The Dynamics of Cash

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August 2011

Abstract

In this paper, we show that firms monotonically and substantially decrease their cash holdings over the corporate life-cycle, presenting a contrasting view to the aggregate upward trend in corporate cash holdings in recent years. Further, the dynamics and theoretical models that govern firm's cash holdings change drastically as a firm matures. Young firms adjust cash holdings towards a precautionary savings-based target ratio and time equity markets to raise cash. In contrast, mature firms rebalance their cash more slowly and let their cash holdings vary with transitory fluctuations in their financing deficit, consistent with the financing hierarchy hypothesis. Overall, our evidence calls into question the precautionary savings motive as the unified framework to understanding corporate cash holdings and suggests that existing cash models hold for young firms but fail to explain the cash holdings of mature firms. By showing that different models apply at different stages of the life cycle, this paper reconciles conflicting theoretical literatures on financing and cash policy.

JEL classification: G30; G31; G32

Keywords: cash holdings, life-cycle, precautionary savings, financing hierarchy, market timing

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* We appreciate helpful comments from Viral Acharya, Kenneth Ahern, Murillo Campello, Michael Faulkender, Charles Hadlock, Peter Iliev, Jan Mahrt-Smith, John Matsusaka, Oguzhan Ozbas, Henri Servaes, Ivo Welch, Toni Whited, an anonymous referee and associate editor, and seminar participants at the 2011 American Finance Association, 2010 European Finance Associations, and University of Michigan. Contact the authors at The Ross School of Business, University of Michigan, Ann Arbor, MI 48109-1234; adittmar@umich.edu and duchin@umich.edu.

> *"U.S. companies are holding more cash in the bank than at any point on record, underscoring persistent worries about financial markets and about the sustainability of the economic recovery…. (In 2008), even large companies faced the threat that they wouldn't be able to do the everyday, short-term borrowing needed to make payrolls and purchase inventory."* WSJ, U.S. Firms Build Up Record Cash Piles, June 10, 2010

As the above quote indicates, the conventional wisdom motivating firms' increasing demand for cash, dating back to Keynes' precautionary savings motive (1936), is that it provides financing when the firm may not have sufficient funds to invest or meet its obligations [Kim et al. (1999)]. This general idea is consistent with recent survey evidence [Lins et al. (2010); Campello et al. (2011)] and the existing empirical findings. For instance, Opler et al. (1999) show that firms with lower, more volatile cash flows and higher investment opportunities hold more cash; Almedia et al. (2004) find that financially constrained firms save more cash out of cash flow; and, Bates et al. (2009) show that firms' cash holdings have steadily increased since 1980 and that this increase in cash is explained by the precautionary savings motive.

This paper questions the precautionary savings-based framework as the unified economic driver of firms' cash policies. We analyze the firm-level evolution of cash holdings over the corporate life-cycle. Contrary to the monotonic *increase* in aggregate cash holdings over the last three decades, firm-level cash holdings monotonically *decline* each year, as firms age. Further, the models and dynamics that govern cash policies change drastically over time. Whereas young firms actively maintain a target cash ratio, which is largely determined by the precautionary savings motive, and exploit high market valuations to raise cash [Baker and Wurgler (2002)], older firms adjust their cash ratios much slower, with significantly less regard for the precautionary savings motive. Instead, older firms allow their cash balances to fluctuate with transitory financing deficits and surpluses. This evidence indicates that existing cash models based on average or aggregate evidence are tilted to reflect the policies of young firms, potentially due to the influx of new listings [Fama and French (2004)]. In contrast, the literature does a poor job at explaining cash policies of older firms, despite the fact that these firms hold the majority of corporate cash in the U.S. Taken together, our results reconcile diverging theoretical models of financing by showing that these models apply at different stages of the corporate life-cycle.

We begin by examining the dynamics of firms' cash holdings over event time, starting at a firm's IPO. As illustrated in Panel A of Figure 1, the average firm-level ratio of cash to book assets exhibits a sharp and steady decline as a firm goes from 1 to 50 years following its IPO, resulting in substantial differences between young and mature firms: Firms listed for 1 (5) years hold an average of 36.0% (24.9%) of their assets in cash, whereas firms that are listed for 25 (30) years hold on average 13.3% (11.6%) of their assets in cash, reflecting a decline of about 23 (13) percentage points. Panels B through D of Figure 1 show that this life-cycle trend is not driven by outliers, isolated to a few industries, or the result of an influx of new firms in any one period. This trend is considerably different than the one that is implied by the monotonically upward-sloping trend in aggregate cash holdings found by Bates et al. (2009).

We next ask why cash ratios decline over the corporate life-cycle, focusing on the predominant, precautionary savings-based approach to understanding corporate cash holdings. Our evidence shows that, perhaps not surprisingly, firms' cash flows increase substantially while their capital expenditures decline sharply over time. Firms' cash-flows increase from -3.3% when they are listed for less than five years to 7.9% of book assets when they are 46-50 years of age. Conversely, firms' capital expenditures decline from 7.5% at 1-5 years of age to 5.7% at 46-50 years of age. Combined with a decrease in the volatility of cash flows, these findings suggest that the precautionary savings motive for holding cash will lead firms to hold less cash over their life-cycle. Consistent with a declining need for precautionary cash, we show that the youngest quintile of firms has a predicted cash ratio of 24.1% whereas the oldest quintile of firms has a predicted ratio of 16.8%, based on the full sample and using variables related to the precautionary savings motive to predict the cash ratio.

The above comparison uses a common model of cash policy across all firms. However, the predicted cash ratios consistently underestimate (overestimate) the cash holdings of young (old) firms. In particular, the above predicted values underestimate the actual cash of the youngest firms by 9.2% and overestimate the cash of the oldest firms by 6.8%. These findings suggest that the standard empirical models of cash holdings [e.g., Opler et al. (1999) and Bates et al. (2009)] may not apply uniformly across the life-cycle. To test whether and how the empirical cash model changes over the life-cycle, we allow the regression coefficients to vary across age quintiles. The results are compelling. The coefficients on all of the variables associated with the precautionary savings motive (cash flow volatility, cash flow, the market-to-book ratio, and capital expenditure) decrease in importance over the life of a firm, and the differences across the age quintiles are highly statistically significant at the 1% level. Thus, both the need for holding precautionary cash and the validity of the precautionary savings model decline as a firm ages. To illustrate this effect, if we were to predict cash holdings based on the youngest (oldest) firms, we would overestimate (underestimate) the actual cash ratios of the oldest (youngest) firms by 14.8 (17.4) percentage points. Moreover, even when we estimate the model separately across age quintiles, its explanatory power is asymmetrically lower for older firms: the adjusted R-squared of the model falls from 0.55 in the youngest quintile to 0.36 in the oldest quintile. These results suggest that our current cash theories do a reasonable job at explaining the cash of young firms but cannot explain the cash holdings of mature firms. This conclusion is particularly troubling since over 50% of the total amount of corporate cash held by public firms in the U.S. is concentrated in the top age quintile.

If the precautionary savings motive does not explain how older firms manage their cash holdings, what drives these firms' cash policies? To answer this question, we investigate three non-mutually-exclusive dynamics of cash policies. First, we examine whether a generalized tradeoff model of cash, where firms weigh costs and benefits to determine a target cash ratio, consistently holds for all age quintiles. To investigate how firms manage cash to a target, we estimate partial adjustment models of cash ratios across age quintiles. These models are discussed collectively in Fama and French (2002), Flannery and Rangan (2006), and Lemmon, Roberts, and Zender (2008), among others. We find that the speed of adjustment (SOA) decreases monotonically through a firm's life-cycle. These results are robust across various measures of SOA and are highly statistically significant at the 1% level. The economic magnitudes are substantial: using the OLS-based measure of SOA, we estimate the annual SOA of cash to be 0.30 for firms in the youngest quintile and 0.16 for firms in the oldest quintile.[1] The results suggest that older firms have weaker motives to adjust their cash holdings towards a target ratio. Coupled with the decreasing importance of the precautionary savings motive, these results strongly suggest that the commonly-used model of cash does not apply to older firms.

The second alternative hypothesis that we examine is whether cash management adheres to a market timing theory of corporate financing. This hypothesis suggests that firms exploit temporary fluctuations in the cost of equity relative to other forms of financing to raise capital [Loughran and Ritter (1995, 1997); Baker and Wurgler (2002)]. If firms stockpile the proceeds in cash, as found by Kim and Weisbach (2008), this hypothesis implies that cash reserves will be persistently positively correlated with the overvaluation of a firm's equity. Using a measure similar to that employed in Baker and Wurgler (2002), we find that market timing is an important determinant of cash holdings, statistically significant at the 1% level. However, the importance of market timing in explaining cash holdings decreases monotonically over a firm's life-cycle. A one standard deviation increase in the equity overvaluation-based measure of market timing corresponds to an increase of 3.5% (1.3%) in cash holdings for firms in the youngest (oldest) quintile. This evidence is consistent with declining levels of information asymmetry over a firm's life-cycle, which restricts a firm's ability to take advantage of equity misevaluation.

The third hypothesis that we investigate is the financing hierarchy theory, which implies that there is no optimal level of cash holdings. As proposed by Myers and Majluf (1984), information asymmetries make equity financing costly. Therefore, firms use debt when they do not have sufficient resources, and when they do have enough resources, they repay debt that becomes due, and accumulate cash otherwise. This, in turn, implies that cash rises and falls with the fortunes of the firm. To test this hypothesis, we regress annual changes in the cash ratio on the flow of funds deficit (defined as cash

[1] One way to gain intuition into the meaning of these SOA estimates is to translate them into "half-lives". The SOA is the expected percentage by which the gap between the past cash and the target closes in one period. Half-life is the time that it takes a firm to adjust one-half the distance to its target cash after a one unit shock to the error term. For an AR(1) process, half life is log(0.5)/log(1-SOA). Thus, an SOA of 0.30 implies a half-life of 1.97, whereas an SOA of 0.16 implies a half-life of 3.90. Moving from firms in the youngest quintile to firms in the oldest quintile therefore implies a difference of 1.93 years in terms of half-lives.

dividends plus capital expenditures plus the change in net working capital (excluding cash), plus the current portion of long-term due, minus the operating cash flows, where all variables are deflated by assets). We find that the change in cash is positively related to the financial deficit in younger firms and negatively related to the financial deficit in mature firms. These findings suggest that older firms' cash policies adhere to a financing hierarchy-implied dynamics, under which firms use their cash reserves when deficits are higher and build these reserves when deficits are lower. In contrast, younger firms increase their cash holdings in response to higher deficits, consistent with the precautionary savings view, thus emphasizing a fundamental difference between younger and older firms.

In a final step, we investigate whether various market frictions, which may be correlated with firm age, can explain why cash policies differ so dramatically across the life-cycle. Specifically, we consider information asymmetries, incentives, taxes, and credit constraints, which may all impact the firm's optimal cash holdings and financing policies.[2] To test whether our findings are robust to considering these frictions, we augment our empirical model of cash holdings with proxies for these frictions and re-estimate the results presented throughout the paper. We find that these augmented models continue to underestimate the cash holdings of young firms and overestimate the cash holdings of mature firms. Further, we continue to find a robust effect of a firm's age on the SOA of its cash holdings, as well as its cash holdings' adherence to a market-timing-based financing scheme, and covariance with the financing deficit. These results suggest that firm age is not simply a proxy for the above market frictions and that these frictions do not explain the differences in cash policies across the corporate life-cycle.

Overall, our findings portray a two-tier market structure of corporate cash holdings and reconcile conflicting theoretical literatures on financing and cash policy. Mature firms hold the bulk of cash in terms of dollar amount but their cash holdings remain largely unexplained by the prominent precautionary savings theory of cash. While younger firms actively manage their cash holdings towards a precautionary target level, mature firms' cash policies adhere to a financing hierarchy theory, under which cash holdings

[2] Myers and Majluf (1984), Myers (2003), and Stiglitz (1973) explore the impact of information asymmetry, agency conflicts, and taxes, respectively, on the pecking order of financing. These frictions have been shown to affect cash holdings by e.g., Opler et al. (1999), Harford (1999), Almedia et al. (2004), and Harford et al. (2008).

increase (decrease) when the financing deficit is negative (positive). Our evidence that the corporate life-cycle significantly impacts corporate cash policies is consistent with the studies by DeAngelo et al. (2006, 2010), who show that the corporate life-cycle has nontrivial implications for firms' dividend and issuance policies. Thus, in addition to contributing to the cash literature, this paper builds on this growing literature documenting the importance of the corporate life-cycle.

The paper proceeds as follows. Section I describes the sample and how cash varies over calendar time and the corporate life-cycle. Section II examines the importance of the precautionary savings motive. Section III discusses and tests alternative hypotheses and drivers of the dynamics of cash policy. Section IV explores the implications of various market frictions. Section V provides concluding remarks.

I. The Evolution of Cash Holdings over the Corporate Life-cycle

A. Data

We analyze the evolution of cash holdings over the corporate life-cycle for a sample of 11,414 industrial firms in the CRSP/Compustat file over 1980-2009. Industrial firms are defined as companies with SIC codes outside the ranges 4900-4949 (utilities) and 6000-6999 (financials). We exclude firms that are not incorporated in the U.S. and those that do not have securities assigned a CRSP security code of 10 or 11. A firm enters our sample when it has a nonmissing value for total assets on Compustat and a nonmissing share price on CRSP. A firm remains in the sample as long as Compustat continues to report nonmissing values of total assets and the firm's shares remain listed. For the relatively few firms that change their fiscal year during our sample period, we keep the most recent fiscal year convention.

We winsorize all variables except age at the 1^{st} and 99^{th} percentiles to lessen the influence of outliers. Our two main variables of interest are a firm's *cash holdings* and *age*. *Cash holdings* are defined as cash and short term investments divided by book assets. Table 1 shows that cash holdings have a pooled mean of 21.5% and a pooled standard deviation of 23.1%. The median is at 12.3%, suggesting that the distribution of cash is right-skewed. *Age* is the number of years since the firm's IPO. The IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. The average age of firms in our sample is 11.9 years and the median is 8.0; the standard deviation is 11.8 years. The average values of the other variables are consistent with previous studies. In particular, the average firm has a market-to-book ratio of 2.1, cash flow-to-assets ratio of 1.1%, capital expenditures equal to 6.7% of assets, and a debt-to-assets ratio of 21.4%.

B. How Do Cash Holdings Evolve Over Time?

In Table 2, we compare how cash holdings evolve over calendar time from 1980 to 2009 to how they evolve over a firm's age. The first four columns correspond to calendar time and show that the cross-sectional average cash holding has increased dramatically from 1980 and through our sample period. The average cash-to-assets ratio was 11.9% in 1980, 17.7% in 1990, 24.4% in 2000, and 24.5% in 2009. This increase is not driven by outliers as the median cash ratio has also increased monotonically, from 7.0% in 1980 to 16.4% in 2009. These numbers are consistent with the findings in Bates et al. (2009). The sample period in Bates et al. ends in 2006, just before the subprime mortgage credit crisis. Our findings show that average cash holdings peaked just before the crisis, decreased somewhat in 2008, and started rising again in 2009. The decline in 2008 is consistent with the evidence in Duchin et al. (2010), who show that firms with more cash on hand prior to the crisis cut investment by less. However, collectively, firms used only a fraction of their cash holdings in response to the negative shock to the supply of credit, possibly due to the decline in demand that followed in later stages of the crisis. Interestingly, firms continue to build up their cash reserves in the aftermath of the crisis.

The last four columns of Table 2 present a strikingly different picture for firm-level cash holdings over the corporate life-cycle. While average cash holdings have increased over the last 3 decades, individual firms substantially reduce their cash holdings as they age. Newly-listed firms hold 36.0% of their assets in cash; firms listed for 15 years hold only 17.7% of their assets in cash; and firms listed for

30 years hold 11.6% of their assets in cash. The same downward-sloping trend persists if we consider median cash holding instead of averages, implying that the documented trend is not driven by outliers. The median firm listed for 1 (5) years holds 28.7% (16.8%) of its assets in cash, whereas the median cash holdings at 25 (30) years of age are 7.3% (6.2%) of book assets. These differences are all statistically significant at the 1% level (not reported in Table 2).

Figure 1 plots the time series of cash holdings over the corporate life-cycle. Panels A and B correspond to the reported numbers in Table 2, extending the range of firms' ages to 50 years. We only present firms up to 50 years old because there are very few firms older than 50 years in our sample. Panels A and B show that the average and median cash holdings decline monotonically as firms age. Furthermore, these figures show that the magnitude of the marginal decrease in cash holdings declines with age or, in other words, the relation between cash holdings and age is monotonically decreasing and convex. While the average cash holdings decline by a total of 28.4 percentage points over the first 50 years of a firm's life, 41.7% of this decrease occurs in the first 5 years, and 73.0% of this decrease occurs within 20 years.[3]

One possibility is that these findings are driven by the change in the composition of firms during our sample period due to an influx of newly listed firms (Fama and French (2004)). If these firms tend to hold more cash, our results may be picking up a change in the composition of firms rather than a life-cycle effect. To examine this, Panel C of Figure 1 plots average cash holdings across different firm ages for a constant composition sample, that is, for firms that exist in every year over the sample period 1980-2009. By definition, this sample excludes new listings during our sample period. As Panel C shows, the downward trend in average cash holdings over the corporate life-cycle persists in the constant composition sample, thus suggesting that it is not driven by the influx of newly listed firms.

Another possibility is that our findings are driven by certain industries, in which the demand for cash declines over the life-cycle. Thus, Panel D plots the average cash holdings across the Fama-French

[3] The very early stage of the corporate life-cycle may be impacted by the cash raised in the IPO. Nevertheless, as Figure 1 shows, the above trend holds if we consider those firms that are beyond this post-IPO stage. The results that follow are also robust to the exclusion of those firms.

five industries: Consumer, Manufacturing, Hi-tech, Health, and all other. The Figure shows a similar decline in cash holdings over the life-cycle across each of these industries. In untabulated analysis, we confirm that these results persist across the other Fama-French industry classifications.

Taken together, our results show that corporate cash holdings monotonically decline over the different stages of the corporate life-cycle. This result is particularly interesting because it opposes the trend implied by the aggregate increase in average cash holdings from 1980 to 2006, documented by Bates et al. (2009). In this paper, we investigate why cash ratios decline with age in order to better understand the economic drivers of firms' cash policies. In the next section, we investigate whether the existing cash models, which largely focus on the precautionary savings motive, can explain the cross-sectional variation and decline in cash holdings over the corporate life-cycle.

II. The Precautionary Savings Motive of Cash and the Corporate Life-cycle

The exiting literature on corporate cash holdings proposes that the predominant motivation to hold cash dates back to Keynes' (1936) precautionary savings motive. According to this motive, firms hold liquid assets to hedge against future states of nature in which adverse cash flow shocks, coupled with external finance frictions, may lead to underinvestment or default. The empirical predictions of this theory suggest that firms with lower cash flows, higher cash flow volatility, and better investment opportunities, will hold more cash. Opler et al. (1999) and papers that follow find empirical support for these predictions.

It is therefore possible that firms' cash holdings decline over the life-cycle since the precautionary savings motive weakens. Specifically, young firms tend to hold more cash because they face relatively abundant investment opportunities, limited internally generated cash flows, and higher costs of external finance. Conversely, mature firms have higher profitability, fewer attractive investment opportunities, and higher costs of holding cash (e.g, agency costs of free cash flow). Based on this hypothesis, all firms have some 'optimal' or target cash but that needed precautionary cash is lower (or potentially even zero) for older firms. These explanations are advanced in the context of dividend payments by Fama and French (2001), DeAngelo et al. (2008), and others, and are consistent with DeAngelo et al. (2006, 2010).

To examine how the demand for precautionary savings changes over a firm's life, we examine how several variables related to firms' financing needs evolve. Panel A of Table 3 tracks the changing of the standard empirical proxies for the precautionary savings motive over the corporate life-cycle. Specifically, the firm-year observations in our panel are sorted into bins formed on their age. Each bin corresponds to a range of 5 years of age, starting from ages 1-5, and ending in ages 46-50. The Table reports the average value for the various proxies in each bin.

Consistent with Table 2 and Figure 1, the numbers show that the average cash holding decreases monotonically from the youngest bin (29.0%) to the oldest bin (7.8%). The trend in the other variables presented implies that the decline in cash is accompanied by a decline in the importance of the need for precautionary cash. Specifically, the cash flow-to-assets ratio increases from -3.3% in the youngest bin to 7.9% in the oldest bin. Cash flow volatility, measured at the firm level as the standard deviation of cash flow over a rolling window of the past 10 years, also declines over the life-cycle. Since our calculation of the volatility of cash flow requires 5 years of available data or more, it cannot be calculated for firms in the youngest bin. The volatility of cash flow for firms in the second youngest bin is 7.8%, and it declines to 3.0% for firms aged 31-35 and stays constant thereafter. Also consistent with the weakening of the precautionary savings motive, the market-to-book ratio declines from 2.5 for firms in the youngest bin to 1.5 for firms aged 36-40 years, reflecting a decrease in growth opportunities. Interestingly, it goes up to 1.7 and 2.0 for firms aged 41-45 and 46-50 years, respectively. Finally, capital expenditures and R&D expenditures also decline over the corporate life cycle, while the payout-to-assets ratio goes up.

Panel A of Table 3 also shows that, collectively, the financing deficit, computed as cash flow minus capital expenditures and payout, increases substantially over the life-cycle, from -13.1% for firms in the youngest bin to 0.0% for firms in the oldest bin. These results imply that mature firms are better-positioned to fund investment internally and face significantly lower cash flow uncertainty. This evidence is consistent with the hypothesis that cash holdings decline over the corporate life-cycle due to a parallel decline in the precautionary demand for cash.

To test this directly, Panel B of Table 3 sorts the firm-year observations in our sample into equally-sized quintiles on firm age, which are recalculated annually. We then calculate the predicted cash holdings, estimated from panel regressions explaining firm-level cash holdings using the same set of variables reported in Panel A, which correspond to the precautionary savings motive, and augmented with year fixed effects to account for the time-trend in cash holdings documented by Bates et al. (2009). The ability of the precautionary savings model to explain the decline in cash holdings over the corporate life-cycle can be measured by the accuracy of the predicted cash holdings when compared to the actual cash holdings in each quintile.

The results indicate that the change in the factors driving the precautionary savings motive cannot fully explain the decline in cash holdings over the life-cycle. Specifically, the predicted cash holdings from this model underestimate the cash holdings of firms in the youngest quintile by 9.2 percentage points, and overestimate those of firms in the oldest quintile by 6.0 percentage points. The predicted cash holdings decrease from an average of 24.1% for firms in the youngest quintile to 16.8% for firms in the oldest quintile, a decline of 7.3%. In contrast, actual cash holdings decline by 22.6 percentage points when moving from the youngest quintile to the oldest one. This implies that based on a uniform precautionary savings model, the change in the factors driving the need for precautionary savings explains roughly one third of the decline in cash holdings over the corporate life-cycle.

To further test whether the existing empirical models of cash holdings can explain the decline in cash over the life-cycle, we augment the precautionary savings model with additional determinants of cash holdings, following the model in Bates et al. (2009). Specifically, the set of independent variables is extended to include firm size, a foreign income dummy, net working capital (excluding cash), and leverage. These variables capture the possibility of economies of scale in cash holdings [Miller and Orr (1966)], tax costs associated with repatriating foreign income [Foley et al. (2007)], substitutes for cash holdings [Opler et al. (1999)], and the relation between cash holdings and debt [Acharya et al. (2007)]. Importantly, some of these variables, such as net working capital and cash, are jointly endogenous with cash holdings. Our goal is not to test the causal effects of these variables on cash holdings, but rather, to estimate whether these augmented, possibly endogenous, models are able to explain the decline in cash over the corporate life-cycle.

Panel B of Table 3 shows that even the augmented model of cash holdings does not fully explain the decline in cash holdings over the life-cycle. Specifically, this model underestimates the cash holdings of firms in the youngest quintile by 6.3 percentage points and overestimates those of firms in the oldest quintile by 5.0 percentage points. The predicted cash holdings decrease from an average of 27.1% for firms in the youngest quintile to 15.8% for firms in the oldest quintile, a decline of 11.3 percentage points. This implies that even this comprehensive model of cash holdings only explains one half of the decline in cash holdings over the corporate life-cycle.

These findings suggest that the decline in cash holdings over the corporate life-cycle is only partly explained by the decline in firms' need for precautionary savings. They further imply that even an augmented empirical model of cash holdings, which includes potentially endogenous variables, can only explain about half of the decline in cash over the life-cycle.

Having found that firm characteristics related to the precautionary savings motive only explain a fraction of the decline in cash holdings over the corporate life-cycle, we turn to examine whether the relation between firm characteristics and cash holdings changes over the life-cycle. In other words, we investigate whether the cash model changes over the life-cycle, and whether the various determinants of cash holdings play a different role across the different stages of the life-cycle. To test this possibility, we re-estimate the panel regressions explaining cash holdings separately across quintiles sorted on firms' age. If the cash model changes over time, the regression coefficients, or the sensitivities of cash holdings to the various factors, should change over the life-cycle.

Panel A of Table 4 reports these results. The results are compelling. The coefficients on *all* of the variables associated with the precautionary savings motive decrease in importance over the life of the firm, indicating that the effectiveness of the precautionary savings model as a driver of cash policy is decreasing in the age of the firm.[4] For instance, the coefficient on cash flow volatility decreases from 1.57 in the youngest quintile to 0.47 in the oldest quintile. Furthermore, the coefficients on cash flow and the market-to-book ratio decline from -0.14 and 0.02 to -0.026 and 0.0, respectively. The decline in the economic magnitudes is equally impressive. For example, an increase of one standard deviation in cash flow volatility (the market-to-book ratio) corresponds to an increase of 3.7 (4.6) percentage points in the cash holdings of firms in the youngest quintile, compared to an increase of 1.2 (2.2) percentage points for firms in the oldest quintile. To further determine if the difference in the coefficients is statistically significant, Panel B of Table 4 interacts each of these variables with the firm's age quintile. The results show that the differences in the coefficients across the life-cycle quintiles are also highly statistically significant at the 1% level.

Panel C of Table 4 further illustrates this effect by estimating the regression coefficients in either the youngest or oldest quintile only, and then calculating the predicted cash holdings for all five quintiles. We repeat this analysis with two models: the precautionary savings model and the comprehensive empirical model of cash holdings. The results suggest that if we were to estimate the precautionary savings model using the youngest firms alone, we would find that the oldest firms' predicted cash ratio is 25.6%, or 14.8% *over* their actual cash ratio. Conversely, if we were to estimate the model based on only the oldest quintile, we would find that the youngest firms' predicted cash ratio is 16.0%, or 17.4% *under* their actual cash ratio. As Panel C shows, we obtain qualitatively similar results when we estimate the comprehensive model rather than the precautionary savings model.

Our results indicate that the factors driving the demand for precautionary savings as well as the economic importance of each of these variables decrease over the corporate life cycle. Further, both the precautionary savings model and a more comprehensive model are better able to explain the cash holdings of younger firms than those of mature firms, as evidenced by the decline in the adjusted R-squared from 0.55 in the quintile of the youngest firms to 0.36 in the quintile of the oldest firms. Thus, we

[4] These results are robust to including industry fixed effects as well as a high-tech indicator variable.

find that our current theories of cash holdings are asymmetrically biased towards younger firms: they do a reasonable job at explaining the cash of young firms but cannot explain the cash holdings of mature firms.

Taken together, these results suggest that the unified framework to understanding cash holdings, put forth in prior literature, does not explain the cash holdings of all firms. In particular, the literature provides little insight into understanding the cash policy of older firms. This conclusion is particularly troubling given that these firms hold the bulk of cash in dollar amounts. Panels B and C of Table 1 report the total amount of cash holdings held by firms in each of the age quintiles as of 1980 (Panel B) and 2009 (Panel C). In 1980, 70% of corporate cash was held by firms in the older quintile. In 2009, 50% of the cash is held by firms in the oldest quintile. Therefore, in the next section we explore the dynamics that govern the management of cash policies across the different stages of the corporate life-cycle.

III. Alternative Theories of Cash Management Over The Life-cycle

Our results thus far suggest that firms' cash holdings change drastically over the life-cycle and that the existing cash models can only partly explain the changes. Furthermore, we find that different models correspond to different stages of the corporate life-cycle and that our models are better suited to explain the cash holdings of younger firms than those of older firms. We therefore turn to investigate what are the differences in the way firms manage their cash across the different stages of the life-cycle. To answer this question, we investigate three non-mutually-exclusive dynamics of cash policy and how their importance varies across the stages of firms' life cycles.

Our tests focus on three non-mutually exclusive classes of cash dynamics. First, we examine whether firms manage their cash holdings toward a target cash ratio, which may or may not be driven by the precautionary savings motive. In other words, we investigate if a general model of cash policy, where firms weigh the costs and benefits to determine a target cash ratio, consistently holds for all age quintiles, even if the factors driving that target are different or unclear. Thus, this model is consistent with tradeoff theories of cash policy such as Kim et al. (1999). Our specification, however, is more general in that it does not hinge on a specific set of factors driving the costs and benefits of cash. Specifically, we compare partial adjustment models estimated separately across age quintiles. To the extent that the potential estimation errors are uncorrelated with the corporate life-cycle, this approach mitigates some of the concerns about partial adjustment models raised by previous studies [Iliev and Welch (2010)].

The second alternative hypothesis that we examine is that cash management adheres to a market timing theory of corporate financing. This hypothesis suggests that firms exploit temporary fluctuations in the cost of equity relative to other forms of financing to raise capital [Baker and Wurgler (2002)]. In turn, this hypothesis implies that cash reserves will be persistently positively correlated with the overvaluation of a firm’s equity. Note that this hypothesis does not contradict the target adjustment view. Timing capital markets to raise cash may be consistent with a generalized version of cash rebalancing, under which firms temporarily deviate from their target ratio due to adjustment costs [Leary and Roberts (2005)]. We test the importance of this theory across the various stages of the life-cycle

The third hypothesis that we investigate is the financing hierarchy theory. This view strictly implies that there is no optimal amount of cash. Firms use cash when they do not have sufficient internal resources. When they do have excess resources, after repaying debt that becomes due, they accumulate cash. This implies that cash rises and falls with the fortunes of the firm. We investigate this hypothesis by studying the relation between changes in cash holdings and the financing deficit across the age quintiles. The three subsections below correspond to these hypotheses.[5]

A. Partial Adjustment Models

To test a more general trade off model of cash policy, we estimate the speed of adjustment (SOA) of cash across the different stages of the corporate life-cycle. To calculate the SOA of cash ratios, we estimate a target adjustment model, in which cash adjusts over time to a target. We consider different target

[5] Another alternative hypothesis may be that older firms have more established banking relationships and are therefore more likely to be able to obtain and use lines of credit, thus providing a substitute for cash holdings. However, the existing evidence suggests that this is not the case. Sufi (2009) examines the relation between the firm's age and lines of credit. He shows that age is negatively (but often insignificantly) related to the probability of having a line of credit and to the use of lines of credit relative to overall liquidity.

adjustment estimation procedures, building on the voluminous body of research on capital structure rebalancing.

Next, we describe the different methods used to investigate cash target adjustment. Tests of capital structure target behavior go back to Taggart (1977) and Auerbach (1985).[6] In their general form, applied to cash, these models are given by:

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

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

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

We consider 3 different estimators of the speed of adjustment (SOA) of cash ratios. The first, which we call *OLS*, is a pooled OLS regression. In this estimate, cash is regressed on past cash and a set of control variables similar to the ones employed in Bates et al. (2009), which include lagged cash flow, industry cash flow volatility, Tobin's Q, capital expenditure, debt, a dividend dummy, firm size, net working capital (excluding cash), R&D expenditures, and acquisitions:

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

where X_{it-1} is the vector of control variables. This procedure resembles the procedure to estimate target capital structure in Fama and French (2002) and Lemmon, Roberts, and Zender (2008).[7]

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

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

[6] More recent examples include Shyam-Sunder and Myers (1999), Welch (2004), and Chang and Dasgupta (2009).
[7] We have also estimated Eq. (3) in differences instead of levels and obtained similar results.

However, one potential problem with the *FE* estimator is that the fixed effects consume a large number of degrees of freedom. As discussed in Huang and Ritter (2009) and Iliev and Welch (2010), the loss of degrees of freedom may lead to the 'Hurwicz bias', implying mean-reversion even when there is not one. This bias arises in small samples, with few firms and time periods, where the lagged residuals and the independent variables are not orthogonal. In our context, a large error term in period *t* will create a large independent variable in period *t+1*, thus violating the orthogonality assumption. While this bias is not important for the *OLS* estimator (Eq. (3)) because our sample is large, with many more firms than time periods, it reappears with the *FE* estimator (Eq. (4)) because the intercepts assume the mean error realizations. One possible solution is to use the GMM procedure in Blundell and Bond (1998), as implemented by Lemmon, Roberts, and Zender (2008).[8]

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

Table 5 reports the results of the different estimators across the age quintiles. The table reports 1-α from Eq. (3) and (4), which is simply the coefficient on lagged cash. This coefficient should be interpreted as the 1-SOA or 1 minus the rate of adjustment to the target. The main take away from Table 5 is that the speed of cash adjustment declines monotonically with the firm's age. The *OLS* model results suggest that the SOA of cash falls from 0.30 to 0.16 when moving from the youngest quintile to the oldest quintile, whereas the *FE* model suggests it falls from 0.87 to 0.36, and the *GMM* model suggests it drops from 0.43 to 0.29. As the interaction terms of *Age x Lagged cash* suggest, the drop over the corporate life-

[8] An econometric derivation of the *GMM* estimator is beyond the scope of our paper. Intuitively, the moment conditions are derived based on the argument that firms-specific residuals, $Cash_{it} - (1-\alpha)\cdot Cash_{it-1}$, are uncorrelated with lagged cash.

cycle is statistically significant at the 1% level in all cases. Thus, we conclude that irrespective of the estimation procedures, the readjustment of cash ratios monotonically declines over the corporate life-cycle.

One way to gain intuition into the meaning of these SOA estimates is to translate them into "half-lives." The SOA is the expected percentage by which the gap between the past cash and the target closes in one period. Half-life is the time that it takes a firm to adjust one-half the distance to its target cash after a one unit shock to the error term. For an AR(1) process, half life is log(0.5)/log(1-SOA). Thus, for example, the *OLS* estimate indicates a half life of 1.97 years for firms in the youngest quintile and a half life of 3.90 for firms in the oldest quintile, a difference of 1.93 in terms of half-lives. These results suggest that the cash holdings of older firms are not managed as actively towards a target ratio as those of younger firms. One possible interpretation of these results is that older firms do not have a target cash ratio or that they are less concerned about rebalancing their cash towards a target ratio. We revisit this interpretation when we investigate the financing hierarchy view below. Another interpretation is that older firms face higher adjustment costs. While this is inconsistent with the standard view that financing costs decrease over the life-cycle [DeAngelo et al. (2006,2010)], we address this possibility directly in section IV, when we examine the influence of several market frictions on cash policy.

B. Market Timing

The second alternative hypothesis that we examine is that cash management adheres to a market timing theory of corporate financing. This hypothesis suggests that firms exploit temporary fluctuations in the cost of equity relative to other forms of financing to raise capital. This theory is fueled by evidence that firms that conduct seasoned equity offerings (SEOs) typically have high equity valuations that increase markedly before the SEO [Asquith and Mullins (1986), Masulis and Korwar (1986), and Korajczyk, Lucas, and McDonald (1991)]. If the relation between high market valuations and equity issuance is due to misvaluation [Loughran and Ritter (1995, 1997) and Baker and Wurgler (2002)], then firms may issue at times when they do not need to fund investment, leading to an increase in cash reserves.[9]

Thus, if firms stockpile the SEO proceeds in cash, as found by Kim and Weisbach (2008), adherence to the market timing hypothesis implies that cash reserves will be persistently positively correlated with the overvaluation of a firm's equity. In this subsection, we test the importance of the market timing hypothesis for firms' cash policies across the different stages of the corporate life-cycle. We use a *Market timing* measure similar to that employed in Baker and Wurgler (2002), which measures the interaction between external financing decisions and the market-to-book ratio. Formally, this measure is defined as the "external finance weighted-average" market-to-book ratio:

$$Market\ timing = \sum_{s=1}^{t-1} \frac{e_s + d_s}{\sum_{r=1}^{t-1} e_r + d_r} \left(\frac{M}{B}\right)_s \qquad (5)$$

Where e_s, d_s are net equity issues and net debt issues, respectively, and *t=1* is the first year after the IPO. As Baker and Wurgler point out, this variable is a practical summary of the market-to-book ratios that prevailed when external finance decisions were being made. It takes high values for firms that raised external finance – equity *or* debt – when the market-to-book ratio was high.

Table 6 reports the results of estimating panel regressions explaining firm-level cash holdings with the *Market timing* measure and the comprehensive set of control variables. Column 1 reports the results for the entire sample. We find a positive correlation between cash holdings and market timing, statistically significant at the 1% level. Column 2 interacts market timing with a firm's age and shows that the effect of market timing diminishes as the firm ages. This decline is statistically significant at the 1% level. The last four columns estimate similar regressions separately for each age quintile, starting with the second quintile, since the youngest firms in the first quintile do not have a long enough time-series to calculate the *market timing* measure. The coefficient is cut by more than 50% when moving from the

[9] Other reasons that may lead to the relation between price and issuances include time-varying information asymmetry [Lucas and McDonald (1990) and Choe, Masulis and Nanda (1993)] and agreement between managers and investors [Dittmar and Thakor (2007)]. However, these motives should not lead to an increase in cash holdings since these firms issue equity to fund investment.

youngest firms, with a market timing coefficient of 0.02, to the oldest firms, with a market timing coefficient of 0.009.

These results suggest that the importance of market timing in explaining cash holdings decreases monotonically over a firm's life-cycle. Economically, a one standard deviation increase in the equity overvaluation-based measure of market timing corresponds to an increase of 3.5% (1.3%) in cash holdings for firms in the youngest (oldest) quintile. This evidence is consistent with declining levels of information asymmetry over a firm's life-cycle, which restricts the firm's ability to take advantage of equity misevaluation.

C. Financing Hierarchy

The third hypothesis that we investigate is the financing hierarchy theory, which implies that there is no optimal level of cash holdings. As proposed by Myers and Majluf (1984), information asymmetries make equity financing too costly; therefore, firms prefer to finance investments internally and use debt only when they do not have sufficient resources. Alternatively, when cash flow exceeds investment needs, firms repay debt that comes due and accumulate any additional cash. This, in turn, implies that cash rises and falls with the fortunes of the firm. Assuming that holding cash has no costs for the shareholders, there is no reason for shareholders to object if the firm has large amounts of cash at times.

To test this hypothesis, our specification follows that of Opler et al. (1999), estimated separately across the corporate life-cycle quintiles. Specifically, we assume that changes in cash holdings are given by the flow of funds deficit, measured as cash dividends plus capital expenditures plus the change in net working capital (excluding cash), plus the current portion of long-term due, minus the operating cash flows, normalized by total assets. The financing hierarchy view predicts that a firm's cash is negatively correlated with its financing deficit. This is so because under this view, firms first use their cash to cover financing deficits before issuing debt, and symmetrically, they save their cash surpluses after repaying debt that become due. Indeed, Opler et al. (1999) find a highly statistically significant negative relation between changes in cash holdings and the flow of funds deficit.

Table 7 reports the estimation results of panel regressions explaining annual changes in cash holdings using the financing deficit and the standard set of controls. In contrast to Opler et al. (1999), we find an insignificant relation between cash and the financing deficit in the full sample. However, as shown in Column 2, the interaction between the deficit and a firm's age is negative and statistically significant at the 1% level, suggesting that the relation becomes more negative as the firm ages. These results can also be seen in the next 5 columns, which estimate the same regression separately across the age quintiles. The results indicate that the change in cash holdings is positively related to the financial deficit in younger firms (quintiles 1 and 2), and negatively related to the financial deficit in mature firms (quintiles 4 and 5). Broadly interpreted, these findings suggest that older firms' cash policies adhere to a financing hierarchy-implied dynamics, under which firms use their cash reserves when deficits are higher and build these reserves when deficits are lower or the firm has a surplus. In contrast, younger firms' cash holdings are actually positively related to the financing deficit, suggesting that they increase their cash in response to higher deficits, consistent with the precautionary savings view.

Collectively, the results in this section are consistent with our finding that the model that governs firms' cash policies changes over the corporate life-cycle and provide insight into the policy that drives older firms' cash policy. Young firms' cash policies are largely dictated by precautionary needs; they are actively managed towards a target cash ratio that reflects the firm's precautionary demand for liquid assets, and hence are positively related to the flow of funds deficit. Further, younger firms replenish their cash reserves by taking advantage of market timing to reduce the costs of raising capital, potentially due to greater information asymmetries that facilitate market misvaluation of their securities. In contrast, the cash policies of mature firms are significantly less influenced by the precautionary savings motive; they adhere to a financing model in which cash reserves fluctuate with the fortunes of the firm. Cash is used to cover financing deficits and is replenished when the firm generates a financing surplus. These results call into question the existence of a single model explaining corporate cash holdings. The existing literature, which has mainly focused on the precautionary savings motive, is therefore biased towards younger firms, potentially due to the influx of new listings in recent years. Nevertheless, it is equally important to understand how older firms manage their cash holdings, particularly because they collectively hold more than 50% of corporate cash.

IV. Market Frictions

This section examines whether the observed changes in firms' cash policies over the corporate life-cycle result from various market frictions that arise or weaken as a firm matures. We consider three types of market frictions: (i) information asymmetry, (ii) incentives, and (iii) taxes. We examine each friction's potential effects on both the level of cash holdings and the financing theory that is driving the way firms are managing their cash holdings.

The first friction we consider is information asymmetry, which is likely decreasing with a firm's age, as argued by DeAngelo et al. (2006) and others. Standard theory shows that information asymmetry leads to greater credit rationing, which translates into higher costs of financing in the context of financing theories. Coupled together, these arguments imply that older firms may face lower costs of external finance, which may weaken their precautionary savings motive, thus leading to lower cash holdings.

The second friction that we consider is incentive conflicts, which are typically found to be exacerbated in older firms because their management is more likely entrenched [Shleifer and Vishny (1989)] and because they generate more free cash flow [Jensen (1986)]. While it is unclear a-priori whether such firms would hold more cash or less, there is some empirical evidence suggesting that they spend their cash reserves quicker, thus maintaining lower cash reserves [Harford (1999); Harford et al. (2008)]. Agency problems may also affect the dynamics of a firm's financing. For instance, Myers (2003) illustrates how incentive conflicts, in the sense of Jensen and Meckling (1976), can generate a similar pecking order because the costs of private benefits stay internalized with a debt issuance but are shared with outside shareholders with an equity issuance.

The third friction we consider is corporate taxes. As noted by Opler et al. (1999), taxes increase the cost of holding cash because the interest income from cash is taxed twice. This income is taxed first at the corporate level and then taxed again as it generates income for the shareholders. If, for example, shareholders pay no/lower capital gains taxes, they would prefer the firm to use its cash holdings to repurchase shares. If older, more profitable firms pay higher taxes, they may find it optimal to hold less cash since the tax costs associated with cash holdings are higher. Once again, taxes may also generate a pecking order of financing in which debt is preferred to equity, as shown by Stiglitz (1973).

To test whether these frictions can explain the evolution of cash policies over the life-cycle and whether our results are robust to controlling for these effects, we proceed in two steps. First, we augment our comprehensive empirical cash model with proxies for these frictions and examine whether these augmented models better predict the average cash holdings across the age quintiles. Second, we sort the sample on these proxies and split it into terciles. We then re-estimate the partial adjustment, market timing, and financing hierarchy models in each tercile and investigate how they interact with a firm's life-cycle.

Of course, a limitation of this approach is that the empirical proxies for market frictions are often noisy. Consequently, our inferences may be confounded by other omitted correlated variables. To mitigate this concern, we rely on proxies identified by previous studies to be significantly associated with these market frictions. Specifically, we use the dispersion in quarterly earnings forecasts as our proxy for information asymmetry; we use the Gompers, Ishii, and Metrick (2003) g-index as a measure for agency costs; and we use operating loss carryforwards as our measure for the tax burden.

Panel A of Table 8 reports the predicted values from our cash model augmented with proxies for the various frictions. Augmenting the model with the friction proxies results in predicted cash holdings that continue to underestimate the observed cash holdings for the youngest quintile of firms by 4.7 to 5.7 percentage points. These predicted values improve on the accuracy of the original model by 0.6 to 1.6 percentage points (see Table 3). Conversely, the augmented models continue to overestimate the cash holdings of the oldest quintile of firms by 2.4 to 4.7 percentage points. These predicted values improve on the accuracy of the original model by 0.3 to 2.6 percentage points.

In Panel B, we re-estimate the partial adjustment, market timing, and financing hierarchy models in terciles sorted on information asymmetry, incentives, and taxes. For brevity, we only report the interaction between a firm's age and the relevant variables, namely lagged cash, market timing, and the financing deficit. We estimate that the interaction between a firm's age and lagged cash is positive and highly statistically significant at the 5% level or better across all terciles formed on these frictions. Thus, older firms consistently exhibit lower speeds of adjustment of cash, even after controlling for these market frictions. Furthermore, the robustness of these results to the inclusion of various market frictions, which possibly proxy for potential adjustment costs, imply that the differences in SOA over the life-cycle are unlikely driven by differences in adjustment costs. A possible interpretation of these findings is that older firms rebalance their cash holdings significantly slower because they are less concerned about managing their cash towards a target ratio.

Similarly, we find that the relation between cash holdings and the measures of market timing and financing deficit diminish as a firm ages across all terciles. These results suggest that firms' cash holdings are less affected by market timing and adhere more to a financing hierarchy view over the corporate life-cycle, even after we control for information asymmetry, incentive conflicts, and corporate taxes. Taken together, these results suggest that the corporate life-cycle does not simply proxy for a change in the importance of any specific market friction, which might change firms' equilibrium cash policies.

V. Conclusion

We provide new evidence on the evolution and dynamics of firm-level cash holdings and re-evaluate the extant theories of cash in light of our findings. We find that cash holdings decline monotonically and substantially from an average of 36.0% of book assets in the first year after the IPO to an average of 11.6% of book assets 30 years after the IPO. The precautionary savings motive accounts for only approximately 33% of the decline and an extended empirical model of cash holdings similar to Opler et al. (1999) accounts for about 50% of the decline. Moreover, while the existing models do reasonably well explaining the cash holdings levels of younger firms, they do poorly explaining the cash holdings of older firms. These findings are particularly disturbing given that more than 50% of the cash held by public corporations in the U.S. is held by firms in the oldest quintile.

To better understand the economic mechanism driving cash policy, we investigate a broad set of theories of cash policy and the relative importance of each in determining how firms manage their cash holdings over their life-cycle. We find a striking dichotomy between young and old firms. Young firms actively rebalance their cash holdings toward a target ratio, which is strongly affected by precautionary savings motives. Further, the cash holdings of young firms are positively and significantly correlated with equity market timing, implying that these firms exploit periods of equity overvaluation to issue equity and replenish their cash stocks. In contrast, older firms exhibit significantly weaker cash rebalancing and market timing behaviors and are much less influenced by the need to save precautionary cash. Rather, older firms' cash holdings fluctuate with the fortunes of the firm, as proxied by firms' financing deficits, consistent with a financing hierarchy theory of cash holdings.

Taken together, our findings call into question the unified approach to corporate cash holdings, based on the precautionary savings motive, prevalent in the existing literature on cash holdings. We find that this model does not apply uniformly across the corporate life-cycle and cannot fully explain why old firms hold so much less cash than young firms. Our evidence on the importance of the financing hierarchy theory sheds light on how older firms manage their cash and presents some of the first evidence on the importance of this hypothesis to corporate cash holdings. Further, by showing that different models apply at different stages of the corporate life cycle, this paper reconciles conflicting theoretical literatures on financing and cash policy. Additional empirical and theoretical investigations of the determinants of the striking change in cash policies over the corporate life-cycle are a fruitful avenue for future research.

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Appendix: Variable Definitions

Note: Compustat data items are given in parentheses

Cash is cash + short term investments (che) divided by total assets (at).

Age is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period.

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

Industry cash flow volatility is the 10-year rolling window median volatility of cash flow/assets across 2 digit SIC industries.

Market to book is the market value of assets, defined as total assets (at) minus book equity (ceq) plus market value of equity (csho*prcc), divided by total assets (at).

Net Working Capital is net working capital (wcap) excluding cash(che), divided by total assets (at).

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

Leverage is short-term debt (dlc) plus long-term debt (dltt),divided by total assets (at).

R&D is research and development (xrd) divided by sales (sale). Missing values are set to 0.

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

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

Foreign income dummy is an indicator variable equal to 1 if the firm reported nonmissing pretax foreign income (pifo).

Deficit is the flow of funds deficit, defined as cash dividends plus capital expenditures plus the change in net working capital (excluding cash), plus the current portion of long-term due, minus the operating cash flows, normalized by total assets.

Market timing $= \sum_{s=1}^{t-1} \frac{e_s + d_s}{\sum_{r=1}^{t-1} e_r + d_r} \left(\frac{M}{B}\right)_s$, where e_s, d_s are net equity issues and net debt issues, respectively, and *t=1* is the first year that the firm appears on Compustat.

Information asymmetry is measured by the dispersion in quarterly earnings forecasts on IBES.

Incentives are measured using the g-index [Gompers et al. (2003)], where missing years are filled out with the most recent value.

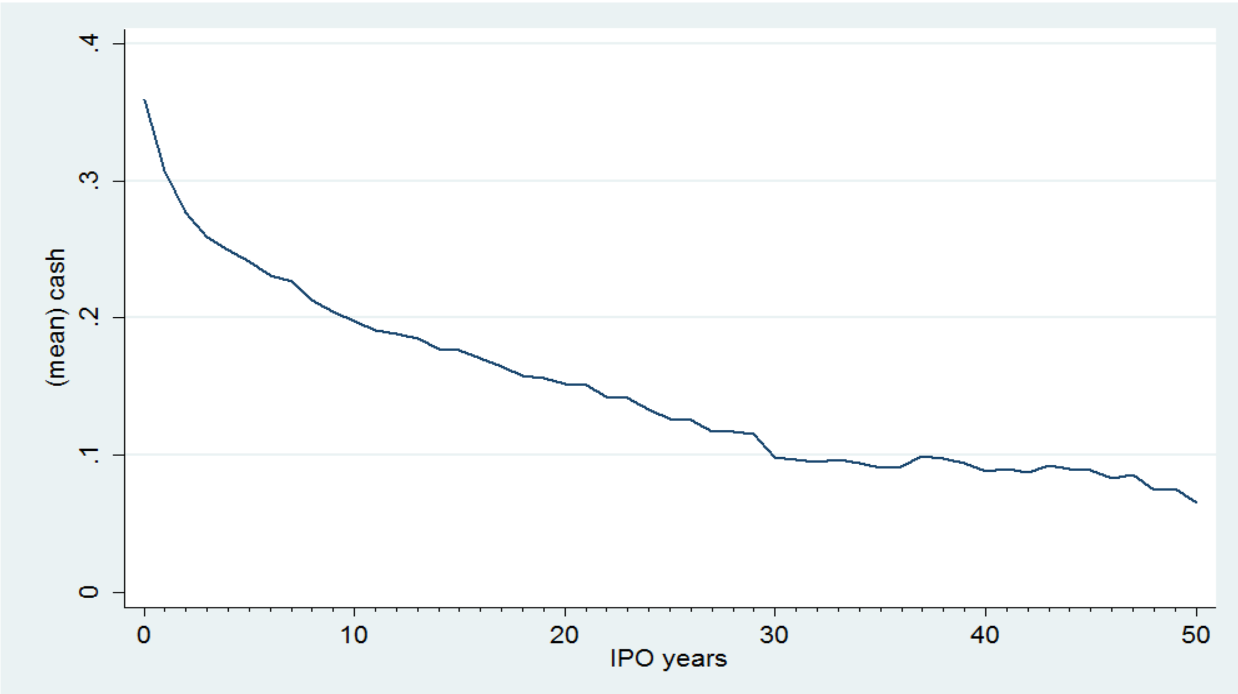
Taxes are measured by the tax loss carry forward (tlcf).

Figure 1

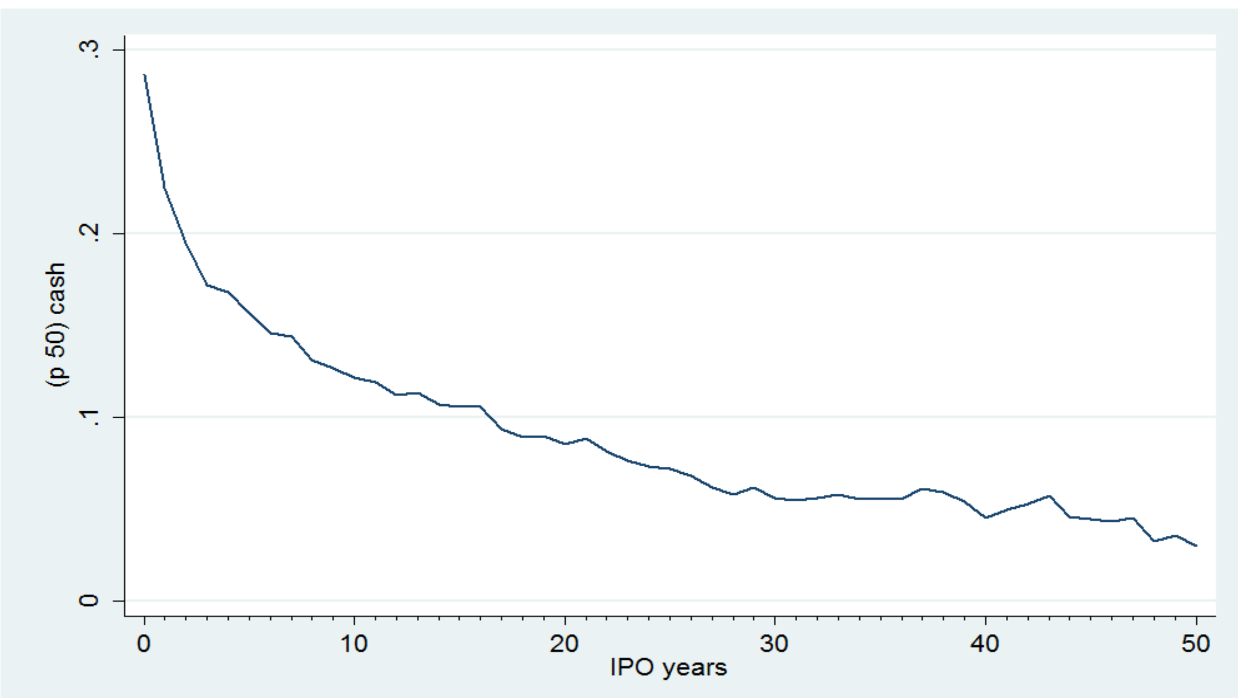
The Life-cycle of Corporate Cash Holdings

This figure presents evidence on the evolution of cash holdings over the corporate life-cycle, measured by the number of years since the firm's IPO. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period.

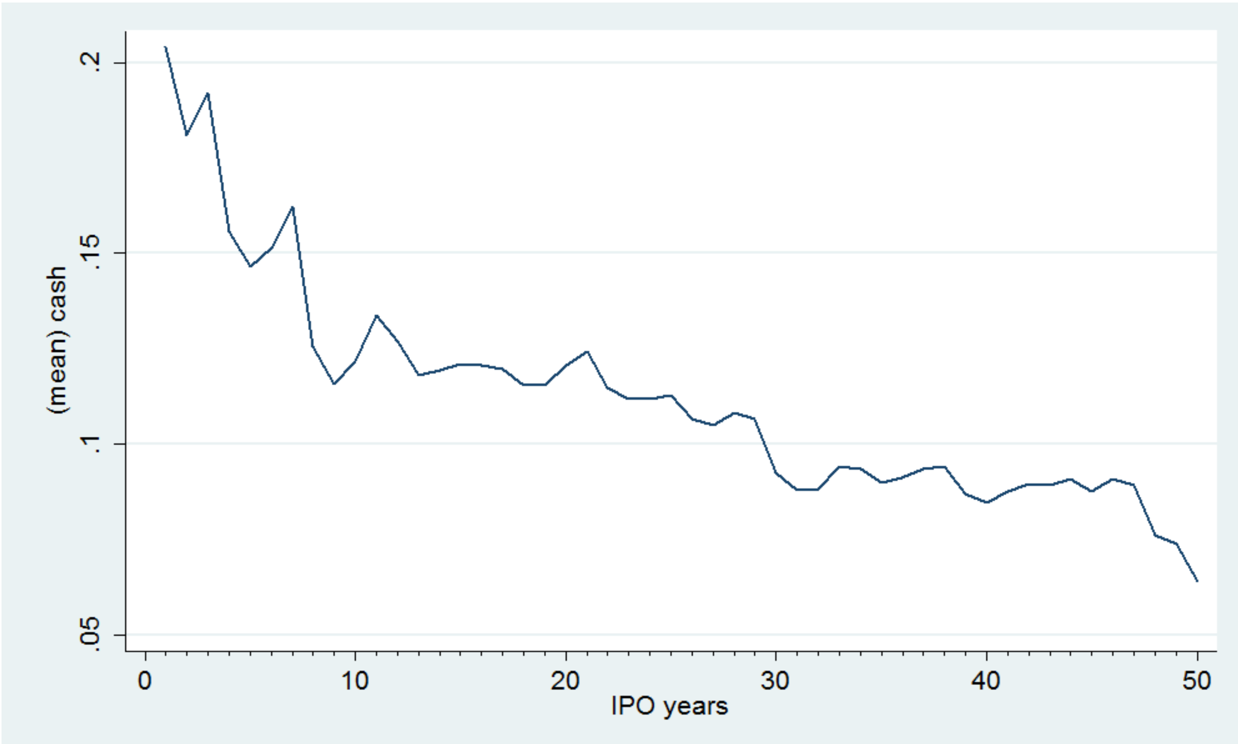
Panel A: Average cash holdings



Panel B: Median cash holdings



Panel C: Average cash holdings -- constant composition sample



Panel D: Average cash holdings -- 5 Fama-French industries

Table 1

Summary Statistics

Panel A presents summary statistics for the sample, which consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. *Cash* is cash and short term investments. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. *Industry cash flow volatility* is the 10-year rolling window median volatility of cash flow/assets across 2 digit SIC industries. *Market-to-book* is measured as the book value of total assets minus book value of equity plus market value of equity divided by total assets. *Size* is the natural logarithm of the book value of total assets. *Cash flow* is measured as earnings less interest and taxes, divided by total assets. *Foreign income dummy* is an indicator variable equal to 1 if the firm reported nonmissing pretax foreign income. *Net working capital* is net working capital excluding cash, divided by book assets. *Capital expenditure* is capital expenditure divided by total assets. *Leverage* is short-term debt plus long-term debt divided by total assets. *R&D* is research and development expense, divided by total sales, where missing values are set to zero. Acquisitions is acquisition expense, divided by total assets. *Payout* is dividends plus stock repurchases divided by total assets. Panels B and C sort all firms as of 1980 and 2009, respectively, into quintiles on their age, and report the aggregate cash amount, in millions of dollars, held by all the firms in each quintile.

Panel A: Sample-wide Summary

Variable	Mean	Median	Std. Dev.	N
Cash/assets	0.215	0.123	0.231	93,675
Age	11.862	8.000	11.818	93,584
Industry cash flow volatility	0.055	0.045	0.032	93,478
Market-to-book	2.055	1.465	1.722	92,605
Size	5.129	4.977	1.967	93,675
Cash flow	0.011	0.065	0.256	86,999
Foreign income dummy	0.307	0.000	0.461	93,675
Net working capital	0.096	0.085	0.186	91,064
Capital expenditure	0.067	0.046	0.068	92,454
Leverage	0.214	0.163	0.239	93,310
Research & Development	1.801	0.000	104.184	93,675
Acquisitions	0.020	0.000	0.055	93,675
Payout	0.025	0.005	0.049	86,256

Panel B: Cash Holdings Across Life Cycle Quintiles As of 1980

Age quintile	Average age	Number of firms	Total cash amount ($M)	% of total cash
Young	1.39	420	3,656	4.25%
2	6.04	221	1,724	2.01%
3	8.33	580	7,833	9.11%
4	14.67	520	12,873	14.98%
Old	28.70	351	59,868	69.65%
Total	11.69	2092	85,954	100%

Panel C: Cash Holdings Across Life Cycle Quintiles As of 2009

Age quintile	Average age	Number of firms	Total cash amount ($M)	% of total cash
Young	2.19	614	89,145	7.34%
2	7.88	523	130,597	10.75%
3	13.01	554	115,962	9.55%
4	19.42	621	267,558	22.03%
Old	38.85	607	611,108	50.32%
Total	16.55	2919	1,214,370	100%

Table 2

Cross-Sectional Average Cash Holdings: Calendar vs. Event (IPO) Time

This table presents average and median cash ratios corresponding to calendar years (Columns 1-4) and firms' age (Columns 5-8). The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. The definitions of all other variables are provided in the Appendix.

Year	Average cash ratio	Median cash ratio	N_obs	Age	Average cash ratio	Median cash ratio	N_obs
1980	0.119	0.070	2,098	1	0.360	0.287	8,049
1981	0.146	0.085	2,258	2	0.307	0.225	7,019
1982	0.149	0.087	2,242	3	0.277	0.195	6,196
1983	0.189	0.119	2,537	4	0.259	0.172	5,454
1984	0.182	0.112	2,573	5	0.249	0.168	4,862
1985	0.180	0.108	2,509	6	0.241	0.156	4,362
1986	0.201	0.120	2,626	7	0.231	0.146	3,995
1987	0.202	0.125	2,715	8	0.226	0.144	3,717
1988	0.185	0.109	2,605	9	0.213	0.131	3,854
1989	0.178	0.103	2,516	10	0.205	0.127	3,603
1990	0.177	0.098	2,498	11	0.198	0.122	3,301
1991	0.194	0.108	2,676	12	0.191	0.119	3,060
1992	0.201	0.115	2,930	13	0.189	0.112	2,809
1993	0.212	0.128	3,304	14	0.185	0.113	2,577
1994	0.197	0.113	3,510	15	0.177	0.107	2,321
1995	0.206	0.113	3,713	16	0.177	0.106	2,098
1996	0.232	0.126	4,192	17	0.171	0.106	1,938
1997	0.225	0.129	4,306	18	0.165	0.093	1,747
1998	0.213	0.113	4,171	19	0.158	0.089	1,669
1999	0.228	0.115	4,134	20	0.156	0.089	1,533
2000	0.244	0.132	4,034	21	0.152	0.085	1,433
2001	0.246	0.144	3,646	22	0.151	0.088	1,349
2002	0.241	0.145	3,442	23	0.143	0.081	1,289
2003	0.252	0.159	3,320	24	0.142	0.077	1,155
2004	0.260	0.174	3,331	25	0.133	0.073	1,049
2005	0.256	0.172	3,299	26	0.126	0.072	954
2006	0.255	0.165	3,260	27	0.125	0.068	869
2007	0.260	0.160	3,251	28	0.117	0.062	754
2008	0.234	0.139	3,058	29	0.117	0.057	712
2009	0.245	0.164	2,921	30	0.116	0.062	659

Table 3

Explaining the Life-Cycle Trend in Corporate Cash Holdings

Panel A presents cross-sectional averages of firm-level characteristics corresponding to firms' age. Panel B presents predicted cash holdings estimated from panel regressions explaining firm-level cash holdings based on two empirical models: the precautionary savings model and the comprehensive model of cash holdings. The precautionary savings model includes the following variables: cash flow, cash flow volatility, the market-to-book ratio, capital expenditure, R&D expenditure, acquisitions, and year dummies. The comprehensive model augments the precautionary savings model with firm size, a foreign income dummy, net working capital (excluding cash), and leverage. All variable definitions are provided in the Appendix. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period.

Panel A: Average Values across Life-Cycle Bins

Age	Cash	Cash flow	Cash flow volatility	Market-to-book	Capital expenditure	R&D	Acquisitions	Payout	Cash flow-CAPEX-Payout
1-5	0.290	-0.033	N/A	2.470	0.075	2.937	0.023	0.017	-0.131
6-10	0.215	0.013	0.078	1.975	0.063	1.693	0.018	0.024	-0.068
11-15	0.185	0.031	0.066	1.863	0.063	2.148	0.018	0.028	-0.049
16-20	0.161	0.043	0.051	1.728	0.061	0.266	0.018	0.029	-0.036
21-25	0.140	0.054	0.044	1.631	0.060	0.071	0.019	0.032	-0.026
26-30	0.115	0.065	0.037	1.565	0.062	0.032	0.020	0.033	-0.017
31-35	0.095	0.067	0.030	1.533	0.062	0.026	0.019	0.038	-0.014
36-40	0.094	0.064	0.032	1.521	0.059	0.608	0.022	0.042	-0.016
41-45	0.090	0.071	0.032	1.679	0.056	0.020	0.018	0.040	-0.003
46-50	0.078	0.079	0.032	2.009	0.057	0.024	0.023	0.052	-0.002

Panel B: Predicted Cash Holdings

Model		Precautionary savings model		Comprehensive model	
Age quintile	Observed cash	Predicted cash	Difference from observed cash	Predicted cash	Difference from observed cash
Young	0.334	0.241	-0.092	0.271	-0.063
2	0.249	0.214	-0.035	0.225	-0.024
3	0.207	0.198	-0.009	0.198	-0.009
4	0.177	0.193	0.016	0.178	0.001
Old	0.108	0.168	0.060	0.158	0.050

Table 4

Regression Models of Cash Holdings and the Corporate Life-Cycle

Panels A and B of this table present estimates from panel regressions explaining firm-level cash ratios. In Panel A, the regressions are estimated separately in quintiles formed annually on firms' age. Panel B interacts the cash determinants with age. Panel C presents predicted values from estimating the regression coefficients separately for the youngest or oldest quintile only, and then calculating the predicted cash holdings for all five quintiles. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. All other variables follow the model in Bates, Kahle, and Stulz (2009), which includes industry cash flow volatility, cash flow, the market-to-book ratio, a foreign income dummy, net working capital (excluding cash), capital expenditure, debt, R&D expenditure, acquisitions, payout, and firm size. All variable definitions are provided in the Appendix. All regressions include year fixed effects. Intercept and year fixed effects are not shown. The standard errors (in brackets) are heteroskedasticity consistent. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A: Subsamples

Sample	Age quintile				
	Youngest	2	3	4	Oldest
Model	(1)	(2)	(3)	(4)	(5)
Industry cash flow volatility	1.573*** [0.138]	1.468*** [0.117]	1.231*** [0.120]	1.210*** [0.099]	0.466*** [0.085]
Cash flow/assets	-0.140*** [0.015]	-0.119*** [0.014]	-0.101*** [0.013]	-0.063*** [0.017]	-0.026 [0.054]
Market-to-book	0.017*** [0.002]	0.014*** [0.002]	0.014*** [0.002]	0.013*** [0.003]	0.003* [0.002]
Foreign income dummy	0.007 [0.005]	0.007 [0.005]	0.008 [0.005]	0.004 [0.005]	0.014*** [0.005]
Net working capital/assets	-0.354*** [0.016]	-0.256*** [0.012]	-0.226*** [0.018]	-0.250*** [0.016]	-0.208*** [0.018]
Capital expenditure/assets	-0.611*** [0.021]	-0.562*** [0.031]	-0.499*** [0.022]	-0.482*** [0.027]	-0.432*** [0.039]
Debt/assets	-0.391*** [0.013]	-0.273*** [0.018]	-0.249*** [0.014]	-0.236*** [0.019]	-0.232*** [0.022]
R&D/assets	0.000 [0.000]	0.000* [0.000]	0.000*** [0.000]	0.000** [0.000]	0.001*** [0.000]
Acquisitions/assets	-0.506*** [0.021]	-0.391*** [0.021]	-0.329*** [0.023]	-0.301*** [0.023]	-0.184*** [0.019]
Payout/assets	-0.137*** [0.035]	0.019 [0.043]	0.055 [0.044]	0.080** [0.038]	0.175*** [0.043]
Size	-0.041*** [0.002]	-0.029*** [0.002]	-0.024*** [0.002]	-0.022*** [0.001]	-0.022*** [0.001]
N Observations	17,292	18,425	16,977	19,863	19,999
R-Squared	0.549	0.510	0.465	0.456	0.364

Panel B: Interactions

Var	Industry cash flow volatility	Cash flow	Market-to-book	Net working capital	Capital expenditure	Debt	R&D	Acquisitions	Payout	Size
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(8)	(9)
Years on Compustat	-0.005*** [0.001]	-0.016*** [0.001]	-0.019*** [0.003]	-0.017*** [0.001]	-0.016*** [0.001]	-0.024*** [0.002]	-0.015*** [0.001]	-0.016*** [0.001]	-0.017*** [0.001]	-0.043*** [0.002]
Years on Compustat x Var	-0.208*** [0.028]	0.029*** [0.008]	-0.002*** [0.002]	0.020*** [0.007]	0.027*** [0.009]	0.042*** [0.005]	0.000 [0.000]	0.077*** [0.006]	0.081*** [0.012]	0.006*** [0.000]
Industry cash flow volatility	1.832*** [0.110]	1.206*** [0.062]	1.175*** [0.060]	1.196*** [0.061]	1.198*** [0.062]	1.186*** [0.062]	1.198*** [0.062]	1.196*** [0.062]	1.198*** [0.062]	1.218*** [0.062]
Cash flow/assets	-0.122*** [0.011]	-0.191*** [0.019]	-0.127*** [0.011]	-0.125*** [0.011]	-0.128*** [0.011]	-0.127*** [0.011]	-0.128*** [0.011]	-0.127*** [0.011]	-0.129*** [0.011]	-0.119*** [0.010]
Market-to-book	0.008*** [0.003]	0.008*** [0.003]	0.006*** [0.002]	0.008*** [0.003]	0.008*** [0.003]	0.008*** [0.003]	0.008*** [0.003]	0.008*** [0.003]	0.008*** [0.003]	0.008*** [0.003]
Foreign income dummy	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]	0.013*** [0.003]
Net working capital/assets	-0.271*** [0.010]	-0.274*** [0.009]	-0.269*** [0.009]	-0.331*** [0.020]	-0.271*** [0.010]	-0.270*** [0.010]	-0.272*** [0.010]	-0.272*** [0.010]	-0.271*** [0.010]	-0.265*** [0.010]
Capital expenditure/assets	-0.508*** [0.015]	-0.521*** [0.015]	-0.515*** [0.015]	-0.515*** [0.015]	-0.580*** [0.024]	-0.505*** [0.015]	-0.512*** [0.015]	-0.514*** [0.015]	-0.512*** [0.015]	-0.519*** [0.015]
Debt/assets	-0.296*** [0.010]	-0.297*** [0.010]	-0.299*** [0.009]	-0.299*** [0.010]	-0.299*** [0.010]	-0.418*** [0.018]	-0.300*** [0.010]	-0.299*** [0.010]	-0.298*** [0.010]	-0.290*** [0.010]
R&D/assets	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]
Acquisitions/assets	-0.351*** [0.011]	-0.355*** [0.011]	-0.353*** [0.011]	-0.356*** [0.011]	-0.353*** [0.011]	-0.349*** [0.011]	-0.354*** [0.011]	-0.571*** [0.021]	-0.353*** [0.011]	-0.351*** [0.011]
Payout/assets	0.053** [0.025]	0.040 [0.024]	0.025 [0.020]	0.047* [0.024]	0.048* [0.024]	0.063** [0.025]	0.047* [0.024]	0.048* [0.024]	-0.200*** [0.039]	0.039 [0.024]
Size	-0.027*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.026*** [0.001]	-0.045*** [0.002]
N Observations	92,556	92,556	92,556	92,556	92,556	92,556	92,556	92,556	92,556	92,556
R-Squared	0.506	0.506	0.506	0.505	0.505	0.508	0.505	0.505	0.505	0.510

Panel C: Predicted Cash Holdings

Model		Precautionary savings model				Comprehensive model			
Sample		Youngest firms (bottom quintile)		Oldest firms (top quintile)		Youngest firms (bottom quintile)		Oldest firms (top quintile)	
Age quintile	Observed cash	Predicted cash	Difference from observed cash	Predicted cash	Difference from observed cash	Predicted cash	Difference from observed cash	Predicted cash	Difference from observed cash
Young	0.334	0.320	-0.014	0.160	-0.174	0.310	-0.024	0.231	-0.103
2	0.249	0.298	0.049	0.139	-0.110	0.263	0.014	0.191	-0.058
3	0.207	0.285	0.078	0.127	-0.080	0.234	0.027	0.168	-0.039
4	0.177	0.280	0.103	0.121	-0.056	0.211	0.034	0.151	-0.026
Old	0.108	0.256	0.148	0.106	-0.003	0.172	0.064	0.106	-0.002

Table 5

The SOA of Cash Holdings and the Corporate Life-Cycle

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

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

where: X_{it-1} is a vector of control variables following the model in Bates, Kahle, and Stulz (2009), which includes industry cash flow volatility, cash flow, the market-to-book ratio, a foreign income dummy, net working capital (excluding cash), capital expenditure, debt, R&D expenditures, acquisitions, payout, and firm size.

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

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

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

In all cases, the SOA is given by $1 - \alpha$, where α is the coefficient corresponding to lagged cash. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. The regressions are estimated separately for quintiles formed annually on firms' age. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. The standard errors (in brackets) are heteroskedasticity consistent. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Estimator	Sample	Complete sample		Age quintile				
				Youngest	2	3	4	Oldest
	Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
OLS	Lagged cash	0.791*** [0.004]	0.721*** [0.007]	0.703*** [0.008]	0.782*** [0.006]	0.809*** [0.007]	0.827*** [0.007]	0.837*** [0.009]
	Age		-0.007*** [0.000]					
	Age x Lagged cash		0.025*** [0.002]					
FE	Lagged cash	0.543*** [0.007]	0.442*** [0.011]	0.134*** [0.041]	0.228*** [0.019]	0.327*** [0.017]	0.480*** [0.016]	0.635*** [0.015]
	Age		-0.009*** [0.001]					
	Age x Lagged cash		0.034*** [0.003]					
GMM	Lagged cash	0.620*** [0.012]	0.609*** [0.028]	0.566*** [0.041]	0.573*** [0.022]	0.641*** [0.020]	0.654*** [0.020]	0.707*** [0.022]
	Age		-0.014*** [0.003]					
	Age x Lagged cash		0.009*** [0.002]					

Table 6

The Importance of Market Timing over the Corporate Life-Cycle

This table presents estimates from panel regressions explaining firm-level cash ratios. The definition of market timing follows Baker and Wurgler (2002):

$$Market\ timing = \sum_{s=1}^{t-1} \frac{e_s + d_s}{\sum_{r=1}^{t-1} e_r + d_r} \left(\frac{M}{B}\right)_s$$

Where e_s, d_s are net equity issues and net debt issues, respectively, and *t=1* is the first year that the firm appears on Compustat. All other variables follow the model in Bates, Kahle, and Stulz (2009), which includes industry cash flow volatility, cash flow, the market-to-book ratio, a foreign income dummy, net working capital (excluding cash), capital expenditure, debt, R&D expenditures, acquisitions, payout, and firm size. The regressions are estimated separately for quintiles formed annually on firms' age. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. All other variable definitions are provided in the Appendix. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. All regressions include year fixed effects. Intercept and year fixed effects are not shown. The standard errors (in brackets) are heteroskedasticity consistent. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Age quintile	Full sample	Full sample interaction	Young	3	4	Old
Market timing	0.018*** [0.001]	0.022*** [0.002]	0.020*** [0.002]	0.017*** [0.002]	0.012*** [0.002]	0.009*** [0.003]
Age		-0.005*** [0.002]				
Market timing x Age		-0.004*** [0.001]				
Industry cash flow volatility	0.904*** [0.061]	0.917*** [0.060]	1.130*** [0.124]	1.298*** [0.136]	0.731*** [0.112]	0.278*** [0.084]
Cash flow/assets	-0.105*** [0.010]	-0.105*** [0.010]	-0.107*** [0.018]	-0.071*** [0.024]	-0.093*** [0.025]	-0.230*** [0.043]
Market-to-book	0.021*** [0.001]	0.020*** [0.001]	0.020*** [0.002]	0.022*** [0.002]	0.023*** [0.003]	0.020*** [0.004]
Net working capital/assets	-0.302*** [0.009]	-0.293*** [0.009]	-0.279*** [0.016]	-0.262*** [0.015]	-0.310*** [0.019]	-0.229*** [0.023]
Capital expenditure/assets	-0.607*** [0.020]	-0.619*** [0.020]	-0.628*** [0.031]	-0.605*** [0.034]	-0.629*** [0.041]	-0.398*** [0.050]
Debt/assets	-0.222*** [0.013]	-0.224*** [0.013]	-0.221*** [0.018]	-0.180*** [0.023]	-0.218*** [0.022]	-0.192*** [0.031]
R&D/assets	0.000* [0.000]	0.000* [0.000]	0.000* [0.000]	0.000*** [0.000]	0.000 [0.000]	0.001*** [0.000]
Acquisitions/assets	-0.354*** [0.013]	-0.366*** [0.013]	-0.392*** [0.027]	-0.394*** [0.027]	-0.301*** [0.025]	-0.201*** [0.023]
Payout/assets	-0.048** [0.024]	-0.011 [0.024]	0.005 [0.050]	-0.026 [0.047]	0.080* [0.045]	-0.004 [0.042]
Size	-0.029*** [0.001]	-0.027*** [0.001]	-0.027*** [0.002]	-0.027*** [0.002]	-0.025*** [0.002]	-0.022*** [0.002]
N Observations	55,215	55,171	10,569	10,701	11,521	11,876
R-Squared	0.517	0.520	0.507	0.496	0.491	0.355

Table 7

Cash Holdings and the Financing Hierarchy Hypothesis over the Corporate Life-Cycle

This table presents estimates from panel regressions explaining annual changes in cash holdings. The dependent variable is the change in the level of cash/assets from the prior year. The finance deficit is the flow of funds deficit, defined as cash dividends, plus capital expenditures, changes in net working capital (less cash) and current portion of long-term debt due, less operating cash flow, where all variables are deflated by assets. The regressions are estimated separately for quintiles formed annually on firms' age. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. All other variable definitions are provided in the Appendix. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. Standard errors (in brackets) are heteroskedasticity consistent. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Age quintile	Full sample	Full sample interaction	1	2	3	4	5
Finance deficit	0.001 [0.001]	0.006*** [0.002]	0.011*** [0.002]	0.006*** [0.002]	-0.001 [0.002]	-0.011*** [0.002]	-0.036*** [0.004]
Age		0.006*** [0.000]					
Finance deficit x Age		-0.002*** [0.001]					
Industry cash flow volatility	-0.040** [0.019]	-0.035* [0.019]	-0.068 [0.067]	-0.094* [0.049]	-0.063 [0.044]	-0.079** [0.034]	0.030 [0.027]
Cash flow/assets	0.060*** [0.003]	0.061*** [0.003]	0.072*** [0.007]	0.079*** [0.007]	0.050*** [0.007]	0.029*** [0.005]	0.014 [0.012]
Market-to-book	0.000 [0.000]	0.000 [0.000]	0.001 [0.001]	-0.001 [0.001]	0.000 [0.001]	0.002*** [0.001]	0.003*** [0.001]
Net working capital/assets	-0.054*** [0.003]	-0.060*** [0.004]	-0.082*** [0.013]	-0.070*** [0.008]	-0.064*** [0.007]	-0.056*** [0.006]	-0.036*** [0.006]
Capital expenditure/assets	-0.358*** [0.010]	-0.350*** [0.010]	-0.425*** [0.028]	-0.382*** [0.021]	-0.339*** [0.020]	-0.304*** [0.019]	-0.191*** [0.019]
Debt/assets	0.004 [0.003]	0.005* [0.003]	0.020** [0.009]	0.002 [0.006]	-0.003 [0.006]	-0.013** [0.006]	0.002 [0.005]
R&D/assets	0.000 [0.000]	0.000 [0.000]	0.000 [0.000]	0.000** [0.000]	-0.000*** [0.000]	0.000 [0.000]	0.006 [0.005]
Acquisitions/assets	-0.483*** [0.011]	-0.472*** [0.011]	-0.522*** [0.033]	-0.501*** [0.024]	-0.464*** [0.024]	-0.515*** [0.022]	-0.335*** [0.016]
Payout/assets	-0.144*** [0.012]	-0.164*** [0.012]	0.028 [0.050]	-0.185*** [0.033]	-0.151*** [0.025]	-0.246*** [0.022]	-0.201*** [0.018]
Size	0.005*** [0.000]	0.003*** [0.000]	0.012*** [0.001]	0.007*** [0.001]	0.003*** [0.001]	0.003*** [0.001]	0.000 [0.000]
N Observations	27,460	27,449	3,893	5,626	6,018	6,257	5,655
R-Squared	0.124	0.130	0.140	0.135	0.106	0.136	0.127

Table 8

Market Frictions

Panel A presents estimates of predicted cash holdings from panel regressions explaining firm-level cash ratios using our baseline empirical model of cash augmented with proxies for information asymmetry, incentives, and taxes. Information asymmetry is measured by the dispersion in quarterly earnings forecasts. Incentives are measured using the G-index. Taxes are measured using the tax loss carry forward. The baseline empirical model includes industry cash flow volatility, cash flow, the market-to-book ratio, capital expenditure, debt, R&D expenditures, acquisitions, and year dummies. Panel B presents estimates from the SOA, market timing, and financial hierarchy regressions reported in tables 5, 6, and 7, respectively. The regressions are estimated separately in subsamples sorted on proxies for information asymmetry, incentives, and taxes. For brevity, only the interaction terms are reported. *Age* is the number of years since the firm's IPO. IPO date is gathered from SDC. If the date is missing from this source, we use Jay Ritter's database provided on his Web page. If the date is not available from either of these sources, we use the first date the firm was listed on CRSP, checking this with the Jovanovic and Rousseau (2001) data for the pre-CRSP period. All other variable definitions are provided in the Appendix. The sample consists of all industrial firms in the Compustat/Crsp file from 1980 to 2009, with non-missing observations on total assets and cash. The standard errors (in brackets) are heteroskedasticity consistent. Significance levels are indicated as follows: * = 10%, ** = 5%, *** = 1%.

Panel A: Predicted values

Friction	Information asymmetry			Incentives			Taxes		
Age quintile	Observed cash	Predicted cash	Difference from observed cash	Observed cash	Predicted cash	Difference from observed cash	Observed cash	Predicted cash	Difference from observed cash
Young	0.316	0.261	-0.056	0.183	0.136	-0.047	0.317	0.260	-0.057
2	0.248	0.222	-0.026	0.171	0.153	-0.018	0.234	0.219	-0.014
3	0.203	0.189	-0.014	0.145	0.131	-0.014	0.201	0.196	-0.005
4	0.169	0.159	-0.010	0.106	0.109	0.004	0.166	0.165	-0.001
Old	0.094	0.141	0.047	0.078	0.103	0.024	0.102	0.140	0.039

Panel B: SOA, market timing, and financial hierarchy regressions

Friction	Information asymmetry			Incentives			Taxes		
Degree	Low	Medium	High	Low	Medium	High	Low	Medium	High
Age x Lagged cash	0.026*** [0.005]	0.020*** [0.004]	0.012*** [0.004]	0.009*** [0.003]	0.005** [0.002]	0.007*** [0.002]	0.031*** [0.005]	0.034*** [0.004]	0.009** [0.004]
Age x Market timing	-0.007*** [0.003]	-0.006*** [0.002]	-0.004*** [0.001]	-0.034*** [0.004]	-0.032*** [0.004]	-0.012*** [0.004]	-0.017*** [0.003]	-0.006*** [0.002]	-0.006*** [0.002]
Age x Deficit	-0.002 [0.002]	-0.003** [0.001]	-0.007*** [0.002]	-0.004*** [0.002]	-0.004*** [0.002]	-0.003 [0.002]	-0.004*** [0.001]	-0.005*** [0.001]	-0.003*** [0.001]