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Abstract

Little is known about how firms manage their cash policy over time. This paper fills this gap by examining if and how firms manage cash toward a target cash ratio. Estimating partial adjustment models of cash, we find that firms actively adjust their cash toward a target; however, adjustment is imperfect and there is large dispersion in the speed of adjustment across firms. We investigate the causes for this and find evidence consistent with the presence of adjustment costs. We also examine the implications of these results for previous interpretations of cross-sectional results through simulations of firms' cash paths allowing for costly adjustment. The emerging patterns question the interpretation of some of the standard results in the empirical cash literature.

JEL classification: G30; G31; G32
Keywords: cash, liquidity, adjustment costs, financial constraints

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Introduction

A large literature examines the cross-sectional determinants of cash. However, little is understood about how firms manage their cash because there is virtually no empirical work on the time-series dynamics of corporate cash management. This paper attempts to fill this gap by studying the speed of adjustment (SOA) of corporate cash toward its target, the properties and determinants of the SOA of cash, and the implications of the emerging dynamics for the interpretation of previous empirical findings in the cash literature. Our results are compelling and suggest that firms actively rebalance their cash holdings, yet imperfectly, consistent with the presence of adjustment costs. We further illustrate that there is substantial firm-level heterogeneity in the SOA of cash and examine what factors explain differences in firms' SOA. We then investigate the importance of imperfect adjustment to the current interpretation of cross-sectional results in the cash literature and find evidence that calls into question results consistent with the precautionary motive for holding cash. This paper is the first to examine adjustment costs of rebalancing cash and in doing so contributes not only to our understanding of the dynamics of cash but also to what is generally accepted as the primary driver of cash policy, namely the precautionary motive.

We begin by examining the evolution of firms' cash ratios over time. To do this, firms are sorted on unexpected cash, relative to the empirical model of cash in Bates, Kahle, and Stulz (2009), into four portfolios: Very high, High, Medium, and Low. Their unexpected cash positions are then tracked over the subsequent 20 years. This method is similar to the approach in Lemmon, Roberts, and Zender (2008), applied to cash ratios instead of capital structure. Figure 1 presents the results. Two main patterns emerge: (i) Adjustment toward a target cash ratio is imperfect, and (ii) There is some persistence in cash ratios, albeit less than the documented persistence in capital structure: In contrast to capital structure, the differences between the unexpected cash portfolios gradually become insignificant. However, it is clear that firms do not fully adjust in any one period and there is a substantial, unexplored transitory component of cash holdings that has been largely ignored by the existing literature on cash holdings. The goal of this paper is to understand the causes and consequences of this imperfect adjustment to the target cash ratio.

To study the speed of adjustment of cash, we calculate the pooled annual speed of adjustment (SOA), i.e., the rate at which firms revert back to their target cash ratio. An SOA of 1 implies perfect, continuous adjustment, whereas an SOA of 0 implies perfect non-readjustment. Because there is an ongoing debate in the literature about the proper estimation procedure of SOA[1] (e.g., Iliev and Welch (2010)), we employ a wide battery of SOA estimators.[2] We estimate the annual SOA of cash to lie between 0.2 and 0.4, suggesting that cash is imperfectly adjusted toward its target. To provide economic intuition, we translate these SOAs into half-lives, the time that it takes a firm to adjust one-half the distance to its target cash after a one unit shock to the error term. The half-life ranges from 1.4 to 3.1 years, which further highlights the imperfect adjustment of cash toward its target.

Theoretically, imperfect adjustment might be consistent with a "pecking order theory" of cash (or the "financial hierarchy hypothesis" of cash as referred to in Opler, Pinkowitz, Stulz, and Williamson (1999)), under which firms have no optimal cash ratio, and therefore do not actively manage their cash. Alternatively, it might still be consistent with a “trade-off theory” of cash, under which firms have an optimal cash level, if firms do rebalance their cash holdings,

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[1] While Iliev and Welch (2010) find that the estimates of the SOA of leverage are likely biased, they are less likely to be biased for cash ratios because unlike leverage, very few firms report zero cash ratios. In fact, only 1.9% of the observations in our sample correspond to zero cash holdings.

[2] These methods are discussed collectively in Fama and French (2002), Flannery and Rangan (2006), Lemmon, Roberts, and Zender (2008), and Huang and Ritter (2009).

albeit infrequently, due to adjustment costs. To distinguish between these two alternatives, we investigate whether or not firms actively manage their cash balances. We find that financing, in the form of large net debt and equity issues, as well as stock repurchases, is associated with higher speeds of adjustments. We also show that large investments push firms towards their target cash ratio, suggesting that firms build cash reserves in anticipation of future, substantial investments. Taken together, these results suggest that firms actively manage their cash reserves. The natural question that arises is: Why do we observe imperfect readjustment?

To answer this question, we investigate whether adjustment costs impact the rebalancing of cash. We find that firms that are below their target exhibit significantly lower SOAs. This result is consistent with higher, asymmetric adjustment costs of building cash reserves relative to disgorging cash. We also find that firms that are further away from their target readjust cash holdings more rapidly, consistent with lower marginal adjustment costs (relative to the marginal benefits) when further away from the target. In addition, we examine how access to bank lines of credit impacts the SOA of cash. If lines of credit provide lower cost of access to capital, we would expect firms with access to a line of credit to have higher SOAs. We find results consistent with this hypothesis; firms with access to bank lines of credit have significantly higher SOA of cash.

To further determine the impact of adjustment costs, we build on the insight in Faulkender et al. (2009) and seek out cross-sectional differences in adjustment costs related to free cash flows (FCF). We test whether firms with significantly negative or very high FCF have higher SOAs due to lower adjustment costs, relative to those around the median free cash flow. Those with significantly negative free cash flow should have low adjustment costs because they must raise external capital or use cash to cover their financing deficit, and thus the adjustment cost becomes a sunk cost. Symmetrically, firms with large positive free cash flows are most likely to be distributing excess capital or retain cash to move toward their target cash. Our results indeed reveal a U-Shape relation between the SOA of cash and FCF: SOA is significantly higher for firms with low/high FCF. We therefore conclude that adjustment costs are an important determinant of how a firm manages its cash balances.

In addition to examining how adjustment costs impact SOA, we also examine other variables that are important to cash policy. We find that there is substantial cross-sectional dispersion in the SOA of cash across firms and investigate its determinants. Our findings suggest that better governance is associated with more rapid SOA, implying that cash rebalancing is efficient. Surprisingly, we do not find any evidence that links between the SOA of capital structure and the SOA of cash. This suggests that rapid rebalancing of leverage does not entail rapid readjustment of cash. It also implies that there is no simple relation between the impact of adjustment costs on the rebalancing of leverage and cash, thus highlighting the importance of cash policy.

In a final step, we examine the implications of costly adjustment for previous findings in the cash literature. As shown in the capital structure literature (e.g., Leary and Roberts (2005), Strebulaev (2007)), the presence of adjustment costs might hamper the interpretation of some of the conclusions drawn based from cross-sectional patterns. To investigate this idea, we simulate corporate cash paths allowing for costly adjustment. In the simulation, all firms are endowed with the same level of target cash. We then let their cash holdings mechanically fluctuate with random draws of cash flows and capital expenditures, unless they hit the cash lower or upper bounds, in which case they revert to their target. We vary the interval between the lower and upper bound to test the implications of lower adjustment costs (smaller intervals) versus higher adjustment costs (larger intervals).[3]

We conjecture that firms with larger cash flow shocks will hold more cash in the presence of costly adjustment because firms will take longer to rebalance cash back to its target given the adjustment costs. Similarly, firms with larger capital expenditure shocks will hold less cash in the presence of costly adjustment. Since larger shocks to cash flow (capital expenditures) will cause higher volatility in cash flow (capital expenditures), a mechanical relation between volatility in cash flow/capital expenditure and cash holdings will exist that would not exist without adjustment costs. We find evidence consistent with our hypotheses: The relation between cash holdings and cash flow/capital expenditure volatility increases dramatically when adjustment costs increase. However, this relation is not economically meaningful. All simulated cash paths correspond to the same target cash level, regardless of cash flow/capital expenditure volatility. Thus, these findings cast doubt on the standard interpretation of the empirically observed relation between cash and volatility and suggest that we might need to rethink our tests of cash holdings in the presence of costly adjustment. Given that volatility is the primary driver of the aggregate increase in cash, documented by Bates, Kahle, and Stulz (2009), this result is particularly interesting.

Our paper adds to prior literature in a number of important ways. First, it argues that the dynamic, time-series dimension of cash management should not be overlooked in favor of cross-sectional tests, which have been the focus of the previous literature (e.g., Opler, Pinkowitz, Stulz, and Williamson (1999), Almeida, Campbello, and Weisbach (2004), Faulkender and Wang (2006)). Second, it suggests that costly adjustment plays an important role in liquidity policies.

[3] To account for the asymmetrically higher adjustment costs below the target cash, we also consider a specification of skewed adjustment bounds, in which the high bound is asymmetrically closer to the target relative to the low bound. This specification yields similar results.

The role of adjustment costs has been emphasized in the context of other financial policies, such as capital structure[4] and investment (e.g., Leary and Roberts (2005), Strebulaev (2007), Zhang (2005)), but has not received attention in the cash literature. Finally, this paper shows that costly adjustment has implications for how we interpret standard results in the cash literature and calls into question some of the empirical findings in previous studies.

The paper proceeds as follows. Section I describes the data and examines the properties of the rebalancing of cash holdings. Section II investigates whether firms actively rebalance their cash holdings. Section III explores the presence of adjustment costs, while Section IV studies the cross-sectional determinants of SOA. Section V studies the implications of costly adjustment through simulations, and Section VI concludes.

I. Rebalancing of Cash Holdings

A. Data

Our sample consists of annual data on publicly traded firms available on Standard and Poor's Compustat. The sample period starts in 1965 and ends in 2006, before the beginning of the 2007 credit crisis. We stop before the beginning of the crisis because recent evidence suggests that cash reserves played an important role in firms' operating performance during the crisis, and thus including this period may alter our results (Duchin, Ozbas, and Sensoy (2009)).

We exclude financial firms and utilities, defined as firms with SIC codes between 6000-6999 and 4900-4949, respectively. For the relatively few firms that change their fiscal year during our sample period, we keep the most recent fiscal year convention. Because our analysis relies on the estimation of cash rebalancing over the sample period, we restrict attention to firms

[4] There are alternative explanations for the slow SOA of leverage that do not rely on adjustment costs. For example, the slow SOA in DeAngelo et al. (2010) is a result of intentional deviations from the target as a response to shocks to investment opportunities.

with available data on cash and short-term investments for at least 15 years.[5] Our final sample consists of 106,091 annual observations for 4,285 firms.

Variables are defined in Appendix 1. We winsorize all variables, except Tobin's Q, at the 1st and 99th percentiles to lessen the influence of outliers. Tobin's Q is computed as in Kaplan and Zingales (1997) with an upper bound of 10, following Baker, Stein, and Wurgler (2003).

Table 1 provides summary statistics for the variables employed in this study. Average cash flow is 8.0% of book assets, whereas average capital expenditures are 7.2% of book assets. In both cases, the cross-sectional variation suggests there is a substantial degree of heterogeneity across firms. Also, the average firm has outstanding short-term (long-term) debt of 6.0% (20.0%) of book assets, a cash flow volatility of 4.9%, and Tobin's Q that is greater than one.

B. The Speed of Adjustment of Cash

We begin by examining the evolution of firms' cash ratios over time. To do this, we sort firms on unexpected cash, relative to the empirical model of cash in Bates, Kahle, and Stulz (2009), into four portfolios: Very high, High, Medium, and Low. We then track their unexpected cash positions over the subsequent 20 years. This method is similar to the approach in Lemmon, Roberts, and Zender (2008), applied to cash ratios instead of capital structure. Figure 1 presents the results.

Figure 1 suggests that there is significant convergence among the four portfolios' cash averages over time. After 16 years, the differences between the unexpected cash portfolios become insignificant. Yet, convergence is slow and a significant portion of it occurs in the first few years after the formation period, as evidenced by the flattening slope over time in the Low and Very High portfolios. Therefore, a preliminary examination of cash ratios suggests that the

[5] We obtain similar results if we remove this restriction and include firms with fewer than 15 observations.

previously identified cross-sectional determinants of cash, used by Bates, Kahle, and Stulz (2009) and others, explain the heterogeneity of cash ratios across firms. Nevertheless, Figure 1 suggests the presence of a transitory or short run component in cash ratios. This component receives virtually no attention in previous studies of firms' cash policies and is the focus of this paper. Thus, we start our empirical investigation by estimating the pooled speed of adjustment (SOA) of the firms in our sample.

To calculate the SOA of cash ratios, we estimate a target adjustment model, in which cash adjusts over time to a target. This section offers a comprehensive treatment of the target adjustment properties of cash. We consider various measures of cash and different target adjustment estimation procedures, building on the voluminous body of research on capital structure rebalancing.

Table 2 presents the properties of the cash measures used in our paper, and the Appendix summarizes the definitions of each variable. The primary measure we use is cash divided by book assets. Table 2 shows that the cash-to-assets ratio has a pooled mean of 10.4%, a pooled standard deviation of 13.3%, and an average cross-sectional standard deviation of 12.5%. The median is at 5.5%, suggesting that the distribution of cash is right-skewed. We consider two alternative measures. The most common alternative measure is the cash-to-net-book-assets ratio, where net book assets are defined as book assets excluding cash. Table 2 shows that it has a pooled mean of 17.0%, a pooled median of 5.8%, a pooled standard deviation of 43.8%, and an average cross-sectional standard deviation of 38.5%. This suggests that the cash-to-net-assets ratio is also skewed to the right. Another possibility is to normalize cash by market, instead of book, values. As Table 2 shows, cash-to-market value has a lower pooled mean (7.8%) and lower pooled and cross-sectional standard deviations (9.6% and 9.0%, respectively). Based on the median of 4.6%, this measure is also skewed to the right. Table 2 also considers dollar cash reserves directly. It shows that the pooled mean cash reserve is $105.7 million, the pooled median is $9.6 million, the pooled standard deviation is $339.0 million, and the average cross-sectional standard deviation is $286.8 million. Thus, cash amounts are also heavily skewed to the right.[6]

Next, we describe the different methods used to investigate cash target adjustment. Tests of capital structure target behavior go back to Taggart (1977) and Auerbach (1985).[7] In their general form, applied to cash, these models are given by:

$$cash_{it} - cash_{it-1} = \alpha \cdot (cash_{it}^{*} - cash_{it-1}) + \varepsilon_{it} \qquad (1)$$

where the target-adjustment coefficient α is greater than zero if firms adjust toward the target, and it is strictly less than one if adjustment is imperfect. $cash_{it}$ and $cash_{it}^{*}$ denote, respectively, the cash ratio and the target ratio at *t*. The expression $cash_{it-1} - cash_{it}^{*}$ is called the "deviation from the target." Rearranging Eq. (1) yields:

$$cash_{it} = (1 - \alpha) \cdot cash_{it-1} + \alpha \cdot cash_{it}^{*} + \varepsilon_{it} \qquad (2)$$

We consider four different estimators of the speed of adjustment (SOA) of cash ratios. The first, which we call *OLS*, is a pooled OLS regression. In this estimate, cash is regressed on past cash and a set of control variables similar to the ones employed in Bates, Kahle, and Stulz (2009), which include lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions:

$$Cash_{it} = a_0 + (1 - \alpha) \cdot Cash_{it-1} + \beta X_{it-1} + \epsilon_{it} \qquad (3)$$

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[6] Table 2 also presents summary statistics on measures of cash relative to the target, which we explain and discuss in Section III.
[7] More recent examples include Shyam-Sunder and Myers (1999), Welch (2004), and Chang and Dasgupta (2009).

where X_{it-1} is the vector of control variables. This procedure resembles the procedure to estimate target capital structure in Fama and French (2002) and Lemmon, Roberts, and Zender (2008).[8]

Flannery and Rangan (2006) suggest adding fixed effects into the estimator to control for omitted variables that might drive the heterogeneity across firms' targets. We call this model *FE*, and estimate it as follows:

$$Cash_{it} = a_0 + (1-\alpha) \cdot Cash_{it-1} + \beta X_{it-1} + \delta_i + \epsilon_{it} \tag{4}$$

However, one potential problem with the *FE* estimator is that the fixed effects consume a large number of degrees of freedom. As discussed in Huang and Ritter (2009) and Iliev and Welch (2010), the loss of degrees of freedom may lead to the 'Hurwicz bias', implying mean-reversion even when there is not one. This bias arises in small samples, with few firms and time periods, where the lagged residuals and the independent variables are not orthogonal. In our context, a large error term in period *t* will create a large independent variable in period *t+1*, thus violating the orthogonality assumption. While this bias is not important for the *OLS* estimator (Eq. (3)) because our sample is large, with many more firms than time periods, it reappears with the *FE* estimator (Eq. (4)) because the intercepts assume the mean error realizations. One possible solution is to use the GMM procedure in Blundell and Bond (1998), as implemented by Lemmon, Roberts, and Zender (2008). Table 3 reports this estimator in the *GMM* column.[9]

Huang and Ritter (2009) also compute a Long-Differencing (*LD*) estimator, proposed by Hahn, Hausman, and Kuersteiner (2007) for dynamic panels with highly persistent data series.

[8] We also have estimated Eq. (3) in differences instead of levels and obtained similar results.
[9] An econometric derivation of the *GMM* estimator is beyond the scope of our paper. Intuitively, the moment conditions are derived based on the argument that firms-specific residuals, $Cash_{it} - (1-\alpha) \cdot Cash_{it-1}$, are uncorrelated with lagged cash.

This estimator is estimated from the following equation using iterated two-stage least squares (2SLS) with lagged residuals as instruments:

$$cash_{i,t} - cash_{i,t-7} = \alpha_0 + (1-\alpha) \cdot (Cash_{it-1} - cash_{it-8}) + \varepsilon_{it} \quad (5)$$

The *LD* estimator requires a long time-series and can be estimated with different length periods. As can be seen from Eq. (5), we focus our attention to overlapping 7 years, but the results are similar if we use other time lengths.

Following Faulkender et al. (2010), we also consider a modified adjustment model that focuses on active rebalancing. This specification attempts to correct for passive changes in the cash ratio that are simply due to the company posting its annual income to its equity account. Thus, instead of normalizing lagged cash by lagged book asset, it is normalized by the sum of lagged book assets and contemporaneous net income. The *OLS* model in Eq. (3), for example, becomes:

$$Cash_{it} = a_0 + (1-\alpha) \cdot Cash^{p}_{it-1} + \beta X_{it-1} + \epsilon_{it} \quad (3a)$$

where: $Cash^{p}_{it-1} = \frac{cash_{it-1}}{A_{t-1}+NI_t}$. We change the estimators in Eq. (4) and (5), in a similar fashion to Eq. (3a), and call this measure *Active cash/book assets.*

The estimators in Eq. (3), (4), (5) have been collectively criticized and shown to generate biased estimates of the SOA of leverage in Iliev and Welch (2010). Yet, these estimators are considerably less likely to be biased in the context of the SOA of cash because very few firms in our sample report zero cash holdings. In fact, only 1.9% of the observations in our sample correspond to zero cash ratios. Furthermore, most of our subsequent analysis concentrates on the cross section of firms' SOA, which is unlikely to be affected by biases in the SOA estimators, as long as these biases are not systematically related to the cross-sectional determinants of SOA.

Table 3 reports the results of the different estimators in our sample using each of the cash measures. The table reports α from Eq. (3), (4), and (5). The variable α is equal to one minus the influence of past cash, which is simply one minus the coefficient on lagged cash. This coefficient can be interpreted as the SOA or the rate of adjustment to the target.

The main take away from Table 3 is that the speed of cash adjustment is imperfect. The *OLS* model results suggest that the SOA of cash lies between 0.220 and 0.248, depending on the measure of cash being used. SOA is slightly higher when estimated with the *FE* model, and lies between 0.393 and 0.431, again depending on the measures of cash being used. Similarly, the *GMM* estimators lie between 0.353 and 0.433, whereas the *LD* estimators lie between 0.338 and 0.356. Thus, we conclude that regardless of the estimation procedures and measures of cash, the readjustment of cash ratios is imperfect. Further, even after correcting for passive changes in the cash ratio that are simply due to the company posting its annual income to its equity account, the SOA remains virtually unchanged. These results are different from the results in Faulkender et al. (2010), where the SOA of leverage doubles after correcting for passive changes.

One way to gain intuition into the meaning of these SOA estimates is to translate them into "half-lives." The SOA is the expected percentage by which the gap between the past cash and the target closes in one period. Half-life is the time that it takes a firm to adjust one-half the distance to its target cash after a one-unit shock to the error term. For an AR(1) process, half-life is log(0.5)/log(1-SOA). Thus, focusing on cash as fraction of book assets, the *OLS* estimate indicates a half-life of 2.8 years, whereas the *GMM* estimator indicates a half-life of 1.6 years.

Our results clearly suggest less than perfect and continuous adjustment to the target. These results can occur for three reasons: 1) Firms do not have a target cash ratio and therefore do not manage their cash holdings toward it; 2) Firms have a target cash ratio but the target model is misspecified; or 3) Firms have a target cash ratio and they do manage cash toward the target, but there are costs to adjust their cash ratios. These costs may arise due to the cost of raising cash through financing or due to the cost of distributing cash through a dividend or stock repurchase.

These three conflicting views have very different implications. If firms do not have a target cash ratio, we would not expect them to actively manage their cash ratios toward their targets through financing activities, investment policies, and distributions to shareholders. If firms do have target cash ratios, but they slowly adjust their cash toward the target due to the presence of adjustment costs, we would expect the speed of adjustment to vary across firms based on the adjustment costs they face. Finally, if the model for target cash levels is misspecified, we would not expect firms to rebalance or converge to that target even slowly. Nevertheless, the evidence presented in Figure 1 suggests that firms do rebalance toward the target cash ratios implied by the empirical model in Bates, Kahle, and Stulz (2009). In fact, the differences between our Low and Very High unexpected cash portfolios disappear completely in 16 years. Thus, we devote the next two sections to the investigation of active cash management (Section II) and adjustment costs (Section III).

II. Active Management of Cash

The results in Table 3 suggest that the rebalancing of cash ratios is imperfect, possibly because firms actively but slowly manage their cash ratios to maintain a target level of cash. Another alternative is that firms do not actively manage their cash holdings toward a target and that one should not necessarily equate mean-reversion with active cash management.

To distinguish between these two possibilities, we start by examining the relation between the SOA of cash ratios and the underlying dynamics of actual cash ratios vis-à-vis the dynamics of the implied target cash ratio. Specifically, we estimate the firm's unexpected cash ratio at time t as the residual from the target cash ratio implied by Eq. (3) over a five-year rolling window [*t-5*,*t-1*] and denote it by $xcash_{it}$. Then, we examine if changes in unexpected cash from time *t-1* to time *t* are due to (passive) changes in the implied target or (active) changes in actual cash. Denoting the target cash ratio by $cash_{it}^{*}$, the change in unexpected cash can be written as:

$$xcash_{it} - xcash_{it-1} = (cash_{it}^{*} - cash_{it}) - (cash_{it-1}^{*} - cash_{it-1}) \tag{6a}$$

Rearranging Eq. (6a) yields:

$$xcash_{it} - xcash_{it-1} = (cash_{it}^{*} - cash_{it-1}^{*}) + (cash_{it-1} - cash_{it}) \tag{6b}$$

Using Eq. (6b), we create a dummy variable equal to 1 if more than 50% of the change in unexpected cash from year *t*-1 to *t* is due to the change in cash and equal to 0 if 50% or more of the change is due to the change in the target cash ratio. We refer to this variable as *Active*, defined formally as:

$$\frac{(cash_{it-1} - cash_{it})}{(xcash_{it} - xcash_{it-1})} > \frac{(cash_{it}^{*} - cash_{it-1}^{*})}{(xcash_{it} - xcash_{it-1})} \tag{6c}$$

The summary statistics for *Active* are given in Table 2. They indicate that changes in unexpected cash are due to changes in cash rather than changes in the target in 55.4% of the observations. This indicates that firms experience dramatic changes in both their target cash ratios and their actual cash ratios.

Panel A of Table 4 reports the results of estimating the *OLS* pooled SOA of cash ratios in subsamples sorted on *Active*.[10] Our conjecture is that if companies actively manage their cash holdings, the SOA of cash should be significantly higher when *Active=1*. The evidence presented

[10] Here, as well as in subsequent tables, we obtained similar results with the other 3 estimators of SOA (*FE* ,*GMM*, *LD*). For brevity, we focus our attention on the OLS estimates.

in Panel A is consistent with our conjecture. For all three measures of cash ratios, the SOA of cash is significantly higher when *Active=1*, that is, when most of the change in unexpected cash is due to changes in actual cash rather than in the implied target cash ratio. Thus, the preliminary evidence suggests that changes in cash, rather than in implied target ratios, lead to substantially faster rebalancing of cash, consistent with firms actively changing their actual cash ratios towards a target.

In the remainder of this section, we consider three channels through which firms might actively manage their cash ratios to maintain a target ratio. In Panel B of Table 4, we examine the correlation between investment, as measured by scaled capital expenditure, and the SOA of cash ratios. Each year *t*, we divide the sample into below-median and above-median capital expenditures, and estimate the SOA of cash from year *t-1* to *t*. If firms actively manage their cash ratios toward a target and adjust their cash reserves to accommodate future investment needs, we would observe more rapid cash rebalancing once investments materialize. The evidence in Panel B suggests that this is indeed the case. The SOA of cash is significantly higher when firms make substantial investments. For instance, the SOA coefficient on our cash-to-assets ratio is 0.23 when firms do not make significant investments and is 0.31 when they do make such investment (i.e., an increase of 35% in SOA). As panel B shows, the results are similar for the two other measures of cash ratios.

Another way of managing cash ratios is issuing debt and equity to raise capital. If firms were actively managing cash, they would do so when their cash ratios lie below the target. Alternatively, if they were not actively managing their cash ratios, they would issue debt and equity regardless of whether they are below or above their target cash level. To examine these alternatives, we divide our sample into firms that made and did not make significant net debt and equity issues (defined as issues with values of at least 5% of book assets, see the Appendix for variable definitions) each year *t*, and compare the SOA of cash across these two groups from year *t-1* to year *t*. These results are given in Panel C of Table 4. As Panel C clearly shows, the SOA of large net debt and equity issuers is significantly higher compared to that of non-issuers. For example, the SOA of cash/book assets is 0.20 for non-issuers and 0.33 issuers (i.e., an increase of 65% in SOA). As can be seen from Panel C, we obtain similar results when we scale cash by net book assets or the market value of assets.

The firm can also actively manage its cash ratios by distributing cash to shareholders if its cash ratio is above the target. Given that dividends are relatively smooth over time, we focus our attention on share repurchases, which have become increasingly important in the last two decades as the primary payout method. We examine the stock repurchasing activity of firms in the four unexpected cash portfolios described earlier. The results are presented in Figure 2.[11] We find that the tendency to repurchase shares noticeably differs across the portfolios. The propensity to repurchase shares is monotonically positively related to firms' unexpected cash ratios. This tendency is stronger in earlier years, consistent with Figure 1, which shows that much of the convergence in cash ratios is achieved during the first few years, but does persist in later years as well. This finding suggests that firms might be using share repurchase policy to rebalance their cash holdings.[12] This result is consistent with the evidence in Brav et al. (2005), who find that stock repurchases are made out of residual cash flows after investment. It also helps identify the mechanism behind the initial convergence of cash ratios observed in Figure 1.

[11] We detrend stock repurchases by first regressing them on year dummies to get rid of the secular upward trend in share repurchase activity in our sample period.
[12] As stock repurchases became more common after 1984, we repeat the analysis excluding observations prior to 1984 and obtain similar results.

Finally, Figure 3 attempts to track the relation between cash balances and companies' inflows and outflows, as reported in their statements of cash flows. It sorts firms on the level of their previous year's cash ratios around the median, and compares subsequent year changes in cash, debt issues, stock repurchases, dividend payments, capital expenditure, and acquisitions. Firms with beginning-of-year low cash ratios tend to increase their cash during the year. They issue debt and tend to engage in less stock repurchases and dividend payments. Interestingly, their capital expenditure and acquisition activity is only lightly affected by their cash balances. This evidence is broadly consistent with the pecking order theory, and suggests that companies attempt to increase their cash levels if they start with low cash reserves and to finance their activities by issuing debt. Due to the upward trend in cash holdings over our sample period, even companies with high beginning-of-year cash tend to increase their cash reserves.

Overall, the findings in this section present evidence consistent with active cash management toward a target ratio. Thus, it suggests that the imperfect rebalancing of cash ratios found in section II is not due to firms not having target cash ratios and therefore not managing their cash toward a target. These results are supportive of the "trade-off theory" of cash, under which firms have an optimal cash level, as opposed to the "financial hierarchy hypothesis" of cash (as referred to in Opler, Pinkowitz, Stulz, and Williamson (1999)) where firms have not optimal cash ratio. In the next section, we consider another possible explanation for the imperfect rebalancing of cash ratios that is consistent with active cash management toward a target, namely the presence of adjustment costs.

III. Adjustment Costs

The results in the previous section suggest that firms actively manage their cash policies toward a target cash ratio. However, our pooled estimates of the speed of adjustment of cash suggest that cash rebalancing is imperfect. Thus, a natural question that arises is why cash readjustment is imperfect. In other words, what prevents firms from continuously and perfectly adjusting their cash ratios toward their target? One possible explanation, suggested by Leary and Roberts (2005), Strebulaev (2007), and others in the context of leverage rebalancing, is the presence of adjustment costs. Facing adjustment costs, firms might find it optimal to rebalance their cash holdings only infrequently. This, in turn, will yield imperfect, non-continuous readjustment of cash ratios, which is consistent with active readjustment of cash, albeit only at "readjustment points." The purpose of this section is to test the hypothesis that adjustment costs affect the speed of adjustment of cash ratios.

We create two variables to explore the effect of the firm's unexpected cash on its rebalancing activity. The first variable, denoted *Positive Xcash*, is an indicator variable that equals 1 if the company's unexpected cash is positive, that is, if its actual cash ratio lies above its implied target, as calculated from the empirical cash model in Bates, Kahle, and Stulz (2009). Formally, *Positive Xcash* is defined as:

$$xcash_{it} > 0 \tag{7}$$

The purpose of this variable is to test whether the SOA of cash is different when firms' cash ratios are above vs. below the target. The adjustment costs hypothesis would imply that SOA is asymmetrically lower below the target, as adjustment costs are higher below the target cash ratio due to financing constraints and the costs of external financing.

Second, we create a dummy variable equal to 1 if the absolute difference between the firm's cash ratio and its implied target ratio is greater than the sample-wide median in each year t, and zero otherwise. We refer to this variable as *Away from target*. Formally, this variable is defined as:

$$abs(cash_{it} - cash^{*}{}_{it}) > median\left[abs(cash_{it} - cash^{*}{}_{it})\right] \tag{8}$$

This variable is designed to test whether firms that are further away from their target tend to rebalance their cash ratios more rapidly. Such a finding would be consistent with the presence of fixed adjustment costs, which would make it optimal to rebalance only when sufficiently far away from the target, when the costs of being away from the target are high enough.

Panel A of Table 2 presents summary statistics of these variables and Panel B of Table 2 presents the correlations between the various measures. The summary statistics for *Positive Unexpected Cash* indicate that approximately 60% of the observations correspond to cash ratios that lie below the target. The vast majority of the literature on corporate liquidity focuses on positive unexpected cash in the context of agency concerns. Little is known about the implications of holding less cash than the target, and this paper is therefore one of the first to distinguish firms based on having negative unexpected cash. Table 2 also shows that the average absolute unexpected cash, that is, the average absolute deviation from the target ratio, is 7.3% of book assets. Given that the mean cash ratio in our sample is 10.4%, the average deviation is large.

Panel A of Table 5 presents the results of estimating *OLS* pooled SOAs of cash ratios separately for firms with positive unexpected cash and negative unexpected cash. The results suggest that cash rebalancing is faster when firms' cash ratios are above their implied target ratios. The difference persists across all three measures of cash ratios and is of substantial magnitudes. This finding is consistent with the presence of asymmetrically higher adjustment costs when firms are below their target ratio, consistent with the presence of financing frictions and constraints.[13] In Panel B, we estimate cash SOA separately when the absolute difference between actual cash ratios and implied target ratios lie below and above the median. Again, consistent with the presence of fixed adjustment costs, we find that the SOA of cash is substantially higher when further away from the target across all three measures of cash ratios.

We also examine whether access to a bank line of credit impacts the SOA of cash. One hypothesis is that a bank line of credit implies lower financing constraints and therefore lower adjustment costs of cash and a higher SOA. This hypothesis is examined in the context of the rebalancing of capital structure by Lockhart (2009), who finds that credit lines are associated with a significantly higher SOA of leverage. Alternatively, firms with access to a line of credit may care less about their cash holdings because they have access to an alternative source of liquidity. This implies that the SOA of cash for such firms would be lower due to the substitutability of cash and credit lines.

To test the relation between the SOA of cash and bank lines of credit, we collect data on revolving credit facilities from DealScan. For each firm-year in our sample, we document whether the firm had access to a revolving credit facility that year and code a binary variable that equals 0 if the firm did not have access to a line of credit that year, and 1 if it did have access.[14] Then we estimate the SOA of cash separately when this variable equals 0 and when it equals 1.

Panel C of Table 5 reports these results. Across all three measures of cash ratios, access to a line of credit is associated with a more rapid SOA of cash. For example, the SOA of cash-to-

[13] Furthermore, in unreported results, we find that the SOA of cash is even lower during recessions, when the costs of accessing external capital markets are even higher. In fact, the slowest SOA corresponds to firms that enter economic downturns with negative excess cash. Note, however, that the target cash ratio itself might be affected by the business cycle (e.g., Gryglewicz (2008)).

[14] The cross-sectional relation between bank lines of credit and cash was first studied in Sufi (2009).

assets ratios without access to a line of credit is 0.26, whereas the SOA with access to a line of credit is 0.32. These results are consistent with the hypothesis that access to a bank line of credit implies lower financing constraints and therefore lower adjustment costs of cash, which make it optimal for the firm to rebalance its cash holdings more rapidly. Taken together, the results in Table 5 are consistent with the presence of asymmetric, fixed adjustment costs that cause firms to optimally rebalance cash ratios infrequently.

To further explore whether there is evidence consistent with the presence of adjustment costs, we build on the insight in Faulkender et al. (2009) and try to find cross-sectional differences in adjustment costs. We identify firms with large (positive or negative) free cash flows, which are likely to confront a relatively low marginal cost of adjustment and, hence, should manifest relatively rapid adjustment speeds. Specifically, we hypothesize that firms with significantly negative free cash flows should have low adjustment costs because they must raise external capital or use cash to cover their financing deficit and thus the adjustment cost is a sunk cost. Symmetrically, firms with large positive free cash flows are most likely to be distributing excess capital or retain cash to move toward their target cash. Paying dividends or repurchasing shares will decrease cash, while retaining free cash flow will increase cash. On the other hand, firms with free cash flows close to zero will confront the largest incremental costs. We therefore would expect that when we estimate the SOA separately across these three groups, we would find higher adjustment speeds for those firms whose incremental adjustment costs are lower.

Table 6 presents the results of estimating the speed of adjustment of cash ratios across three subsamples sorted on free cash flow (FCF): (i) the top 15% sample-wide of FCF, (ii) the bottom 15% sample-wide of FCF, and (iii) the medium 70% sample-wide of FCF. Our adjustment costs hypothesis suggests that the SOA of cash would be more rapid in the top and bottom 15%, where incremental adjustment costs are lower, relative to the SOA when FCF is particularly low or high.

Consistent with the adjustment costs hypothesis, the results in Table 6 reveal a U-Shape relation between the SOA of cash ratios and free cash flows across all three measures of cash ratios. SOA is significantly higher for firms with low/high FCF relative to medium FCF. Consider, for example, the cash-to-assets ratio in Panel A. The estimated SOA is 0.27 when FCF is high, 0.23 when FCF is low, and 0.19 for medium level of FCF. Thus, we conclude that firms tend to rebalance cash ratios more rapidly when free cash flows are particularly low or high and, therefore, the incremental costs of rebalancing through cash flow retention, payout, or external capital-raising are particularly low.

Taken together, the results in this section are consistent with the presence of adjustment costs in the management of cash policies towards target ratios. These findings are consistent with our previous findings that companies actively manage their cash ratios toward a target, albeit imperfectly. In the next section, we further investigate the cross-section of cash SOA, focusing on the relation between cash and two corporate dimensions that received significant attention in the cash literature, namely corporate governance and leverage.

IV. Cross-sectional Differences in Cash Rebalancing

Figure 4 presents the distribution of the SOA of cash across firms, where the SOA is estimated by firm, with the mass concentrated in the lower half of the distribution.[15] As evidenced in this figure, there is substantial cross-sectional dispersion in the speed of adjustment of cash across firms. In this section, we examine factors that explain the cross section of SOA and test whether

[15] Note that estimating the SOA by firm reintroduces the Hurwicz bias and therefore biases the SOA estimates upwards. However, we are mainly interested in the cross-section of SOA, for which the upward bias is less important.

corporate governance and leverage, two areas that were studied extensively in the context of cash holdings (e.g., Acharya, Almeida, and Campello (2007), Dittmar and Mart-Smith (2007), and Harford, Mansi, and Maxwell (2008)), relate systematically to the cross-sectional variation in SOA. In doing so, we add to the previous literature that mainly considered the connection between the *level* and *value* of corporate cash holdings and corporate governance and leverage.

Specifically, we ask whether better-governed firms, which have been shown to waste less cash than poorly governed firms, also rebalance their cash ratio more rapidly toward their target level. While interesting in itself, this approach also has the advantage of allowing cash to be above or below the target, whereas previous studies have largely concentrated on the relation between positive "excess" cash, or having too much cash, and corporate governance.[16] To test the relation between corporate governance and the SOA of cash, we use multiple measures of internal and external corporate governance including the degree of managerial entrenchment due to takeover defenses and the presence of large shareholder monitoring. These governance measures are collectively examined in Gompers, Ishii, and Metrick (2003) and Cremers and Nair (2005), who show that governance has a positive impact on firm value. Our first measure is the Gompers, Ishii, and Metrick (2003) corporate governance index, which measures the number of anti-takeover provisions in a firm's charter and in the legal code of the state in which the firm is incorporated. Gompers, Ishii, and Metrick establish that more anti-takeover provisions are an indication of poor corporate governance. We also employ two measures of large shareholder monitoring. One measure is the percentage of shares held by institutional investors and the other is the sum of all ownership positions greater than 5% held by institutional investors. For each measure, we divide the sample at the median and designate the corresponding halves as poor

[16] One exception is Nikolov and Whited (2009), who estimate a structural model of investment and cash holdings in the presence of agency problems, and find an inverse U-shape relation between empire-building tendencies and cash holdings.

governance and good governance. Then, we estimate the SOA of cash separately in each subsample.

Table 7 gives the results of our corporate governance tests, with each panel corresponding to a different governance measure. Using cash scaled by either assets or market values and across all three measures of governance, we find that the SOA is more rapid in well-governed firms compared to poorly governed firms. These results suggest that well-governed firms not only waste less cash, but also rebalance their cash holdings toward their target more rapidly. However, magnitudes of the differences are not always significant. For example, the SOA of cash-to-assets for poorly governed firms is 0.20 when governance is measured by the g-index, 0.23 when it is measured by the percentage of shares held by institutional investors, and 0.23 when it is measured by the number of large block holders. The SOA for well-governed firms, however, is 0.24 when governance is measured by the g-index, 0.28 when it is measured by the percentage of shares held by institutional investors, and 0.28 when it is measured by the number of large block holders. Further, when we scale by net assets poorly governed firms have a higher SOA. Thus, though taken together the results suggest that well-governed firms rebalance more quickly than poorly governed firms, the differences are not dramatic.

Next, we investigate the relation between the management of capital structure and the management of cash holdings. The "negative debt" view of cash suggests that since cash balances are readily available to redeem debt, they should not be viewed as independent of leverage but rather "negative debt." Under this view, firms should be managing their cash and debt positions together, i.e., managing their net debt positions. This view would imply that the rebalancing of cash and debt is highly correlated and thus we would expect the SOA of cash to be highly correlated with the SOA of debt. An alternative view, put forth by Opler et al. (1999)

and more recently by Acharya et al. (2007), suggests that in the presence of financing frictions, cash plays a separate role and should therefore be managed and studied in its own right. Under this view, the rebalancing (SOA) of cash and debt should not necessarily be highly correlated, since firms will be managing their capital structure and cash policies separately. As Opler et al. (1999) point out, however, the cross-sectional determinants of cash and debt are very similar, only with opposite signs and possibly different magnitudes. Previous literature did not consider, however, the relation between the dynamic rebalancing of the two, which might shed further light on the interaction between the two policies.

In Table 8, we test the relation between the SOA of cash ratios and the SOA of leverage ratios. The SOA of debt is estimated by firm from an autoregressive *OLS* procedure similar to the one in Figure 4, using the set of control variables in Byoun (2008), which includes industry median debt, the marginal tax rate, Q, operating income, depreciation and amortization, a dividend dummy, size, fixed assets, R&D expenses, and Altman's Z-score. We then divide the sample into two groups, consisting of firms with an SOA of debt below and above the median debt SOA, respectively, and estimate the SOA of cash ratios separately in each subsample.

The results in Table 8 reveal no significant relation between the SOA of cash and the SOA of leverage. Across all three measures of cash ratios, the difference between the SOA of cash for the two subsamples is negligible. For example, the SOA of cash-to-assets is 0.258 for firms with low SOA of debt, and 0.254 for firms with high SOA of debt. Thus, not only is the difference small, the SOA is actually higher for firms with slower SOA of debt. Additionally, the direction of the differences is not consistent across the three cash measures, with the relation using the cash-to-net-assets and the cash-to-market-assets ratios being opposite of the relation using cash-to-assets. These results suggest that cash management is not simply an artifact of capital structure management since the dynamic rebalancing of cash does not coincide with that of leverage.

V. Implications of Costly Adjustment

So far, we have shown that the slow speed of adjustment of cash ratios is consistent with costly adjustment, thus implying that firms rebalance their cash ratios only infrequently. Further, we have shown that there are systematic differences across firms in their speed of adjustment. These systematic differences raise the natural question: What are the implications of adjustment costs for the voluminous body of research on corporate cash policy?

Previous studies of cash focused on the cross-sectional variation in cash holdings to discriminate between theories of corporate liquidity. Examples include Opler, Pinkowitz, Stulz, and Williamson (1999), who estimate panel regressions explaining firm-level cash holdings and find that cash holdings are positively related to investment opportunities and cash flow volatility and negatively related to size, debt, and net working capital; Almeida, Campbello, and Weisbach (2004), who use panel regressions to show that cash is only positively related to cash flow when firms are financially constrained; and Faulkender and Wang (2006), who estimate cross-sectional regressions explaining the marginal value of cash and show that it declines with larger cash holdings, higher leverage, and higher bond ratings. However, our results emphasize a dynamic aspect of cash management, possibly correlated with previously documented cross-sectional determinants of cash, such as financing constraints, which might affect the interpretation of these cross-sectional determinants. In what follows, we test via simulations how costly adjustment of cash affects the interpretation of the results of cross-sectional estimations.

This line of investigation builds on recent developments in the research on the costly adjustment of leverage. Leary and Roberts (2005), for example, show that the persistent effect of shocks on leverage is consistent with optimizing behavior in the presence of adjustment costs and is not necessarily due to firms' indifference toward capital structure. Strebulaev (2007) shows that cross-sectional patterns that commonly lead to the rejection of a dynamic tradeoff model of capital structure are actually consistent with such a model. In both papers, simulated capital structure paths that allow for costly adjustment are used to demonstrate the implications of adjustment costs.

This paper uses a similar approach. Specifically, we simulate corporate cash paths allowing for costly adjustment. Each firm is endowed at time 0 with the same target level of cash, *Cash**, set equal to 15% of book assets. In each subsequent period, cash flows and capital expenditures arrive randomly. To keep the simulation as realistic as possible, we maintain the same universe of industry-firms observed empirically. Each firm in our empirical sample has a simulated counterpart in the same industry, with cash flows and capital expenditures generated randomly to match the distribution of cash flows and capital expenditures. Then, given the time-series of cash flows and capital expenditures, we simulate cash paths. In our simulation, firms let their cash holdings fluctuate mechanically with cash flows and capital expenditures as long as cash holdings lie within an optimal range. Thus, as long as cash holdings lie within an optimal range, the cash holdings in period $t+1$ are given by:

$$Cash_{t+1} = cash_t + CF_{t+1} - CAPEX_{t+1} \tag{9}$$

However, if the stream of cash flows and capital expenditures result in a cash ratio below the lower bound (above the upper bound) in period t, the firm calculates the amount of cash it needs to accumulate (dispense) in order to bring the cash ratio to its target post-adjustment level. The rebalancing takes place in the beginning of period *t+1*, according to

$$Cash_{t+1} = Cash^{*} - E[CF] + E[CAPEX] + CF_{t+1} - CAPEX_{t+1} \qquad (10)$$

which takes into account the firm's expected cash flow and capital expenditure in period *t+1*.

We repeat this procedure for each firm in our sample, allowing for different degrees of speed of cash adjustment: 1) Cash interval of [0.14, 0.16] around the target, 0.15, representing low/no adjustment costs, 2) Cash interval of [0.10, 0.20] around the target, 0.15, representing medium adjustment costs, and 3) Cash interval of [0.05, 0.25] around the target, representing high adjustment costs.[17] Given our previous findings that adjustment costs are asymmetrically higher when cash ratios lie below the target, we repeat the above tests with skewed adjustment bounds. Specifically, we let the cash intervals be wider below the target, and cut the distances between the target (of 0.15) and the upper bounds in (1)-(3) above by half.

We conjecture that firms with larger cash flow shocks, whose cash flows are therefore more volatile, will hold more cash in the presence of costly adjustment because costly adjustment keeps the firm from rebalancing. Similarly, firms with larger capital expenditure shocks, whose capital expenditures are more volatile, will hold less cash in the presence of costly adjustment. This will generate a mechanical relation between volatility in cash flow/capital expenditure and cash holdings that would not exist without adjustment costs. Without costly adjustment, firms' cash balances will frequently rebalance back to their target and therefore will not sustain a durable effect of cash flow/capital expenditure shocks.

Table 9 reports the simulation results and compares them with the results obtained using real-world data. The results are estimates from panel regressions explaining cash holdings.

[17] Note that our choice of the maximal interval between the upper and lower bounds (0.25-0.05=0.20) is conservative. In our sample, the median firm-level interval between the maximum and minimum cash is 0.22.

Independent variables include *cash flow*, capital expenditure (*CAPEX*), *cash flow volatility*, and *CAPEX volatility*, and all regressions include time fixed-effects and cluster standard errors by firm. Panel A reports the results for the symmetric adjustment bounds, whereas Panel B reports them for the skewed bounds. Volatilities are measured at the Fama-French 48 industries level because previous cash literature measured cash flow volatility at the industry level to proxy for risk. The rationale for using industry-level volatility was to mitigate concerns about an endogenous/mechanical relation between firm-level cash holdings and firm-level cash flows. Thus, it is important to show that adjustment costs generate a mechanical relation between cash and industry-level volatility as well as cash and firm-level volatility. We present the results using industry-level volatility but note that the results are similar if we use firm-level volatility.

The results in Table 9 are striking and consistent with our hypotheses. In both panels, there is very little persistent shock effect to cash flow and capital expenditure without adjustment costs; and, therefore, the relation between cash ratios and the volatility in cash flow or in capital expenditure is very small. However, once the simulation allows for costly adjustment, the simulated data yields a substantial positive relation between cash flow volatility and cash and a substantial negative relation between capital expenditure volatility and cash. These effects are statistically significant at the 1 percent level and are qualitatively similar to the relation between cash and cash flow volatility or cash and capital expenditure volatility that we observe in the real-world data. Moreover, the effects strengthen considerably when the speed of adjustment (SOA) is lower. In both panels, the magnitude of the volatility effect on cash increases substantially when the implied SOA decreases. Note that although the results are qualitatively similar with symmetric and skewed bounds, the effect of volatility is smaller with skewed bounds. The reason is that skewed bounds imply faster speeds of adjustment, which in turn weaken the effect of adjustment costs on the relation between cash holdings and volatility.

The positive cross-sectional relation between cash and cash flow volatility is typically interpreted as consistent with the precautionary savings motive, which suggests that riskier firms should hold more cash. In contrast, our simulated result is purely mechanical. All simulated firms are assumed to have an identical target level of cash, which is unrelated to their cash flow volatility. Thus, the simulated positive relation between cash and cash flow volatility is a consequence of persistent cash flow shocks and infrequent rebalancing rather than a result of higher precautionary saving needs.

Further, we also find that both in real-world data and in simulations with costly adjustment, the volatility of capital expenditure is negatively related to cash. This result is surprising in the context of the precautionary savings theory, as higher volatility in expenditures (or investment) is predicted to imply higher cash reserves similar to the effect of higher cash flow volatility. To our knowledge, the negative relation between capital expenditure volatility and cash has not been previously shown. This relation is consistent with costly adjustment but inconsistent with the common view of precautionary savings.

Overall, these findings cast doubt on the interpretation of the standard results in the cash literature. The results suggest that cross-sectional relations between cash and cash flow volatility or capital expenditure volatility are not necessarily indicative of a precautionary saving motive and, in fact, might even be inconsistent with such a story. In contrast, our results show that these relations are consistent with, and mechanically driven by, adjustment costs. Furthermore, given that volatility is the primary driver of the aggregate increase in cash, documented by Bates, Kahle, and Stulz (2009), these results are particularly interesting.

VI. Conclusion

What are the time-series dynamics of cash holdings? In this paper, we investigate this question by examining how firms manage cash reserves over time. We find evidence consistent with active, albeit imperfect, cash rebalancing due to costly adjustment. To show this, we estimate the speed of adjustment of the cash ratio to the target. In doing so, this paper is the first to apply the importance of costly adjustment to the cash literature. Given the importance of adjustment costs in other financial policies (such as leverage and investment), it is only natural that these costs would also impact cash policy.

Using a battery of estimation procedures and a wide range of cash ratio measures, we find that the rebalancing of cash is imperfect, with speeds of adjustment ranging from 0.22 to 0.43 (where 0 implies perfect non-readjustment and 1 implies perfect adjustment). Slow rebalancing might be consistent with firms either *not* managing their cash to maintain a target ratio or *imperfectly* managing it due to adjustment costs. To distinguish between these two alternatives, we test whether firms actively manage cash ratios through financing, investment, and payout activities and find that such activities are indeed associated with higher speeds of adjustment. We then examine whether the patterns of cash rebalancing are consistent with the presence of adjustment costs and find that rebalancing is slower exactly when cost of adjustment is expected to be higher. We therefore conclude that firms do manage their cash ratios but do so imperfectly in the presence of adjustment costs.

We also find that there is much cross-sectional variation in the speed of adjustment. We examine what factors influence a firm's speed of adjustment. We find that firms with poorer corporate governance have slower adjustment. Interestingly, though, we find no correlation between the SOA of cash and the rebalancing of capital structure.

Given the impact of costly adjustment on cash policy, we then ask what the implications of adjustment costs are for the interpretation of previous results in the voluminous body of research on corporate cash policy. To do this, we simulate corporate cash data allowing for costly adjustment. We hypothesize that firms with greater cash flow (capital expenditure) volatility will hold more (less) cash in the presences of costly adjustment and that this will generate a mechanical relation between volatility and cash holdings. We find evidence to support this hypothesis: There is virtually no relation between cash holdings and cash flow/capital expenditure volatility when adjustment costs are low and a significant relation between them when adjustment costs are high. Given that all simulated cash paths correspond to the same target cash level, regardless of cash flow/capital expenditure volatility, these findings cast doubt on the standard interpretation of the empirically observed relation between cash and volatility. The results therefore suggest that we might need to rethink our tests of cash holdings in the presence of costly adjustment.

Appendix: Variable Definitions

This appendix describes all variables used in this paper and presented in the following tables. When we employ Compustat data, we provide the Compustat variable name in parentheses.

Cash Variables:

Cash is cash + short term investments (che).

Cash to Net Book Assets is cash (che) divided by book assets (at) excluding cash (che).

Cash-to-Book Assets is cash (che) divided by book assets (at).

Cash to Market Value is cash (che) divided by market value of assets, defined as book assets (at) minus book equity (ceq) plus market value of equity (csho*prcc) minus deferred taxes (txdb), following Kaplan and Zingales (1997).

Target cash is estimated over a rolling 5-year window [t-5,t-1], and is defined as the predicted value from the empirical cash model Bates, Kahle, and Stulz (2009), which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions.

Unexpected Cash for Firm *i* is defined as the difference between its implied target cash ratio and its actual cash ratio.

Active is an indicator variable that equals 1 if more than 50% of the change in unexpected cash from year *t-1* to year *t* is due to the change in cash, and 0 if 50% of the change or more is due to the change in target cash.

Positive unexpected cash is an indicator variable that equals 1 if the firm had positive unexpected cash at year *t*, and 0 otherwise.

Distance from target is the absolute value of unexpected cash.

Estimates of Speeds of Adjustment of Cash (SOA)

OLS procedure resembles the procedure to estimate target capital structure in Fama and French (2002) and Lemmon, Roberts, and Zender (2008), and is defined as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1-\alpha)\cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of controls that corresponds to the empirical cash model in Bates, Kahle, and Stulz (2009).

FE procedure resembles the procedure in Flannery and Rangan (2006), and is defined as follows:

$$Cash_{it} = a_0 + (1-\alpha)\cdot Cash_{it-1} + \beta \cdot X_{it-1} + \delta_i + \epsilon_{it}$$

where: δ_i are firm fixed effects

GMM procedure is similar to the model in Blundell and Bond (1998), implemented by Lemmon, Roberts, and Zender (2008).

LD (long differencing) estimator is similar to the one proposed by Hahn, Hausman, and Kuersteiner (2007) and implemented by Huang and Ritter (2009) using 2SLS:

$$cash_{i,t} - cash_{i,t-7} = \alpha_0 + (1-\alpha)\cdot(Cash_{it-1} - cash_{it-8}) + \varepsilon_{it}$$

Other Accounting Variables:

Cash Flow is measured as earnings less interest and taxes (ib+dp), divided by total assets (at).

CAPEX is capital expenditure (capx) divided by total assets (at).

STDebt and **LTDebt** are short-term debt (dlc) and long-term debt (dltt) divided by total assets (at), respectively.

Payout is defined as the sum of dividend payments (dvp) and stock repurchases (prstkc), divided by book assets (at).

Size is the natural logarithm of the book value of total assets (at).

Net Equity Issues follows Baker and Wurgler (2002), and is defined as the difference between the change in book equity (at-lt-pstkr+txditc) and the change in retained earnings (re).

Net Debt Issues is defined as difference between the change in book assets (at) and the change in book equity (at-lt-pstkr+txditc).

CF Volatility is the industry-level volatility in cash flows over the past 10 years.

ROA is net income (oibdp) divided by book assets (at).

Q is Tobin's Q, computed as in Kaplan and Zingales (1997), i.e., measured as the market value of assets, defined as book assets (at) minus book equity (ceq) plus market value of equity (csho*prcc) minus deferred taxes (txdb) divided by book assets (at). Outliers in Tobin’s Q are handled by bounding Q above at 10, following the alternative measure of Baker, Stein, and Wurgler (2003).

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Figure 1

Average unexpected cash of unexpected cash portfolios in event time

The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. The figure presents the average cash ratio of four portfolios in event time, where year zero is the portfolio formation period. That is, for each calendar year, we form four portfolios by ranking firms based on their unexpected cash (defined below). Holding the portfolios fixed for the next twenty years we compute the average unexpected cash for each portfolio. For example, in 1965 we sort firms into four groups based on the unexpected cash ratios. For each year from 1965 to 1984, we compute the average unexpected cash ratio for each of these four portfolios. We repeat this sorting in 1966 and averaging from 1976 to 1985 and so on for every year in our sample horizon. After performing this sorting and averaging for each year from 1965 to 2006, we then average the average unexpected cash across "event time" to obtain the lines in the figure. Unexpected cash is defined as the residuals from a cross-sectional regression of cash on the cross-sectional determinants of cash in Bates, Kahle, and Stulz (2009), which include lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix.

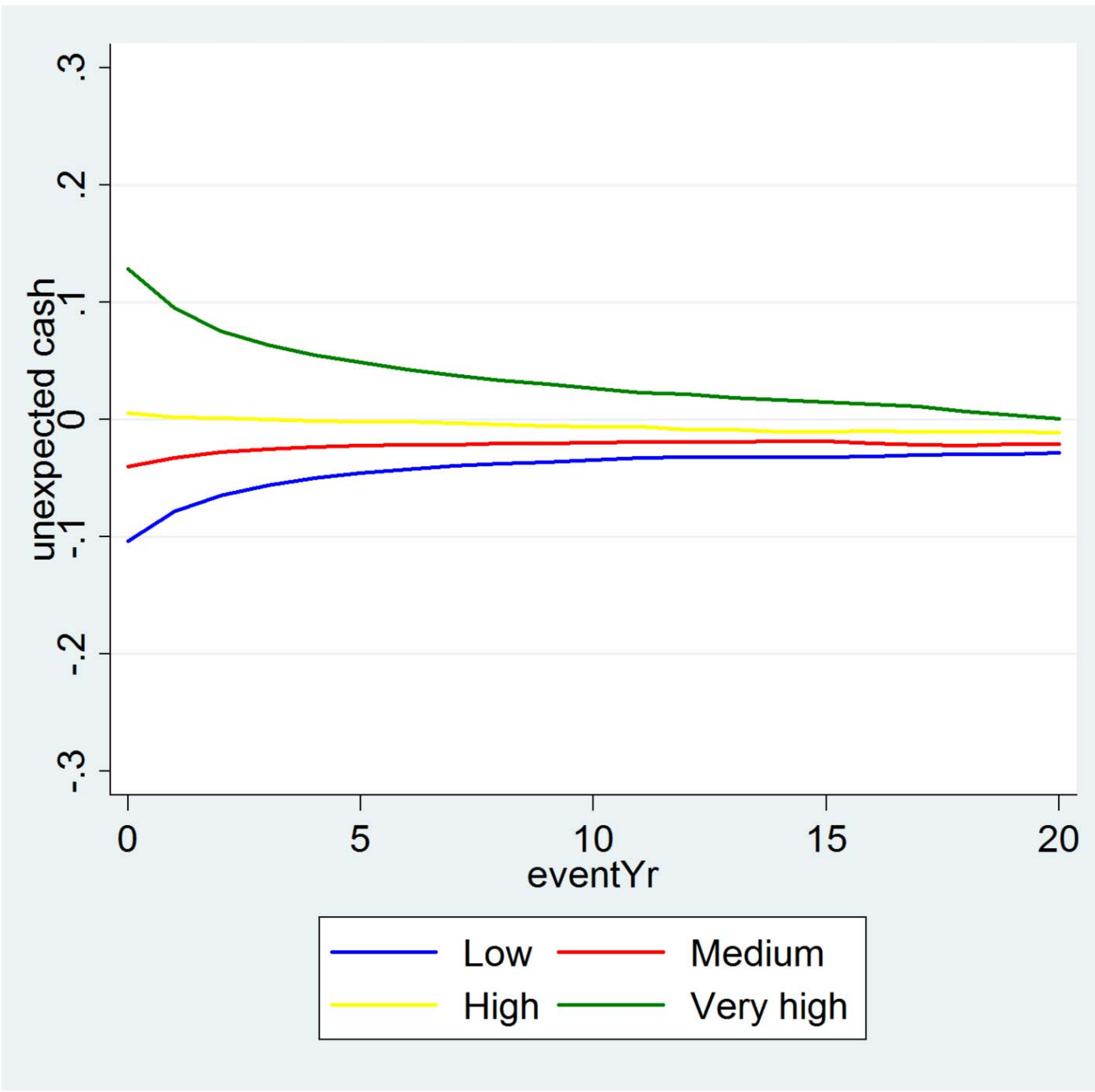

Figure 2

Average (detrended) stock repurchases of unexpected cash portfolios in event time

The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. The figure presents the average stock repurchases to assets ratio of four portfolios in event time, where year zero is the portfolio formation period. That is, for each calendar year, we form four portfolios by ranking firms based on their unexpected cash (defined below). Holding the portfolios fixed for the next twenty years we compute the average stock repurchases to assets ratio for each portfolio. For example, in 1965 we sort firms into four groups based on the unexpected cash ratios. For each year from 1965 to 1984, we compute the average stock repurchases to assets ratio for each of these four portfolios. We repeat this sorting in 1966 and averaging from 1976 to 1985 and so on for every year in our sample horizon. After performing this sorting and averaging for each year from 1965 to 2006, we then average the average stock repurchases to assets ratio across "event time" to obtain the lines in the figure. Unexpected cash is defined as the residuals from a cross-sectional regression of cash on the cross-sectional determinants of cash in Bates, Kahle, and Stulz (2009), which include lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix.

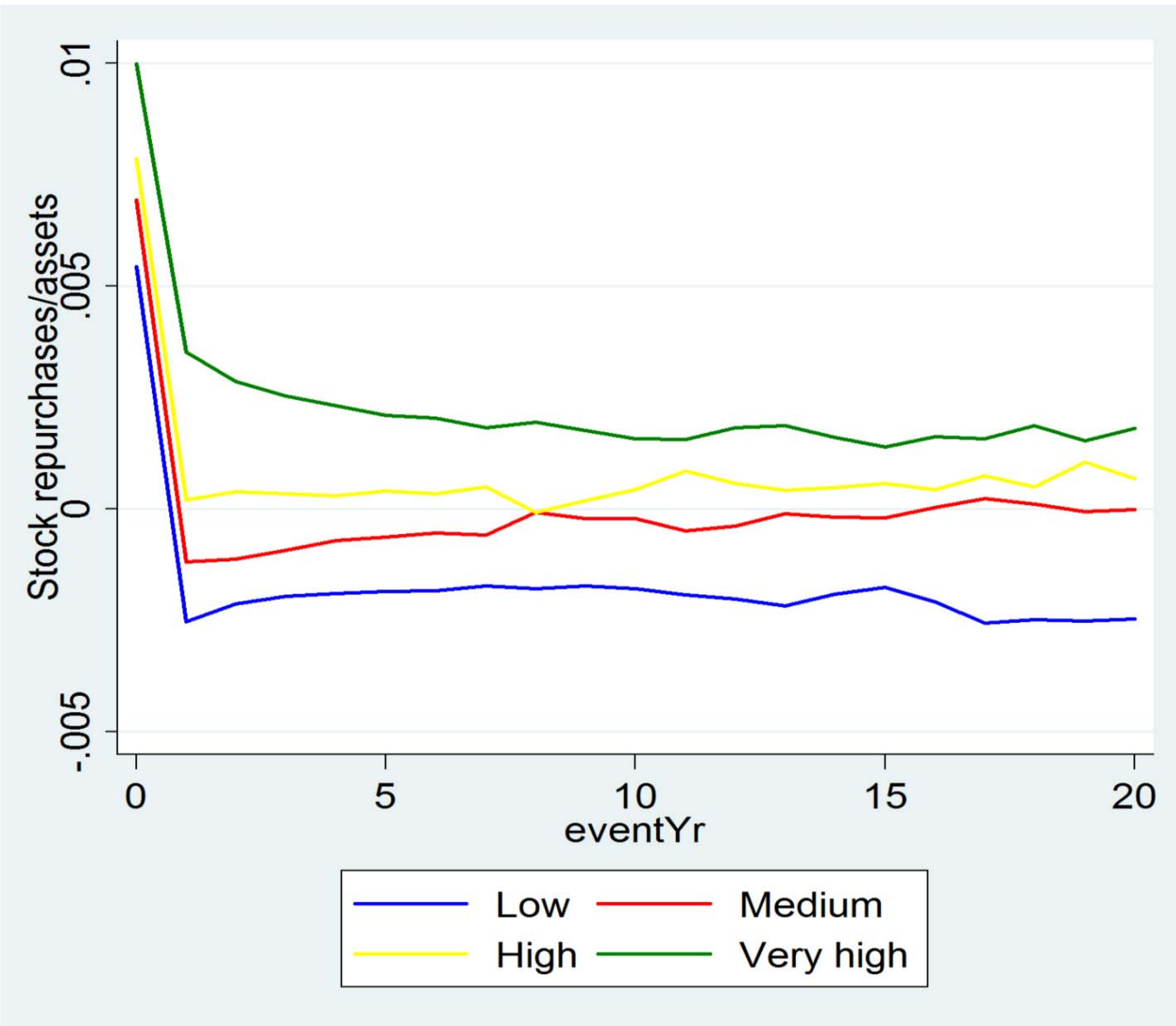

Figure 3

Cash and Inflows vs. Outflows (Based on the Statement of Cash Flow)

This figure presents mean statement-of-cash-flow estimates (as a percentage of book assets) for subsamples sorted on lagged cash ratios. Low cash (high cash) is an indicator that equals 1 if the company's lagged cash ratio is lower (higher) than the sample-wide previous years' median cash ratio. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more.

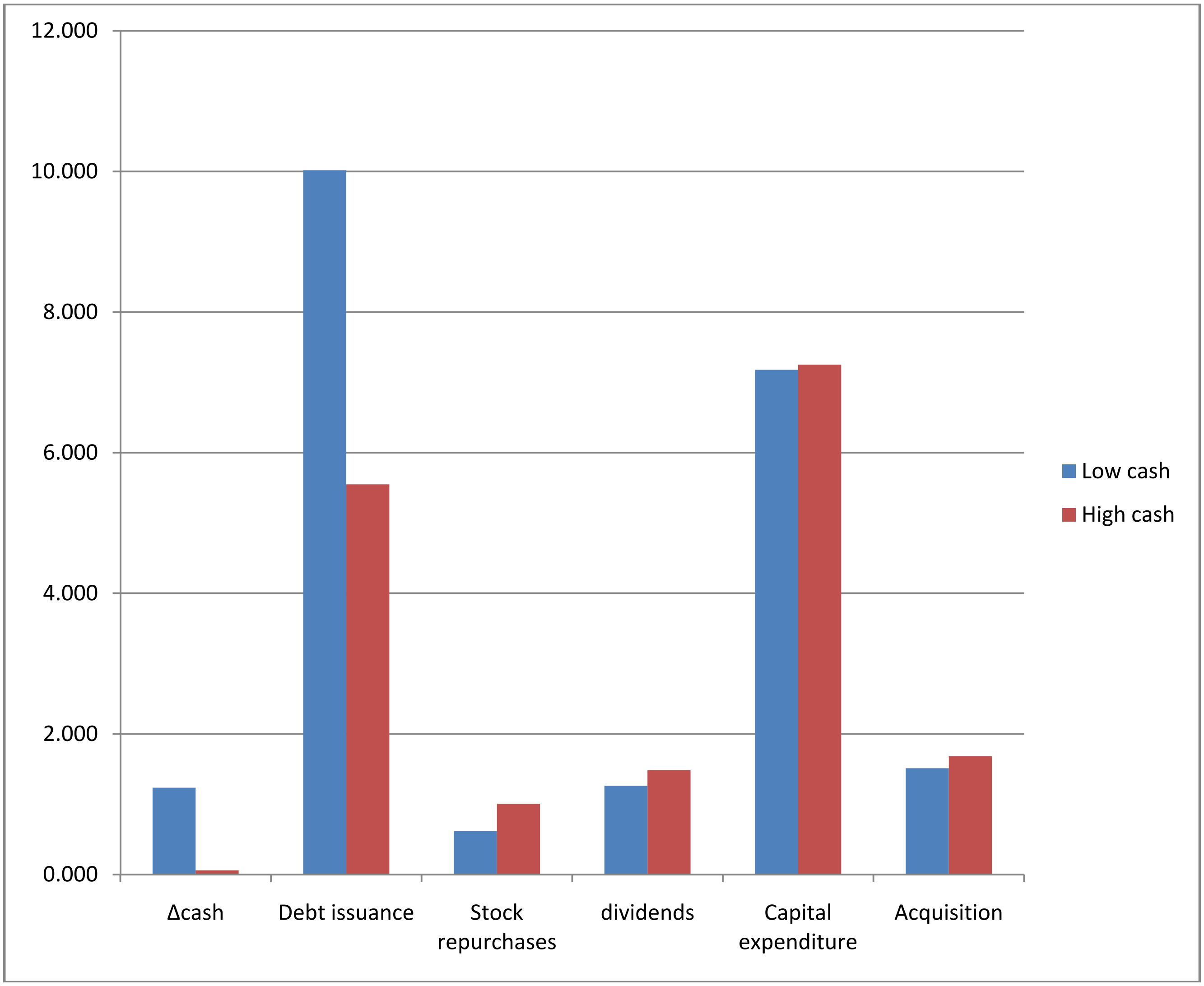

Figure 4

The Cross-Sectional Distribution of Firm-Level Speed of Adjustment (SOA) of Cash

This Figure presents a histogram of the cross-sectional distribution of firm-level SOA of cash. The SOA is estimated from the following target model estimated by firm:

$$\Delta cash_{i,t} = \alpha_0 + \alpha \cdot (cash^*{}_{it} - cash_{it-1}) + \varepsilon_{it}$$

where: $\Delta cash_{it} = cash_{it} - cash_{it-1}$, and the optimal cash is the predicted value from the empirical cash model in Bates, Kahle, and Stulz (2009), estimated over a rolling 5-year window [t-5,t-1], which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more.

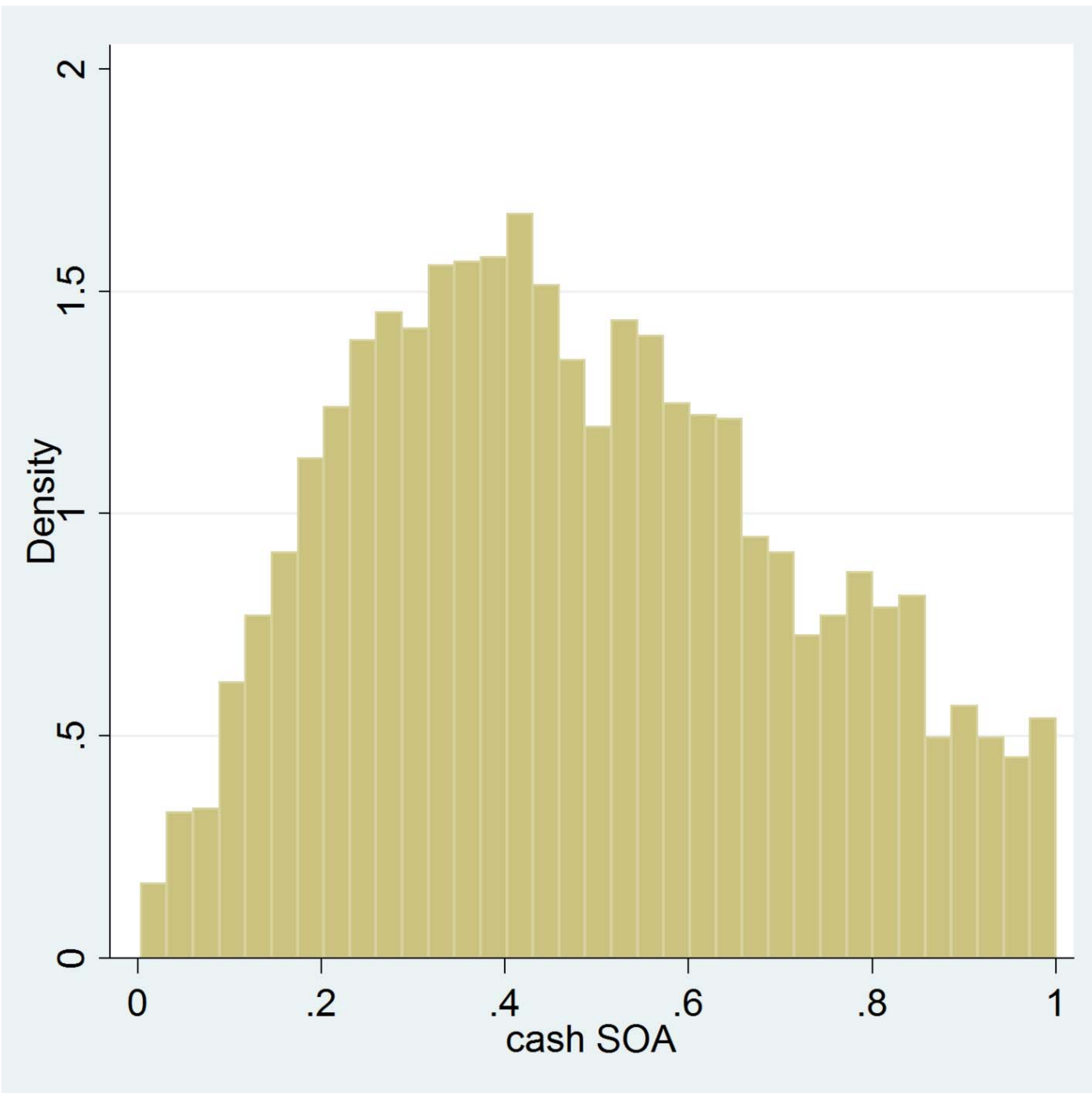

Table 1

Summary Statistics

This table presents summary statistics for the sample, which consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Cash flow is measured as earnings less interest and taxes, divided by total assets. CAPEX is capital expenditure divided by total assets. STDebt and LTDebt are short-term debt and long-term debt divided by total assets, respectively. Payout is defined as the sum of dividend payments and stock repurchases, divided by book assets. Size is the natural logarithm of the book value of total assets. NWC is net working capital excluding cash, divided by book assets. R&D is research and development expense, divided by total assets, where missing value are set to zero. Acquisitions is acquisition expense, divided by total assets. Net equity issues follows Baker and Wurgler (2002), and is defined as the difference between the change in book equity and the change in retained earnings. Net debt issues is defined as difference between the change in book assets and the change in book equity. Deficit is the difference between the change in book assets and the change in retained earnings. CF volatility is the industry-level volatility in cash flows over the past 10 years. ROA is net income divided by book assets. Q is Tobin's Q, computed as in Kaplan and Zingales (1997), i.e., measured as the book value of total assets minus book value of equity plus market value of equity divided by total assets. Outliers in Tobin’s Q are handled by bounding Q above at 10, following the alternative measure of Baker, Stein, and Wurgler (2003).

Variable	**Mean**	**Median**	**Std. Dev.**	**n_obs**
CF	0.080	0.090	0.104	105,921
CAPEX	0.072	0.055	0.065	106,091
STDebt	0.060	0.028	0.087	105,846
LTDebt	0.204	0.178	0.177	106,091
Payout	0.024	0.013	0.038	106,091
Size	5.692	5.466	1.798	106,091
NWC	0.146	0.140	0.187	102,556
R&D expenses	0.019	0.000	0.046	106,091
Acquisitions	0.014	0.000	0.046	106,091
Net debt issues	0.025	0.020	0.155	68,979
Net equity issues	0.029	0.006	0.105	68,180
CF volatility	0.049	0.043	0.027	106,091
ROA	0.135	0.138	0.107	105,526
Q	1.377	1.169	0.690	94,239

Table 2

Cash Measures

This table presents summary statistics for the various cash and cash-adjustment related measures. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Cash is cash plus short-term investments. Target cash is the predicted value from the empirical cash model in Bates, Kahle, and Stulz (2009), estimated over a rolling 5-year window [t-5,t-1], which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. Firm *i's* unexpected cash at year *t* is defined as the difference between its target cash and it actual cash ratio at year *t*. Absolute unexpected cash is the absolute value of unexpected cash. Active is an indicator variable that equals 1 if more than 50% of the change in unexpected cash from year *t-1* to year *t* is due to the change in cash, and 0 if 50% of the change or more is due to the change in target cash. Positive unexpected cash is an indicator variable that equals 1 if the firm had positive unexpected cash in year *t*, and 0 otherwise. Away from target is an indicator variable that equals 1 if the absolute distance between the firm's cash ratio and its target ratio was greater than the sample-wide median in year t, and 0 otherwise.

Panel A: Summary Statistics

	Mean	Median	Pooled Std. Dev.	Avg. Cross-sectional Std. Dev.	Min	Max	n_obs
Cash/book assets	0.104	0.055	0.133	0.125	0.000	0.846	106,091
Cash/net book assets	0.170	0.058	0.438	0.385	0.000	5.476	106,091
Cash/market value of assets	0.078	0.046	0.096	0.090	0.000	0.667	94,239
Cash ($millions)	105.739	9.635	338.991	286.804	0.000	2,304.000	106,091
Unexpected cash	-0.003	-0.018	0.105	0.101	-0.621	0.843	85,587
Absolute unexpected cash	0.073	0.052	0.075	0.071	0.000	0.843	85,587
Active	0.554	1.000	0.497	0.494	0.000	1.000	80,834
Positive unexpected cash	0.396	0.000	0.489	0.488	0.000	1.000	80,834

Panel B: Pair-wise Correlations

	Cash/book assets	Cash/net book assets	Cash/market value of assets	Cash ($millions)	Unexpected cash	Absolute unexpected cash	Active	Positive unexpected cash	Away from target
Cash/book assets	1.000								
Cash/net book assets	0.842	1.000							
Cash/market value of assets	0.789	0.590	1.000						
Cash ($millions)	0.164	0.090	0.094	1.000					
Unexpected cash	0.765	0.651	0.734	0.144	1.000				
Absolute unexpected cash	0.613	0.624	0.514	0.059	0.396	1.000			
Active	0.262	0.118	0.285	0.080	0.208	0.057	1.000		
Positive unexpected cash	0.518	0.333	0.527	0.132	0.708	0.158	0.199	1.000	
Away from target	0.242	0.199	0.205	-0.005	0.042	0.624	0.023	0.019	1.000

Table 3

Estimates of Speed of Adjustment (SOA) of Cash

This table presents estimates from different estimation procedures of the speed of adjustment (SOA) of cash for different measures of cash (defined in Table 2). The OLS procedure resembles the procedure to estimate target capital structure in Fama and French (2002) and Lemmon, Roberts, and Zender (2008), and is defined as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1 - \alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes lagged cash flow, cash flow volatility, Tobin's Q, capital expenditure, debt, dividend payout dummy, size, net working capital excluding cash, R&D expenditure, and acquisition expenditure.

The fixed-effects (FE) procedure resembles the procedure in Flannery and Rangan (2006), and is defined as follows:

$$Cash_{it} = a_0 + (1 - \alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \delta_i + \epsilon_{it}$$

The GMM procedure is similar to the model in Blundell and Bond (1998), implemented by Lemmon, Roberts, and Zender (2008).

The long differencing (LD) estimator is similar to the one proposed by Hahn, Hausman, and Kuersteiner (2007) and implemented by Huang and Ritter (2009) using 2SLS:

$$cash_{i,t} - cash_{i,t-7} = \alpha_0 + (1 - \alpha) \cdot (Cash_{it-1} - cash_{it-8}) + \varepsilon_{it}$$

The active adjustment estimator follows Faulkender et al. (2010) and re-estimates a modified version of the above regressions, where the lagged independent cash variables are scaled by the sum of lagged book assets and current net income (NI), i.e.,: $Cash^{p}_{it-1} = \frac{Cash_{it-1}}{Assets_{it-1}+NI_{it}}$.

In all cases, the table reports the SOA, given above by α. Significance levels for $1 - \alpha$ are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Measure	**Method**	**OLS**	**FE**	**GMM**	**LD**
Cash/book assets	SOA	0.220*** [0.004]	0.393*** [0.005]	0.353*** [0.012]	0.338*** [0.003]
	Observations	86,933	86,933	86,933	70,810
	R-squared	0.732	0.763		0.436
Cash/net book assets	SOA	0.246*** [0.012]	0.431*** [0.017]	0.429*** [0.029]	0.347*** [0.003]
	Observations	86,933	86,933	86,933	70,810
	R-squared	0.700	0.737		0.419
Cash/market value of assets	SOA	0.248*** [0.005]	0.418*** [0.007]	0.421*** [0.012]	0.356*** [0.003]
	Observations	86,527	86,527	86,527	59,851
	R-squared	0.605	0.648		0.408
Active cash/book assets	SOA	0.230*** [0.005]	0.440*** [0.007]	0.433*** [0.012]	0.355*** [0.003]
	Observations	86,844	86,844	86,844	70,632
	R-squared	0.687	0.740		0.371

Table 4

Active Rebalancing of Cash Ratios

This table presents estimates of the speed of adjustment (SOA) of cash for subsamples sorted on Active, which is an indicator that equals 1 if more than 50% of the change in unexpected cash from year *t-1* to year *t* is due to the change in cash, and 0 if 50% of the change or more is due to the change in target cash (Panel A), below- versus above-median investment, as measured by capital expenditures (panel B), and large net issues of debt and equity of more than 5% of book assets (panel C). The SOA is estimated as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1 - \alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. Target cash is the predicted value from the empirical model in Bates, Kahle, and Stulz (2009), estimated over a rolling 5-year window [t-5,t-1], and unexpected cash is the difference between the firm's actual cash and its implied target cash ratio. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A: SOA & Active Adjustment

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Passive	Active	Passive	Active	Passive	Active
SOA	0.042*** [0.002]	0.361*** [0.005]	0.017*** [0.002]	0.395*** [0.015]	0.047*** [0.002]	0.417*** [0.006]
R-squared	0.966	0.681	0.979	0.618	0.946	0.566
N obs	36,058	44,776	47,242	33,592	33,600	47,234

Panel B: Investment

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Low	High	Low	High	Low	High
SOA	0.228*** [0.005]	0.314*** [0.005]	0.214*** [0.014]	0.401*** [0.019]	0.286*** [0.007]	0.359*** [0.007]
R-squared	0.779	0.719	0.724	0.677	0.658	0.602
N obs	43,952	44,933	43,952	44,933	42,839	43,649

Panel C: Large Net Debt and Equity Issues (> 5% of Firm Assets)

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	No	Yes	No	Yes	No	Yes
SOA	0.196*** [0.005]	0.328*** [0.007]	0.203*** [0.015]	0.310*** [0.019]	0.234*** [0.006]	0.441*** [0.010]
R-squared	0.796	0.737	0.734	0.690	0.708	0.548
N obs	34,608	26,484	34,608	26,484	34,230	25,713

Table 5

Adjustment Costs

This table presents estimates of the speed of adjustment (SOA) of cash for subsamples sorted on negative versus positive unexpected cash (Panel A), small versus large distance from the target (Panel B), and whether or not the firm has access to a bank line of credit (Panel C). The SOA is estimated as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1-\alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. Target cash is the predicted value from the empirical model in Bates, Kahle, and Stulz (2009), estimated over a rolling 5-year window [t-5,t-1], and unexpected cash is the difference between the firm's actual cash and its implied target cash ratio. Positive unexpected cash is an indicator variable that equals 1 if the firm had positive unexpected cash in year *t*, and 0 otherwise. Distance from the target is the absolute value of unexpected cash. Bank line of credit is an indicator variable that equals 1 if the company has access to a revolving credit facility based on the DealScan database, and 0 otherwise. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A: SOA & Positive Unexpected Cash

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Negative xcash	Positive xcash	Negative xcash	Positive xcash	Negative xcash	Positive xcash
SOA	0.179***	0.208***	0.005***	0.263***	0.173***	0.271***
	[0.011]	[0.009]	[0.034]	[0.020]	[0.011]	[0.011]
R-squared	0.469	0.758	0.400	0.753	0.310	0.598
N obs	46,314	30,503	46,379	30,438	47,143	29,299

Panel B: SOA & Distance from Target

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Distance < median	Distance > median	Distance < median	Distance > median	Distance < median	Distance > median
SOA	0.184***	0.221***	0.000***	0.251***	0.215***	0.250***
	[0.009]	[0.004]	[0.070]	[0.012]	[0.012]	[0.006]
R-squared	0.572	0.763	0.428	0.721	0.434	0.644
N obs	40,835	40,627	40,835	40,627	40,663	40,402

Panel C: SOA & Lines of Credit

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
			Bank Line of Credit?			
	No	Yes	No	Yes	No	Yes
SOA	0.255***	0.319***	0.250***	0.466***	0.304***	0.385***
	[0.004]	[0.024]	[0.012]	[0.133]	[0.005]	[0.031]
R-squared	0.760	0.639	0.709	0.502	0.645	0.529
N obs	84,254	4,631	84,254	4,631	81,914	4,574

Table 6

The Speed of Adjustment and Free Cash Flow

This table presents estimates of the speed of adjustment (SOA) of cash for subsamples sorted on free cash flow (FCF). The low (high) FCF bin consists of the bottom (top) 15% of firms in terms of FCF, while the medium bin consist of the remaining 70%. The SOA is estimated as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1-\alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A: Cash/ book assets

	Free Cash Flow		
	Low	Medium	High
SOA	0.270*** [0.009]	0.191*** [0.005]	0.231*** [0.011]
R-squared	0.766	0.721	0.692
N obs	12,744	60,245	12,716

Panel B: Cash/net book assets

	Free Cash Flow		
	Low	Medium	High
SOA	0.283*** [0.017]	0.213*** [0.020]	0.277*** [0.042]
R-squared	0.733	0.643	0.658
N obs	12,744	60,245	12,716

Panel C: Cash/market value of assets

	Free Cash Flow		
	Low	Medium	High
SOA	0.306*** [0.012]	0.217*** [0.006]	0.321*** [0.019]
R-squared	0.566	0.639	0.481
N obs	12,695	59,982	12,659

Table 7

The Speed of Adjustment and Corporate Governance

This table presents estimates of the speed of adjustment (SOA) of cash for subsamples sorted on various measures of corporate governance. The SOA is estimated as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1-\alpha)\cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix. In panel A, corporate governance is measured by the Gompers, Ishii, and Metrick (2003) corporate governance index, which measures the number of antitakeover provisions in a firm’s charter and in the legal code of the state in which the firm is incorporated. In panel B, governance is measured by the percentage of shares held by institutional investors, whereas in Panel C it is measured by the sum of all ownership positions greater than 5% held by institutional investors. For each of these measures, we divide the sample around the median, and code the corresponding halves as poor governance and good governance. The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A:GIM Index

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Poor	Good	Poor	Good	Poor	Good
SOA	0.202*** [0.009]	0.240*** [0.013]	0.244*** [0.031]	0.217*** [0.026]	0.273*** [0.015]	0.293*** [0.022]
R-squared	0.838	0.783	0.728	0.753	0.713	0.674
N obs	8,616	7,187	8,616	7,187	8,609	7,179

Panel B:% Shares Owned by Institutional Investors

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Poor	Good	Poor	Good	Poor	Good
SOA	0.230*** [0.006]	0.278*** [0.005]	0.250*** [0.018]	0.258*** [0.016]	0.298*** [0.009]	0.310*** [0.006]
R-squared	0.803	0.719	0.728	0.683	0.686	0.620
N obs	26,968	61,917	26,968	61,917	26,647	59,841

Panel C: Block Holders (5% or More of Shares)

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Poor	Good	Poor	Good	Poor	Good
SOA	0.230*** [0.006]	0.281*** [0.005]	0.253*** [0.017]	0.256*** [0.017]	0.297*** [0.008]	0.311*** [0.006]
R-squared	0.805	0.713	0.729	0.678	0.686	0.618
N obs	28,126	60,759	28,126	60,759	27,803	58,685

Table 8

The Speed of Adjustment of Cash and Debt

This table compares estimates of the speed of adjustment (SOA) of cash and debt. The SOA of cash is estimated as follows (*i* denotes firm *i* and *t* denotes year *t*):

$$Cash_{it} = a_0 + (1-\alpha) \cdot Cash_{it-1} + \beta \cdot X_{it-1} + \epsilon_{it}$$

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009 which includes lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions. Variable definitions are provided in the Appendix.

The SOA of debt is estimated using the empirical model of debt in Byoun (2008) as follows:

$$debt_{it} = \beta_0 + \beta_1 Industry\_median\_debt_{it} + \beta_2 Tax_{it} + \beta_3 Q_{it} + \beta_4 Operating\_Income_{it} + \beta_5 Depriciation\_Amortization_{it} + \beta_6 Div_{it} + \beta_7 Size_{it} + \beta_8 Fixed\_Assets_{it} + \beta_9 RD_{it} + \beta_{10} Altman's\_Z\_Score_{it} + \varepsilon_{it}$$

The sample consists of all industrial firms in Compustat's annual files from 1965 to 2006, with non-missing observations on cash for 15 years or more. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

	Cash/ book assets		Cash/net book assets		Cash/market value of assets	
	Low debt SOA	High debt SOA	Low debt SOA	High debt SOA	Low debt SOA	High debt SOA
Cash SOA	0.258*** [0.005]	0.254*** [0.005]	0.245*** [0.018]	0.256*** [0.016]	0.301*** [0.007]	0.306*** [0.007]
R-squared	0.745	0.767	0.699	0.712	0.643	0.644
N obs	44,834	44,046	44,834	44,046	43,783	42,703

Table 9
Simulation

This table presents estimates from panel regressions explaining firm-level annual cash holdings. In both panels, Column 1 reports regression results for Compustat annual data from 1965 to 2006. Columns 2-4 report regression results for simulated cash paths corresponding to the empirical universe of Compustat firms, where cash flows and capital expenditures are randomly generated to match the joint empirical distribution of cash flows and capital expenditures observed in the data. At time 0, firms are endowed with cash holdings equal to 15% book assets. In each subsequent period, cash holdings change according to the difference between cash flows and capital expenditures that arrive in that period, unless the cash ratio reaches the lower or upper bound, in which case it is rebalanced to the target ratio of 15%, taking into account the expected cash flows and capital expenditures in the next period. We repeat this procedure for each firm in our sample, allowing for different degrees of speed of cash adjustment, as implied by the adjustment bounds. In Panel A, adjustment bounds are symmetric around the target, whereas in Panel B they are skewed to reflect our finding that adjustment costs are lower above the target. Specifically, in Panel A the bounds are as follows: 1) Low adjustment costs - Cash interval of [14%, 16%], 2) Medium adjustment costs - Cash interval of [10%, 20%], 3) High adjustment costs - Cash interval of [5%, 25%]. In Panel B, the interval above the 15% target is cut by half, representing faster adjustment above the target. The implied speed of adjustment (SOA) is given at the bottom of each column. All regressions include year fixed effects. Standard errors (in brackets) are heteroskedasticity consistent and clustered at the firm level. Significance levels are indicated: * = 10%, ** = 5%, *** = 1%.

Panel A: Symmetric adjustment bounds

	Real Data	Simulated Data		
		Low Adjustment Costs	Medium Adjustment Costs	High Adjustment Costs
Cash flow volatility	2.217*** [0.105]	0.006*** [0.001]	0.053*** [0.011]	0.113*** [0.029]
CAPEX volatility	-0.468*** [0.092]	-0.003*** [0.001]	-0.343*** [0.021]	-0.958*** [0.055]
R-squared	0.114	0.999	0.894	0.72
N Obs	104,364	155,918	155,918	155,918
Implied SOA	0.153	0.871	0.588	0.447

Panel B: Skewed adjustment bounds

	Real Data	Simulated Data		
		Low Adjustment Costs	Medium Adjustment Costs	High Adjustment Costs
Cash flow volatility	2.217*** [0.105]	0.010*** [0.001]	0.042*** [0.007]	0.051*** [0.020]
CAPEX volatility	-0.468*** [0.092]	-0.006*** [0.001]	-0.199*** [0.014]	-0.664*** [0.037]
R-squared	0.114	0.998	0.939	0.805
N Obs	104,364	155,918	155,918	155,918
Implied SOA	0.153	0.918	0.611	0.512