CEO Overconfidence and the Speed of Adjustment of Cash Holdings

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Abstract

We examine the link between CEO overconfidence and speed of adjustment (SOA) of cash holdings for listed US firms. We find a negative effect of overconfident CEOs on the SOA. Further, CEO overconfidence increases the asymmetry in the SOA between firms with excess cash and those with a cash deficit: The SOA is faster (slower) when there is excess cash (deficit). Importantly, we find that the SOA is value-relevant above and beyond cash holding levels. We address endogeneity concerns through difference-in-differences and propensity score matching specifications. Our results are robust to alternative measures of overconfidence, estimation methods, and corporate governance quality.

Keywords: cash holdings, speed of adjustment, CEO overconfidence, corporate governance, financial constraints, leverage

JEL Classifications: G32, G34

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Abstract

We examine the link between CEO overconfidence and speed of adjustment (SOA) of cash holdings for listed US firms. We find a negative effect of overconfident CEOs on the SOA. Further, CEO overconfidence increases the asymmetry in the SOA between firms with excess cash and those with a cash deficit: The SOA is faster (slower) when there is excess cash (deficit). Importantly, we find that the SOA is value-relevant above and beyond cash holding levels. We address endogeneity concerns through difference-in-differences and propensity score matching specifications. Our results are robust to alternative measures of overconfidence, estimation methods, and corporate governance quality.

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I. Introduction

This paper investigates the cash holdings behavior of firms across time in the presence of CEO cognitive biases, namely overconfidence. More specifically, it focuses on how CEO overconfidence affects the speed of adjustment for a sample of non-financial listed US firms during the period between 1992 and 2017. While extant literature has studied the effects of overconfident CEOs on cash holdings levels and values, it has neglected the effects of such CEOs on the speed of adjustment. Studying the speed of adjustment of cash holdings is important: A high speed of adjustment implies that managers deem deviations of cash holdings from the target level to be costly and revert quickly to the target level. Conversely, a slow speed suggests that the costs of adjusting toward the target level are high (Jiang and Lie, 2016).[1] Given the existence of these adjustment costs, Graham and Leary (2018) call for further empirical research on these dynamics. Our paper attempts to answer their call.

We study whether CEO overconfidence and the speed of adjustment of cash holdings are value relevant. We find evidence that both are value relevant. While the value relevance of CEO overconfidence confirms Aktas et al. (2019), the finding that the speed of adjustment is value relevant is novel. Put together, our results suggest that firms with a high speed of adjustment and a non-overconfident CEO have the highest value whereas firms with a low speed of adjustment and an overconfident CEO have the lowest value.

As capital market imperfections create an association between the cash holdings level and firm value (Gao et al., 2013), there exists an optimal cash holdings level, which maximizes firm value. Importantly, cross-sectional studies assume that firms operate close to their optimal levels, and hence, the observed cash holdings level for a firm at any time should not be significantly different from its optimal level (Foley et al., 2007; Bates et al., 2009). In other words, these studies assume that when firms deviate from their optimal level or the

[1] Further, Chang et al. (2017) argue that the speed of adjustment depends on the level and direction of the deviation from the optimal cash holdings level.

optimal level changes, they move to their optimal level virtually instantaneously. However, there may be several factors that reduce the speed at which firms move toward their optimal cash holdings levels (Dittmar and Duchin, 2010). Such factors include capital market frictions (Bates et al., 2018). Additional factors reducing the speed of adjustment include external factors, such as macroeconomic shocks, as well as internal ones including financial constraints and agency conflicts (Gao et al., 2013). More specifically, in the presence of financial constraints, firms with greater information asymmetry about their investment opportunities may hoard more cash and deviate significantly from their optimal cash holdings level (Harford, 1999; Opler et al., 1999; Byoun, 2008; Faulkender et al., 2012). Agency conflicts are another internal factor explaining differences in the speed of adjustment toward the optimal cash holdings level across firms: The speed of adjustment is likely to be slower for firms suffering from such problems. Indeed, Jiang and Lie (2016) find that entrenched managers go hand in hand with a slower speed of adjustment of cash holdings.[2]

While the above studies assume that CEOs are rational, a growing body of literature acknowledges that managerial behavioral biases affect corporate decisions such as decisions about investments (Malmendier and Tate, 2005), financing (Malmendier et al., 2011), mergers and acquisitions (Malmendier and Tate, 2008), and R&D and innovation (Hirshleifer et al., 2012), as well as cash holdings (Chen et al., 2020). Managerial overconfidence should be highly relevant in this context as it might bias the CEO's perceptions about the optimal cash level and the adjustment costs, as well as liquidity, the cost of borrowing, and credit risk. To the best of our knowledge, this is the first study to examine whether overconfident CEOs affect the speed of adjustment of cash holdings.

[2] Nikolov and Whited (2014) find that agency problems, on average, lead to cash holdings above the optimal level, resulting in lower firm value. Similarly, the CEO's desire for a quiet life leads to a higher than optimal level of cash (Bertrand and Mullainathan, 2003). Moreover, Jiang and Lie (2016) find that entrenched managers keep cash holdings at a higher than optimal level.

Based on our review of the literature, we derive the following two testable hypotheses. According to the trade-off theory, firms have an optimal cash holdings level, which is determined by the trade-off between the costs and benefits of holding cash (Opler et al., 1999). Nevertheless, when the CEO is overconfident, what the CEO considers to be the optimal cash holdings level may differ from what investors perceive it to be. More precisely, the CEO's *perceived* optimal level may reflect the CEO's expectations about the cost of future external financing (Deshmukh et al., 2018). CEO overconfidence may thus have two diametrically opposed effects on the level of cash holdings. On the one hand, overconfident CEOs may perceive the cost of future external financing to be relatively expensive. Hence, they hold *higher* levels of cash compared to other CEOs to finance future investments. On the other hand, overconfident CEOs may perceive their firm's equity to be underpriced and hence expect the cost of future external financing to decline. As a result, they hold *lower* levels of cash now as they rely more heavily on internal cash to finance current investments and delay raising external financing. To sum up, whatever the effect of overconfident CEOs on the level of cash holdings, such CEOs tend to slow down the speed of adjustment toward what the market considers to be the optimal cash level. This is our first testable hypothesis.

Apart from CEO overconfidence, the speed of adjustment toward the optimal cash level may also depend on whether the firm has a surplus of cash or a cash deficit (Jiang and Lie, 2016; Chang et al., 2017; Guariglia and Yang, 2018). When the firm has excess cash, the overconfident CEO is willing to invest more (Aktas et al., 2019). We would then expect the excess cash to disappear rapidly. Hence, according to our second hypothesis, an overconfident CEO accelerates the speed of adjustment toward the firm's optimal cash level when there is excess cash.

Our findings support the validity of the above two hypotheses. First, we find that the speed of adjustment is slower for firms with overconfident CEOs. It takes about seven months longer for firms with such CEOs to adjust their cash holdings level relative to the remaining firms. Second, we find that if the actual cash holdings level exceeds its optimal level, i.e., there is a cash surplus, firms with overconfident managers have a greater adjustment speed.

In order to overcome potential endogeneity issues, we proceed as follows. First, we deal with reverse causality by using the 2012 US-Korea Free Trade Agreement (KORUS FTA) as a source of exogenous variation in firms' competitive environment. Difference-in-differences estimations support the causal impact of CEO overconfidence on the speed of adjustment of cash holdings. Second, we use propensity score matching to overcome potential unobserved heterogeneity. We match firm-year observations with overconfident CEOs with firm-year observations with similar characteristics but without overconfident CEOs. The results from these two analyses confirm our main findings.

In further analyses, we investigate whether financial constraints as well as differences in debt levels and credit risk affect the relationship between CEO overconfidence and the speed of adjustment of cash holdings. We find the impact of CEO overconfidence on the speed of adjustment to be more pronounced for financially constrained firms. When we divide our sample into three sub-samples according to the level of debt, namely zero-debt, low-debt, and high-debt levels, we find that a high level of debt leads to a higher speed of adjustment of cash holdings. In contrast, we find that the presence of CEO overconfidence decreases the speed of adjustment of cash holdings. Further, we also control for differences in credit risk as we expect overconfident CEOs to underestimate their firm's credit risk and therefore spend too much of the cash. In line with our expectations, we find that overconfident CEOs increase the speed of adjustment of cash in the presence of both high credit risk and high debt.

Finally, we conduct several robustness tests to check the validity of our results. First, we re-run our main analysis using two alternative measures of CEO overconfidence. Second, we control for the quality of corporate governance. Third, we re-estimate the optimal cash holdings level for each firm using alternative estimation methods. All these robustness tests confirm our main findings.

Our paper provides strong evidence that managerial overconfidence reduces the speed of adjustment of cash holdings. By doing so, our paper contributes to at least two streams of literature. First, it contributes to the literature that investigates the speed of adjustment toward the optimal cash holdings level. Although several factors have been identified to impact the speed of adjustment of cash holdings, our finding that CEO overconfidence reduces this speed is novel. Importantly, our paper suggests that the speed of adjustment is value relevant. Again, our results suggest that firms with a high speed of adjustment and a non-overconfident CEO have the highest firm value whereas firms with a low speed of adjustment and an overconfident CEO have the lowest firm value.

Second, our paper adds to the behavioral finance literature. A growing body of this literature examines the effects of managerial behavioral biases, such as overconfidence, on corporate policies (Malmendier and Tate, 2005, 2008; Hirshleifer et al., 2012). In particular, we complement two recent studies on the effects of CEO overconfidence on the level (Chen et al., 2020) and value (Aktas et al., 2019) of cash holdings, by analyzing the impact of CEO overconfidence on the speed of adjustment of cash holdings. While both studies test the impact of managerial overconfidence on cash holdings levels and value from a static perspective, we focus on the speed at which firms close the gap between their actual and optimal cash ratios, in the presence of overconfident CEOs. Again, we find that the speed matters above and beyond the cash holdings levels.

The paper proceeds as follows. Section II reviews the literature and Section III develops the hypotheses. Section IV discusses the data sources, the sample construction, and the methodology. It is followed by Section V on the summary statistics and the empirical findings. Section VI performs the identification tests. Section VII conducts the additional analyses while Section VIII contains several robustness checks. Section IX concludes the paper.

II. Literature Review

A. The Speed of Adjustment of Cash Holdings

Research on the determinants of cash holdings has focused on the cross-sectional dispersion of cash holdings (e.g., Opler et al., 1999; Kim et al., 1998). More recently, there has been criticism of the static nature of studies on the determinants of cash holdings as such studies tend to ignore investment and financing frictions, which affect the speed of adjustment toward the optimal cash holdings level. Therefore, various researchers have proposed the use of dynamic models of cash holdings, such as partial adjustment models, which allow for the possibility that firms adjust their cash holdings levels gradually over time (e.g., Ozkan and Ozkan, 2004; Flannery and Rangan, 2006; Jiang and Lie, 2016). These models are based on the trade-off theory, which predicts that firms have a target level of cash and move instantaneously toward this target level unless there are prohibitive adjustment costs.

A related literature, i.e., the literature on the speed of adjustment of leverage,[3] has identified several costs that affect the speed of adjustment of leverage toward its target level. These include the issuance cost (Altinkilic and Hansen, 2000), the cost of equity (Zhou et al., 2016), equity overvaluation (Flannery and Rangan, 2006; Warr et al., 2012), the availability of credit lines (Lockhart, 2014), the existence of debt covenants (Devos et al., 2017), and managerial traits (Lin et al., 2018).

Unlike the large body of literature investigating the speed of adjustment of leverage, the equivalent literature on cash holdings is still limited. For example, Opler et al. (1999) find

[3] See e.g., Leary and Roberts (2005), Korajczyk and Levy (2003), Huang and Ritter (2009), and DeAngelo and Roll (2015).

evidence in line with the trade-off theory. They report that when a firm's cash holdings level deviates from what is optimal, the speed of adjustment amounts to 26% of the deviation from the optimal level each year. Dittmar and Duchin (2010) also find that firms actively adjust their cash holdings toward the target ratio. Nevertheless, they conclude that this adjustment is not immediate due to the presence of adjustment costs, with the speed of adjustment ranging from 22% to 43% depending on the estimation method they use. They also find that the speed of adjustment is affected by the firm's age and governance mechanisms. In turn, Jiang and Lie (2016) report a speed of adjustment of 31%. Furthermore, they also study the factors affecting the speed of adjustment. Their focus is on managerial self-interest and entrenchment, measured by the introduction of the Business Combination laws, which is used as an exogenous entrenchment shock. They find that self-interested managers are less willing to distribute excess cash in a timely manner, hence reducing the speed of adjustment of cash holdings. Finally, a recent study by Bates et al. (2018) highlights that market frictions play a role in slowing down the speed at which firms adjust their cash holdings.[4]

B. CEO Overconfidence

A growing body of literature attempts to explain the effects of managerial traits, including managerial overconfidence, on cash holdings decisions (Hirshleifer et al., 2012; Deshmukh et al., 2018; El Kalak and Tosun, 2019). For example, Cho et al. (2018) show that managerial ability, i.e., greater efficiency in generating revenues, plays a role in the speed of adjustment of cash holdings for Korean firms. They find that when cash exceeds its target level, managers with greater ability are more likely to dissipate excess cash compared to managers with less ability.

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[4] Relatedly, Chang et al. (2017) show that firms have an optimal range of cash holdings rather than an optimal level, within which they are likely to move. In turn, when firms exit this target zone the speed of adjustment accelerates.

Overconfidence is a form of self-attribution bias (Doukas and Petmezas, 2007) that leads overconfident managers to believe that they have superior decision-making skills. Managerial overconfidence has been the subject of detailed observation and analysis. For example, Deshmukh et al. (2018) find that firms with overconfident CEOs hold, on average, 24 percentage points less cash than the remaining firms. Heaton (2002) proposes a pecking order of sources of finance for overconfident managers. He argues that since overconfident managers overestimate their firm's future cash flows, they tend to prefer internal to external financing, especially equity. This is due to their perception that their firm's stock is undervalued by the market. Malmendier et al. (2011) provide support for the above argument as they find that overconfident managers issue less equity than their peers. Hence, overconfident managers may underinvest if their firm's internal funds are scarce or the access to debt is limited. Finally, Aktas et al. (2019) find further confirmation of this argument. They show that overconfident CEOs increase the value of a $1.00 cash holding by $0.28. This suggests that additional cash mitigates the underinvestment problem that overconfident CEOs suffer from.

III. Hypothesis Development

A. CEO Overconfidence and the Speed of Adjustment of Cash Holdings

The speed of adjustment toward the target cash level should be fast, if there is an identical set of beliefs between managers and investors. In this case, both managers and investors agree about what constitutes the optimal cash holdings level. However, if the sets of beliefs differ (e.g., due to CEO overconfidence), the CEO may have a different view on what constitutes the optimal cash holdings level, reflecting their expectations about the cost of future external financing (Deshmukh et al., 2018). In this case, the speed of adjustment would be slow.

The above discussion leads to two competing views: The first view is that overconfident CEOs perceive the cost of future external financing to be relatively expensive. Hence, they hold higher levels of cash compared to other CEOs. According to the second view, overconfident CEOs hold lower levels of cash, since they perceive their firm's equity to be underpriced and therefore expect the cost of future external financing to decline. Hence, they delay raising external financing and rely more heavily on internal cash. According to both views, overconfident CEOs affect the speed at which their firm adjusts its cash holdings: Their presence tends to slow down the speed of adjustment toward the target.

H1. *CEO overconfidence is negatively associated with the speed of adjustment toward the target cash holdings ratio*.

B. CEO Overconfidence and Firms with Excess Cash or a Cash Deficit

One expects variation in the speed of adjustment among firms with overconfident CEOs, depending on whether the firm is above or below its optimal cash level. In detail, according to the pecking order theory, asymmetric information and the resulting adverse selection costs are the main determinants of firms' financing decisions (Myers and Majluf, 1984). These costs are associated with a higher preference for internal financing, including cash. The adjustment speed of cash holdings should then be faster if the actual cash level is above the optimal level as it is cheaper and quicker to use cash than to generate it (Jiang and Lie, 2016; Chang et al., 2017; Guariglia and Yang, 2018). In particular, when the firm has excess cash overconfident CEOs are willing to invest more (Aktas et al., 2019). This argument is supported by Malmendier and Tate (2005) who report greater capital expenditures and merger and acquisition activity for overconfident CEOs of cash-rich firms.[5] Therefore, we expect that overconfident managers increase their cash spending, thereby accelerating the

[5] See also Opler et al. (1999) who find that managers tend to hold higher levels of cash if they are risk-averse or if they pursue personal objectives.

speed of adjustment toward the firm's optimal cash level, when the firm has excess cash. Based on these arguments, we hypothesize the following:

H2. *CEO overconfidence is positively associated with the speed of adjustment when the cash holdings are above their optimal level.*

IV. Data and Methodology

A. Sample Selection

Our initial sample of firms is drawn from Compustat and is based on all US firms listed on AMEX, NYSE, and NASDAQ with available data for the period from 1992 (ExecuComp's first year with available data) to 2017. To avoid any survivorship bias we include both active and inactive firms. We eliminate observations for financial firms (SIC codes 6000-6999) and regulated utilities (SIC codes 4900-4999). Further, we restrict our sample to firms with their headquarters located in the USA. We exclude firms with total assets of less than 10 million in the year 2000 US dollars. Finally, all non-binary variables are winsorized at the 1^{st} and 99^{th} percentiles to reduce the potential effects of outliers.

The ExecuComp database is used to construct the measure of managerial overconfidence. To construct this measure we use the Campbell et al. (2011) modified version of the Malmendier and Tate (2005) measure. Hence, we limit our sample to firms with available CEO option data.

B. CEO Overconfidence Measure

A large part of the CEO compensation package is in the form of stocks and options. In addition, CEOs have their human capital invested in the firm (Deshmukh et al., 2018). Putting the two together, individual CEOs are heavily exposed to the idiosyncratic risk of their firm because of their under-diversification. Further, they are prohibited from trading their options or hedging their exposure until a particular date. Therefore, it is expected that CEOs will exercise their options early if they are rational utility maximizers (Hall and Murphy, 2002). However, overconfident CEOs consistently perceive their firm's stock to be undervalued and hence delay the exercise of their options even when the latter are deeply in the money. Based on this argument, Malmendier and Tate (2005) define overconfident CEOs as those CEOs that hold exercisable options that are deep in the money.

The dataset used by Malmendier and Tate (2005) to construct their CEO option-based measure is a comprehensive, proprietary dataset. Yet, ExecuComp does not provide detailed data on the option holdings of CEOs. Hence, we use the modified version of Malmendier and Tate (2005), following the methodology of Campbell et al. (2011). First, we calculate the realizable value per option as the ratio of the total realizable value of the exercisable options to the number of exercisable options. Second, we subtract the fiscal-year-end stock price from the realizable value per option to obtain an estimate of the average exercise price of the options. Third, to compute the average percentage moneyness of the options, we divide the realizable value per option by the estimated average exercise price. Finally, we classify CEOs as overconfident CEOs and rational ones according to an option moneyness threshold. Malmendier and Tate (2005) classify CEOs as being overconfident if they hold exercisable stock options that are at least 67% in the money during the sample period. The choice of the 67% threshold comes from calibrating the Hall and Murphy (2002) model using a detailed dataset on CEOs' stock options holding and exercise decisions. In contrast, Campbell et al. (2011) define CEOs as being overconfident if the threshold exceeds 100% at least twice during the sample period. Unlike Campbell et al. (2011), we assume that overconfidence is a persistent characteristic and hence, we classify the CEO as overconfident if the CEO option moneyness exceeds 67% at least once during the sample period, which is in line with

Hirshleifer et al. (2012).[6] Nevertheless, we revisit the assumption of persistency of overconfidence in Section VIII with the robustness tests.

C. Partial Adjustment Model

The estimation of the speed of adjustment of cash ratios is similar to the partial adjustment methodology used in the capital structure literature (e.g., Byoun, 2008; Warr et al., 2012). For example, Dittmar and Duchin (2010) use a dynamic partial adjustment model to examine the speed of adjustment of cash holdings over the firm's life cycle. Bates et al. (2018) and Jiang and Lie (2016) also employ a partial adjustment model to examine the speed at which the levels of cash holdings change over time.

We follow the existing literature by employing the following two-step estimation procedure. In the first step, we estimate the target cash holdings ratio. In the second step, we use the estimated target cash holdings ratio in the estimation of a partial adjustment model of the firm's rebalancing decisions in the presence of CEO overconfidence. This method is particularly suitable for our analysis as it allows for estimating the speed of adjustment in the presence of interactive effects as well as estimating differential adjustment speeds for firms with excess cash and those with a cash deficit (Jiang and Lie, 2016).

The simplest method for estimating the firm's target cash ratio is based on a pooled OLS regression where the firm's cash holdings level is regressed on some firm-specific variables (Dittmar and Duchin, 2010). We employ regressions for each year from 1992 to 2017, i.e., 26 annual regressions, to allow for time-varying determinants of optimal cash holdings. Nevertheless, this method may still lead to biased coefficients if omitted variables affect the heterogeneity across firms' cash targets. Therefore, we employ the Fama-Macbeth method using cross-sectional regressions to estimate Eq. (1) below.[7]

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[6] As a robustness check, in Section VII, we apply the threshold of 100% to classify overconfident CEOs.

[7] In the robustness section, we use two alternative methods to estimate the target cash ratio. First, we re-estimate the dynamic panel data regressions using the system generalized method of moments (GMM). Second, we re-

$$Cash_{i,t} = \sum_1^n \beta X_{i,t} + \varepsilon_{i,t} \tag{1}$$

where *Cash* represents the cash holdings levels for firm i in year *t*. X is a vector of firm and industry characteristics. Our choice of variables coincides with Opler et al. (1999) and Bates et al. (2009). We include the following variables: firm size, net working capital, industry cash flow risk, cash flows, capital expenditures, Tobin's Q, leverage ratio, dividend dummy, and R&D expenditures. Following Dittmar and Duchin (2010) and Cheung (2016), we control for the effect of the firm's stage in its life cycle on cash policy by including firm age.

Some studies on capital structure (e.g., Cook and Tang, 2010; Devos et al., 2017) also include the main variable of interest when estimating target leverage to check whether the results change compared to those obtained from a model excluding this variable. Following these studies, in a second instance, we add our main variable of interest, the CEO overconfidence measure, to Eq. (1) to estimate the target cash holdings. The reason for including the main variable of interest is that overconfident CEOs may have a different view about what constitutes the target cash level than investors (see also Section III). Including the variable of interest in Eq. (1) would adjust for this.

The second step consists of using the estimated target cash holdings level from Eq. (1) to estimate the following partial adjustment equation:

$$\Delta Cash_{i,t} = \lambda \, DevCash_{i,t} + \varepsilon_{i,t} \tag{2}$$

where $\Delta Cash_{i,t}$ represents the change in cash holdings between the current year and the last year ($Cash_{i,t} - Cash_{i,t-1}$); $DevCash_{i,t}$ represents the difference between this year's fitted cash holdings and last year's actual cash holdings ($Cash^*_{i,t} - Cash_{i,t-1}$). The coefficient -λ represents the speed of adjustment, potentially ranging from zero to one. A value of one for

estimate the regressions while controlling for firm and year fixed effects as well as heteroscedasticity and autocorrelation. Our main results are upheld.

-λ indicates an immediate adjustment toward the optimal cash level, whereas a value of zero indicates no adjustment toward the target level.

To allow for the speed of adjustment to be asymmetric between firms with excess cash and those with a cash deficit (Bates et al., 2009; Dittmar and Duchin, 2010), we augment Eq. (2) with a dummy variable (*High*) that equals one if the firm's actual cash ratio is above the optimal cash ratio, and zero otherwise:

$$\Delta Cash_{i,t} = \lambda\, DevCash_{i,t} + \Upsilon DevCash_{i,t} * High_{i,t} + \varepsilon_{i,t} \quad (3)$$

D. Differential Speed of Adjustment of Cash Holdings

In order to examine further the impact of CEO overconfidence on the speed of adjustment of cash holdings, we interact the CEO overconfidence variable with the cash deviation variable as follows:

$$\Delta Cash_{i,t} = \alpha_1 + \beta_1 DevCash_{i,t} + \beta_2 CEO\_OC_{i,t} + \beta_3\, DevCash_{i,t} \times CEO\_OC_{i,t} + \varepsilon_{i,t} \quad (4)$$

where again *ΔCash* is the annual change in cash holdings; *DevCash* represents the difference between this year's fitted cash holdings and last year's actual cash holdings; and *CEO_OC* is a dummy variable that equals one if the CEO is overconfident, and zero otherwise. Our focus is on the coefficient (β_3) on the interaction term. A positive (negative) sign indicates that the presence of CEO overconfidence decreases (increases) the speed of adjustment of cash holdings. The speed at which non-overconfident CEOs adjust their cash holdings can be interpreted as $\lambda = -\beta_1$, whereas overconfident CEOs adjust their cash holdings at a speed of $\lambda = -(\beta_1 + \beta_3)$.

Furthermore, we estimate a regression model, based on Eq. (5) below, to test for a potential differential speed of adjustment between firms with excess cash and those with a deficit (see e.g., Devos et al., 2017).

$$\Delta \text{Cash}_{i,t} = \alpha_1 + \beta_1 DevCash_{i,t} + \beta_2 CEO\_OC_{i,t} + \beta_3\ DevCash_{i,t} \times CEO\_OC_{i,t} + \beta_4\ High_{i,t} + \beta_5 DevCash_{i,t} \times High_{i,t} + \beta_6 CEO\_OC_{i,t} \times High_{i,t} + \beta_7 DevCash_{i,t} \times CEO\_OC_{i,t} \times High_{i,t} + \varepsilon_{i,t} \quad (5)$$

Our focus is on the coefficient (β_7) of the triple interaction term. A positive (negative) sign indicates that the presence of CEO overconfidence decreases (increases) the speed of adjustment of cash holdings conditional on having a cash surplus. When there is a cash deficit, the speed at which overconfident CEOs adjust their cash holdings can be interpreted as $\lambda =$ -($\beta_1 + \ \beta_3$). On the contrary, when the firm has a cash surplus, overconfident CEOs adjust their cash holdings at a speed of $\lambda =$ -($\beta_1 + \ \beta_3 + \beta_5$).

V. Summary Statistics and Empirical Findings

A. Summary Statistics

Table 1 provides summary statistics for the main variables used in this study. The first two columns provide the mean and median values for the full sample, whereas the next four columns report the mean and median values for the firm-year observations with overconfident CEOs and those with non-overconfident CEOs, respectively. The table suggests that firm-year observations with overconfident CEOs, on average, have higher levels of cash (18%) compared to the remaining observations (13%). This finding is in line with previous studies such as Hirshleifer et al. (2012), Deshmukh et al. (2018), and Aktas et al. (2019). In addition, firms with overconfident CEOs are small, have a lower Tobin's Q, a higher cash flow ratio, higher capital expenditures, and higher R&D expenditures than firms with non-overconfident CEOs. All the above differences are statistically significant at the 1% level.

<INSERT TABLE 1 HERE>

B. Estimation of Partial Adjustment Model

Using pooled cross-sectional regressions with year, industry, and firm fixed effects, Table 2 presents the regression results of the main determinants of cash holdings based on Eq. (1). These regressions are used to estimate the target cash holdings level for each firm. The first two regressions include year fixed effects, the next two year and industry fixed effects, and the last two year and firm fixed effects. In contrast to regressions (1), (3), and (5), regressions (2), (4), and (6) include the CEO overconfidence measure.

Most of the coefficients are statistically significant and their expected signs are in line with the findings of previous literature on cash holdings. Regressions (2), (4), and (6) suggest a significantly negative effect of CEO overconfidence on cash holdings. These results are in line with Deshmukh et al. (2018) who also report a negative association between the cash holdings level and CEO optimism. However, these results differ from the findings of Chen et al. (2020) who report a positive association between CEO overconfidence and cash holding levels.

<INSERT TABLE 2 HERE>

Panel A of Table 3 presents the regression results estimating the speed of adjustment of cash holdings based on Eq. (2). Regressions (1) and (2) are estimated using the target cash ratio from Eq. (1) without including CEO overconfidence as an explanatory variable (based on regression (3) of Table 2), whereas regressions (3) and (4) are estimated using the target cash ratio from Eq. (1) including CEO overconfidence (based on regression (4) of Table 2). Finally, in contrast to regressions (1) and (3), regressions (2) and (4) include the dummy variable *High*, which equals one if the firm's actual cash ratio is above the optimal cash ratio, and zero otherwise.

In regression (1), the coefficient on the deviation from the optimal cash ratio is -0.265, suggesting that the adjustment speed is 26.5%. This result is similar to Dittmar and Duchin

(2010) and Jiang and Lie (2016) who find an adjustment speed of 22% and 31%, respectively.

Regression (2) of Panel A shows that both the coefficient on the deviation of cash from the optimal level and the coefficient on the latter's interaction with the dummy variable *High* are statistically significant. The value of the coefficient is -0.286 and 0.037, respectively. This suggests a speed of adjustment of 28.6% when the cash ratio is below target and 24.9% (28.6% – 3.7%) when the cash ratio is above target. Our results contradict the findings of Jiang and Lie (2016) who find the speed of adjustment to be faster when cash holdings are above target. Furthermore, in order to assess whether the inclusion in Eq. (1) of the main explanatory variable (*CEO_OC*) to estimate the target cash ratio affects the estimated speed of adjustment, we compare the results of regressions (1) and (2) with those of regressions (3) and (4). We conclude that the inclusion of *CEO_OC* does not yield qualitatively different findings.[8]

Panel B of Table 3 presents the mean values for the cash holdings target (*Target*) and the difference between the target cash holdings level[9] and the actual cash holdings level (*DevCash*). The t-tests are conducted to examine the differences in the means between firm-year observations with overconfident CEOs and those with non-overconfident CEOs. We find that firm-year observations with overconfident CEOs have a significantly lower target cash holdings ratio (i.e., 0.133) than firm-year observations with non-overconfident CEOs (i.e., 0.172). We also find the overconfident CEOs to negatively deviate from this optimal level (i.e., by -0.002), whereas the non-overconfident CEOs positively deviate from the optimal level (i.e., by 0.005).

<INSERT TABLE 3 HERE>

[8] All subsequent analyses are conducted using the target cash ratio from Eq. (1) without including CEO overconfidence as an explanatory variable.
[9] The target cash holdings level is estimated via the first step of the above two-step estimation procedure.

C. Estimation of Speed of Adjustment of Cash Holdings

We now focus on the effect of CEO overconfidence on the speed of adjustment. The first two Regressions in Table 4 present the results from estimating Eq. (4): Regression (1) excludes the firm-specific control variables whereas regression (2) includes these controls. In addition to including all the same variables as in regression (2), regression (3) includes the *High* dummy, the interaction of this dummy with *DevCash* and *CEO_OC*, respectively, as well as the interaction of all three variables. Further, all three regression models include the interaction term between *DevCash* and the *CEO_OC* dummy.

The latter interaction term has a statistically significant (at the 5% level or lower) coefficient and a positive sign in all three regression models. The coefficient of 0.017 (regression (1)) suggests that CEO overconfidence decreases the speed of adjustment by 6.2% (0.017/|-0.273|). Namely, it takes about three months longer for firms with overconfident CEOs to revert to their target cash holdings than the remaining firms.[10] In regression (2), when controlling for firm characteristics, we still find similar results in terms of the effect of CEO overconfidence on the speed of adjustment. However, the negative effect of CEO overconfidence on the speed of adjustment is greater (11.7% = 0.028/|-0.239|) compared to regression (1). It now takes firms with overconfident CEOs an additional seven months, when compared to other CEOs, to revert to their target cash holdings. These findings support our first hypothesis whereby CEO overconfidence plays a significant role in reducing the speed at which firms move toward their optimal cash holdings level.

Finally, regression (3) in Table 4 provides the regression results based on Eq. (5). In line with the second hypothesis, the coefficient on the triple interaction *DevCash*CEO_OC*High* is statistically significant (at the 1% level) and negative with a value of -0.047. Further, the explanatory power of regression (3), measured by its adjusted R^2, is almost double (0.478)

[10] The difference in months is computed as: $\left(\frac{1}{-(\beta_1+\beta_3)} - \frac{1}{-\beta_1}\right) * 12$.

that of regression (2) (0.257). Therefore, there is evidence that CEO overconfidence increases the speed of adjustment when there is excess cash. This finding suggests the role of CEO overconfidence in increasing the asymmetry in the speed of adjustment between firms with excess cash and those with a cash deficit.

<INSERT TABLE 4 HERE>

D. Firm Value, CEO Overconfidence and the Speed of Adjustment of Cash Holdings

In this section, we test whether firm value is sensitive to differences in the speed of adjustment of cash holdings. In other words, we investigate whether the speed of adjustment is value relevant and whether focusing on the speed creates value beyond a focus on the target cash levels. We also aim to examine how firm value, measured by Tobin's Q, is affected when the firm is managed by an overconfident CEO compared to a non-overconfident one.

In order to do this, we run a mean comparison test for Tobin's Q across three sub-samples corresponding to a low, medium, and high speed of adjustment. These three sub-samples are obtained by dividing the sample into terciles based on the firms' speed of adjustment. We set the cut-off points for the terciles based on the firms with non-overconfident CEOs only.[11] We know from the support for our first hypothesis that CEO overconfidence reduces the speed of adjustment. If we were to use the entire sample, we would be classifying too many firms as firms with a slow speed. Therefore, to disentangle the direct effect of CEO overconfidence on Tobin's Q from the indirect effect (via the slower speed of adjustment), we use the firms with non-overconfident CEOs to set the cut-off levels for a low, average, and high speed of

[11] We removed firms with a change in CEO during our sample period (e.g., a change from an overconfident to a non-overconfident CEO, and vice versa). This results in the exclusion of 544 firms.

adjustment. We then divide the firms with non-overconfident and those with overconfident CEOs into sub-samples using these cut-off levels.

We obtain the speed for each firm in our sample by estimating Eq. (2) separately for each firm (Panel A). In addition, to account for the asymmetry of the speed of adjustment for overconfident CEOs, we re-estimate the speed for each firm by estimating Eq. (3) separately for each firm again (Panel B). In other words, there is only one speed of adjustment and one average Tobin's Q per firm. Hence, each firm i is characterized by SOA_i, $Average\ Tobin's Q_i$, and CEO_OC_i.

The results are provided in Table 5. Again, the table is based on the firm as a unit rather than on the firm-year observations. We compare the mean value of Tobin's Q across each sub-sample while using the corresponding high speed of adjustment sub-sample as the base case. We find that the speed of adjustment matters for both the entire sample and the sub-sample of non-overconfident CEOs. As per Panel A, estimating the speed of adjustment using Eq. (2), we find that the high speed of adjustment sub-sample has a significantly larger Tobin's Q with a value of 2.692 compared to the low speed sub-sample with a Tobin's Q of 2.356. Similarly, for the entire sample of firms, the sub-sample of firms with a high speed has a significantly larger Tobin's Q compared to that of the firms with a low speed of adjustment. In Panel B, using Eq. (3), we find further support for the importance of the speed of adjustment on firm value.

We find that firm value is significantly lower for firms with overconfident CEOs compared to firms with non-overconfident CEOs across the three types of speed of adjustment. These results hold when we adjust for excess cash holdings by using Eq. (3) to estimate the speed of adjustment. For example, as per Panel A, the Tobin's Q for firms with overconfident CEOs has a value of 1.850, 2.030, and 1.974 for the sub-samples with low, medium, and high speed of adjustment, respectively. Conversely, the Tobin's Q value for the firms with non-overconfident CEOs for the sub-samples with low, medium, and high speed of adjustment is 2.356, 2.400, and 2.692, respectively.[12]

We conclude that both CEO overconfidence and the speed of adjustment of cash holdings are value relevant. In detail, our results suggest that firms with a high speed of adjustment and a non-overconfident CEO have the highest firm value whereas firms with a low speed of adjustment and an overconfident CEO have the lowest firm value.

<INSERT TABLE 5 HERE>

VI. Identification tests

A. Difference-in-differences method

There remains the concern that our estimates could be biased given endogenous matching between CEO overconfidence and corporate cash holdings decisions. Namely, overconfident CEOs may choose to work for firms with a slow speed of adjustment of cash holdings. Nevertheless, the likelihood of this type of endogeneity (i.e., reverse causality) is rather low, as in real life it is unlikely that managers would search for firms with less dynamic cash policies as their potential employers. Nevertheless, in an attempt to overcome this endogeneity concern, we identify two scenarios with an exogenous change in a firm's cash holdings. First, we use the 2012 US-Korea Free Trade Agreement (KORUS FTA) as a source of exogenous variation in the firm's competitive environment. This agreement resulted in tariffs on US imports to South Korea and South Korean imports to the USA being phased out.[13] We expect this exogenous change to be accompanied by changes in the cash holdings

[12] As a robustness check, we use all of the firms in the sample to set the cut-off points. We find qualitatively similar findings (not tabulated) to those reported in Table 5.

[13] The time it took to phase out the tariffs depended on the product category. There were 11 product categories with times to phase out tariffs ranging from tariffs being phased out immediately (or remaining at zero) to tariffs being phased out by year 15 of the agreement (year 1 being the first year of the agreement). Tariffs that were not phased out immediately were phased out gradually in equal annual stages up to the final year of the phasing out period. See Chapter 2 of Final - United States - Korea FTA Texts at: https://ustr.gov/trade-agreements/free-trade-agreements/korus-fta/final-text.

decisions (see also, Fresard, 2010). In other words, we re-examine our main findings in the presence of a shock to cash flows.

KORUS FTA became effective from 2013. The trade relations between the USA and South Korea changed without a related economic or political change as a response to changes in macroeconomic conditions or pressures from individual companies.[14] Therefore, this agreement represents a quasi-natural experiment exploiting the elimination of tariffs between both countries across a large number of industries. From an individual firm's perspective, the agreement constitutes an exogenous and unanticipated shock to the firm's competitive environment. Therefore, we use this setting to assess the impact of CEO overconfidence on the speed of adjustment of cash holdings. The tariff data is sourced from World Integrated Trade Solution (WITS).[15]

Figure 1.A shows a substantial drop in the overall average tariff rate from the year 2011 (Pre-FTA) to the year 2013 (Post-FTA). The average tariff rates were slightly under 4% in both 2011 and 2012 and then dropped to less than 1% in 2013. In addition, Figure 1.B shows a jump in the aggregate value of imports across industries from Korea to USA. Imports amounted to less than \$60 billion in both 2011 and 2012, and then increased to around \$65 billion in 2013. This pattern validates the use of this agreement as a source of an exogenous shock to firms' cash holdings.

<INSERT FIGURE 1 HERE>

Following Alimov (2014), we merge our dataset with the tariff data obtained based on the two-digit SIC industry codes.[16] We then divide the industries into three groups with respect to the pre-FTA tariff levels. While the phasing-out periods vary across industries and may

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[14] For a further discussion on the validity of FTAs as an exogenous shock, see Guadalupe and Wulf (2010) and Alimov (2014).

[15] WITS was developed by the World Bank, with the help of the United Nations Conference on Trade and Development (UNCTAD) and in consultation with the International Trade Center, the United Nations Statistical Division (UNSD) and the World Trade Organization (WTO) (see https://wits.worldbank.org/).

[16] While merging the two datasets, we lost 3,518 observations relating to firms that did not survive the introduction of the KORUS FTA in 2012.

therefore not be endogenous, this approach ensures that all industries are treated the same. The pre-FTA tariffs (i.e., the 2011 tariffs) at the two-digit SIC industry level ranged from zero to 10.37%. High tariff industries are those located in the top tercile of the pre-FTA tariffs (in excess of 2%), whereas low tariff industries are those located in the bottom tercile of the pre-FTA tariffs (below 0.1%).

Using the difference-in-differences method, we compare the speed of adjustment of cash holdings in the years before and after the FTA (first difference) between firms with a greater increase in competitive pressure due to the tariff reduction and those with a lower increase (second difference). We do this for the two sub-samples of firm-year observations with and without overconfident CEOs. Therefore, we create a dummy variable *HighTariff* to identify the firms in industries located in the top tercile of the pre-FTA tariffs. This variable equals one if the firm belongs to an industry with a pre-FTA tariff in excess of 2%, and zero otherwise. Finally, we create another dummy variable (*PostFTA*) that equals one for observations in the post-2012 period, and zero otherwise.

We employ a regression model based on Eq. (6) below for the two sub-samples. Again, the first sub-sample includes firm-year observations with overconfident CEOs and the second sub-sample includes firm-year observations with non-overconfident CEOs.

$$\Delta \mathrm{Cash}_{i,t} = \alpha_1 + \beta_1 DevCash_{i,t} + \beta_2 HighTariff_{i,t} + \beta_3 PostFTA_{i,t} + \beta_4 DevCash_{i,t} \times PostFTA_{i,t} + \beta_5 DevCash_{i,t} \times HighTariff_{i,t} + \beta_6 PostFTA_{i,t} \times HighTariff_{i,t} + \beta_7 DevCash_{i,t} \times PostFTA_{i,t} \times HighTariff_{i,t} + \varepsilon_{i,t} \quad (6)$$

Table 6 provides the results. For regressions (1) and (2), the coefficient estimates for *DevCash* suggest a speed of adjustment of 23.7% and 23.8%, respectively. Our main focus is on the triple interaction term *DevCash*PostFTA*HighTariff*. This term captures the incremental impact of the trade agreement on the speed of adjustment of cash holdings for firms that experience relatively large tariff reductions on Korean imports compared to those that experience relatively small tariff reductions. We find a negative and significant (at the 1% level) coefficient on the interaction term for the sub-sample of firm-year observations with overconfident CEOs. In contrast, the coefficient on the same interaction term is not statistically significant for the sub-sample of firm-year observations with non-overconfident CEOs. This indicates that, following this exogenous shock, overconfident CEOs tend to increase the speed of adjustment of cash holdings for firms with larger tariff reductions after the FTA was implemented. These findings further support our results from Section V in that CEO overconfidence increases the asymmetry in the speed of adjustment between firms with excess cash and those with a cash deficit.

<INSERT TABLE 6 HERE>

Second, we re-examine whether our main findings hold when there is a one-dollar increase in cash flows. Assuming the cost of future external financing is unaffected, we expect that overconfident CEOs are more likely to spend the additional cash rather than increasing the cash holdings. Hence, a one-dollar increase in cash flows should increase the speed of adjustment in the presence of an overconfident CEO. To do so, we modify the model of Almeida et al. (2004), which estimates the cash flow sensitivity of cash, and run a regression based on Eq. (7) below for the above mentioned two sub-samples.

$$\Delta \mathrm{Cash}_{i,t} = \alpha_1 + \beta_1 DevCash_{i,t} + \beta_2 CashFlow_{i,t} + \beta_3 DevCash_{i,t} \times CashFlow_{i,t} + \beta_4 \Delta \mathrm{ShortTermDebt}_{i,t} + \beta_5 Growth_{i,t} + \beta_6 Expenditures_{i,t} + \beta_7 Acquisitions_{i,t} + \beta_8 Size_{i,t} + \varepsilon_{i,t} \quad (7)$$

where *CashFlow* is the ratio of earnings before extraordinary items and depreciation (minus dividends) to total assets. *ΔShortTermDebt* is the annual change in the ratio of short-term debt to total assets. *Growth* is the market value divided by the book value of assets.

Expenditure is the firm's capital expenditures divided by total assets. All other variables are as defined above.

In untabulated results (available upon request), we find the coefficient estimate on the interaction term *DevCash*CashFlow* to be negative and significant for the sub-sample of firm-year observations with overconfident CEOs, whereas it is insignificant for the sub-sample of firm-year observations with non-overconfident CEOs. This pattern indicates that in the presence of a positive shock to cash flows the speed of adjustment of cash holdings is faster conditional on having an overconfident CEO. These results confirm our main findings and provide further support for our second hypothesis.

B. Propensity Score Matching

Firms with overconfident CEOs may be fundamentally different from those with non-overconfident CEOs. Table 1 gives credence to this argument. Although we include various control variables in our main regression estimation, our results could still be biased and could pick up non-linear effects of the control variables on the speed of adjustment of cash holdings. To address this concern, we create two sub-samples of firm-year observations that are comparable across all the control variables but differ only in terms of whether the CEO is overconfident or not. To do so, we implement propensity score matching (PSM) following (Drucker and Puri, 2005) and match firm-year observations with overconfident CEOs with firm-year observations with similar characteristics but without overconfident CEOs.

Specifically, we run a logit regression to estimate the propensity scores, p(Y=1/X=x), based on the probability of receiving a binary treatment, Y, conditional on all the control variables, X. Based on our study, we regard firm-year observations with overconfident CEOs as having received the "treatment" and we estimate the probability of having an overconfident CEO using a set of independent variables. The independent variables are the same as those used in regression (4) of Table 4.

Panel A of Table 7 presents the logistic regression results for the determinants of CEO overconfidence. We find that firm size, Tobin's Q, net working capital, and capital expenditures are negatively related to CEO overconfidence. In contrast, firm age is positively related to CEO overconfidence.

Next, for each firm-year observation with an overconfident CEO, we use the propensity scores obtained from the logistic regression to find a comparable firm-year observation with a non-overconfident CEO based on the nearest-neighbor method, combined with one-on-one matching without replacement. To ensure the quality of the matching, we require that the caliper (i.e., the absolute difference in propensity scores) among pairs does not exceed 0.1%. If there is more than one firm-year observation with non-overconfident CEOs that meets this criterion, we retain the firm-year observation with the smallest difference in the propensity scores. Further, we make sure that for each value of a control variable, there is a positive probability of being treated and untreated. In other words, we consider only the observations whose propensity score belongs to the intersection of the supports of the propensity score of treated and controls; thus, satisfying the common support condition (Caliendo and Kopeinig, 2008). We obtain 7,469 pairs of matched firm-year observations.

To test for the validity of the conditional independence assumption, we perform two diagnostic tests. If this assumption is satisfied, it implies that after controlling for the observation characteristics, the assignment of units to treatment is as good as random (Lechner, 1999). The first test consists of re-estimating the logistic regression for our post-match sample. Regression 2 of Panel A shows the results using the post-match sample. All regression coefficients for the post-match sample are statistically insignificant. Thus, there are no significant differences in the observable characteristics between the treatment group and the control group. The pseudo R^2 also decreases substantially from 0.070 for the pre-match sample to 0.001 for the post-match sample. These results indicate that by using the

PSM technique, we successfully remove any differences in the observable characteristics other than the difference in the presence of CEO overconfidence.

The second test compares the mean differences for each observable firm characteristic between the treated and control groups. The mean differences and their t-tests are reported in Panel B of Table 7. All the mean differences between firm-year observations with overconfident CEOs and those with non-overconfident CEOs are statistically insignificant. Based on the above two tests, we confirm that we have successfully removed all observable differences other than the difference in the presence of CEO overconfidence; hence, we provide supporting evidence of the conditional independence assumption. This increases the likelihood that any difference in firms' speed of adjustment of cash holdings is due to the presence of CEO overconfidence.

Finally, we present the difference in of the average $\Delta Cash$ between the treated and the control groups. Panel C indicates that there is a significant difference in the average $\Delta Cash$ between the firm-year observations with overconfident CEOs and those with non-overconfident CEOs. Therefore, the results obtained from applying the PSM further confirm our hypothesis while mitigating the concern about self-selection bias.

<INSERT TABLE 7 HERE>

VII. Additional Analyses

A. Financial Constraints

In this section, we examine the effect of financial constraints on the relationship between CEO overconfidence and the speed of adjustment of cash holdings. Dittmar and Duchin (2010) argue that financial constraints and the cost of external financing influence a firm's speed of adjustment of cash holdings as well as its ability to move toward its target.[17] Further, Aktas et al. (2019) study the effect of CEO overconfidence on the value of cash when controlling for the firm's financial constraints. Consistent with the costly external finance hypothesis, for financially constrained firms, they find a positive effect of CEO overconfidence on the value of cash holdings. In contrast, for financially unconstrained firms, they find overconfident CEOs to negatively affect the value of cash holdings, reflecting overinvestment. Finally, Bates et al. (2018) find that financial constraints affect the speed at which firms adjust their cash holdings toward the target level over time. They report a decline in the speed of adjustment for financially constrained firms, i.e., firms with cash deficits in the 1990s and 2000s.

As overconfident CEOs believe external financing to be overly costly, they are predicted to act as if their firms were financially constrained (Deshmukh et al., 2018). Hence, they rely more heavily on internal funding. Therefore, actual financial constraints further amplify the biased belief of overconfident CEOs about the high cost of external financing and lead them to rely even more heavily on internal funds; hence, reducing the speed of adjustment of cash holdings. Based on these findings, we expect overconfident CEOs to adapt the speed of adjustment of cash holdings depending on the presence of financial constraints. More specifically, since financially constrained firms face difficulty in raising external funds, the speed of adjustment of such firms should be slower.

In order to examine how CEO overconfidence affects the speed of adjustment of cash holdings in the presence of financial constraints, we re-estimate Eq. (4) after dividing our sample into financially constrained and unconstrained firm-year observations. Following the existing literature (e.g., Almeida et al., 2004; Farre-Mensa and Ljungqvist, 2016; Aktas et al., 2019), we use dividends, the credit rating, and the size-age (SA) index of Hadlock and Pierce

[17] Similarly, the capital structure literature suggests that the costs of adjusting leverage toward its target differ between financially constrained and unconstrained firms (Faulkender and Petersen, 2006; Faulkender et al., 2012).

(2010) to proxy for financial constraints, where zero dividends capture the firm's internal financial constraints whereas the absence of a credit rating and an above-median size-age index capture the firm's external financial constraints (Aktas et al., 2019). More specifically, for each year, we define financially constrained firms as those: (i) that do not pay dividends; (ii) that do not have a credit rating; and (iii) with an SA index value above the sample median.[18] If the firm's financial constraints affect the relation between CEO overconfidence and the speed of adjustment of cash holdings, we expect the interaction between *DevCas*h and *CEO_OC* to be significant and more positive for financially constrained firms. As is revealed in Table 8, this is indeed the case.

The first regression in Table 8 is based on financially constrained firm-year observations as proxied by zero dividends whereas the second regression is based on firm-year observations without financial constraints as proxied by non-zero dividends. For the financially unconstrained firm-year observations, the coefficient on the interaction term is insignificant, while it is significantly positive for the constrained firm-year observations. For the latter type of firms, the size of this coefficient (0.031) suggests that the effect is economically significant as CEO overconfidence decreases the speed of adjustment by 12.3% (0.031/|-0.253|). Namely, it takes about six months longer for overconfident CEOs of financially constrained firms to adjust their target cash holdings. Compared with our findings in Table 4 where CEO overconfidence decreases the speed of adjustment by 11.7%, the existence of internal financial constraints further slows down this adjustment process. Similarly, when we divide the sample according to the presence of external financial constraints as indicated by the absence of a credit rating as well as an above-median value for the SA index, the coefficient on the interaction between *DevCash* and *CEO_OC* is significantly positive for the financially constrained firm-year observations (regressions (3)

[18] The definition of each financial constraint proxy is reported in the Appendix.

and (5)). In contrast, it is insignificant for the unconstrained firm-year observations (regressions (4) and (6)). The coefficients in regressions (3) and (5) are also economically significant as CEO overconfidence decreases the speed of adjustment by 12.8% and 16.1%, respectively. These results suggest that the effect of external financial constraints is even more pronounced than that of internal financial constraints in reducing the speed of adjustment of cash holdings in the presence of CEO overconfidence.

<INSERT TABLE 8 HERE>

B. Different Debt Levels

Another factor that may affect the speed of adjustment of cash holdings is the firm's capital structure. Dittmar and Duchin (2010) view cash holdings as negative debt with the firm managing its cash and debt levels jointly rather than separately from each other. The relationship between the firm's debt and the speed of adjustment of cash holdings could be explained by the following two competing hypotheses. On the one hand, higher levels of debt may make cash holdings less important as the firm has access to debt as a source of liquidity. Given this substitutability between cash holdings and debt (Strebulaev and Yang, 2013), the speed of adjustment of cash holdings is expected to be lower with high levels of debt (Dittmar and Duchin, 2010). On the other hand, it could be argued that higher debt levels indicate lower financing constraints. As a result, firms with high leverage should have lower adjustment costs for cash and hence a higher speed of adjustment of cash. Dittmar and Duchin (2010) find supporting evidence for the latter hypothesis as greater liquidity, measured by the firm's access to a revolving credit facility, is associated with a higher speed of adjustment of cash.

The question then arises whether, after controlling for different levels of debt, CEO overconfidence still affects the speed of adjustment. We attempt to answer this question by dividing our sample into three sub-samples, namely zero-debt, low-debt, and high-debt firm-year observations. We follow Strebulaev and Yang (2013): The zero-debt sub-sample includes firm-year observations for which the outstanding amounts of both short-term debt and long-term debt equal zero. The low-debt sub-sample includes firm-year observations for which the book leverage ratio (the sum of short-term debt and long-term debt over total assets) is less than 15%, excluding zero-debt firms. Finally, we include firm-year observations in the high-debt sub-sample for which the book leverage ratio is higher than 50%.

Furthermore, Acharya et al. (2012) argue that a firm can been regarded as a portfolio of assets, of which cash is one. In turn, the assets structure in this portfolio depends on the composition of the firm's liabilities (i.e., the firm's debt structure). Acharya et al. find that firms with greater credit risk have greater cash reserves. Furthermore, the literature on debt structure highlights the importance of credit risk and information asymmetry on the firm's debt decisions (e.g., Bali and Skinner, 2006; Hackbarth et al., 2006; Daniels et al., 2010). For example, the survey by Graham and Harvey (2001) shows that managers care the most about the firm's credit rating and financial flexibility when making debt issuance decisions. One would expect that, especially for firms with high debt, it is important to control for credit risk. Therefore, in order to get a better estimate of the optimal level of cash holdings, we include a measure of credit risk, namely the interest coverage ratio. This is defined as the firm's earnings before interest and tax (EBIT) divided by the interest expenses. We expect that overconfident CEOs of high-debt firms with a high credit risk underestimate their firm's credit risk and therefore spend too much of the cash; hence, we expect a greater speed of adjustment for such firms.

We use a regression based on Eq. (8) below to test for the differential speed of adjustment for firms with high and those with low credit risk across the three sub-samples of debt:

$$\Delta\text{Cash}_{i,t} = \alpha_1 + \beta_1 DevCash_{i,t} + \beta_2 CEO\_OC_{i,t} + \beta_3\, DevCash_{i,t} \times CEO\_OC_{i,t} + \beta_4\, CreditRisk_{i,t} + \beta_5 DevCash_{i,t} \times CreditRisk_{i,t} + \beta_6 CEO\_OC_{i,t} \times CreditRisk_{i,t} + \beta_7 DevCash_{i,t} \times CEO\_OC_{i,t} \times CreditRisk_{i,t} + \varepsilon_{i,t} \quad (8)$$

where *CreditRisk* is a dummy variable that equals one if the interest coverage ratio for firm *i* in year *t* is lower than two, and zero if the interest coverage ratio is equal to or higher than two.

Table 9 suggests that the speed of adjustment is highest for firm-year observations with high debt levels (32%), lowest for firm-year observations with low debt levels (24.6%), and somewhere in between for firm-year observations with zero debt (28.9%). This suggests that high levels of debt reflect lower financial constraints, resulting in lower adjustment costs of cash and a greater speed of adjustment. Therefore, firms with high debt are much more likely to operate around their optimal cash level as well as reverting quickly to it should they be pushed away from it. These results support the findings of Dittmar and Duchin (2010) and Jiang and Lie (2016).

The coefficient on the interaction between *DevCash* and *CEO_OC* is significant (at the 1% level) and positive for the three regressions. The coefficient has a value of 0.062, 0.047, and 0.087 for regression (1), (2), and (3), respectively. This suggests that CEO overconfidence decreases the speed of adjustment of cash holdings by 21.45% (0.062/|-0.289|), 19.1% (0.047/|-0.246|), and 27.19% (0.087/|-0.320|), for firms with zero debt, low debt, and high debt, respectively. This confirms our previous results and provides additional support for our first hypothesis. Further, the largest reduction in the speed of adjustment of cash holdings due to managerial overconfidence is observed for firm-year observations with high debt levels.

Regression (3), which is based on the high-debt firm-year observations, is the only case where the coefficient on the triple interaction *DevCash*CEO_OC*CreditRisk* is statistically significant (at the 1% level) and negative with a value of -0.157. The speed at which overconfident CEOs adjust their cash holdings for firms with high and low credit risk can be obtained via $\lambda = -(\beta_1 + \beta_3 + \beta_5 + \beta_7)$ and $\lambda = -(\beta_1 + \beta_3)$, respectively; hence, the speed of adjustment for firms with overconfident CEOs and high credit risk equals 26.5% (= -[-0.32 + 0.087 + 0.125 - 0.157]), whereas the speed of adjustment for firms with overconfident CEOs and low credit risk equals only 23.3% (=-[-0.32 + 0.087]). Therefore, there is evidence that CEO overconfidence in the high-debt sub-sample increases the speed of adjustment when credit risk is high. This finding is in line with our argument that overconfident CEOs underestimate their firm's credit risk and therefore spend too much of the cash; hence, the greater speed of adjustment. Based on these findings, we conclude that CEO overconfidence still affects the speed of adjustment of cash holdings when considering the firm's debt level.

<INSERT TABLE 9 HERE>

VIII. Robustness Tests

A. Alternative Measures of CEO Overconfidence

As a robustness check, we re-estimate our main regressions using two alternative measures of CEO overconfidence. The first measure is based on Campbell et al. (2011) and their definition of overconfident CEOs. It is the dummy variable *CEO_OC100*, which equals one if the CEO holds exercisable options that are 100% deep in the money at least once during the CEO's tenure period, and zero otherwise.[19]

Our existing measure of CEO overconfidence (*CEO_OC*) as well as the above alternative measure (*CEO_OC100*) assumes that overconfidence is an inherent characteristic, i.e., a fixed

[19] Strictly speaking, Campbell et al. (2011) require that for a CEO to be classed as overconfident, they should hold exercisable options that exceed the 100% threshold for at least two years during their tenure. However, we follow Deshmukh et al. (2018), who also focus on cash holdings behavior, and require the CEO to hold such options only once.

effect over the CEO's tenure. However, it could be argued that overconfidence varies with past experience and performance (Hilary and Menzly, 2006; Billett and Qian, 2008). Therefore, we construct a post-overconfidence measure (*Post*) that allows for variation over time in CEO overconfidence and eliminates the forward-looking information in the CEO classification (Deshmukh et al., 2018). This is a binary measure that equals one if the CEO holds options that are more than 67% in the money in a given year (starting with the first year of the CEO in the firm and ending with the last one), and zero otherwise. This measure is based on the long-holder measure of CEO overconfidence used by Campbell et al. (2011).

Table 10 presents the estimation results for Eq. (4) where we replace the overconfidence variable *CEO_OC* with the variables *CEO_OC100* and *Post*. Regressions (1) and (2) are estimated using *CEO_OC100* as the measure for CEO overconfidence without and with the control variables, respectively. The positive coefficient on the interaction between *DevCash* and *CEO_OC100* confirms our previous results and provides further support for the first hypothesis that firms with overconfident CEOs reduce the speed of adjustment of cash holdings. The same conclusion can be drawn from regressions (3) and (4), where the variable *Post* replaces the overconfidence variable *CEO_OC*.

<INSERT TABLE 10 HERE>

B. Corporate Governance

According to extant literature, the quality of a firm's governance plays a role in its cash holdings policy. For example, Dittmar and Mahrt-Smith (2007) as well as Kalcheva and Lins (2007) find that good corporate governance practices have a positive effect on the value of cash holdings. They further report that poorly governed firms dissipate cash quickly in ways that significantly reduce their operating performance, whereas this is not the case for well-governed firms. Aktas et al. (2019) also control for the firm's governance when examining the impact of CEO overconfidence on the value of cash holdings and they find that it matters. Hence, we re-estimate Eq. (4) while controlling for the quality of the firm's governance.

In regression (1) of Table 11, we control for the quality of corporate governance by employing the entrenchment index (E-index) developed by Bebchuk et al. (2008). This index measures the degree of managerial entrenchment by counting the presence of the following anti-takeover provisions: (i) a classified board; (ii) limitations to shareholders' ability to amend the bylaws; (iii) supermajority voting for business combinations; (iv) supermajority requirements for charter amendments; (v) poison pills; and (vi) golden parachutes. Therefore, the higher the value of the E-index the stronger is managerial entrenchment and, hence, the lower is the corporate governance quality. We create a dummy variable *GoodGov* that equals one for the sample of firm-year observations with an E-index value of zero, and zero otherwise. In regression (2) of Table 11, we define the quality of corporate governance by the CEO-duality dummy variable *Duality*, where CEO duality is assumed to reflect bad corporate governance (Dahya et al., 2002; Aktas et al., 2019). The findings from both regressions (1) and (2) are robust after controlling for corporate governance quality and our main results still hold.

<INSERT TABLE 11 HERE>

C. Alternative Estimation Methods

Given that a reliable estimation of the optimal cash holdings level is vital for our study, we conduct two robustness tests using alternative methods to estimate the optimal cash holdings level for each firm. In the first robustness check, we employ the Blundell and Bond (1998) system generalized method of moments (GMM). This allows us to control for omitted variable bias as well as simultaneous and dynamic endogeneity (Wintoki et al., 2012; Abdallah et al., 2015) in the first step, where we use Eq. (9) below to estimate the optimal cash holdings level.

$$\text{Cash}_{i,t} = (1 - \lambda) Cash_{i,t-1} + \gamma_n \sum_1^n Control\ variables + \varepsilon_{i,t} \quad (9)$$

In the second step and similar to the main analysis, we include this estimated value in Eq. (2) to estimate the firm's speed of adjustment of cash holdings.

The second robustness test consists of using the Driscoll and Kraay (1998) estimator. In the first step, using this estimator permits us to estimate the optimal cash holdings level while controlling for heteroscedasticity and autocorrelation, assuming that the standard errors are heteroscedastic, autocorrelated up to some lags, and possibly correlated between groups (Jiang and Lie, 2016). This method allows us to correct for the presence of cross-sectional correlation. In the second step, we include this estimated value using the Driscoll and Kraay estimator in Eq. (2) to estimate the firm's speed of adjustment of cash holdings.

Panel A of Table 12 reports the results for these two robustness checks. The results are similar to our previous findings: We still find a significantly positive association between the interaction *DevCash*CEO_OC* and the change in cash for each of the two alternative estimation methods, providing further support for the first hypothesis. Furthermore, Panel B of Table 12 provides post-estimation summary statistics (mean and median) for the optimal cash holdings ratio as well as for the deviation from the optimal cash level for the two alternative estimation methods as well as the annual cross-sectional regressions used in the main analysis to estimate the target cash ratio. Overall, the mean and median values for *Target* and *DevCash* are comparable across the three different estimation methods. For example, the mean value for *Target* has a value of 15.09%, 14.79%, and 15.10% using annual cross-sectional regressions, GMM estimation, and Driscoll-Kraay estimation, respectively.

<INSERT TABLE 12 HERE>

IX. Conclusion

The key finding of this study is that CEO overconfidence plays a significant role in affecting the speed of adjustment of cash holdings for US firms. We find that overconfident CEOs reduce the speed at which their firm adjusts toward its target cash level: Firms managed by overconfident CEOs spend, on average, an additional seven months adjusting toward their optimal cash holdings level compared to firms managed by rational CEOs.

Our findings provide evidence supporting the trade-off theory. Indeed, we find that if the actual cash holdings exceed their optimal level, overconfident CEOs increase the adjustment speed, potentially because of overinvesting. Hence, overconfident managers exacerbate differences in the speed of adjustment between firms with excess cash and those with a cash deficit. Importantly, we find that both CEO overconfidence and the speed of adjustment of cash holdings are value relevant. In detail, we conclude that firms with a high speed of adjustment and a non-overconfident CEO have the highest value whereas firms with a low speed of adjustment and an overconfident CEO have the lowest value.

Lastly, we address various endogeneity concerns, namely reverse causality, unobserved heterogeneity and dynamic endogeneity. To this end, we implement the difference-in-differences estimation method using the 2012 US-Korea Free Trade Agreement as an exogenous shock and propensity score matching to match firm-year observations with overconfident CEOs with firm-year observations with non-overconfident CEOs by certain firm characteristics. In addition, our findings are robust to using various estimation techniques to determine the target cash holdings level, to alternative measures for CEO overconfidence, and to the inclusion of controls for the quality of the firm's governance. Overall, our study highlights the importance of CEO overconfidence for the speed of adjustment of cash holdings, and in particular the difference in the speed of adjustment between firms with excess cash and those with a cash deficit.

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TABLE 1

Descriptive Statistics

Table 1 displays summary statistics on firm characteristics for the entire sample as well as the sub-samples of firm-year observations corresponding to overconfident CEOs and the firm-year observations corresponding to non-overconfident CEOs. See the Appendix for the variable definitions. The sample consists of 23,868 firm-year observations that cover the period 1992-2017. T-tests (Wilcoxon-Mann-Whitney z-tests) are conducted to test for differences in means (medians) between firm-year observations with overconfident and those with non-overconfident CEOs. All variables are winsorized at the 1st and 99th percentiles. ***, **, and * denotes a statistically significant difference at the 1%, 5% and 10% level, respectively.

	Entire Sample		Overconfident CEOs		Non-overconfident CEOs	
	Mean	Median	Mean	Median	Mean	Median
Cash	0.151	0.086	0.175	0.104	0.130***	0.073***
Size ($ millions)	7403	1414	8300	1593	6338***	1204***
Tobin's Q	2.037	1.607	1.823	1.504	2.291***	1.768***
Dividend	0.492	0.000	0.588	1.000	0.411***	0.000***
IndSigma	0.063	0.041	0.073	0.048	0.055***	0.036***
CF	0.076	0.084	0.082	0.092	0.071***	0.078***
NWC	0.065	0.056	0.062	0.053	0.068**	0.059***
CAPEX	0.055	0.038	0.059	0.039	0.052***	0.037***
Leverage	0.234	0.215	0.218	0.194	0.248***	0.230***
R&D	0.033	0.004	0.040	0.005	0.028***	0.003***
Acquisitions	0.028	0.000	0.029	0.000	0.027***	0.000
Age (years)	27.804	23	30.574	27	24.516***	20***

TABLE 2

Determinants of cash holdings ratio

Table 2 reports the determinants of the optimal level of cash holdings. The dependent variable is the cash ratio and the independent variables include the firm characteristics as per Table 1. See the Appendix for the variable definitions. Year, industry, and/or firm dummies are included in the regressions to control for year, industry, and firm fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firms are reported in parentheses.

	Year fixed effects		Year & industry fixed effects		Year & firm fixed effects	
	(1)	(2)	(3)	(4)	(5)	(6)
CEO_OC		-0.008**		-0.007*		-0.009***
		(0.004)		(0.004)		(0.003)
Size	-0.014***	-0.014***	-0.015***	-0.015***	-0.020***	-0.020***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Tobin's Q	0.020***	0.019***	0.020***	0.020***	0.012***	0.012***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Dividend	0.020***	0.019***	0.014***	0.014***	0.003	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
IndSigma	0.361***	0.357***	0.336***	0.332***	0.245***	0.244***
	(0.046)	(0.046)	(0.046)	(0.046)	(0.063)	(0.062)
CFR	-0.113***	-0.115***	-0.140***	-0.141***	-0.088***	-0.088***
	(0.024)	(0.024)	(0.024)	(0.024)	(0.018)	(0.018)
NWC	-0.231***	-0.232***	-0.225***	-0.226***	-0.267***	-0.267***
	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.016)
CAPEX	-0.450***	-0.454***	-0.398***	-0.402***	-0.382***	-0.385***
	(0.033)	(0.033)	(0.038)	(0.038)	(0.034)	(0.033)
Leverage	-0.206***	-0.206***	-0.190***	-0.190***	-0.139***	-0.138***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.011)
R&D	0.773***	0.771***	0.586***	0.585***	0.062	0.063
	(0.048)	(0.048)	(0.056)	(0.056)	(0.055)	(0.055)
Acquisitions	-0.312***	-0.315***	-0.339***	-0.341***	-0.228***	-0.229***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.012)	(0.012)
Age	-0.014***	-0.013***	-0.012***	-0.012***	-0.034***	-0.034***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Constant	0.275***	0.282***	0.265***	0.272***	0.412***	0.418***
	(0.017)	(0.017)	(0.018)	(0.018)	(0.021)	(0.021)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	No	No	Yes	Yes	No	No
Firm fixed effects	No	No	No	No	Yes	Yes
Number of firms	1,913	1,913	1,913	1,913	1,913	1,913
Observations	23,868	23,868	23,868	23,868	23,868	23,868
Adj. R-squared	0.535	0.536	0.546	0.547		
Wald Chi^2	-	-	-	-	1811.84	1848.79

TABLE 3

Cash holdings estimation results

Table 3 Panel A reports the regressions for estimating the cash holdings adjustment speed. *DevCash* is the difference between target cash holdings and actual cash holdings, where the target cash holdings are the predicted values from the cash holdings regression (regression (3) of Table 2 for the regressions in the first two columns and regression (4) of Table 2 for the last two columns). *High* is a dummy variable that equals one if the cash ratio is above the target ratio, and zero otherwise. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. Standard errors robust to clustering by firm are reported in parentheses. Panel B presents the means of target cash holdings and cash holdings deviations, estimated from annual regressions as per Eq. (1). *Target* is the predicted value from the cash holdings cross-sectional regressions and *DevCash* is the difference between target cash holdings and actual cash holdings. T-tests are conducted to test for differences between means for firms with overconfident and those with non-overconfident CEOs. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively.

Panel A – Adjustment speed for cash holdings

	Target cash holdings estimated excluding CEO_OC		Target cash holdings estimated including CEO_OC	
	(1)	(2)	(3)	(4)
DevCash	-0.265***	-0.286***	-0.265***	-0.288***
	(0.004)	(0.007)	(0.004)	(0.007)
DevCash * High		0.037***		0.040***
		(0.010)		(0.010)
Constant	-0.006	-0.006	-0.006	-0.006
	(0.005)	(0.005)	(0.005)	(0.005)
Year dummies	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes
Observations	23,868	23,868	23,868	23,868
Adj. R-squared	0.186	0.187	0.187	0.187

Panel B – Post-estimation summary statistics

	CEO_OC = 1 (Obs.: 10,913)		CEO_OC = 0 (Obs.: 12,955)	
	Target	DevCash	Target	DevCash
Mean	0.133	-0.002	0.172***	0.005***

TABLE 4

The effect of CEO overconfidence on the speed of adjustment of cash holdings

Table 4 presents the OLS regressions of CEO overconfidence on the adjustment speed for the cash ratio. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. *CEO_OC* is a dummy variable that equals one for firms with an overconfident CEO, and zero for firms with a non-overconfident CEO. *High* is a dummy variable that equals one if the cash ratio is above the target ratio, and zero otherwise. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firms are reported in parentheses.

	(1)	(2)	(3)
DevCash	-0.273***	-0.239***	-0.496***
	(0.005)	(0.005)	(0.008)
CEO_OC	-0.001	-0.004***	0.008***
	(0.001)	(0.001)	(0.001)
DevCash* CEO_OC	0.017**	0.028***	0.078***
	(0.007)	(0.007)	(0.012)
High			0.103***
			(0.001)
DevCash*High			0.042***
			(0.011)
CEO_OC*High			-0.021***
			(0.002)
DevCash*CEO_OC*High			-0.047***
			(0.015)
Constant	-0.004	0.031***	0.001
	(0.005)	(0.006)	(0.005)
Controls	No	Yes	Yes
Observations	23,868	23,868	23,868
Adj. R-squared	0.187	0.257	0.478

TABLE 5

Firm value and the speed of adjustment of cash holdings

Table 5 displays the mean values for Tobin's Q across three sub-samples corresponding to a low, medium, and high speed of adjustment of cash holdings (SOA). We use the firms with non-overconfident CEOs only to set the cut-off points for low, medium, and high SOAs. These cut-off points are obtained by dividing the sample into terciles. We further distinguish between firms with overconfident CEOs and those with non-overconfident CEOs. Panel A (B) uses Eq. (2) (Eq. (3)) in Section IV to estimate the SOA for each firm. For each sub-sample, we compare the mean values of Tobin's Q for firms with an overconfident CEO with firms with a non-overconfident CEO. ***, **, and * denotes a statistically significant difference in Tobin's Q between firms with an overconfident CEO and firms with a non-overconfident CEO at the 1%, 5% and 10% level, respectively. In addition, we compare the mean values of Tobin's Q for firms between each sub-sample while using the high SOA sub-sample as the base line for comparison. †††, ††, and † denotes a statistically significant difference in Tobin's Q for a given sub-sample and the high SOA sub-sample at the 1%, 5% and 10% level, respectively. The entire sample consists of 1,391 firms for the period 1992-2017. Values in parentheses correspond to the number of observations in each sub-sample.

Panel A – Using Eq. (2) to estimate the speed of adjustment for each firm

	Low SOA sub-sample	Medium SOA sub-sample	High SOA sub-sample	Entire Sample
Overconfident CEOs	1.85	2.03	1.974	1.942
	(349)	(270)	(268)	(887)
Non-Overconfident CEOs	2.356***(†)	2.400***	2.692***	2.483***
	(168)	(168)	(168)	(504)
Entire Sample	2.014(†††)	2.172	2.251	
	(517)	(438)	(436)	

Panel B – Using Eq. (3) to estimate the speed of adjustment for each firm

	Low SOA sub-sample	Medium SOA sub-sample	High SOA sub-sample	Entire Sample
Overconfident CEOs	1.916	1.931	1.987	1.942
	(331)	(292)	(264)	(887)
Non-Overconfident CEOs	2.414***(†)	2.272***(†††)	2.762***	2.483***
	(168)	(168)	(168)	(504)
Entire Sample	2.084(††)	2.056(†††)	2.29	
	(499)	(460)	(432)	

TABLE 6

Difference-in-differences estimation method

Table 6 presents the difference-in-differences analysis using the 2012 US-Korea Free Trade Agreement as an exogenous shock. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. *HighTariff* is a dummy variable equal to one if the firm experiences tariff reductions following the FTA in excess of 2.5% (top tercile of the tariff distribution), and zero otherwise. *PostFTA* is a dummy variable equal to one for observations in the post-2012 period, and zero otherwise. Year dummies are included in all the regressions to control for year fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firms are reported in parentheses.

	CEO_OC = 1	CEO_OC = 0
	(1)	(2)
DevCash	-0.237***	-0.238***
	(0.016)	(0.015)
HighTariff	0.003**	0.006**
	(0.002)	(0.002)
PostFTA	-0.001	0.030**
	(0.011)	(0.014)
DevCash * PostFTA	0.074***	0.086***
	(0.023)	(0.030)
DevCash * HighTariff	0.051*	-0.044
	(0.030)	(0.035)
PostFTA * HighTariff	0.011***	0.005
	(0.003)	(0.004)
DevCash * HighTariff * PostFTA	-0.169***	-0.103
	(0.055)	(0.064)
Constant	0.027***	0.020
	(0.010)	(0.013)
Controls	Yes	Yes
Observations	9,651	8,774
Adj. R-squared	0.275	0.264

TABLE 7

Propensity score matching estimation method

Table 7 presents the propensity score matching estimation results. Panel A reports the results from logit regressions of the likelihood of the presence of overconfident CEOs. The dependent variable is a dummy variable set to one if the CEO is overconfident, and zero otherwise. Panel A presents the pre-match logit regression predicting the probability of having an overconfident CEO and the post-match diagnostic regression. Panel B presents the univariate comparison between the treatment group (firm-year observations with overconfident CEOs) and the control group (firm-year observations with non-overconfident CEOs). Panel C presents estimates of the average treatment effect. The dependent variable is the annual change in cash. Variable definitions are given in the Appendix. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. Standard errors robust to clustering by firm are reported in parentheses. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively.

Panel A – Logit regression results

	Pre-match	Post-match
	(1)	(2)
DevCash	0.206	0.184
	(0.776)	(0.657)
Size	-0.074**	-0.004
	(-2.300)	(-0.111)
Tobin's Q	-0.484***	-0.013
	(-7.809)	(-0.430)
Dividend	-0.498***	0.045
	(-5.466)	(0.478)
IndSigma	-2.102***	0.020
	(-2.952)	(0.028)
CFR	-0.503	0.119
	(-1.516)	(0.350)
NWC	-0.773**	0.037
	(-2.574)	(0.116)
CAPEX	-2.154***	-0.211
	(-3.089)	(-0.277)
Leverage	0.210	-0.017
	(1.068)	(-0.083)
R&D	-0.003	0.390
	(-0.003)	(0.473)
Acquisitions	-0.891**	-0.015
	(-2.494)	(-0.038)
Age	0.181***	0.030
	(2.662)	(0.424)
Constant	2.546***	-0.085
	(6.547)	(-0.197)
Observations	23,868	14,938
Pseudo R-squared	0.070	0.001

TABLE 7 (continued)

Panel B – Differences in firm characteristics

	Treatment Group (CEO_OC = 1)	Control Group (CEO_OC = 0)	Difference	*t*-test
DevCash	0.001	-0.002	-0.003	-1.324
Size	7.367	7.385	0.018	0.668
Tobin's Q	1.930	1.945	0.014	0.709
Dividend	0.508	0.498	-0.010	-1.276
IndSigma	0.062	0.061	0.000	-0.435
CFR	0.074	0.075	0.000	0.099
NWC	0.067	0.066	-0.001	-0.262
CAPEX	0.054	0.054	0.001	0.723
Leverage	0.235	0.237	0.002	0.480
R&D	0.033	0.032	-0.001	-1.070
Acquisitions	0.028	0.028	0.000	0.324
Age	3.113	3.109	-0.004	-0.359

Panel C – PSM estimator

	Treatment Group (CEO_OC = 1)	Control Group (CEO_OC = 0)	Difference	*t*-test
ΔCash	0.001	-0.001	-0.002**	-1.935

TABLE 8

The effect of financial constraints

Table 8 presents the regressions of CEO overconfidence on the speed of adjustment for the cash ratio for the sub-samples of firm-year observations according to their financial constraints status. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. *CEO_OC* is a dummy variable that equals one for firms managed by overconfident CEOs, and zero otherwise. For each year, we define financially constrained firms as those: (i) that do not pay dividends; (ii) that do not have credit ratings; and (iii) with an SA index value above the sample median. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firm are reported in parentheses.

	Dividends		Credit Rating		SA Index	
	Constrained	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained
	(1)	(2)	(3)	(4)	(5)	(6)
DevCash	-0.253***	-0.189***	-0.243***	-0.216***	-0.255***	-0.207***
	(0.007)	(0.008)	(0.006)	(0.011)	(0.007)	(0.007)
CEO_OC	-0.006***	-0.002**	-0.005***	-0.001	-0.005***	-0.002*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
DevCash*CEO_OC	0.031***	-0.012	0.031***	-0.014	0.041***	-0.003
	(0.011)	(0.010)	(0.009)	(0.014)	(0.010)	(0.010)
Constant	0.036**	0.013**	0.047***	-0.015**	0.045***	-0.001
	(0.015)	(0.006)	(0.010)	(0.008)	(0.012)	(0.009)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11,747	12,121	16,877	6,991	11,931	11,937
Adj. R-squared	0.279	0.231	0.273	0.201	0.261	0.257

TABLE 9

The role of the debt level

Table 9 presents the regressions of CEO overconfidence on the speed of adjustment for the cash ratio for the sub-samples of firm-year observations according to the level of the debt ratio. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. *CEO_OC* is a dummy variable that equals one for firms managed by overconfident CEOs, and zero otherwise. *CreditRisk* is a dummy variable that equals one if the interest coverage ratio for a firm *i* in year *t* is lower than two, and zero if the interest coverage ratio is equal to or higher than two. Interest coverage ratio is defined as the firm's EBIT divided by the interest expenses. Regression (1) is based on the sub-sample of firm-year observations with no debt in their capital structure. Regression (2) is based on the sub-sample of firm-year observations with low debt levels, i.e. debt levels not exceeding 15% of the firm's total assets. Regression (3) is based on the sub-sample of firm-year observations with high debt levels, i.e., debt levels above 50% of the firm's total assets. Year and industry dummies are included in regressions (1), (2), and (3) to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firms are reported in parentheses.

	Zero debt (1)	Low debt (2)	High debt (3)
DevCash	-0.289***	-0.246***	-0.320***
	(0.015)	(0.011)	(0.030)
CEO_OC	-0.003	-0.004*	0.001
	(0.004)	(0.002)	(0.005)
DevCash* CEO_OC	0.062***	0.047***	0.087**
	(0.022)	(0.016)	(0.038)
CreditRisk	-0.001	-0.017***	0.001
	(0.009)	(0.005)	(0.005)
DevCash* CreditRisk	-0.071*	-0.051**	0.125***
	(0.042)	(0.022)	(0.039)
CEO_OC* CreditRisk	-0.004	0.011*	-0.010
	(0.011)	(0.006)	(0.006)
DevCash* CEO_OC* CreditRisk	0.027	-0.023	-0.157***
	(0.057)	(0.033)	(0.052)
Constant	0.140***	0.045***	-0.004
	(0.032)	(0.013)	(0.030)
Controls	Yes	Yes	No
Observations	2,842	6,088	2,176
Adj. R-squared	0.350	0.332	0.202

TABLE 10

Alternative CEO overconfidence measures

Table 10 presents the regressions of CEO overconfidence on the speed of adjustment for the cash ratio using two alternative measures for CEO overconfidence. For regressions (1) and (2), CEO overconfidence is defined as per Campbell et al. (2011) with overconfident CEOs holding more than 100% in the money options (*CEO_OC100*). For regressions (3) and (4), CEO overconfidence is based on the post-overconfidence measure (*Post*), which is a binary measure that equals one in all CEO-years following (and including) the first year in which the CEO options are 67% in the money, and zero otherwise. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firm are reported in parentheses.

	CEO_OC100		Post	
	(1)	(2)	(3)	(4)
DevCash	-0.277***	-0.243***	-0.269***	-0.230***
	(0.005)	(0.005)	(0.004)	(0.004)
CEO_OC100	-0.002*	-0.004***		
	(0.001)	(0.001)		
DevCash * CEO_OC100	0.023***	0.034***		
	(0.008)	(0.007)		
Post			-0.001	-0.002*
			(0.001)	(0.001)
DevCash * Post			0.023**	0.026***
			(0.010)	(0.009)
Constant	-0.004	0.031***	-0.005	0.028***
	(0.005)	(0.006)	(0.005)	(0.006)
Controls	No	Yes	No	Yes
Observations	23,868	23,868	23,868	23,868
Adj. R-squared	0.187	0.257	0.186	0.256

TABLE 11

The role of corporate governance

Table 11 presents the regressions of CEO overconfidence on the speed of adjustment for the cash ratio after controlling for the quality of the firm's governance. The dependent variable is the annual change in cash. *DevCash* is the difference between target cash holdings and actual cash holdings. *CEO_OC* is a dummy variable that equals one for firms managed by overconfident CEOs, and zero otherwise. Regression (1) includes the *GoodGov* variable that equals one if the Bebchuk et al. (2009) entrenchment index from RiskMetrics equals zero, and zero otherwise. The index is a count variable based on the presence of the following provisions: 1) a classified board; 2) limitations to shareholders' ability to amend the bylaws; 3) supermajority voting for business combinations; 4) supermajority requirements for charter amendments; 5) poison pills; and 6) golden parachutes. Regression (2) controls for CEO/Chairman duality using a dummy variable that equals one if the CEO of the firm is also the chairman of the board, and zero otherwise. Year and industry dummies are included in both regressions (1) and (2) to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firms are reported in parentheses.

	Entrenchment index	Duality
	(1)	(2)
DevCash	-0.219***	-0.249***
	(0.007)	(0.006)
CEO_OC	-0.004***	-0.003***
	(0.001)	(0.001)
DevCash * CEO_OC	0.027***	0.027***
	(0.007)	(0.007)
GoodGov	-0.001	
	(0.001)	
DevCash * GoodGov	-0.028***	
	(0.008)	
Duality		-0.002**
		(0.001)
DevCash * Duality		0.026***
		(0.008)
Tenure		0.0001319**
		(0.0000625)
Gender		0.002
		(0.003)
Constant	0.032***	0.029***
	(0.006)	(0.007)
Controls	Yes	Yes
Observations	23,868	23,426
Adj. R-squared	0.257	0.259

TABLE 12
Alternative estimation methods

Table 12 Panel A represents the second step of the estimation results of the speed of adjustment of cash holdings using system GMM (regressions (1) to (3)) and Driscoll-Kraay (regressions (4) to (6)). The estimation results for estimating the target ratio in the first step using both methods are not reported in this table. *DevCash* is the difference between target cash holdings and actual cash holdings, where target cash is the predicted value from the cash holdings regression. Year and industry dummies are included in all the regressions to control for year and industry fixed effects. The significance levels of 10%, 5%, and 1% are represented by *, **, ***, respectively. Standard errors robust to clustering by firm are reported in parentheses. Panel B presents the descriptive statistics for the target cash levels and the deviations from target cash levels across different first-stage estimation methods, namely annual cross-sectional regressions, system GMM, and Driscoll-Kraay.

Panel A – Second step of the estimation results of the speed of adjustment of cash holdings using system GMM and Driscoll-Kraay

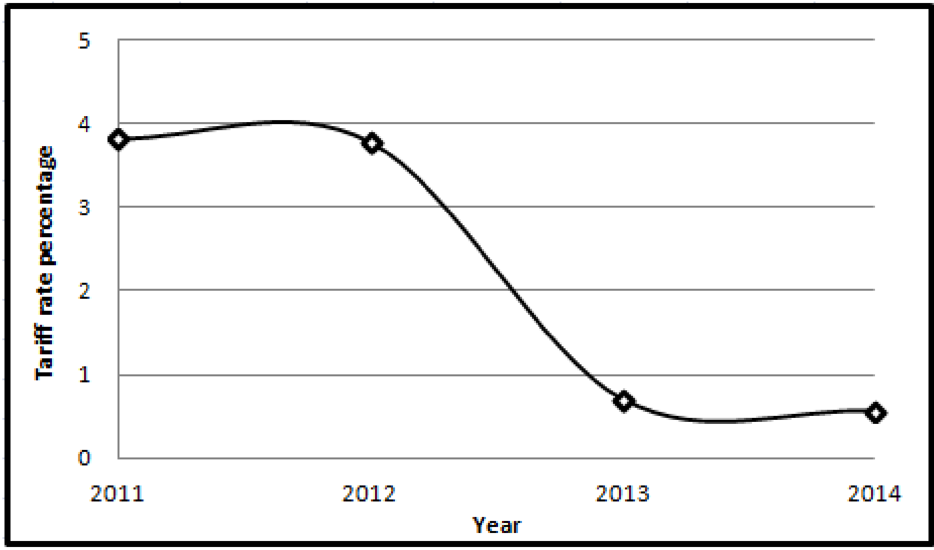
	System GMM			Driscoll–Kraay		
	(1)	(2)	(3)	(4)	(5)	(6)
DevCash	-0.753***	-0.723***	-0.862***	-0.256***	-0.286***	-0.244***
	(0.016)	(0.017)	(0.017)	(0.004)	(0.004)	(0.004)
CEO_OC		-0.002*	-0.004***		-0.002	-0.004***
		(0.001)	(0.001)		(0.001)	(0.001)
DevCash * CEO_OC		0.167***	0.135***		0.096***	0.091***
		(0.007)	(0.006)		(0.006)	(0.006)
Constant	-0.010**	-0.008	0.066***	-0.007	-0.004	0.030***
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)
Controls	No	No	Yes	No	No	Yes
Observations	21,953	20,284	20,284	21,955	20,286	20,286
Adj. R-squared	0.107	0.131	0.264	0.182	0.191	0.265

Panel B – Descriptive statistics for target cash levels and deviations from target cash levels using annual cross-sectional regressions, system GMM, and Driscoll-Kraay

Method	Target		DevCash	
	Mean	Median	Mean	Median
Annual cross-sectional regressions	0.151	0.121	-0.001	0.016
GMM	0.148	0.089	0.004	-0.002
Driscoll–Kraay	0.151	0.121	0.000	-0.016

Figure 1

Figure 1.A shows the overall average percentage tariff of Korean imports to the USA between 2011 and 2014 for all industries. The x-axis represents the year whereas the y-axis represents the tariff rate percentage. Figure 1.B shows the aggregate values of imports across all industries from Korea to the USA between 2011 and 2014. The x-axis represents the year whereas the y-axis represents the import values in billions of US$ (nominal values). Source: World Integrated Trade Solution (WITS; https://wits.worldbank.org/)



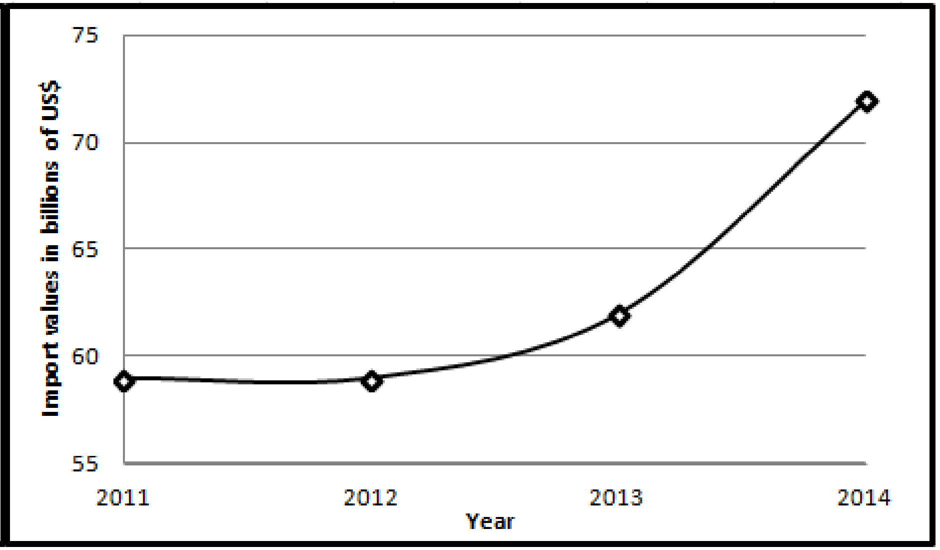


Figure 1.A: Overall Average Tariff (%)

Figure 1.B: Aggregate Value of Imports across all Industries (in billions of US$)

Appendix

TABLE A

Definition of variables and Compustat data items

Variable	Definition
Cash Holdings:	
Cash	Ratio of cash and short-term investments to total assets (CHE/AT).
Target	Target cash holdings level, defined as the predicted value from the annual cross-sectional regressions of Opler et al. (1999) and Bates et al. (2009), which include lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditures, leverage, dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and expenditures on acquisitions.
DevCash	Deviation from target cash holding level, which is the difference between this year's fitted cash holdings based on the annual cross-regression model and last year's actual cash holdings.
High	Dummy variable, set to on if the level of actual cash is larger than the target cash, and zero otherwise.
Firm Characteristics:	
Size	Firm size calculated as the logarithm of total assets (AT).
NWC	Net working capital ratio ((WCAP – (CH + MSA))/AT).
IndSigma	Industry risk calculated as the ten-year rolling window median volatility of cash flow/assets across the 48 Fama-French industries. See Dittmar and Duchin (2010).
CF	Cash flow ratio calculated as earnings less interest and taxes (IB+DP), divided by total assets (AT). See Dittmar and Duchin (2010).
CAPEX	Capital expenditure divided by total assets (CAPX/AT).
Tobin's Q	The market value of assets, defined as book value of assets (AT) minus book value of equity (CEQ) plus market value of equity (CSHO*PRCC) minus deferred taxes (TXDB) divided by book value of assets (AT). See Kaplan and Zingales (1997).
Leverage	Total debt divided by total assets ((DLTT +DLC) / AT).
Dividend	Dummy variable, set to one if if the firm paid in the year any common dividends (DV), and zero otherwise.
R&D	Research and development expenditures over total assets (XRD/AT).
Age	The logarithm of the number of years the firm has been covered by the Compustat database.
Acquisitions	The ratio of expenditures on acquisitions to the book value of total assets (AQC/AT).
Managerial Characteristics:	
Option moneyness	For each CEO-year, we measure the realizable value per option by dividing the total realizable value of the options from ExecuComp (OPT-UNEX-EXER-EST-VAL) by the number of exercisable options (OPT-UNEX-EXER-NUM). We then subtract the average realizable value per option from the stock price (PRCC-F) to estimate the average exercise price. The average option moneyness ratio then equals the per option realizable value divided by the average exercise price ((PRCC-F/PRCC-F- (OPT-UNEX-EXER-EST- VAL/OPT-UNEX-EXER-NUM))-1).
CEO_OC	A dummy variable, measuring CEO overconfidence and set to one if if *Option moneyness* exceeds 67% at least once during the sample period, and zero otherwise.
Corporate Governance:	
E-index	We follow Bebchuk et al. (2008) to construct the entrenchment index (E-index) as follows: we augment the index by 1 for the presence of each of the following provisions: (i) classified board; (ii) limitations to shareholders' ability to amend the bylaws; (iii) supermajority voting for business combinations; (iv) super-majority requirements for charter amendments; (v) poison pills; and (vi) golden parachutes.
GoodGov	Dummy variable: 1 if for the sample of firm-year observations with an E-index value of zero, and 0 otherwise.
Duality	Dummy variable: 1 if if the CEO is also the chairman of the firm, and 0 otherwise.
Financial Constraints Measures:	
Dividends	Firm-year observations with zero dividends are classified as financially constrainted, and otherwise as financially unconstrainted.
Credit Rating	Firm-year observations without an S&P Domestic Long Term Issuer Credit Rating (SPLTICRM) are classified as constrained, otherwise as financially unconstrained.
SA Index	Observations with an SA index above the sample median are classified as financially constrained. The SA index is the Size-Age Index and is measured as HP = −0.737*SIZE + 0.043*SIZE2 − 0.04*AGE1 where AGE1 is measured as the number of years since the firm's incorporation.

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