managers to state firms' planned investment spending (targets) for the entire upcoming year. As we refer to survey information to measure firms' target investments, we restrict our sample period from 2004 to 2013.⁷ Our sample period is restricted to 2013 as survey data is only available up to 2013 due to disclosure considerations.

Since the ifo Investment Survey neglects to poll relevant information on firms' cash flows, size or investment opportunities, we use accounting data provided by either Amadeus or Bisnode. If information for a firm is available from both accounting databases, information from Bisnode is preferred due to its higher accuracy and quality (Seiler, 2012). In addition, we do not want our study to be entirely based on survey data and, hence, use accounting data to measure firms' realized investments.⁸ In addition, we will consider standard balance sheet items such as firms' cash flows, size and sales growth (as a proxy

⁷Our full sample spans the time period 2003 to 2013 as we need lagged values as controls and instruments for subsequent analyses.

⁸Unreported analyses indicate that the correspondence between stated realized investments from survey and realized investments reported in annual reports are very similar. For details, we refer to Klepsch (2013)

for investment opportunities) as control variables. Both accounting databases consider German accounting standards and data are available over the time period 1987-2014.

Our final database thus represents the combination of survey and accounting data, whereas data sets are linked via firms' registered name and address information using a record linkage approach.⁹ Following Almeida et al. (2004), we account for firm discontinuities caused by merger activities, reorganizations, and other corporate actions by removing all firm-year observations with total assets or sales growth exceeding 100%. We further delete all firms with fewer than two consecutive years of data and three public firms (20 firm-year observations) as we only focus on private firms. However, results do not change if we include these observations. We deflate all unscaled accounting variables by a price index to express nominal values in 2005 Euros.¹⁰ Finally, we winsorize all continuous variables at the 5% and 95% levels to control for outliers.

3.2 Model specification and construction of variables

3.2.1 Base model

To estimate firms' speed of adjustment toward target investments, we apply a standard partial adjustment model for firms' investments which allows a firm's target investment to vary over time and tolerates that deviations from targets must not be balanced infinitely fast. Based on the model derived in Section 2.1, the equation to be estimated is

$$I_{i,t} - I_{i,t-1} = \lambda(I_{i,t}^* - I_{i,t-1}) + \beta X_{i,t-1} + \eta i + \theta_t + \epsilon_{i,t}, \quad (9)$$

The index $i = 1, \dots, N$ is an index for individuals and the index $t = 1, \dots, T$ indicates time. $I_{i,t}$ is the i th firm's realized investment ratio which is defined as firm's realized investment expenditures in property, plant and equipment (PPE) in t over beginning-of-year total assets. Since data from cash flow statements are not available, we calculate

⁹For a detailed description of the exact matching approach we refer to information provided on the web page of the Economics & Business Data Center (EBDC). For theoretical details on the record linkage approach see, e.g., Newcombe et al. (1959); Fellegi and Sunter (1969). For a general description on the data sets provided by the EBDC see, e.g., Hoenig et al. (2010) or Seiler (2012).

¹⁰Price deflator data are obtained from the AMECO database provided by the European Commission.

realized investments in PPE as the change in tangible assets from year $t-1$ to t and add firms' depreciation as of t .

$I_{i,t}^*$ is a firm's desired investment spending for year t stated in year $t-1$ scaled by beginning-of-year total assets. Data on firms' desired investments are obtained from the Ifo Investment Survey, in which managers provide information on firms planned investment spending in PPE in absolute values for the entire upcoming calendar year. Although managers state investment plans in fall of a year for the entire upcoming year (15-month-ahead prediction), plans refer to firms' investments over a time period of twelve months (entire upcoming calendar year).

$X_{i,t-1}$ reflects standard control variables used in the investment literature. In particular, we control for firms' cash flows, investment opportunities and size. To control for size effects, we include the natural logarithm of firms' total assets (*Size*). Firms' operating cash flows (*CF*) are calculated as firms' earning after tax plus depreciation, scaled by beginning-of-year total assets. Given that our sample consists of only private firms, we follow Asker et al. (2015), Carpenter and Guariglia (2008) and Bloom et al. (2007) and use sales growth as our measure for investment opportunities. More precisely, we use the two-digit level of the common statistical classification of economic activities in Germany (WZ 2008 industry codes) to calculate industry's sales growth as a proxy for investment opportunities (*Inv. opport.*).¹¹ All control variables are measured as of $t-1$ to avoid endogeneity concerns.

Firm fixed effects (η_i) are included to control for omitted variables that vary across firms, but are constant over time. By including time fixed effects (θ_t), we control for all variables that are constant across firms but evolve over time. The error-term is denoted by ϵ . For ease of reference, we simplify Equation (9) to

$$\Delta I_{i,t} = \lambda DEV_{i,t} + \beta X_{i,t-1} + \eta_i + \theta_t + \epsilon_{i,t}, \quad (10)$$

¹¹Untabulated results indicate that results remain rather unchanged if we use firms' sales growth or average industry's sales.

where

$$\Delta I_{i,t} = I_{i,t} - I_{i,t-1} \quad \text{and} \quad DEV_{i,t} = (I_{i,t}^* - I_{i,t-1}). \quad (11)$$

Equation (10) states that the current level of realized investments will only move partially from its previous position to the target level. λ measures the speed of adjustment and can take values between zero and one. While smaller values of λ indicate greater adjustment costs and hence slower adjustment toward targets, a value of one implies zero adjustment costs and thus immediate adjustment.

3.2.2 Extension of base model

As described in Section 2.2, economic theory suggests a number of factors that determine adjustment costs: financing costs, disruption costs, and costs due to asset irreversibility. To examine the impact of these factors on firms' adjustment costs, we include each factor and its interaction with $DEV_{i,t}$ in our base model (Equation (10))

$$\Delta I_{i,t} = \lambda DEV_{i,t} + \gamma Z_{i,t} + \delta(DEV_{i,t} * Z_{i,t}) + \beta X_{i,t-1} + \eta i + \theta_t + \epsilon_{i,t}. \quad (12)$$

$Z_{i,t}$ hereby reflects each factor influencing firms' adjustment costs as described in Section 2.2. The key variable of interest is the coefficient δ of the interaction term between DEV and Z . δ shows whether firms' speed of adjustment significantly differs across groups. For instance, if Z captures whether firms have sufficient cash flows to finance stated target investments (H1), δ indicates whether the speed of adjustment of firms with sufficient cash flows significantly differs from the speed of adjustment of firms with insufficient cash flows. Accordingly, the coefficient of the interaction term measures the additional speed of adjustment toward targets for firms with sufficient cash flows. To test our four Hypotheses, $Z_{i,t}$ will reflect one of the following variables:

Suff. CF dummy. To examine whether the speed of adjustment is faster for firms with sufficient cash flows (H1), we construct a dummy variable which takes the value of one if firms' cash flows in year t exceed firms' target investments planned for year t , and zero else.

Major inv. dummy. If major investment plans entail higher adjustment costs, we expect to find firms with major investment plans to adjust slower toward targets (H2). To test this relation, we construct a dummy variable which takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else. A threshold level of 20% to identify major investments is standard in the investment literature (see e.g., Cooper et al. (1999), Nilsen and Schiantarelli (2003), Letterie et al. (2010) and Elsas et al. (2013)). For robustness tests, we also study threshold levels of 5%, 10% and 15%. The results indicate that our findings are not sensitive to the threshold level we use.

Replacem. dummy. To examine whether planned replacement investments are adjusted more quickly (H3), we use managers' survey responses on the purpose of firms' investments for year t stated in year $t-1$. In detail, the ifo Investment Survey asks managers in $t-1$ how investments for t are allocated to capacity extensions, restructuring, rationalization, replacement and other investments, each as a percentage of total investments.¹² We use this information and construct a binary variable, which takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. An investment type is major if the stated fraction is largest across all types, hence if it exceeds the stated fraction of all other investment types. We exclude the cases for which stated fractions are equal. In robustness tests, we also test slightly different specifications. However, results remain qualitatively the same.

Irreversibility dummy. To test our last hypotheses (H4), we follow Chirinko and Schaller (2009) and Guariglia et al. (2012) and measure firms' degree of asset irreversibility by taking into account firms' depreciation rate. The authors argue that irreversibility arises if firms cannot easily sell previously acquired capital goods. Consequently, the only way of reducing unwanted capital stock will be through depreciation. A firm is thus more likely to face asset irreversibility if its depreciation rate is below the median depreciation rate of the industry the firm is operating in. Our irreversibility dummy thus takes the value of one if firms' depreciation rate is below the median depreciation rate of two-digit

¹²Figure 1 of the Appendix shows the allocation of investments into the different types (left axis) over the time period 2004 to 2013.

industry, and zero else.

3.3 Estimation methodology

Equations (10) and (12) can be estimated using standard dynamic panel estimators such as the ones proposed by Arellano and Bond (1991) and Blundell and Bond (1998). We apply dynamic panel estimators as Equation (10) can be transformed into:

$$I_{i,t} = (1 - \lambda)I_{i,t-1} + \lambda I_{i,t}^* + \epsilon_{i,t}, \quad (13)$$

which contains as explanatory variable lagged values of the dependent variable. Consequently, estimating Equation (10) using standard pooled ordinary least squares regressions would yield in upwards biased and inconsistent results due to the correlation between the lagged dependent variable and the fixed effect (Flannery and Hankins, 2013). Applying a fixed effects estimator, which controls for time-invariant heterogeneity across firms, would lead to downward biased coefficients as the lagged dependent variable is correlated with the error term Baltagi (2005). Nickell (1981) can show that this bias especially occurs for samples with large N and small T . As this is the case for our data set, an application of standard fixed effects estimators would not be appropriate.

We therefore estimate both Equations (10) and (12) using a Systems Generalized Method of Moments estimator (System-GMM) for dynamic panel models as suggested by Arellano and Bover (1995) and Blundell and Bond (1998). The Blundell and Bond (1998) estimator uses additional lagged levels and differences as instruments and is asymptotically unbiased for a sample consisting of a large number of firms with few time observations (Cameron and Trivedi, 2009). We treat $DEV_{i,t}$, $Z_{i,t}$ and their interaction as predetermined and use lags dated $t + 2$ and $t + 6$ as instruments.¹³ All control variables are treated as exogenous.

¹³In models with endogenous regressors, using too many instruments could result in biased estimates. We thus only use a sub sample of the whole history of the series as instruments. To determine the optimal lag length of instruments, we follow the downward testing procedure proposed by Andrews and Lu (2001). Hence, we begin with using the full set of moment conditions and gradually reduce them. For each set of moment conditions, we then compare the Hansen test to the Hansen test of the previous regression. Once the Hansen test increases in significance, we take the previous specification, which has the highest p-value for the Hansen test.

As, for our sample, the one- and two-step Blundell-Bond system GMM estimator produce rather similar results, we only present the (asymptotically) more efficient two-step estimates. To control for downward biased estimates of the error terms when using the two-step procedure (Arellano and Bond, 1991; Blundell and Bond, 1998), we use the finite-sample correction suggested by Windmeijer (2005).

Since the consistency of the System-GMM estimator depends on two assumptions: (i) the error term is not serially correlated; (ii) instruments are valid, we apply two tests suggested by Arellano and Bond (1991) to examine the validity of both assumptions. To test the validity of the first assumption, we examine whether the differenced error term is second-order serially correlated. If we cannot reject the null hypothesis of no second-order serial correlation, the first assumption is valid. To test the second assumption, we apply the Hansen test of over-identifying restrictions, which proofs the overall validity of the instruments (Hansen, 1982). A failure to reject the null hypothesis that all instruments are valid supports our estimation model.

We prefer System-GMM over the standard First-Differencing GMM according to Arellano and Bond (1991) as it controls for a possible weak instrument problem, which occurs if the lagged dependent and the explanatory variables are persistent over time (Blundell and Bond, 1998). In addition, monte carlo simulations (which are available from the authors upon request) indicate that coefficients are least biased if we estimate Equation (10) using the estimators proposed by Blundell and Bond (1998). However, our robustness tests indicate that results do not change much if we apply the Arellano and Bond (1991) estimator. The results are also qualitatively similar if we use pooled ordinary least squares or panel fixed effects estimators.

3.4 Summary statistics

Table 1 contains summary statistics of our main variables over the time period 2004 to 2013. Summary statistics indicate that the firms in our sample are quite large and mature, as the median firm has 232 employees and is 81 years old. For firms' realized investment spending in PPE, we find that firms invest on average 5.0% of firms' beginning-of-year

total assets. Similar results are found by Asker et al. (2015) who study public and private U.S. firms from 2001 to 2011 and find that listed firms invest approx. 4.1% and private firms invest about 7.5% of beginning-of-year total assets. From Table 1 it becomes further evident that firms' planned investments are higher than realized investments, as firms plan to invest about 6.0% of beginning-of-year total assets. Untabulated tests indicate that these differences are significant at the 1% level. Our figures for investment plans are comparable with the ones found by Guiso and Parigi (1999). The authors find average investment plans of 5.99% of beginning-of-year total assets when studying survey data on Italian manufacturing firms in 1993.

Furthermore, we find that 65% of all firms in our sample generate cash flows which exceed firms' stated investment plans (Suff. CF dummy). Moreover, approx. 73% of all firm-year observations plan to undertake replacement investments and at least 8% of all firm-year observations plan to undertake major investment projects. About 42% of all firm-year observations face a high degree of asset irreversibility as these observations have depreciation rates below industry median. The summary statistics shown in Table 1 further indicate a certain cross-sectional variation within our data set, as our sample also contains firms with negative equity, profitability, cash flows, and sales growth.

[Table 1 about here.]

4 Empirical results

4.1 How and when do firms adjust toward target investments?

Table 2 contains the results when estimating firms' speed of adjustment toward target investments using Equation (10). We apply System-GMM estimators as described in Section 3.3. In Column 1, we do not include any of our control variables and find that firms' average speed of adjustment toward target investments is 0.684. By applying the concept of half-life, it takes at this rate approximately one year to close half the gap

between a typical firm's current and desired investment spending.¹⁴ If we include year dummies and control for lagged levels of firms' cash flows, investment opportunities and size (Column 2), we find quite similar results. Hence, the inclusion of additional control variables does not significantly change our results. We therefore include in all following specifications our lagged control variables and year dummies. The failure to reject the null hypothesis of the Hansen test displayed at the bottom of Table 2 confirms the validity of our used instruments. In addition, $m2$ is a test for second-order serial correlation. The stated p-values for $m2$ indicate that there is no second-order correlation of error terms in Columns 1 and 2.

In Columns 3 to 7 of Table 2, we estimate Equation (12) to examine how financing costs, disruption costs and costs for asset irreversibility influence firms' adjustment behavior. In Column 3, we begin with studying the impact of sufficient cash flows on firms' adjustment behavior by including our *Suff. CF dummy* and its interaction with *DEV*. We find a positive and significant effect for the interaction term, which indicates that firms with sufficient cash flows adjust significantly faster toward target investments than firms with insufficient cash flows. In detail, firms with sufficient cash flows adjust with $\lambda = 0.795$ ($0.578 + 0.217$), while firms with insufficient cash flows adjust with $\lambda = 0.572$. These results suggest that firms with sufficient cash flows need 0.87 years to close half their deviation from target investments, while firms with insufficient cash flows need 1.20 years. Untabulated results further indicate, that this positive and significant effect on firms' speed of adjustment remains if we use the difference between firms' cash flows and stated plans as our measure for sufficient cash flows. However, if we simply interact *DEV* with firms' cash flows, we cannot find a significant coefficient for the interaction term (untabulated). Accordingly, it is not important for firms to have high cash flows, but to have sufficient cash flows in terms of being able to finance all planned investment projects with internally generated funds. The Hansen test and the test for second-order serial correlation of error terms confirm our specification.

¹⁴As standard in the capital structure literature, we apply the concept of half-life which measures the number of years that the speed of adjustment implies for a firm to move halfway toward its target (Flannery and Rangan, 2006; Huang and Ritter, 2009). We calculate half-life as $\log(2)/\lambda$.

In Column 4, we examine whether firms with minor investment plans adjust faster than firms with major investment targets. We therefore include our *Major inv. dummy* and its interaction with *DEV*. The negative coefficient of the interaction variable indicates that firms with major investment targets adjust significantly slower. More precisely, while firms with major investment plans adjust with $\lambda = 0.510$ ($0.779 - 0.269$), firms with minor investment adjust with $\lambda = 0.779$. At this rates, firms with major investment plans need 1.36 years to close half their deviation from target investments, while firms with minor targets need only 0.89 years. The reason for slower adjustment for firms with major investment projects is that these firms face higher adjustment costs. Again, the Hansen test and the test for second-order serial correlation confirm our specification. Our results do not depend on how we categorize major adjustments. Untabulated robustness tests indicate that the results are qualitatively the same if we classify investments as major if they exceed 5%, 10% or 15% of total assets.

To analyze how stated investment purposes influence firms' adjustment behavior, we interact *DEV* with our *Replacem. dummy*. In Column 5, we find that firms planning to undertake replacement investments adjust significantly faster toward targets. More precisely, firms with replacement investments adjust with $\lambda = 0.715$ ($0.58 + 0.125$) while firms with investments into capacity expansion adjust with $\lambda = 0.580$. Accordingly, we can confirm our hypothesis that firms planning to do replacement investments adjust faster toward stated targets. This seems reasonable as these firms face significantly lower adjustment costs in terms of disruption costs. Our results are not sensitive to the specification of our replacement dummy. For instance, if we categorize our replacement dummy to take the value of one if only stated fractions for replacement investments are highest, we obtain very similar results.

Finally, the results in Column 6 of Table 2 indicate that firms with high asset irreversibility adjust more slowly toward target investments. This can be seen from the negative and statistically significant coefficient of the interaction term between our *Irreversibility dummy* and *DEV*. Firms with high asset irreversibility adjust thus with $\lambda = 0.524$ ($0.719 - 0.195$) and firms with low asset irreversibility adjust with $\lambda = 0.719$.

These findings indicate that firms with high asset irreversibility need 0.36 years longer to close half their deviation from target investments compared to firms with low asset irreversibility. The reason for slower adjustment is that these firms face more difficulties in selling used equipment due to a lack of a secondary market. Hence, these firms face higher adjustment costs which prevent them from quickly adjusting toward targets. Our results are in accordance with the results found by Chirinko and Schaller (2009) who study Compustat data over the sample period 1980 to 2001. The authors find that firms with depreciation rates below industry median have to pay an irreversibility premium of 220 basis points.

[Table 2 about here.]

4.2 Robustness tests

Beside testing different measures and specifications for our Z variables (as described in the previous section), we also perform several other tests to examine the robustness of our results. For instance, we run all regressions without including any control variables and year dummies. Results (untabulated) indicate that our results are qualitatively unchanged if we do not include any control variables or if we only include any subset of our control variables.

To examine whether the results of Table 2 are sensitive to the specification of our control variables, we treat our control variables as predetermined (instead of strictly exogenous) and use lagged levels dated $t-2$ to $t-6$ as instruments. Table 3 contains the results. Obviously, the speed of adjustment is, in terms of size and significance, quite similar to the estimates of Table 2. The most obvious difference is that we find a significant influence of investment opportunities for all specifications. Moreover, when treating our control variables as predetermined, the p -values of the Hansen test indicate that we have to reject the null hypothesis for most specifications (Columns 1, 3 and 5). This indicates that treating our control variables as predetermined leads to misspecified models. Even if we increase or decrease the numbers of instruments for our controls, we have to reject the null hypothesis of the Hansen test. Hence, treating our lagged control variables as

strictly exogenous seems to be appropriate in our sample.

[Table 3 about here.]

Moreover, our results are also robust to the number of instruments we use for our predetermined variables DEV , Z and its interactions. Untabulated results indicate that if we use longer lagged levels and differences as instruments, the results remain almost unchanged. However, Hansen specification tests often can be rejected which might indicate a misspecification of the model and the instruments used.

For completeness, we also provide estimation results when applying Difference-GMM estimators on Equation (10) and (12) as suggested by Arellano and Bond (1991). The difference between Difference- and System-GMM estimators lies in the variables used as instruments. While System-GMM applies lagged levels as well as lagged differences as instruments, Difference-GMM estimators only use lagged levels as instruments. As for the System-GMM estimations, we treat DEV and Z and their interactions as predetermined using lagged levels dated $t-2$ to $t-6$ as instruments. Our lagged control variables are again treated as strictly exogenous. The results can be found in Table 4 of the Appendix. Obviously, our results are robust to the estimation method applied as we find very similar results as in Table 2. The slightly higher estimates for our DEV coefficients and the slightly lower estimates for the interaction terms are negligible.

[Table 4 about here.]s

As dynamic panel estimators are inconsistent if error terms are second-order autocorrelated, we also estimate Equations (10) and (12) using pooled ordinary least squares or fixed effects estimators. Untabulated results indicate that our main results are very similar to the results found in Table 2. Hence, even if we do not control for the dynamic process in our model and estimate Equation 10 using standard panel estimators, our results remain qualitatively unchanged. Results can be obtained upon request from the authors.

5 Adjustment behavior during the financial crisis of 2008 and 2009

Beside the adjustment costs which arise out of firms' environment, adjustment costs might also be the result of external shocks. For example, changes in government support for investments, changes in firms' corporate tax rates or amortization rules or changes in the overall economic situation might lead to revisions in firms' optimal capital stock (Hamermesh and Pfann, 1996). In the following, we thus examine how shocks to the overall economic situation influences firms' adjustment behavior. More precisely, we study the consequences of the recent financial crisis of 2008 and 2009. Before we examine the impact of the financial crisis on firms' adjustment behavior, we begin with examining the effects of the financial crisis on firms' realized investment spending (Section 5.1) and on stated investment plans (Section 5.2). In Section 5.3, we then examine the impact of the crisis on firms' speed of adjustment.

5.1 Influence of the financial crisis on firms' realized investments

To examine the effects of the financial crisis on firms' realized investment spending, we estimate a dynamic investment model following Bond and Meghir (1994); Carpenter and Guariglia (2008) and Brown et al. (2009). We hence regress firms' realized investments on last years' realized investments, standard control variables and a dummy variable for the financial crisis. As control variables, we include lagged levels of firms' operating cash flows, investment opportunities and the natural logarithm of total assets to account for size effects. Our financial crisis dummy variable takes the value of one during the years of the financial crisis and zero else. Since the exact time period of the financial crisis varies between the years 2007 and 2009, we control for the financial crisis by considering all reasonable year combinations between 2007 and 2009. For instance, we construct a dummy variable $Crisis_{2007}$ which takes the value of one in 2007 and zero else. Analogously, $Crisis_{2008-2009}$ takes the value of one for the years 2008 and 2009, and zero else. All other crisis dummies are construed analogously.

Table 5 contains the results when estimating a dynamic investment model using System-GMM estimator. We use lagged levels dated t-4 to t-5 as instruments for the lagged dependent variable.¹⁵ Lagged control variables are treated as strictly exogenous. In Column 1 we regress firms actual investments on lagged actual investments and our control variables. The coefficient of the lagged dependent variable is positive (0,468) and significant at the 5% level. Compared to prior studies estimating dynamic investment models, our coefficient estimate is slightly higher. For instance, Ding et al. (2013) find a coefficient estimate of 0.18 for the lagged dependent variable when studying Chinese firms over the sample period 2000 to 2007. Similarly, Carpenter and Guariglia (2008) find an estimate of 0.163 for the lagged dependent variable when studying UK firms over the time period from 1980 to 2000. However, Bond and Meghir (1994) studying also UK firms over the time period from 1968 to 1986 estimate Euler investment equations and find a coefficient of the lagged dependent variable of 0.4857, which is quite close to our estimate. Finally, Eberly et al. (2012) also estimate dynamic investment models for a sample of U.S. listed firms available in Compustat over the sample period 1981 to 2003. The authors test several different specifications and estimators and find an estimate for the lagged dependent variable of 0.42 when using Arellano and Bond (1991) estimators, which is very similar to our results. The positive and significant effects of lagged cash flows and investment opportunities are in accordance with the results found by prior literature.

When including our financial crisis dummies in Columns 2 to 7, we find that the financial crisis only negatively influenced firms' actual investment spending if we use *Crisis*_{2008–2009} and *Crisis*₂₀₀₉ (Columns 5 and 6). Accordingly, private manufacturing firms in Germany, were most hit by the financial crisis in 2009. These findings are in accordance with the results found by several other studies showing that the financial crisis led to a lower demand for investments (Campello et al., 2010; Duchin et al., 2010; Kahle and Stulz, 2013; Asker et al., 2015). The Hansen test and the test for second-order serial correlation confirm our specification.

[Table 5 about here.]

¹⁵If we use different lagged values as instruments, we have to reject the null hypotheses of the Hansen test rendering the model specification invalid.

5.2 Influence of the financial crisis on firms' target investments

In this sections, we examine whether the financial crisis also influenced firms stated investment plans. We therefore regress firms stated investment plans on last years' investment plans, a financial crisis dummy and some control variables. Again, we estimate a dynamic investment model to control for lagged adjustment due to adjustment costs. We use lagged levels dated $t-2$ to $t-6$ as instruments for the lagged dependent variable. Since investment plans are stated one year in advance, we only consider information which are available to the manager in the year when they are asked to state their plans. We hence only use information on cash flows and investment opportunities dated one year in advance to the year in which plans have been stated. All control variables are thus measured as of $t-2$ and are treated as strictly exogenous.

The results can be found in Table 6. Except for a positive and weakly significant effect in 2008, we cannot find any influence of our crisis dummies on target investments. This positive effect in 2008 might be attributed to reductions in corporate tax rates and trade tax rates resulting from the German corporate tax reform (Unternehmensteuerreform 2008) effective as of 2008.¹⁶ Our results indicate that the recent financial crisis seems to have no negative effect on firms target investments in our sample of German manufacturing firms. Accordingly firms did not adjust their investment plans during the recent crisis and did not significantly lower their stated targets. The Hansen test and the test for second-order serial correlation confirm our specification. Our findings are robust to several different specifications using for instance longer instruments series or treating control variables as predetermined. Even if we do not control for lagged investments plans as additional regressor, we cannot find any effects of the financial crisis.

[Table 6 about here.]

¹⁶With the corporate tax reform of 2008, the German government wanted to enhance firms' investment spending and therefore decreased corporate tax rates from 25% to 15% and adjusted depreciation rules making investment more attractive.

5.3 Influence of the financial crisis on firms' speed of adjustment

Prior results indicate that firms' realized investments are negatively influenced by the financial crisis, while stated investment plans are not. In the following, we examine the influence of the financial crisis on firms' adjustment behavior toward targets. We argue that the financial crisis could influence firms' adjustment costs either positively or negatively. On the one hand, the financial crisis could lead to an increase in firms' adjustment costs if firms face difficulties in obtaining external financing or if output demand decreased leading to a decrease in firms' operating cash flows. On the other hand, adjustment costs might be lower during the crisis if firms focused to undertake mainly replacement investments during the financial crisis. This is reasonable if firms did not want to invest into capacity expansions due to increased uncertainty regarding future outlook. If this is the case, firms speed of adjustment would increase during the crisis, since replacement investments incur lower adjustment costs.

To analyze which of these two effects prevail, we estimate Equation (12) and interact our main variable of interest *DEV* with our financial crisis dummy variable. Again, we will test all possible classifications of the financial crisis dummy. As before, we use lagged levels dated t-2 to t-6 as instruments for *DEV* and its' interactions. All control variables are treated as exogenous. Table 7 contains our results when examining the effects of the financial crisis on firms' speed of adjustment. Obviously, we cannot find any effect of the recent financial crisis on firms adjustment behavior. This finding holds for several different specification of our financial crisis dummy. The results indicate that the financial crisis did not influence firms' adjustment costs beyond the adjustments in cash flows and investment opportunities. These findings might indicate that during the financial crisis both positive and negative effects on adjustment costs occurred and in sum netted each other out.

[Table 7 about here.]

To examine whether this is the case, we re-estimate Table 2 and include interactions with our financial crisis dummy. Since our *Crisis*₂₀₀₉ dummy has been found to have a

negative and significant effect on firms' realized investment spending, we restrict ourselves to only test the *Crisis*₂₀₀₉ dummy variable. However, untabulated results indicate that the estimation results are qualitatively the same if we use the *Crisis*_{2008–2009} dummy variable.

Table 8 contains our results. Unfortunately, we cannot find any effect of the crisis on firms' adjustment behavior for firms with sufficient cash flows or major investment projects (Columns 1 and 2). But at least the main effects we found in Table 2 remain even after controlling for the financial crisis. In Column 3 and 4, we find that the financial crisis influences firms' speed of adjustment when we account for investment purpose and asset irreversibility. From Column 3, we find that firms which planned to undertake replacement investments during the crisis adjusted with $\lambda = 0.526$ ($0.578 - 0.182 + 0.130$), while firms which planned to undertake investments into capacity expansions adjusted with $\lambda = 0.346$ ($0.578 - 0.182$). The lower speed of adjustment during the crisis for replacement and capacity expansion investments might be explained by cyclicity of investments. For instance, Albonico et al. (2014) show that replacement investments are cyclical which indicates that during an economic downturn replacement investments decrease. During the non crisis period, replacement targets are adjusted with $\lambda = 0.708$ ($0.578 + 0.130$), while capacity expansion targets are adjusted with $\lambda = 0.578$. Accordingly, the crisis led to a lower speed of adjustment for both replacement and capacity expansion investments, however, firms which planned to undertake replacements during the crisis still adjusted significantly faster compared to firms which planned to do capacity investments. An explanation might be that firms restricted themselves to undertake only the most necessary replacement investments during the crisis.

In Column 4, we further find that the financial crisis decreased firms' speed of adjustment for firms with a low degree of asset irreversibility, while the speed of adjustment increased for firms with high asset irreversibility during the crisis. More precisely, firms with low asset specificity adjusted fastest during the non crisis period (0.722), while during the crisis these firms adjusted with only 0.578 (0.722-0.144). In comparison, firms with a high degree of irreversibility adjusted with $\lambda = 0.485$ ($0.722 - 0.237$) during the non

crisis period and with $\lambda = 0.573$ ($0.722 - 0.144 - 0.237 + 0.232$) during the crisis period. The results indicate that differences in asset irreversibility lead to different adjustment behavior in non-crisis periods but during the crisis period, firms with both low and high asset specificity adjust almost with the same speed (0.578 vs. 0.573). An explanation for this finding might be that during the crisis especially the firms with low irreversibility face difficulties in reselling capital stock and therefore adjusted with lower speed. Hence, especially firms with low irreversibility faced a reduced demands for capital goods during the crisis, leading to difficulties in selling unwanted capital stock. The fact that firms with high asset irreversibility adjusted even faster toward targets during the crisis might indicate that these firms were not hit that much by the crisis or could at least better deal with the impact of the crisis.

[Table 8 about here.]

In untabulated results, we also examine a possible impact of the overall economic situation on firms' adjustment costs by including a measure capturing the overall degree of uncertainty. More precisely, we include include returns of the VIX index and its interaction with *DEV*. Again, we cannot find any significant effect on firms' speed of adjustment. In addition, we include GDP growth rates and its interaction with *DEV* to examine whether the overall economic situation influences firms' adjustment behavior. We find no significant impact. We also control for a possible effect of other macroeconomic variables, such as interest rates or inflation rates. All of these macro economic factors do not seem to play a role in influencing firms' adjustment behavior.

6 Summary and concluding remarks

Several studies examine the factors determining firms' investment behavior by analyzing ex-post data on firms' actual investment spending as a proxy for investment demand. However, observed investments and desired investments may differ for a number of reasons, which makes it impossible to ascertain the optimality of the observed investment process. In this study, we thus exploit data on firms' stated investment plans for the

upcoming year and analyze how well firms adjust their actual investments toward stated investment plans (targets).

We therefore present a partial adjustment model applicable to firms' investments and show that due to adjustment costs, firms only partially move toward targets. Moreover, as economic theory suggests a number of factors that determine the importance of adjustment costs such as financing costs, disruption costs, and costs due to asset irreversibility, we examine the impact of each factor on firms' adjustment costs and thus adjustment behavior. We do so by exploiting unique data on large, private manufacturing firms in Germany over the sample period 2004 to 2013. Using firms' realized investments and firms stated investment plans as targets, we are able to estimate partial adjustment models for investments. To account for the dynamics associated with these models, we apply System-GMM estimators suggested by Blundell and Bond (1998).

We find that due to adjustment costs, firms only partially adjust toward target investments. In detail, firms need approximately one year to close half the gap between a typical firm's current and desired investment spending. Moreover, we find differences in adjustment behavior across firms. For instance, we find that firms with sufficient cash flows adjust significantly faster toward targets than firms with insufficient cash flows. While replacement investments are adjusted toward targets more quickly, major investment projects are adjusted more slowly. We further find that firms with a high degree of asset irreversibility adjust slower toward targets than firms with low degree of asset irreversibility. We provide several tests which confirm the robustness of our results.

Finally, we examine the impact of the recent financial crisis of 2008 and 2009 on firms' adjustment behavior. Although the recent financial crisis reduced firms' realized investment spending, firms' speed of adjustment toward target investments did not respond to the financial crisis. We propose several explanations for these findings.

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A Data sources

Two main sources have been used for our empirical analysis. The ifo Investment Survey conducted by the ifo Institute and the financial statement databases of Amadeus and Bisnode.

A.1 ifo Investment Survey

The main purpose of the ifo Investment Survey is to directly capture realized and planned investments at the firm level. The survey is conducted twice a year, the spring survey between March and May and the fall survey between September and November. Both surveys have been conducted since fall 1964 on mainly private manufacturing firms in West Germany. The spring survey contains identifying information such as firms' size and firms' emphasis on production as well as information on previous years' revenues, employees and investment expenditures in property, plant and equipment. Managers are further asked to state expected changes in investments (in percentages) for the current year and firms' investment purposes for the last and the current year. Regarding firms' investment purposes, managers can choose between investments into capacity expansion (with or without a change in the production program), rationalization investments and/or replacement investments.

In accordance with the spring survey, the fall survey contains information on firms' sales and employee figure as well as firms' current years' investment spending in PPE. In addition, managers have to also state information on firms' upcoming years' investment spending. To assess the factors influencing firms' investments spending, managers are asked to state the degree of influence of certain factors to influence firms' investment behavior. Finally, managers have to assign the percentage of investments which are spent in the current and the upcoming year on capacity, replacement, restructuring, rationalization and other investments.

Only since 1993, the survey has also been introduced to former East Germany. But as surveys in East and West Germany deviate in content and cyclicity of data collection, we only consider data from West Germany for all analyses. The number of sent out questionnaires is approx. 4,000 every year and the average number of firms responding is roughly 3,000 in year 1989 and declines to approx. 1,500 towards 2012.¹⁷ The majority of firms, which do not participate any longer in the survey, disappeared due to mergers. Moreover, a generally lower willingness to participate in the survey occurred due to increasing demands on employees (which leads to a lack in time to respond to such surveys) and the proliferation of firms with several other surveys. As we cannot find any systematic relation between firms leaving the survey and firms still participating in the survey, we

¹⁷the number of responding firms is about 550 in year 2004 and rises to approx. 830 towards 2013, whereas approx. 38% of the firms participated in the survey every single year from 2004 to 2013.

do not consider this drop in response rates as problematic. In fact, the average size (total assets) of firms participating in the survey is quite stable over time and approx. 40% of the firms participated in the survey every single year from 1989 to 2011.

Response biases (due to ignorance of respondents), which are a common problem in most surveys, do not pose an obstacle in our sample as respondents of the ifo Investment Survey mainly belong to the higher management of a firm's controlling or finance department. Respondents are thus either directly involved in the financing process of investments or can at least access relevant information. In addition, concerns regarding issues of social desirability of answers do not seem to be important for our sample, as responses are not publicly disclosed. For instance, Mueller (2010) shows that mainly publicly disclosed forecasts on firms' sales and workforce show upward biases, since they serve as a signal to investors.

The surveyed firms are representative of the German manufacturing sector for two reasons. First, the ifo investment survey includes companies representing all fields of the manufacturing industries. Furthermore, despite the decreasing number of participants, no declining firm representation can be observed. This can be attributed to the high amount of large companies in the sample and the ongoing concentration process in the German economy. Moreover, since 1964 the Federal Statistical Office of Germany (Statistisches Bundesamt) undertakes surveys to examine investments in the production industry. This offers the opportunity to verify the results of the ifo investment test, by comparing the ifo survey data with the data of the Federal Statistical Office. In doing so, we find very high congruency. For instance, for the time period from 1980 to 2001 the relative changes in investment spending differ by less than one percent. In addition, Rüdiger and Zorn (2013) can show that aggregate investment figures from the survey are comparable to aggregate investment statistics from the Federal Statistical Office.

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Fax: (089) 9224-1463, -1235 Mr. Jäckel exten. 1239

The information you provide will be treated confidentially.
Legal data protection is fully guaranteed.

IT-Industry West

Id-No. →
WZ*03-No. →
WZ*08-No. →
please indicate, if available

Information on business locations in the former German Länder

Please send back the ifo questionnaire as soon as possible

1. General information for the Fiscal Year (FY) 2012

Employees (as of 30.09.2012) _____ Annual Sales 2012 _____ (in 1000 Euro)

2. Gross fixed asset investments (equipment and buildings) in FY 2012, 2013 and 2014

2012 _____ (in 1000 Euro) 2013 _____ (in 1000 Euro) 2014 _____ (in 1000 Euro) (planned)

3. Influencing factors on investments 2013 and 2014

Our investment activity in the former German Länder was positively/negatively influenced in 2013 / is positively/negatively influenced in 2014 by the following factors:

| Influencing factors | considerable stimulation | slight stimulation | 2013 | slight slackening | considerable slackening | considerable stimulation | slight stimulation | no influence | slight slackening | considerable slackening |
|------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Sales situation/ expectation | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Financing possibilities | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Earnings expectations | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Technical factors | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Economic conditions | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other factors | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

4. Structure of investments in 2013 and 2014

Our investment volume is distributed proportionally in year to the following categories:

shares in % (estimates are sufficient)

| Investment types: | 2013 | 2014 |
|---------------------------|-------|-------|
| Capacity expansion | _____ | _____ |
| Restructuring | _____ | _____ |
| Rationalisation | _____ | _____ |
| Replacement | _____ | _____ |
| Other investment projects | _____ | _____ |
| Total investment | 100 % | 100 % |

We highly appreciate your cooperation!

In case of queries: Which department has completed this questionnaire?

dept., person in charge, telephone, telefax

Please note the explanations and definitions on the following page

e-Mail, address

A.2 Amadeus and Bisnode accounting databases

Accounting data are provided by either Amadeus or Bisnode. The former is run by Bureau van Dijk Electronic Publishing GmbH and offers extensive business and financial statement data on mainly non-listed firms from 43 European countries. The Bisnode accounting database is provided by Bisnode Deutschland GmbH, which is one of the leading databases for business and industry information in Germany. Both accounting databases consider German accounting standards and data are available over the time period 1987-2014. If information for a firm is available from both databases, information from Bisnode is preferred due to its higher accuracy and quality (Seiler, 2012). We deflate all unscaled accounting variables by a price index to express nominal values in 2005 Euros.¹⁸

A.3 Matching of survey and accounting data

The unique feature of our data is that it combines survey data from the Ifo Investment Survey with accounting data from either Bureau van Dijk's Amadeus database (Amadeus) or Bisnode database. While the survey data provide us with information on firms' target investments (stated investment plans), the accounting data enables us to measure firms' realized investment spending. We will need both information to estimate partial adjustment models stated in Section 2. Survey and accounting data are linked via firms' registered name and address information using a record linkage approach.¹⁹

Our final data set includes survey data on firms' stated investment plans and extensive financial statements data containing amongst others firms' realized investments for private manufacturing firms in Germany over the time period 2004 to 2013.

¹⁸Price deflator data are obtained from the AMECO database provided by the European Commission.

¹⁹For a detailed description of the exact matching approach we refer to information provided on the web page of the Economics & Business Data Center (EBDC). For theoretical details on the record linkage approach see, e.g., Newcombe et al. (1959); Fellegi and Sunter (1969). For a detailed description on the data sets provided by the EBDC see, e.g., Hoenig et al. (2010) or Seiler (2012).

B Variable definitions

Actual inv. is defined as firms' capital expenditures in PPE over beginning-of-year total assets. Firms' capital expenditures are calculated as the difference in firms' tangible assets from year $t-1$ to year t plus depreciation in year t .

Planned inv. is defined as firm's desired investment spending for year t stated in year $t-1$ scaled by beginning-of-year total assets. Data on firms' desired investments are obtained from the ifo Investment Survey, in which managers provide information on firms planned investment spending in PPE in absolute values for the entire upcoming calendar year.

Size (ln) is defined as the natural logarithm of total assets in year 2005 real Euros.

Age (ln) is the natural logarithm of years since incorporation.

Cash flow/assets is defined as firms' earning after tax plus depreciation over beginning-of-year total assets.

Cash/assets is defined as firms' cash holdings and cash equivalents over beginning-of-year total assets.

Dividends/assets is defined as firms' dividend payouts over beginning-of-year total assets.

Tang. assets/assets is defined as firms' tangible assets over beginning-of-year total assets.

Total equity/assets is defined as firms' total book equity over beginning-of-year total assets.

Total debt/assets is defined as firms' total debt over beginning-of-year total assets.

Return on Assets (ROA) is defined as operating income before depreciation (profit or loss for period) over total assets.

Sales growth is the annual percentage increase in firm's sales.

Ind. sales growth is the annual percentage increase in sales for two-digit SIC codes.

Suff. CF dummy is a dummy variable which takes the value of one if firms' cash flows in year t exceed firms' target investments planned for year t , and zero else.

Major inv. dummy is a dummy variable which takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else.

Replacem. dummy is a dummy variable which takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. An investment type is major if the stated fraction is largest across all types, hence if it exceeds the stated fraction of all other investment types. We exclude the cases for which stated fractions are equal. Information on the purpose of firms' investments for year t stated in year $t-1$ is obtained from managers' responses from the ifo Investment Survey. In detail, the ifo Investment Survey asks managers in $t-1$ how investments for t are allocated to capacity extensions, restructuring, rationalization, replacement and other investments, each as a percentage of total investments.

Irreversibility dummy is a dummy variable which takes the value of one if firms' depreciation rate is below the median depreciation rate of two-digit industry, and zero else.

Figure 1. Distribution of investment types over the sample period 2004 to 2013

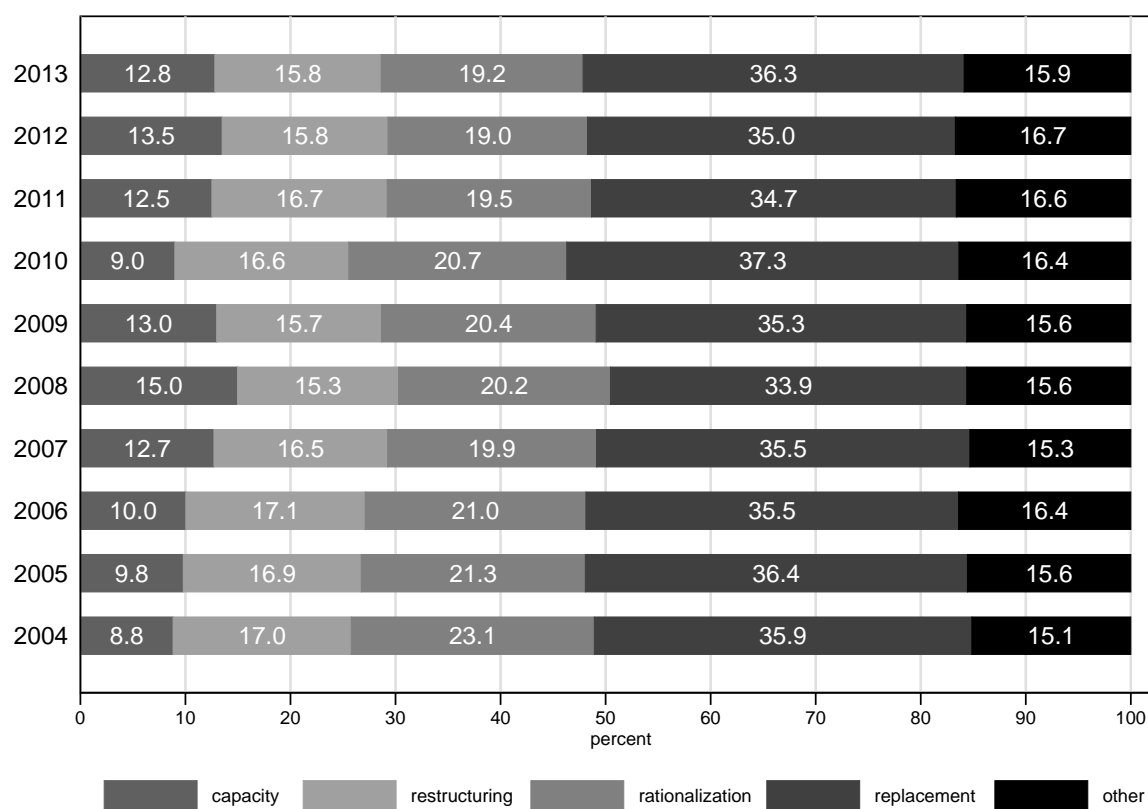


Table 1. Summary statistics

| | N | Mean | SD | Min | p5 | p25 | p50 | p75 | p95 | Max |
|---|-------|-------|-------|--------|--------|--------|-------|-------|-------|-------|
| Size _t (ln) | 4,636 | 3.753 | 1.695 | -0.386 | 1.241 | 2.460 | 3.641 | 4.993 | 6.803 | 6.803 |
| Employees _t (ln) | 1,803 | 5.551 | 1.179 | 2.079 | 3.807 | 4.663 | 5.447 | 6.425 | 7.513 | 7.513 |
| Age _t (ln) | 4,542 | 4.289 | 0.640 | 2.708 | 3.045 | 3.829 | 4.394 | 4.820 | 5.153 | 5.153 |
| Actual inv. _t (<i>I</i>) | 4,568 | 0.050 | 0.049 | -0.014 | -0.009 | 0.014 | 0.035 | 0.072 | 0.175 | 0.179 |
| Planned inv. _t (<i>I</i> *) | 5,796 | 0.060 | 0.056 | 0.001 | 0.003 | 0.020 | 0.043 | 0.080 | 0.194 | 0.232 |
| CF _t | 4,267 | 0.082 | 0.072 | -0.057 | -0.057 | 0.036 | 0.076 | 0.128 | 0.226 | 0.234 |
| Cash _t | 4,605 | 0.079 | 0.102 | 0.000 | 0.000 | 0.005 | 0.034 | 0.117 | 0.334 | 0.369 |
| Tang. assets _t | 4,622 | 0.241 | 0.158 | 0.009 | 0.021 | 0.110 | 0.219 | 0.352 | 0.566 | 0.571 |
| Total equity _t | 4,636 | 0.343 | 0.205 | -0.013 | 0.009 | 0.194 | 0.327 | 0.488 | 0.729 | 0.740 |
| Total debt _t | 3,438 | 0.429 | 0.216 | 0.092 | 0.096 | 0.262 | 0.413 | 0.581 | 0.836 | 0.887 |
| Return on assets _t | 4,277 | 0.033 | 0.067 | -0.110 | -0.110 | 0.000 | 0.026 | 0.072 | 0.166 | 0.176 |
| Sales growth _t (%) | 3,321 | 0.038 | 0.149 | -0.281 | -0.281 | -0.041 | 0.037 | 0.126 | 0.326 | 0.326 |
| Ind. sales growth _t (%) | 5,796 | 0.029 | 0.069 | -0.130 | -0.130 | -0.012 | 0.033 | 0.077 | 0.114 | 0.114 |
| Suff. CF dummy _t | 4,246 | 0.654 | 0.476 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Major inv. dummy _t | 5,796 | 0.084 | 0.278 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 |
| Replacem. dummy _t | 4,535 | 0.725 | 0.446 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Irreversibility dummy _t | 4,582 | 0.418 | 0.493 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 |

The table reports summary statistics for private manufacturing firms in Germany from 2004 to 2013. *Actual inv.* is firms' capital expenditures in PPE over beginning-of-year total assets. *Planned inv.* is firm's desired investment spending for year t stated in year $t-1$ scaled by beginning-of-year total assets. *Suff. CF dummy* takes the value of one if firms' cash flows in year t exceed firms' target investments planned for year t , and zero else. *Major inv. dummy* takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else. *Replacem. dummy* takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. *Irreversibility dummy* takes the value of one if firms' depreciation rate is below the median depreciation rate of two-digit industry, and zero else. Except for the growth variables and the dummy variables, all variables are scaled by beginning-of-year total assets. Continuous variables are winsorized at the 5% tails. For detailed variable definitions and details of their constructions, see Appendix B.

Table 2. Base table: firms' speed of adjustment toward target investments

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---------------------|---------------------|---------------------|----------------------|---------------------|----------------------|
| DEV _t | 0.684*** (0.025) | 0.677*** (0.027) | 0.578*** (0.041) | 0.779*** (0.027) | 0.580*** (0.044) | 0.719*** (0.027) |
| CF _{t-1} | | 0.007 (0.011) | -0.011 (0.012) | 0.022* (0.012) | 0.016 (0.012) | 0.002 (0.012) |
| Inv. opport. _{t-1} | | 0.040 (0.029) | 0.041 (0.026) | 0.063** (0.028) | 0.068** (0.029) | 0.039 (0.030) |
| Size _{t-1} | | 0.001** (0.001) | 0.001** (0.000) | 0.000 (0.001) | 0.002*** (0.001) | -0.000 (0.001) |
| Suff. CF dummy _t | | | 0.008*** (0.002) | | | |
| DEV _t * Suff. CF dummy _t | | | 0.217*** (0.048) | | | |
| Major inv. dummy _t | | | | -0.020*** (0.008) | | |
| DEV _t * Major inv. dummy _t | | | | -0.269*** (0.070) | | |
| Replacem. dummy _t | | | | | 0.002 (0.003) | |
| DEV _t * Replacem. dummy _t | | | | | 0.125** (0.056) | |
| Irreversibility dummy _t | | | | | | -0.012** (0.005) |
| DEV _t * Irreversibility dummy _t | | | | | | -0.195*** (0.056) |
| No. of obs. | 4,568 | 4,272 | 4,200 | 4,272 | 3,377 | 4,272 |
| No. of firms | 1,278 | 1,177 | 1,156 | 1,177 | 1,069 | 1,177 |
| No. of instruments | 45 | 57 | 145 | 145 | 150 | 153 |
| Hansen test (p-value) | 0.240 | 0.132 | 0.320 | 0.259 | 0.541 | 0.126 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.317 | 0.331 | 0.257 | 0.854 | 0.828 | 0.339 |

The table reports regression results of Equations (10) and (12) using System-GMM estimators. The dependent variable is a firms' change in actual investments. DEV is I_t^* minus I_{t-1} . *Suff. CF dummy* takes the value of one if firms' cash flows exceed firms' planned investments, and zero else. *Major inv. dummy* takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else. *Replacem. dummy* takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. *Irreversibility dummy* takes the value of one if firms' depreciation rate is below two-digit industry median depreciation rate, and zero else. DEV , each *dummy* and their interaction are treated as predetermined using lagged values dated t-2 to t-6 as instruments. CF_{t-1} , $Size_{t-1}$ and $Inv. opport._{t-1}$ (firms' sales growth) are treated as strictly exogenous. All columns include time dummies. Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. Detailed variables descriptions can be found in Appendix B. ***, **, * indicate significance at the 1%, 5% and 10% level.

Table 3. Robustness: firms' speed of adjustment (predetermined covariates)

| | (1) | (2) | (3) | (4) | (5) |
|---|---------------------|---------------------|----------------------|---------------------|----------------------|
| DEV _t | 0.678*** (0.028) | 0.594*** (0.038) | 0.800*** (0.031) | 0.605*** (0.042) | 0.722*** (0.028) |
| CF _{t-1} | -0.005 (0.019) | -0.013 (0.017) | 0.007 (0.020) | -0.002 (0.019) | -0.011 (0.018) |
| Inv. opport. _{t-1} | 0.075** (0.031) | 0.061** (0.028) | 0.071** (0.033) | 0.094*** (0.030) | 0.063** (0.030) |
| Size _{t-1} | 0.002* (0.001) | 0.001 (0.001) | 0.001 (0.001) | 0.001 (0.001) | -0.000 (0.001) |
| Suff. CF dummy _t | | 0.011*** (0.002) | | | |
| DEV _t * Suff. CF dummy _t | | 0.208*** (0.045) | | | |
| Major inv. dummy _t | | | -0.023*** (0.008) | | |
| DEV _t * Major inv. dummy _t | | | -0.287*** (0.069) | | |
| Replacem. dummy _t | | | | 0.008** (0.003) | |
| DEV _t * Replacem. dummy _t | | | | 0.107* (0.055) | |
| Irreversibility dummy _t | | | | | -0.008* (0.005) |
| DEV _t * Irreversibility dummy _t | | | | | -0.208*** (0.057) |
| No. of obs. | 4,272 | 4,200 | 4,272 | 3,377 | 4,272 |
| No. of firms | 1,177 | 1,156 | 1,177 | 1,069 | 1,177 |
| No. of instruments | 196 | 284 | 284 | 289 | 292 |
| Hansen test (p-value) | 0.073 | 0.125 | 0.084 | 0.178 | 0.043 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.351 | 0.277 | 0.999 | 0.865 | 0.348 |

The table reports regression results of Equations (10) and (12) using System-GMM estimators. The dependent variable is a firms' change in actual investments. DEV is I_t^* minus I_{t-1} . *Suff. CF dummy* takes the value of one if firms' cash flows exceed firms' planned investments, and zero else. *Major inv. dummy* takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else. *Replacem. dummy* takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. *Irreversibility dummy* takes the value of one if firms' depreciation rate is below two-digit industry median depreciation rate, and zero else. DEV , each *dummy* and their interaction are treated as predetermined using lagged values dated t-2 to t-6 as instruments. CF_{t-1} , $Size_{t-1}$ and $Inv. opport._{t-1}$ (firms' sales growth) are treated as predetermined using as instruments levels t-2 to t-5. All columns include time dummies. Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. Detailed variables descriptions can be found in Appendix B. ***, **, * indicate significance at the 1%, 5% and 10% level.

Table 4. Robustness: Firms' speed of adjustment (Difference-GMM estimation)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---------------------|---------------------|----------------------|----------------------|----------------------|----------------------|
| DEV _t | 0.704*** (0.027) | 0.699*** (0.029) | 0.593*** (0.043) | 0.773*** (0.029) | 0.581*** (0.048) | 0.730*** (0.031) |
| CF _{t-1} | | 0.029 (0.028) | 0.002 (0.016) | 0.025 (0.019) | 0.001 (0.019) | −0.004 (0.018) |
| Inv. opport. _{t-1} | | −0.020 (0.191) | 0.064 (0.051) | −0.011 (0.097) | 0.078 (0.054) | 0.010 (0.103) |
| Size _{t-1} | | −0.037 (0.037) | −0.033*** (0.005) | −0.036*** (0.012) | −0.030*** (0.006) | −0.041*** (0.006) |
| Suff. CF dummy _t | | | 0.008* (0.004) | | | |
| DEV _t * Suff. CF dummy _t | | | 0.203*** (0.051) | | | |
| Major inv. dummy _t | | | | −0.026** (0.011) | | |
| DEV _t * Major inv. dummy _t | | | | −0.145* (0.084) | | |
| Replacem. dummy _t | | | | | −0.005 (0.005) | |
| DEV _t * Replacem. dummy _t | | | | | 0.135** (0.054) | |
| Irreversibility dummy _t | | | | | | −0.015 (0.012) |
| DEV _t * Irreversibility dummy _t | | | | | | −0.155** (0.061) |
| No. of obs. | 3,290 | 3,095 | 3,044 | 3,095 | 2,308 | 3,095 |
| No. of firms | 955 | 880 | 860 | 880 | 741 | 880 |
| No. of instruments | 35 | 38 | 108 | 108 | 112 | 115 |
| Hansen test (p-value) | 0.562 | 0.695 | 0.442 | 0.503 | 0.711 | 0.255 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.356 | 0.470 | 0.215 | 0.948 | 0.815 | 0.277 |

The table reports regression results of Equations (10) and (12) using Difference-GMM estimators. The dependent variable is a firms' change in actual investments. *DEV* is the difference between I_t^* and I_{t-1} . *Suff. CF dummy* takes the value of one if firms' cash flows exceed firms' planned investments, and zero else. *Major inv. dummy* takes the value of one if firms' stated investment targets exceed firms' total assets by more than twenty percent, and zero else. *Replacem. dummy* takes the value of one if a firm's major investment type is replacement, rationalization or other investments, and zero else. *Irreversibility dummy* takes the value of one if firms' depreciation rate is below two-digit industry median depreciation rate, and zero else. *DEV*, each *dummy* and their interaction are treated as predetermined using lagged values dated t-2 to t-6 as instruments. CF_{t-1}, Size_{t-1} and Inv. opport._{t-1} (firms' sales growth) are treated as strictly exogenous. All columns include time dummies. Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. Detailed variables descriptions can be found in Appendix B. ***, **, * indicate significance at the 1%, 5% and 10% level.

Table 5. Influence of the financial crisis on firms' actually realized investments

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Actual inv_{t-1} | 0.468** (0.208) | 0.468** (0.208) | 0.468** (0.208) | 0.468** (0.208) | 0.468** (0.208) | 0.468** (0.208) | 0.468** (0.208) |
| CF_{t-1} | 0.095*** (0.035) | 0.095*** (0.035) | 0.095*** (0.035) | 0.095*** (0.035) | 0.095*** (0.035) | 0.095*** (0.035) | 0.095*** (0.035) |
| Inv. opport. $_{t-1}$ | 0.046* (0.026) | 0.046* (0.026) | 0.046* (0.026) | 0.046* (0.026) | 0.046* (0.026) | 0.046* (0.026) | 0.046* (0.026) |
| Size $_{t-1}$ | -0.002*** (0.001) | -0.002*** (0.001) | -0.002*** (0.001) | -0.002*** (0.001) | -0.002*** (0.001) | -0.002*** (0.001) | -0.002*** (0.001) |
| Crisis ₂₀₀₇ | | 0.004 (0.003) | | | | | |
| Crisis ₂₀₀₇₋₂₀₀₈ | | | 0.002 (0.004) | | | | |
| Crisis ₂₀₀₈ | | | | 0.003 (0.003) | | | |
| Crisis ₂₀₀₈₋₂₀₀₉ | | | | | -0.013*** (0.004) | | |
| Crisis ₂₀₀₉ | | | | | | -0.011*** (0.003) | |
| Crisis ₂₀₀₇₋₂₀₀₉ | | | | | | | 0.002 (0.004) |
| No. of obs. | 7,494 | 7,494 | 7,494 | 7,494 | 7,494 | 7,494 | 7,494 |
| No. of firms | 1,478 | 1,478 | 1,478 | 1,478 | 1,478 | 1,478 | 1,478 |
| No. of instruments | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Hansen test (p-value) | 0.217 | 0.217 | 0.217 | 0.217 | 0.217 | 0.217 | 0.217 |
| m1 (p-value) | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| m2 (p-value) | 0.936 | 0.936 | 0.936 | 0.936 | 0.936 | 0.936 | 0.936 |

The table reports dynamic estimation of realized investments on lagged realized investments, control variables and dummy variables reflecting the financial crisis. Estimations are conducted over the full sample period 2004 to 2013 using System-GMM estimators. The dependent variable is firms' realized investments I_t . All models are estimated assuming I_{t-1} to be predetermined and using lagged values dated t-3 to t-4 as instruments. Each Crisis dummy variable takes the value of one for year i and zero else. For instance *Crisis*₂₀₀₇₋₂₀₀₉ takes the value of one for the years 2007 to 2009 and zero else. All control variables (*Crisis*, CF_{t-1} , $Size_{t-1}$ and $Inv. \text{ opport.}_{t-1}$) are assumed to be strictly exogenous. All columns included time dummies (unreported). Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. A detailed description of all variables can be found in Table B of the Appendix. ***, **, * indicate significant differences at the 1%, 5% and 10% level.

Table 6. Influence of the financial crisis on firms' target investments

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Target inv _{t-1} | 0.307*** (0.040) | 0.285*** (0.039) | 0.285*** (0.039) | 0.285*** (0.039) | 0.285*** (0.039) | 0.285*** (0.039) | 0.285*** (0.039) |
| CF _{t-2} | 0.101*** (0.015) | 0.107*** (0.014) | 0.107*** (0.014) | 0.107*** (0.014) | 0.107*** (0.014) | 0.107*** (0.014) | 0.107*** (0.014) |
| Inv. opport. _{t-2} | 0.037 (0.030) | 0.045 (0.030) | 0.045 (0.030) | 0.045 (0.030) | 0.045 (0.030) | 0.045 (0.030) | 0.045 (0.030) |
| Size _{t-2} | -0.003*** (0.001) | -0.004*** (0.001) | -0.004*** (0.001) | -0.004*** (0.001) | -0.004*** (0.001) | -0.004*** (0.001) | -0.004*** (0.001) |
| Crisis ₂₀₀₇ | | 0.003 (0.004) | | | | | |
| Crisis ₂₀₀₇₋₂₀₀₈ | | | 0.003 (0.004) | | | | |
| Crisis ₂₀₀₈ | | | | 0.006* (0.004) | | | |
| Crisis ₂₀₀₈₋₂₀₀₉ | | | | | -0.001 (0.004) | | |
| Crisis ₂₀₀₉ | | | | | | -0.001 (0.004) | |
| Crisis ₂₀₀₇₋₂₀₀₉ | | | | | | | -0.001 (0.004) |
| No. of obs. | 4,246 | 4,246 | 4,246 | 4,246 | 4,246 | 4,246 | 4,246 |
| No. of firms | 1,142 | 1,142 | 1,142 | 1,142 | 1,142 | 1,142 | 1,142 |
| No. of instruments | 53 | 53 | 53 | 53 | 53 | 53 | 53 |
| Hansen test (p-value) | 0.141 | 0.141 | 0.141 | 0.141 | 0.141 | 0.141 | 0.141 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.551 | 0.463 | 0.463 | 0.463 | 0.463 | 0.463 | 0.463 |

The table reports dynamic estimation of target investments on lagged target investments, control variables and dummy variables capturing the financial crisis. Estimations are conducted over the full sample period 2004 to 2013 using System-GMM estimators. The dependent variable is a firms' target investments I_t^* . All models are estimated assuming I_{t-1}^* to be predetermined and using lagged values dated t-2 to t-7 as instruments. Each Crisis dummy variable takes the value of one for year i and zero else. For instance *Crisis*₂₀₀₇₋₂₀₀₉ takes the value of one for the years 2007 to 2009 and zero else. All control variables (*Crisis*, *CF*_{t-1}, *Size*_{t-1} and *Inv. opport.*_{t-1}) are assumed to be strictly exogenous. All columns included time dummies (unreported). Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. A detailed description of all variables can be found in Table B of the Appendix. ***, **, * indicate significant differences at the 1%, 5% and 10% level.

Table 7. Influence of the financial crisis on firms' speed of adjustment

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|------------------------------|---------------------|---------------------|---------------------|----------------------|---------------------|---------------------|----------------------|----------------------|
| DEV_t | 0.644*** (0.030) | 0.647*** (0.036) | 0.645*** (0.033) | 0.673*** (0.030) | 0.660*** (0.036) | 0.667*** (0.039) | 0.653*** (0.039) | 0.657*** (0.036) |
| CF_{t-1} | 0.009 (0.013) | 0.009 (0.013) | 0.008 (0.013) | 0.008 (0.013) | 0.008 (0.013) | 0.008 (0.013) | 0.008 (0.013) | 0.008 (0.013) |
| $Inv. \text{ oport.}_{t-1}$ | 0.022 (0.036) | 0.016 (0.036) | 0.019 (0.036) | 0.019 (0.036) | 0.018 (0.036) | 0.015 (0.036) | 0.023 (0.036) | 0.019 (0.036) |
| $Size_{t-1}$ | 0.001** (0.000) | 0.001** (0.000) | 0.001** (0.000) | 0.001** (0.001) | 0.001** (0.000) | 0.001** (0.000) | 0.001** (0.001) | 0.001** (0.001) |
| $Crisis_{2007}$ | 0.003 (0.004) | | | | | | 0.003 (0.004) | |
| $DEV_t * Crisis_{2007}$ | -0.071 (0.054) | | | | | | -0.075 (0.058) | |
| $Crisis_{2007-2008}$ | | -0.002 (0.004) | | | | | | |
| $DEV_t * Crisis_{2007-2008}$ | | -0.015 (0.042) | | | | | | |
| $Crisis_{2008}$ | | | -0.003 (0.004) | | | | -0.004 (0.004) | -0.003 (0.004) |
| $DEV_t * Crisis_{2008}$ | | | 0.029 (0.046) | | | | 0.009 (0.052) | 0.022 (0.048) |
| $Crisis_{2009}$ | | | | -0.015*** (0.004) | | | -0.015*** (0.004) | -0.015*** (0.004) |
| $DEV_t * Crisis_{2009}$ | | | | -0.028 (0.049) | | | -0.022 (0.054) | -0.015 (0.052) |
| $Crisis_{2008-2009}$ | | | | | -0.003 (0.004) | | | |
| $DEV_t * Crisis_{2008-2009}$ | | | | | -0.001 (0.041) | | | |
| $Crisis_{2007-2009}$ | | | | | | 0.003 (0.004) | | |
| $DEV_t * Crisis_{2007-2009}$ | | | | | | -0.030 (0.040) | | |
| No. of obs. | 4,272 | 4,272 | 4,272 | 4,272 | 4,272 | 4,272 | 4,272 | 4,272 |
| No. of firms | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 | 1,177 |
| No. of instruments | 58 | 58 | 58 | 58 | 58 | 58 | 60 | 59 |
| Hansen test (p-value) | 0.079 | 0.125 | 0.210 | 0.228 | 0.218 | 0.194 | 0.080 | 0.203 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.255 | 0.277 | 0.281 | 0.309 | 0.299 | 0.284 | 0.257 | 0.291 |

The table reports regression results of Equation (12) using System-GMM estimators. Estimations are conducted over the full sample period 2004 to 2013. The dependent variable is a firms' change in actual investments. DEV is the difference between I_t^* and I_t . DEV is interacted with a Crisis dummy variable which takes the value of one for year i and zero else. For instance $Crisis_{2007-2009}$ takes the value of one for the years 2007 to 2009 and zero else. All control variables (CF_{t-1} , $Size_{t-1}$ and $Inv. \text{ oport.}_{t-1}$) are assumed to be strictly exogenous. All columns included time dummies (unreported). Standard errors shown in brackets are calculated using the finite-sample correction suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. The statistics m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. A detailed description of all variables can be found in Table B of the Appendix. ***, **, * indicate significant differences at the 1%, 5% and 10% level.

Table 8. Understanding the influence of the financial crisis on firms' speed of adjustment

| | (1) | (2) | (3) | (4) |
|---|---------------------|----------------------|----------------------|----------------------|
| DEV _t | 0.556*** (0.047) | 0.765*** (0.028) | 0.578*** (0.046) | 0.722*** (0.032) |
| CF _{t-1} | -0.011 (0.012) | 0.021* (0.011) | 0.012 (0.011) | -0.001 (0.012) |
| Inv. opport. _{t-1} | 0.036 (0.026) | 0.062** (0.029) | 0.064** (0.029) | 0.036 (0.029) |
| Size _{t-1} | 0.001** (0.000) | 0.000 (0.001) | 0.002*** (0.001) | -0.000 (0.001) |
| Crisis ₂₀₀₉ | -0.007** (0.003) | -0.015*** (0.003) | -0.019*** (0.003) | -0.019*** (0.003) |
| DEV _t * Crisis ₂₀₀₉ | -0.104 (0.074) | -0.037 (0.057) | -0.182** (0.089) | -0.144* (0.074) |
| Suff. CF dummy _t | 0.008*** (0.002) | | | |
| DEV _t * Suff. CF dummy _t | 0.210*** (0.054) | | | |
| DEV _t * Suff. CF dummy _t * Crisis ₂₀₀₉ | 0.162 (0.120) | | | |
| Major inv. dummy _t | | -0.020*** (0.008) | | |
| DEV _t * Major inv. dummy _t | | -0.274*** (0.072) | | |
| DEV _t * Major inv. dummy _t * Crisis ₂₀₀₉ | | -0.110 (0.119) | | |
| Replacem. dummy _t | | | 0.002 (0.004) | |
| DEV _t * Replacem. dummy _t | | | 0.130** (0.059) | |
| DEV _t * Replacem. dummy _t * Crisis ₂₀₀₉ | | | 0.050 (0.123) | |
| Irreversibility dummy _t | | | | -0.010** (0.005) |
| DEV _t * Irreversibility dummy _t | | | | -0.237*** (0.055) |
| DEV _t * Irrev. dummy _t * Crisis ₂₀₀₉ | | | | 0.232** (0.112) |
| No. of obs. | 4,200 | 4,272 | 3,377 | 4,272 |
| No. of firms | 1,156 | 1,177 | 1,069 | 1,177 |
| No. of instruments | 147 | 147 | 152 | 155 |
| Hansen test (p-value) | 0.212 | 0.233 | 0.563 | 0.093 |
| m1 (p-value) | 0.000 | 0.000 | 0.000 | 0.000 |
| m2 (p-value) | 0.213 | 0.745 | 0.631 | 0.265 |

The table reports Sytem-GMM estimates of Equations (10) and (12). The regressand is the change in firms' investments. *DEV* is I_t^* minus I_{t-1} . *Crisis_i* takes the value of one for year *i* and zero else, e.g. *Crisis₂₀₀₇₋₂₀₀₉* is one in 2007 to 2009, and zero else. *Suff. CF dummy* is one if cash flows exceed planned investments, and zero else. *Major inv. dummy* is one if stated investment targets exceed total assets by more than twenty percent, and zero else. *Replacem. dummy* is one if a firm's major investment type is replacement, rationalization or other investments, and zero else. *Irreversibility dummy* is one if firms' depreciation rate is below two-digit industry median depreciation rate, and zero else. *DEV*, each *dummy* and their interaction are treated as predetermined using lagged values dated t-2 to t-6 as instruments. CF_{t-1}, Size_{t-1} and Inv. opport._{t-1} are treated as strictly exogenous. All columns include time dummies. Standard errors shown in brackets are calculated as suggested by Windmeijer (2005). The null hypothesis of the Hansen test is that the instruments are not correlated with the error term. m1 and m2 test the null hypothesis of no first- and second-order autocorrelation in the first-differenced residuals. For detailed variables descriptions see Appendix B. ***, **, * indicate significance at the 1%, 5% and 10% level.