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Financial Hedging, Corporate Cash Policy, and the Value of Cash

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We study the implications of financial hedging for corporate cash policy and the value of cash holdings. Using a web crawler program to collect data on the use of financial derivatives between 1993 and 2016, we find that US public firms with financial hedging programs have smaller cash reserves but a higher value of cash than firms without hedging contracts in place. Our empirical results are robust when controlling for potential endogeneity issues, corporate governance, cash regimes and alternative measures of cash holdings. Further, we find that financial hedging not only increases the investment sensitivity to internal cash, but also has a positive effect on investment efficiency. The positive effect of financial hedging on the value of cash is more pronounced for firms with more financial constraints, higher information asymmetry and weaker corporate governance. Collectively, our paper highlights the importance of corporate cash policy as a channel through which financial risk management increases firm value.

Introduction

In the presence of asymmetric information, external borrowing is more costly than using internally generated funds, and firms are more likely to reserve cash to meet the need for future investment expenditures (Myers and Majluf, 1984). Cash holdings can also alleviate underinvestment for firms with tighter financial constraints and greater growth opportunities (Kim, Mauer and Sherman, 1998). As a result, firms may hold cash to hedge for the risk of future cash shortfalls due to the precautionary motive. Meanwhile, previous financial hedging studies suggest that firms with financial hedging programs have lower cash flow volatility, lower external financing costs, greater debt capacity and fewer investment restrictions (e.g. Campello *et al.*, 2011; Chen and King, 2014; Froot, Scharfstein and Stein, 1993; Smith and Stulz, 1985). Taken together, the use of financial derivatives should increase firms' flexibility to finance future investment opportunities and reduce their precautionary motive for holding cash. We posit that firms with financial hedging programs have smaller cash reserves than firms without such programs. Furthermore, financial hedging may also increase firm value through enhancing firms' efficiency in using cash. Recent mergers and acquisitions (M&A) studies show that compared to non-users, derivatives users are more likely to choose the cash payment method in domestic M&A deals (Alexandridis, Chen and Zeng, 2021) and experience higher cross-border M&A deal announcement returns (Chen, Han and Zeng, 2017). We conjecture that the impact of financial hedging on corporate cash policy is positively valued by shareholders, and thus firms with financial hedging programs have a higher value of cash than firms without such programs.

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Due to sample limitations, previous hedging studies do not draw a conclusion on the relation between derivatives use and cash holdings. Based on hand-collected hedging data, Opler *et al*. (1999) show that the intensity of derivatives use is positively related to corporate cash holdings among a sample of S&P 500 firms in 1994, while Haushalter, Klasa and Maxwell (2007) find that derivatives use is negatively related to corporate cash holdings among a sample of S&P 500 manufacturing firms during 1993–1997. To resolve the inconsistent findings in these two papers, we develop a web crawler program to automatically capture the use of financial derivatives from US firms' annual financial statements between 1993 and 2016. Our textual analysis of US firms' 10-K filings results in a sample of 62,859 firm-year observations for 8,235 unique firms. In our sample, 59.5% of firms use at least one type of interest rate (IR) or foreign exchange (FX) derivatives, and 64.3% of firms use at least one type of IR, FX or commodity (COMMD) derivatives.

After controlling for firm characteristics and both the year and industry fixed effects, we show that firms with financial hedging programs have smaller cash reserves. Given that the average cash reserve in our sample is 19.4% of total assets, the difference in the cash to total assets ratio between derivatives users and non-users is about 3.1–3.6% of an average firm's cash holdings. We then explore the value implication of financial hedging on corporate cash holdings by extending Faulkender and Wang's (2006) framework, which estimates the market value of one additional dollar in cash holdings. We find strong evidence that the value of corporate cash holdings is positively related to financial hedging. The marginal value of cash is \$0.06 higher for derivatives users than non-users.

To address the potential endogeneity concerns due to omitted variables, non-random selection bias, reverse causality and measurement errors, we employ three identification methods. First, we adopt Heckman's (1978) treatment effect model and use the tax convexity estimated by Graham and Smith (1999) as the identification variable in the first-stage regressions. Second, we adopt a propensity score matching (PSM) approach to identify a group of control firms without financial hedging programs, which are comparable to firms with such programs. Third, we follow Gormley and Matsa (2014) and employ a high-dimensional fixed effects model to mitigate the potential endogeneity concern due to unobserved heterogeneity across firms and time-varying heterogeneity across industries. Our main results remain robust to these three identification tests.

Next, we examine four plausible mechanisms through which the use of financial derivatives increases the value of cash. First, our analysis indicates that financial hedging is associated with improvements in investment efficiency, evidenced by the increase in investment sensitivity to future growth opportunities and internal cash. Second, we show that the positive financial hedging effect on the value of cash is stronger for financially constrained firms. Financial hedging helps firms with financial constraints to reduce their external financing costs, and subsequently mitigate their precautionary motive for holding cash. Therefore, the market perceived value of cash for financially constrained firms increases with the use of financial derivatives. Third, we find that the positive relation between financial hedging and the value of cash is more pronounced for firms with higher information asymmetry. Financial hedging mitigates the information asymmetry between managers and shareholders and reduces shareholders' monitoring costs, therefore managers may increase the efficiency of internal cash use within an environment with higher information transparency. Fourth, we show that the positive effect of financial hedging on the value of cash is larger among firms with more severe *ex-ante* agency problems, supporting the view that financial hedging mitigates potential agency conflict between managers and shareholders.

In our industry-specific analyses, we find that within each of the Fama–French 10 industries, financial hedging still has a negative impact on cash holdings except for the Telecommunications industry, and a positive impact on the value of cash except for the Consumer Durables, Telecommunications and Wholesale, Retail and Services industries. Our results provide a full picture of the role played by financial hedging in corporate cash policy, which helps to reconcile the opposing views of derivatives use in previous cash-holding studies. In a set of sensitivity tests, we show that our main results remain robust after controlling for corporate governance, trifurcating our sample into *ex-post* cash regimes, using alternative measures of corporate cash holdings that are not essential for corporate operations and investment, controlling for the persistent tone of financial statements

and lagging financial hedging variables by 1 or 2 years.

Our paper contributes to the literature in three ways. First, we add to the broad literature on corporate risk management by providing evidence on the causal effect of derivatives use on cash holdings. Most prior hedging studies either use a small sample of firms (e.g. Géczy, Minton and Schrand, 1997; Graham and Rogers, 2002; Guay and Kothari, 2003; Haushalter, 2000) or focus on a specific industry (e.g. Haushalter, Klasa and Maxwell, 2007; Jin and Jorion, 2006; Mackay and Moeller, 2007; Pérez-González and Yun, 2013; Tufano, 1996). To comprehensively understand the impact of financial hedging on corporate cash holdings and the value of cash, we adopt a textual analysis of all US firms' 10-K filings and provide a full picture of the role played by financial hedging in corporate cash management. Second, our paper sheds light on the roles of financial hedging in reducing the precautionary demand for cash reserves and improving the efficiency of corporate cash policy. To the best of our knowledge, our paper is the first to show that financial hedging not only increases the investment sensitivity to internal cash, but also has a positive effect on investment efficiency. Our paper is related to Campello *et al*. (2011), who find a positive relation between derivatives use and capital expenditures. However, Campello *et al*. (2011) do not tackle the overarching question of how financial hedging affects the quality of investment decisions. Finally, we contribute to the value-of-cash literature by showing that corporate risk management is positively associated with the value of cash, since derivatives use may mitigate financial constraints, information asymmetry and agency problems.

Related literature and hypotheses

A theoretical firm operating in an imperfect capital market generates stochastic cash flows from its existing assets and has uncertain future investment opportunities. The firm cannot raise sufficient funds in external capital markets to finance its investments due to market frictions. Alternatively, it can choose to save a portion of today's earnings as cash holdings. The benefit of carrying cash is the firm's flexibility to finance its future investment opportunities, whilst the cost of doing so is the opportunity cost of forgoing its investment opportunities with a positive net present value (NPV) today. Duchin (2010) indicates that the optimal level of corporate cash holdings is determined by the joint distribution of investment opportunities and cash flows over time. Previous studies propose that financial hedging may influence corporate cash holdings through three channels: cash flow uncertainty, risky investment opportunity and financial risk.

Regarding the cash flow uncertainty channel, Kim, Mauer and Sherman (1998) model the positive relation between cash holding and cash flow volatility. In addition, Bates, Kahle and Stulz (2009) show that the dramatic increase in US firms' cash holdings from 1980 to 2006 can be attributed to the precautionary motive for alleviating cash flow risk instead of agency conflicts. It is generally accepted that corporate financial risk management may reduce future cash flow volatility and the likelihood of negative future cash flows (Froot, Scharfstein and Stein, 1993). Therefore, derivatives users have a lower precautionary motive than non-users to hold cash today. As for the risky investment opportunity channel, Leland (1998) shows that financial hedging increases a firm's external financing capacity. Campello *et al*. (2011) also find that, compared to non-users, derivatives users pay lower interest spreads on their bank loans and are less likely to have capital expenditure covenants in their loan agreements. Carter, Rogers and Simkins (2006) show that airlines with a desire for expansion may hedge future purchases of jet fuel with financial derivatives, since investment opportunities in the airline industry are positively related to jet fuel costs and higher fuel costs are associated with lower cash flow. With greater debt capacity, lower external financing costs and fewer investment restrictions, derivatives users have more flexibility to finance their future investment opportunities, and have less incentive to hold cash today.

Besides the above two channels, Harford and Uysal (2014) document a financial risk channel that firms mitigate the increase in their debt refinancing risk by holding more cash due to the shortened maturity of firms' long-term debt. Since derivatives users have better access to external capital markets (Chen and King, 2014), they also have less debt refinancing risk than non-users. In addition, IR and FX derivatives are the hedging instruments extensively used by US firms to alleviate their future financial risk. Taken together, we propose our first hypothesis as follows:

H1: Firms with financial hedging programs hold less cash than those without such programs.

Previous financial hedging studies show that firms do not operate in the perfect capital market defined by Modigliani and Miller (1958), and therefore financial hedging may have a positive effect on firm value through various channels.[1] We conjecture that financial hedging also has a positive effect on firm value through affecting corporate cash policy. Specifically, financial hedging may increase the market perceived value of corporate cash holdings. We summarize a list of plausible mechanisms which lead to a positive effect of financial hedging on the value of cash.

First, Faulkender and Wang (2006) find that the marginal value of cash decreases with the level of cash holdings. If financial hedging may reduce corporate cash holdings, then it may subsequently increase the value of cash holdings. Second, financial hedging reduces firms' precautionary motive for holding cash, so that they can invest cash more efficiently. Third, financial hedging improves firms' access to external credit markets (Campello *et al*., 2011; Chen and King, 2014), therefore the use of financial derivatives may help financially constrained firms to reduce the costs of external financing. By mitigating financial constraints, firms are less likely to hoard cash for future debt obligation payments. Hence, financially constrained firms may have a more efficient cash policy with the help of financial hedging. Fourth, financial hedging may mitigate the information asymmetry between managers and shareholders (Dadalt, Gay and Nam, 2002; DeMarzo and Duffie, 1995), which reduces the monitoring costs of shareholders. Firms with better external monitoring may manage cash holdings more efficiently and have a higher perceived value of cash by the market. Last, by reducing the monitoring costs of shareholders, financial hedging may mitigate investors' concerns about managerial misconduct relating to internal cash management, so investors place more value on cash holdings. Taken together, our second hypothesis is:

H2: Firms with financial hedging programs have a higher value of cash holdings than those without such programs.

Research design and sample

Baseline regression models

We begin our empirical analysis by investigating the effect of financial hedging on corporate cash holdings. Specifically, we employ the following regression equation:

$$\begin{aligned} &Cash\ holdings_{i,t} \\ &= \alpha + \beta_1 Financial\ hedging\ proxy_{i,t} \\ &\quad + B \times Control\ variables_{i,t} \\ &\quad + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \tag{1}$$

where i is firm index, t is year index, j is industry index, $Cash\ holdings_{i,t}$ is the ratio of cash and marketable securities to total assets, and $Financial\ hedging\ proxy_{i,t}$ is an indicator variable measuring the use of financial derivatives. Following previous corporate cash holding studies (e.g., Acharya, Almeida and Campello, 2007; Bates, Kahle and Stulz, 2009; Opler *et al*., 1999), we control for the variables related to the precautionary explanations for corporate cash holdings. These variables include firm size ($Size_{i,t}$), cash flow ($CF_{i,t}$), market-to-book value ($MTB_{i,t}$), net working capital ($NWC_{i,t}$), capital expenditure ($CAPEX_{i,t}$), acquisition expenses ($Acquisitions_{i,t}$), R&D expenses (R&D/$Sales_{i,t}$), dividends dummy ($Dividends_{i,t}$), cash flow volatility ($Sigma_{i,t}$) and leverage ($Leverage_{i,t}$). To control for the variations of corporate cash holdings across different industries and over time, we include year (μ_t) and Fama and French (1997) 48-industry (θ_j) fixed effects in Eq. (1).

To examine the relation between financial hedging and the value of corporate cash holdings, we adopt Faulkender and Wang's (2006) model, which estimates the market value of one additional dollar in cash holdings for shareholders. We augment Faulkender and Wang's (2006) regression with our financial hedging proxies and their

[1]The benefits of financial hedging include reducing financial distress costs (Mayers and Smith, 1982) and effective tax payments (Smith and Stulz, 1985), mitigating agency costs related to risk-shifting, underinvestment and information asymmetry between firm managers and shareholders (Campbell and Kracaw, 1990; DeMarzo and Duffie, 1995), increasing internal and external financing capacity (Froot, Scharfstein and Stein, 1993; Leland, 1998) and reducing underinvestment costs (Carter, Rogers and Simkins, 2006).

interactions with the change in cash holdings:

$$\begin{aligned} r_{i,t} - R^{B}_{i,t} = {} & \alpha + \beta_1 \textit{Financial hedging proxy}_{i,t} \\ & \times \Delta C_{i,t} + \beta_2 \textit{Financial hedging proxy}_{i,t} \\ & + \beta_3 \Delta C_{i,t} + \beta_4 \Delta E_{i,t} + \beta_5 \Delta NA_{i,t} \\ & + \beta_6 \Delta R\&D_{i,t} + \beta_7 \Delta I_{i,t} + \beta_8 \Delta D_{i,t} \\ & + \beta_9 NF_{i,t} + \beta_{10} C_{i,t-1} + \beta_{11} C_{i,t-1} \\ & \times \Delta C_{i,t} + \beta_{12} L_{i,t} + \beta_{13} L_{i,t} \times \Delta C_{i,t} \\ & + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \quad (2)$$

where i is firm index, t is year index, j is industry index, $r_{i,t}$ is stock return during fiscal year t, $R^{B}_{i,t}$ is benchmark portfolio return at year t and the benchmark portfolio is one of the 25 Fama and French (1993) value-weighted portfolios formed on size and book-to-market ratio, *Financial hedging proxy*$_{i,t}$ is an indicator variable measuring the use of financial derivatives, Δ indicates a change in the corresponding variables over fiscal year t, $C_{i,t}$ is cash and marketable securities, $E_{i,t}$ is earnings before interest and extraordinary items, $NA_{i,t}$ is total assets net of cash, $R\&D_{i,t}$ is R&D expenses, $I_{i,t}$ is interest expenses, $D_{i,t}$ is common dividends, and $NF_{i,t}$ is net financing proceeds. All the above accounting variables are normalized by the 1-year lagged market value of equity ($MV_{i,t-1}$). $L_{i,t}$ is market leverage, equal to total debt divided by the sum of total debt and market value of equity. μ_t and θ_j are year and Fama–French 48-industry fixed effects. The independent variable of interest is the interaction of our financial hedging proxy with the change in cash holdings: *Financial hedging proxy*$_{i,t} \times \Delta C_{i,t}$. Since both the dependent and explanatory variables are normalized by the 1-year lagged market value of equity, the estimated coefficient β_3 measures the marginal value of cash: the dollar change in a firm's market value for a 1-dollar increase in the firm's cash holdings. The estimated coefficient β_1 can be interpreted as the direct effect of financial hedging on the marginal value of cash. The detailed definitions of our variables are provided in Appendix A.

Financial hedging variables

To collect corporate financial hedging data, we adopt a textual analysis of firms' annual financial reports and search for the keywords related to the use of financial derivatives.[2] The annual financial reports include 10-K and 10-K405. For our sample firm-year observations over the period 1993–2016, we develop an automatic web crawler program in Python, and use the program to evaluate their annual financial reports stored in the Electronic Data Gathering, Analysis and Retrieval system (EDGAR) database.[3] Based on the keywords commonly used in previous financial hedging literature (e.g. Campello *et al*., 2011; Chen and King, 2014; Guay, 1999; Hoberg and Moon, 2017), we follow the procedure laid out in Hoberg and Moon (2017), employing three lists of keywords to identify the use of FX, IR and COMMD derivatives. The keywords in List A identify the underlying assets: 'foreign exchange', 'currency', 'interest rate', 'loan rate' and 'commodity'. The keywords in List B detect the type of financial derivatives: 'forward', 'future', 'option', 'swap', 'spot', 'derivative', 'hedge', 'hedging', 'hedged', 'put', 'call', 'cap', and 'collar'. The keywords in List C confirm the financial hedging positions: 'contract', 'position', 'instrument', 'agreement', 'obligation', 'transaction', and 'strategy'. In many cases, firms disclose their financial hedging positions using more than one sentence. If the annual financial report of a firm-year contains at least one word or its plural form from each of these three lists within a paragraph, we classify the firm as a derivatives user in the corresponding year.

Specifically, we follow Hoberg and Moon (2017) and require that the distance between any two keywords from the above three lists is less than 25 words within a paragraph.[4] If a window with 25 words is found to contain keywords from the above three lists, it is called a 'hit'. For each firm–year observation, we count the 'hit' frequency for each type of financial derivatives and the hedging position. We classify a firm as a derivatives user in the corresponding year if the number of 'hits' is

[2]Nguyen, Nguyen and Sila (2019) and Andreou, Harris and Philip (2020) employ a similar textual-based method to enlarge their sample size and reduce sample selection bias.

[3]Companies were phased into EDGAR filing over a 3-year period, ending 6 May, 1996. Our main empirical results are robust over the sample period 1997–2016 during which electronic filings on EDGAR were mandatory.

[4]We also require the difference between any two keywords from the three lists to be less than 20, 30, 35, 40, 45 and 50 words. Untabulated tests show that our main results are robust.

positive, and a non-user otherwise. To enhance the accuracy of our identification, we drop a 'hit' if the paragraph contains false-positive terms such as 'in the future', 'forward-looking', 'not material', 'insignificant', 'do not/don't use', 'do not/don't enter', 'do not/don't cover', or their past-tense forms. To validate the reliability of our classification, we randomly select 2% of our sample firm-year observations and manually assess their annual reports. We find that the accuracy rates for IR, FX and COMMD derivatives are 80%, 87% and 78%. Our accuracy rates are comparable to the range of 80–90% reported in Hoberg and Moon (2017).[5]

Following prior financial hedging studies (e.g. Allayannis and Weston, 2001; Bartram, Brown and Conrad, 2011; Graham and Rogers, 2002; Manconi, Massimo and Lei, 2018), we measure financial hedging activities using two indicator variables: IR/FX and *Hedging*. IR/FX is equal to 1 if a firm uses at least one type of IR or FX derivatives, and 0 otherwise. *Hedging* is equal to 1 if a firm uses at least one type of IR, FX or COMMD derivatives, and 0 otherwise.[6] In this paper, we do not use the notional value of derivatives to measure financial hedging. After SFAS No. 133 became effective in 2000, it is no longer mandatory for US public firms to report the notional value of their derivatives contracts, as previously required by SFAS No. 119. Instead, US public firms were only required to report the fair value of their derivatives positions after 2000.[7] A hedging position with any positive notional value would have a fair value close to zero, if the underlying asset's market price is close to the strike price of the hedging position. As a result, the recent financial hedging studies usually employ categorical hedging variables, representing each firm's use of a specific type of financial derivatives.

Data sources and summary statistics

Our sample covers firms listed on the NYSE, NASDAQ and AMEX over the period 1993–2016. Since firms in the financial industry may hold derivatives for trading purposes and firms in the utility industry are highly regulated, we follow the previous financial hedging studies and exclude firms in these two industries (SIC codes 6000–6999 and 4900–4999) from our sample (e.g. Allayannis and Weston, 2001; Bartram, Brown and Conrad, 2011). Owing to the EDGAR database's adoption of electronic filings in 1993, our sample period begins in the first year in which electronic filings are available. Our sample begins in 1993 because the electronic filings on the EDGAR database only became effective from then. We collect stock return data and financial accounting data from the CRSP/Compustat Merged database, managerial entrenchment data from the Institutional Shareholder Service (ISS, formerly RiskMetrics) database, institutional ownership data from the Thomson Reuters s34 files, Fama–French benchmark portfolio returns from Kenneth R. French's data library and the counts of sentiment words in annual financial statements are from Bill McDonald's personal website. After dropping firm-year observations with negative assets, negative sales or negative dividends, our final sample consists of 62,859 firm-year observations with the required data for estimating Eqs. (1) and (2).

Panel A of Table 1 presents the summary statistics for the variables in our main empirical tests. All variables in dollar-denominated values are inflation adjusted to 2016 dollars using the Consumer Price Index from the Federal Reserve Bank of St. Louis. Following the literature, we winsorize the stock return and accounting variables at the 1% and 99% levels. In our cash-holding tests, cash holdings and annual cash flows account for 19.4% and 2.1% of total assets for an average firm. About 33.1% of firm-years pay positive dividends. In our marginal value of cash tests, the distribution of stock excess returns is right-skewed with a mean annual excess return of 1.4% and a median of −7.7%. On average, firms have increased their cash holdings over our sample period, with the mean and median of ΔC_t standing at 0.5% and 0.1%. The mean of C_{t-1} is 17.7%, suggesting that the prior cash balances, on average, account for 17.7% of the corresponding market value of equity. The average growth in net assets, earnings,

[5]40.6% firm-year observations are FX derivatives users in our sample, lower than 55.3% reported in Hoberg and Moon (2017). However, Hoberg and Moon (2017) only focus on US firms with offshoring output, which are more likely to hedge FX risk.

[6]When we replace IR/FX and *Hedging* by one of IR, FX and COMMD indicator variables, our baseline regression results are qualitatively the same.

[7]Please refer to SFAS No. 133 for detailed information. Although a number of firms voluntarily disclose the notional value of their hedging positions after 2000, the notional value information is still noisy and might lead to a sample selection bias.

Table 1. Summary statistics

Panel A: Summary statistics of variables

Variable	Obs.	Mean	SD	p1	p25	Median	p75	p99
Dependent variables								
Cash holdings$_t$	62,859	0.194	0.221	0.000	0.028	0.104	0.284	0.917
$r_{i,t} - R^B_{i,t}$	62,859	0.014	0.606	−0.981	−0.340	−0.077	0.211	2.960
Independent variables of interest								
IR/FX$_t$	62,859	0.595	0.491	0	0	1	1	1
Hedging$_t$	62,859	0.643	0.479	0	0	1	1	1
Control and instrumental variables								
Size$_t$	62,859	6.118	1.924	2.257	4.692	6.017	7.436	10.887
CF$_t$	62,791	0.021	0.191	−0.952	0.015	0.068	0.110	0.277
MTB$_t$	62,828	1.960	1.449	0.578	1.106	1.486	2.217	8.976
NWC$_t$	61,599	0.082	0.175	−0.377	−0.030	0.067	0.191	0.548
CAPEX$_t$	62,572	0.054	0.058	0.001	0.018	0.036	0.068	0.323
R&D/*Sales*$_t$	62,341	0.255	1.232	0.000	0.000	0.003	0.077	10.338
Acquisitions$_t$	60,811	0.025	0.062	−0.003	0.000	0.000	0.014	0.346
Dividends$_t$	62,859	0.331	0.471	0	0	0	1	1
Sigma$_t$	62,852	0.086	0.048	0.022	0.049	0.077	0.106	0.237
Leverage$_t$	62,859	0.201	0.189	0.000	0.013	0.169	0.328	0.725
C$_{t-1}$	54,147	0.177	0.229	0.000	0.034	0.097	0.225	1.293
ΔC$_t$	54,147	0.005	0.128	−0.471	−0.030	0.001	0.034	0.566
ΔE$_t$	54,147	0.020	0.220	−0.683	−0.029	0.005	0.038	1.262
ΔNA$_t$	54,147	0.006	0.376	−1.712	−0.063	0.011	0.093	1.499
ΔR&D$_t$	54,147	−0.001	0.022	−0.134	0.000	0.000	0.001	0.076
ΔI$_t$	54,147	0.001	0.017	−0.076	−0.002	0.000	0.002	0.081
ΔD$_t$	54,147	0.000	0.008	−0.049	0.000	0.000	0.000	0.038
NF$_t$	54,147	0.028	0.195	−0.569	−0.035	0.000	0.044	1.004
L$_t$	62,859	0.201	0.221	0.000	0.008	0.128	0.319	0.869
Tax convexity$_t$	62,755	5.344	4.972	−0.818	2.185	4.598	7.175	32.689
Governance variables								
G-Index$_t$	18,187	8.920	2.617	4	7	9	11	15
E-Index$_t$	19,546	3.143	1.427	0	2	3	4	6
TMI$_t$	61,975	0.106	0.157	0.000	0.000	0.023	0.156	0.637
TBLC$_t$	61,975	0.168	0.144	0.000	0.054	0.145	0.262	0.578

Panel B. The average use of financial derivatives across industries.

Fama–French 10 industries	Obs.	IR	FX	COMMD	IR/FX	Hedging
Consumer NonDurables	4,396	0.417	0.440	0.239	0.587	0.626
Consumer Durables	2,111	0.431	0.505	0.200	0.597	0.622
Manufacturing	10,797	0.466	0.583	0.310	0.673	0.715
Energy	3,196	0.548	0.315	0.879	0.637	0.936
Business Equipment	15,295	0.346	0.553	0.078	0.636	0.651
Telecommunications	1,677	0.568	0.317	0.082	0.640	0.646
Wholesale, Retail, and Services	8,435	0.397	0.279	0.172	0.503	0.550
Health	8,356	0.351	0.358	0.079	0.516	0.543
Other	8,596	0.469	0.332	0.254	0.573	0.631

This panel reports the summary statistics of the variables used in our main empirical tests. Our sample consists of 62,859 firm-year observations over the fiscal years 1993–2016, with required data for our baseline regressions. The number of observations, mean, standard deviation, 1st percentile, 25th percentile, median, 75th percentile and 99th percentile are reported from left to right, in sequence for each variable. All variables are defined in Appendix A. All accounting variables in dollars are inflation-adjusted to 2016 dollars. All inflation-adjusted accounting variables and stock return variables are winsorized at the 1% and 99% levels.

This panel reports the percentage of firms using financial derivatives across Fama–French 10 industries. Firms in the financial (in the 'Other' group) and utility industries are excluded from our sample. Our sample consists of 62,859 firm-year observations over the fiscal years 1993–2016, with required data for our baseline regressions. We report the percentage of firms using interest rate (IR) derivatives, the percentage of firms using foreign currency (FX) derivatives, the percentage of firms using commodity (COMMD) derivatives, the percentage of firms using at least one type of IR or FX derivatives (IR/FX) and the percentage of firms using at least one type of IR, FX, or COMMD derivatives (Hedging).

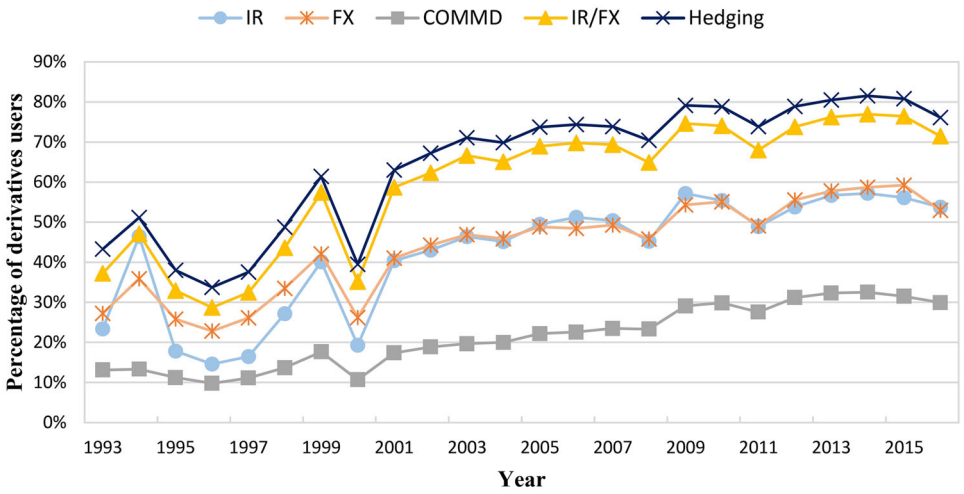

Figure 1. Average percentage of the use of derivatives from 1993 to 2016 [Colour figure can be viewed at wileyonlinelibrary.com] The sample covers all firms listed on the NYSE, NASDAQ and AMEX over the period 1993–2016 with positive values for the book value of total assets and sales revenue. Firms in the financial and utility industries (SIC codes 6000–6999 and 4900–4999) are excluded from the sample, yielding a panel of 62,859 firm-year observations for 8,235 unique firms. The bottom three lines present the percentage of firms using interest rate (IR) derivatives, foreign currency (FX) derivatives and commodity (COMMD) derivatives, respectively. The top two lines present the percentage of firms using at least one type of IR or FX derivatives (IR/FX), and the percentage of firms using at least one type of IR, FX or COMMD derivatives (Hedging).

R&D, interest expenses and dividends are all close to zero. The average leverage is 20.1% and the average of net financing is 2.8%. The summary statistics of these variables are comparable to those reported in earlier value-of-cash studies.

Panel A also shows that among 62,859 firm-years in our effective sample, the mean of IR/FX is 59.5% and the mean of *Hedging* is 64.3%. Specifically, 31.4% of our sample firm-years adopt IR derivatives and 27.8% adopt FX derivatives, which are comparable to the 35.6% and 27.3% reported in Campello *et al.* (2011).[8] Bartram, Brown and Conrad (2011) report that 65.1% of US firms use at least one type of IR, FX or COMMD derivatives, which is comparable to 64.3% in our sample. Figure 1 shows that over our sample period 1993–2016, the mean values of IR, FX, COMMD, IR/FX and Hedging increase from 23.4%, 27.3%, 13.1%, 37.2% and 43.3% to 53.7%, 53.0%, 29.9%, 71.5% and 76.1%, respectively. The popularity of corporate financial hedging declines slightly during the stock market crashes observed in 2000 and 2008. Panel B of Table 1 presents the average use of financial derivatives across the Fama–French 10 industries (Fama and French, 1997), excluding firms in the financial and utility industries. IR, FX and COMMD derivatives are most (least) popularly used among firms in the Telecommunications (Health), Manufacturing (Telecommunications) and Energy (Health) industry, respectively. IR/FX and *Hedging* have the highest mean values in the Manufacturing and Energy industries.

Main results

Baseline regressions

We begin our empirical analysis by investigating the relation between financial hedging and corporate cash holdings. Table 2 presents the results from estimating Eq. (1). In columns (1) and (2), the coefficients of the financial hedging proxy variables are negative and statistically significant at the 1% level after controlling for observable firm characteristics, indicating that derivatives users hold less cash than non-users. The impact of financial hedging on corporate cash holdings is also economically meaningful. Column (1) suggests that on average, firms using at least one type of IR or FX derivatives hold 0.7% lower cash reserves

[8]Campello *et al.* (2011) manually collect financial hedging data using a sample of 2,288 US firm-years over 1996–2002. Campello *et al.*'s (2011) sample only includes firms with unique information on investment restrictions in loan covenants, which have a higher incentive to hedge their IR risk.

Table 2. Baseline regression I: Financial hedging and corporate cash holdings

Variables	(1)	(2)
IR/FX_t	−0.007**	
	[−2.53]	
$Hedging_t$		−0.006**
		[−2.09]
$Size_t$	−0.015***	−0.015***
	[−14.86]	[−15.10]
CF_t	−0.048***	−0.048***
	[−5.18]	[−5.18]
MTB_t	0.029***	0.029***
	[28.32]	[28.32]
NWC_t	−0.320***	−0.320***
	[−30.49]	[−30.50]
$CAPEX_t$	−0.530***	−0.528***
	[−24.96]	[−24.92]
$R\&D/Sales_t$	0.029***	0.029***
	[18.38]	[18.39]
$Acquisitions_t$	−0.396***	−0.396***
	[−35.67]	[−35.67]
$Dividends_t$	−0.022***	−0.022***
	[−6.70]	[−6.69]
$Sigma_t$	0.336***	0.336***
	[8.69]	[8.68]
$Leverage_t$	−0.017***	−0.017***
	[−22.79]	[−22.79]
Constant	0.259***	0.259***
	[12.92]	[12.93]
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	58,796	58,796
Adjusted-R^2	0.528	0.528

This table reports the OLS regressions of corporate cash holdings on financial hedging proxy variables and control variables. The sample consists of 58,796 firm-year observations of US firms over the sample period 1993–2016 with required data for the regressions. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are IR/FX_t and $Hedging_t$. All variables are defined in Appendix A. The coefficients of the year and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

than those without IR and FX hedging programs. Column (2) suggests that on average, firms using at least one type of IR, FX or COMMD derivatives hold 0.6% lower cash reserves than firms that do not utilize these hedging instruments. Given that the average cash-holding ratio in our sample is 19.4%, the reduction in cash holdings is about 3.6% (IR/FX) and 3.1% (*Hedging*) of an average firm's cash holdings.

The sign and statistical significance of the coefficients of our control variables are consistent with those documented in Bates, Kahle and Stulz (2009), who examine the relation between firm characteristics and corporate cash holdings. We find that cash holdings decrease significantly with firm size, net working capital, capital expenditure, acquisition expenditures, dividend payments and leverage. Conversely, cash holdings increase significantly with the market-to-book ratio, R&D expenses and industry cash flow risk. The coefficients of our control variables are statistically significant at the 1% level. These findings support the notion that the precautionary motive for holding cash arises when firms are smaller and have better investment opportunities, but higher external financing costs. Our results also provide strong evidence that firms tend to hold more cash when they possess higher firm-specific risk and have limited access to external capital markets.

Next, we examine the impact of financial hedging on the value of corporate cash holdings using Faulkender and Wang's (2006) framework. Table 3 presents the results of the ordinary least squares (OLS) regressions of firm excess stock returns on the change in cash holdings, financial hedging proxy variables, the interaction of the previous two variables and control variables. In column (1), we replicate Faulkender and Wang's (2006) baseline regression over their sample period 1972–2001. We find that for a firm with zero leverage and cash holdings equal to 5% of their market value of equity, the value of an additional dollar of cash is \$1.52 (\$1.556 + (−0.742 ∗ 5%)), similar to the \$1.43 documented in Faulkender and Wang (2006).[9] Consistent with Faulkender and Wang (2006), the estimated coefficients of $C_{t-1} \times \Delta C_t$ and $L_t \times \Delta C_t$ are negative and statistically significant at the 1% level, indicating that the marginal value of cash decreases with the level of cash holdings and leverage. In columns (2) and (3), the interaction terms between the change in cash holdings and financial hedging proxy variables represent the impact of financial hedging on the marginal value of cash. As shown in

[9]Our replication sample includes 89,565 observations, which are more than the 82,187 observations reported in Faulkender and Wang (2006). Faulkender and Wang (2006) drop the observations in their sample falling beyond the 1% tail, while we winsorize our variables at the 1% and 99% tails. In addition, the CRSP/Compustat Merged dataset was not available in 2006.

Table 3. Baseline regression II: Financial hedging and marginal value of cash

Variables	(1)	(2)	(3)
$IR/FX_t \times \Delta C_t$		0.058**	
		[2.27]	
IR/FX_t		0.037***	
		[7.27]	
$Hedging_t \times \Delta C_t$			0.057**
			[2.24]
$Hedging_t$			0.034***
			[6.41]
ΔC_t	1.556***	2.073***	2.071***
	[40.68]	[33.95]	[33.63]
ΔE_t	0.524***	0.568***	0.567***
	[41.40]	[30.73]	[30.73]
ΔNA_t	0.177***	0.229***	0.230***
	[27.78]	[19.76]	[19.80]
$\Delta R\&D_t$	1.135***	0.704***	0.706***
	[8.64]	[3.97]	[3.98]
ΔI_t	−1.792***	−2.828***	−2.827***
	[−20.99]	[−12.13]	[−12.12]
ΔD_t	3.173***	2.031***	2.046***
	[15.99]	[6.72]	[6.77]
NF_t	0.072***	−0.016	−0.017
	[5.82]	[−0.66]	[−0.70]
C_{t-1}	0.277***	0.369***	0.369***
	[21.57]	[18.90]	[18.86]
$C_{t-1} \times \Delta C_t$	−0.742***	−1.095***	−1.095***
	[−12.81]	[−11.28]	[−11.27]
L_t	−0.474***	−0.513***	−0.512***
	[−57.52]	[−39.81]	[−39.68]
$L_t \times \Delta C_t$	−1.602***	−2.248***	−2.247***
	[−21.10]	[−16.61]	[−16.62]
Constant	0.063***	−0.015	−0.013
	[19.95]	[−0.36]	[−0.33]
Industry fixed effects	No	Yes	Yes
Year fixed effects	No	Yes	Yes
Observations	89,565	54,147	54,147
Adjusted-R^2	0.205	0.218	0.218

This table reports the OLS regressions of firm excess returns on the change in cash holdings, financial hedging proxy variables, the interaction of the prior two variables, and control variables. The sample consists of 54,147 firm-year observations of US firms over the sample period 1993–2016 with required data for the regressions. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. Δ indicates the change in the corresponding variables from year t − 1 to t. In column (1), we replicate Faulkender and Wang's (2006) baseline regression over the sample period 1972–2001. All variables are defined in Appendix A. The coefficients of the year and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

columns (2) and (3), the estimated coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ are positive and statistically significant at the 5% level. Consistent with our hypothesis, the marginal value of cash increases with the use of financial derivatives. The results suggest that the marginal value of cash is about $0.06 higher for derivatives users than non-users. The signs of the estimated coefficients on the other control variables are consistent with those reported in Faulkender and Wang (2006).

Overall, the results of our baseline regressions support H1 and H2.

Endogeneity

One potential endogeneity concern for any corporate financial hedging study is that firms do not

make financial hedging decisions randomly (e.g. Bartram, 2019; Campello *et al*., 2011; Manconi, Massimo and Lei, 2018). Firms' cash policy and decision to employ financial derivatives may be spuriously associated with unobservable firm characteristics. In addition, firms with lower cash reserves may be more likely to hedge future cash flow risk with financial derivatives. The endogeneity issue is slightly attenuated in our value-of-cash study, as the marginal value of cash depends on market investors' expectations. However, since investors' perceived value of cash also depends on firm choices such as cash holdings, use of cash and other corporate strategies, we still need to address the endogeneity concern in our value-of-cash study. As discussed in Abdallah, Goergen and O'Sullivan (2015), failure to adjust for potential endogeneity has severe consequences in business and management research, such as drawing inappropriate inferences. To mitigate the endogeneity concern, we employ the following three identification approaches: Heckman's (1978) treatment effect model, a PSM method and a high-dimensional fixed effects model.

Heckman's treatment effect model

Derivatives users and non-users may differ in many observable or unobservable firm characteristics, leading to the possibility that financial hedging decisions are made endogenously. In addition, firms may choose to employ financial derivatives according to their cash policy and the value of cash holdings. Therefore, self-selection bias could arise and result in unreliable OLS estimates, as shown by Heckman (1978) and Wooldridge (2010). We follow the earlier financial hedging literature (e.g. Allayannis, Lel and Miller, 2012; Chen and King, 2014; Manconi, Massimo and Lei, 2018) and utilize Heckman's treatment effect model as our first identification method.

In Heckman's treatment effect model, the first-stage probit regression estimates the probability of adopting financial derivatives, and the second-stage OLS regression corrects for selection bias by including the inverse Mills ratio (IMR) estimated by the first-stage regression as a control variable. Li and Prabhala (2007) and Huang *et al*. (2015) suggest the inclusion of a variable in the first-stage regression that does not appear in the second-stage regression. Ideally, this variable should have an impact on financial hedging decisions, but should not be related to our outcome variables such as cash holdings and excess stock returns.[10] Inspired by a salient institutional feature of the US corporate tax code – corporate income tax convexity, Campello *et al*. (2011) propose that *Tax convexity* estimated by Graham and Smith (1999) measures the expected tax savings from financial hedging and may serve as a suitable identification variable in financial hedging studies. Firms with a convex income-tax schedule may adopt financial hedging to reduce their expected tax liability (e.g. Géczy, Minton and Schrand, 1997; Nance, Smith and Smithson, 1993; Smith and Stulz, 1985). Since the tax benefits of financial hedging differ across firms with various tax incentives, the cross-sectional heterogeneity in the expected tax benefits related to financial hedging may alleviate the concern of weak exclusion restrictions. To facilitate identification, we follow prior work and use the 1-year lag of *Tax convexity* as our identification variable in the first stage of Heckman's treatment effect model to estimate IMR (e.g. Campello *et al*., 2011; Chen and King, 2014; Manconi, Massimo and Lei, 2018). The detailed definition of *Tax convexity* is provided in Appendix A. To the best of our knowledge, previous studies do not document any relation between *Tax convexity* and our cash-related outcome variables. Therefore, *Tax convexity* does not seem to violate the exclusion restriction. In addition, it is unlikely that there exists any systematic correlation between *Tax convexity* and potential measurement errors in our financial hedging variables.

Panel A of Table 4 reports the results of Heckman's treatment effect model for the corporate cash-holding tests. All the control variables in the first-stage and second-stage regressions are the same as those included in Eq. (1). Columns (1) and (3) report the results of the first-stage selection equation estimated by probit regressions, in which the dependent variables are financial hedging indicator variables IR/FX_t and $Hedging_t$. The coefficients of $Tax\ convexity_{t-1}$ are positive and statistically significant at the 1% level, suggesting that $Tax\ convexity_{t-1}$ is positively associated with firms' propensity to employ financial derivatives and satisfies the relevance condition. Columns (2) and (4) report the results of the second-stage

[10]The exclusion restriction is not critical in Heckman's treatment effect model, as the model is identified by the non-linearity of IMR (Li and Prabhala, 2007).

Table 4. Heckman's treatment effect model

Panel A: Financial hedging and corporate cash holdings.

	IR/FX		Hedging	
Variables	(1)	(2)	(3)	(4)
IR/FX_t		−0.007**		
		[−2.23]		
$Hedging_t$				−0.006*
				[−1.84]
$Tax\ convexity_{t-1}$	0.009***		0.009***	
	[6.29]		[5.83]	
IMR_IR/FX_t		0.017		
		[0.54]		
$IMR\_Hedging_t$				−0.003
				[−0.12]
Constant	0.645***	0.262***	0.706***	0.270***
	[6.41]	[10.55]	[6.87]	[12.08]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	50,013	50,013	50,013	50,013
Pseudo/adjusted–R^2	0.109	0.526	0.133	0.526

Panel B: Financial hedging and marginal value of cash.

	IR/FX		Hedging	
Variables	(1)	(2)	(3)	(4)
$IR/FX_t \times \Delta C_t$		0.058**		
		[2.26]		
IR/FX_t		0.037***		
		[7.27]		
$Hedging_t \times \Delta C_t$				0.057**
				[2.24]
$Hedging_t$				0.034***
				[6.37]
$Tax\ convexity_{t-1}$	0.012***		0.010***	
	[12.36]		[9.74]	
IMR_IR/FX_t		0.022		
		[0.45]		
$IMR\_Hedging_t$				−0.035
				[−0.75]
Constant	0.588***	−0.024	0.680***	0.001
	[6.18]	[−0.51]	[7.00]	[0.03]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	54,054	54,054	54,054	54,054
Pseudo/adjusted–R^2	0.099	0.218	0.123	0.218

This panel reports Heckman's (1978) two-stage regressions of corporate cash holdings on financial hedging proxy variables and control variables. The sample consists of the US firm-year observations over the sample period 1993–2016 with required data for the regressions. $Tax\ convexity_{t-1}$ is the variable which is included in the first-stage regressions to estimate the inverse Mills ratio (IMR). Columns (1) and (3) report the results of the first-stage probit regressions, in which the dependent variables are IR/FX_t and $Hedging_t$. Columns (2) and (4) report the second-stage OLS regression results, in which the dependent variable is $Cash\ holdings_t$. The inverse Mills ratios, IMR_IR/FX_t and $IMR\_Hedging_t$, are estimated from the first-stage regressions. The control variables are the same as those reported in Table 2. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects, and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This panel reports Heckman's (1978) two-stage regressions of firm excess returns on the change in cash holdings, financial hedging proxy variables, the interaction of the prior two variables, and control variables. The sample consists of US firm-year observations over the sample period 1993–2016 with required data for the regressions. $Tax\ convexity_{t-1}$ is the variable which is included in the first-stage regressions to estimate the inverse Mills ratio (IMR). Columns (1) and (3) report the first-stage probit regression results, in which the dependent variables are IR/FX_t and $Hedging_t$. Columns (2) and (4) report the second-stage OLS regression results, in which the dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. The inverse Mills ratios, IMR_IR/FX_t and $IMR\_Hedging_t$, are estimated from the first-stage regressions. Δ indicates the change in the corresponding variables from year $t-1$ to t. The control variables are the same as those reported in Table 3. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

OLS regressions, in which we estimate the impact of financial hedging on corporate cash holdings. In the second-stage regressions, the dependent variables are *Cash holdings*$_t$ and the independent variables of interest are the two financial hedging indicator variables. We include IMR_IR/FX$_t$ and IMR_*Hedging*$_t$ estimated in the corresponding first-stage regressions to control for any potential selection bias. The coefficients of IR/FX$_t$ and *Hedging*$_t$ remain negative and statistically significant at the 5% and 10% levels, suggesting that the hedging effect on cash holdings is robust after controlling for potential self-selection biases.

Panel B of Table 4 reports the results of Heckman's treatment effect model for the marginal value of cash tests. All the control variables in the first-stage and second-stage regressions are the same as those included in Eq. (2). Columns (1) and (3) report the results of the first-stage selection regressions. The coefficients of *Tax convexity*$_{t-1}$ are positive and statistically significant at the 1% level, which supports the relevance condition. Columns (2) and (4) report the results of the second-stage regressions. The coefficients of IR/FX$_t \times \Delta$C$_t$ and *Hedging*$_t \times \Delta$C$_t$ are positive and statistically significant at the 5% level after controlling for the potential selection bias.

Taken together, after mitigating endogeneity concerns with Heckman's treatment effect model, our baseline regression results remain robust. We still observe a negative relation between financial hedging and corporate cash holdings and a positive relation between financial hedging and the marginal value of cash.

Propensity score matching

Heckman's model helps us to mitigate endogeneity concerns due to unobserved firm heterogeneity and measurement errors in our regression variables. If the differences in corporate cash policy or in the value of cash are associated with the firm characteristics affecting firms' financial hedging decisions, then the impact of financial hedging on corporate cash holdings or the value of cash may be driven by other confounding factors. In this section, we employ a PSM strategy as an alternative identification method to alleviate any endogeneity due to potential confounding variables.

Specifically, we follow Bartram, Brown and Conrad (2011) and use probit models to estimate the propensity scores of firms that use financial derivatives. We include the control variables in regression Eqs. (1) and (2) as observable firm characteristics in the probit models to separately estimate the propensity scores. Next, we adopt a nearest-neighbour matching approach without replacement and use the propensity score to find a control firm for each derivatives user. We require that the maximum difference in the propensity scores between derivatives users and non-users does not exceed 0.5% in absolute value. Panels A and B of Table 5 report the univariate comparisons of firm characteristics between derivatives users and matched non-users for our corporate cash-holding tests and marginal value-of-cash tests. In these two panels, we classify firms as derivatives users using IR/FX in columns (1)–(3) and using *Hedging* in columns (4)–(6). Columns (1)–(2) and (4)–(5) report the mean value of firm characteristics, and columns (3) and (6) report the t-statistics of the univariate comparisons between derivatives users and matched non-users. All t-statistics are not statistically significant at the 10% level, except L$_t$ in column (6) of Panel B, indicating that firms in the control groups and treatment groups have comparable firm characteristics.

In Panel C of Table 5, we re-estimate Eq. (1) using the PSM sample. The coefficients of IR/FX$_t$ and *Hedging*$_t$ are negative and statistically significant at the 1% level. On average, firms using at least one type of IR or FX derivatives hold 1.0% lower cash reserves than matched non-users, while firms using at least one type of IR, FX, or COMMD derivatives hold 0.8% lower cash reserves than matched non-users. In Panel D of Table 5, we re-estimate Eq. (2) using the PSM sample. The coefficients of IR/FX$_t \times \Delta$C$_t$ and *Hedging*$_t \times \Delta$C$_t$ remain positive and statistically significant at the 1% level. On average, the marginal value of cash is about \$0.10 higher for firms using at least one type of IR or FX derivatives than matched non-users, while the marginal value of cash is about \$0.12 higher for firms using at least one type of IR, FX or COMMD derivatives than matched non-users. The financial hedging effects on cash holdings and the value of cash remain robust to the PSM identification method.

High-dimensional fixed effects

In the third identification method, we follow Gormley and Matsa (2014) and control for unobserved heterogeneity across firms and time-varying

Table 5. Propensity score matching

Panel A: Differences in firm characteristics between derivatives users and non-users: cash holding tests.

	IR/FX matched sample (16,699 pairs)			Hedging matched sample (15,417 pairs)		
Variables	Users (1)	Non-users (2)	t-Stat. (3)	Users (4)	Non-users (5)	t-Stat. (6)
$Size_t$	5.700	5.681	1.01	5.544	5.548	−0.19
CF_t	0.013	0.013	−0.27	0.007	0.009	−0.87
MTB_t	1.966	1.975	−0.54	2.004	1.987	0.98
NWC_t	0.090	0.090	−0.06	0.093	0.095	−0.71
$CAPEX_t$	0.056	0.056	0.09	0.051	0.052	−0.52
R&D/$Sales_t$	0.307	0.302	0.32	0.343	0.333	0.63
$Acquisitions_t$	0.024	0.024	−0.53	0.024	0.024	0.10
$Dividends_t$	0.301	0.295	1.16	0.286	0.286	−0.09
$Sigma_t$	0.085	0.086	−0.25	0.085	0.085	0.62
$Leverage_t$	0.569	0.566	0.18	0.535	0.540	−0.38

Panel B: Differences in firm characteristics between derivatives users and non-users: Value of cash tests.

	IR/FX matched sample (17,247 pairs)			Hedging matched sample (15,649 pairs)		
Variables	Users (1)	Non-users (2)	t-Stat. (3)	Users (4)	Non-Users (5)	t-Stat. (6)
ΔC_t	0.002	0.002	0.05	0.001	0.002	−0.58
ΔE_t	0.023	0.021	0.57	0.023	0.021	0.66
ΔNA_t	−0.003	0.000	−0.87	−0.004	0.000	−0.87
$\Delta R\&D_t$	−0.001	−0.001	−0.67	−0.001	−0.001	−0.52
ΔI_t	0.000	0.000	−0.20	0.000	0.001	−0.87
ΔD_t	0.000	0.000	−0.75	0.000	0.000	−0.24
NF_t	0.031	0.030	0.56	0.028	0.028	0.01
C_{t-1}	0.184	0.183	0.67	0.188	0.187	0.64
$C_{t-1} \times \Delta C_t$	−0.010	−0.010	−0.16	−0.011	−0.010	−0.97
L_t	0.188	0.190	−0.97	0.178	0.184	−2.38*
$L_t \times \Delta C_t$	0.000	0.000	0.15	−0.001	−0.001	−0.70

Panel C: Financial hedging and corporate cash holdings.

Variables	(1)	(2)
IR/FX_t	−0.010***	
	[−3.33]	
$Hedging_t$		−0.008***
		[−2.70]
Constant	0.254***	0.249***
	[10.91]	[10.20]
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	33,398	30,834
Adjusted-R^2	0.542	0.539

Panel D: Financial hedging and marginal value of cash.

Variables	(1)	(2)
$IR/FX_t \times \Delta C_t$	0.099***	
	[2.64]	
IR/FX_t	0.038***	
	[6.55]	
$Hedging_t \times \Delta C_t$		0.122***
		[3.33]

Table 5. (Continued)

Panel D: Financial hedging and marginal value of cash. Variables	(1)	(2)
$Hedging_t$		0.035***
		[5.76]
ΔC_t	2.127***	2.073***
	[27.76]	[26.47]
Constant	−0.060	−0.088
	[−1.25]	[−1.58]
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	34,494	31,298
Adjusted-R^2	0.223	0.220

This panel reports the univariate comparisons of firm characteristics between derivatives users and matched non-users. We use a probit model to estimate the propensity scores, in which the dependent variables are IR/FX_t and $Hedging_t$, and the independent variables are the control variables in Eq. (1). We use a one-to-one nearest-neighbour match and require that the difference in the propensity scores between derivatives users and matched non-users does not exceed 0.5% in absolute value. In columns (1)–(2) and (4)–(5), we report the mean value of firm characteristics. In columns (3) and (6), we report the t-statistics of the univariate comparisons between derivatives users and matched non-users. All variables are defined in Appendix A. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

This panel reports the univariate comparisons of firm characteristics between derivatives users and matched non-users. We use a probit model to estimate the propensity scores in which the dependent variables are IR/FX_t and $Hedging_t$, and the independent variables are the control variables in Eq. (2). We use a one-to-one nearest-neighbour match and require that the difference in the propensity scores between derivatives users and matched non-users does not exceed 0.5% in absolute value. In columns (1)–(2) and (4)–(5), we report the mean value of firm characteristics. In columns (3) and (6), we report the t-statistics of the univariate comparisons between derivatives users and matched non-users. All variables are defined in Appendix A. ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

This panel reports the results of re-estimating Eq. (1) using the PSM sample. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are IR/FX_t and $Hedging_t$. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This panel reports the results of re-estimating Eq. (2) using the PSM sample. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. Δ indicates the change in the corresponding variables from year t − 1 to t. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects, and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

heterogeneity across industries in our baseline regressions. Unobservable firm characteristics may be correlated with financial hedging and affect corporate cash policies and the value of cash holdings. Since such potential hidden bias may still remain after matching by propensity scores, we adopt a high-dimensional fixed effects model to directly control for unobserved heterogeneity.

In Panel A of Table 6, we re-estimate Eq. (1) with the firm and industry-year fixed effects. Consistent with the baseline regression results reported in Table 2, the estimated coefficients of IR/FX_t and $Hedging_t$ remain positive and statistically significant at the 1% level. After controlling for unobserved firm characteristics, derivatives users hold 1.4% lower cash reserves than non-users. In Panel B of Table 6, we re-estimate Eq. (2) with the firm and industry-year fixed effects. The coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ remain positive and statistically significant at the 1% level. On average, the marginal value of cash is about $0.07 higher for derivatives users than non-users.

Why financial hedging increases the value of cash

Our analysis so far indicates that firms with financial hedging programs tend to hold a lower amount of cash but have a higher market perceived value of cash. We conjecture that financial hedging may reduce corporate cash holdings through three channels: cash flow uncertainty, volatile investment opportunity and financial risk.

Table 6. High-dimensional fixed effects

Panel A: Financial hedging and corporate cash holdings. Variables	(1)	(2)
IR/FX_t	−0.014***	
	[−10.55]	
$Hedging_t$		−0.014***
		[−10.15]
Constant	0.292***	0.294***
	[32.88]	[33.01]
Control variables	Yes	Yes
Industry × Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	57,653	57,653
Adjusted-R^2	0.812	0.811
Panel B: Financial hedging and marginal value of cash. Variables	**(1)**	**(2)**
$IR/FX_t \times \Delta C_t$	0.073***	
	[2.76]	
IR/FX_t	0.018***	
	[2.63]	
$Hedging_t \times \Delta C_t$		0.068***
		[2.63]
$Hedging_t$		0.017**
		[2.31]
ΔC_t	2.004***	2.003***
	[33.43]	[33.13]
Constant	0.026***	0.026***
	[3.37]	[3.23]
Control variables	Yes	Yes
Industry × Year fixed effects	Yes	Yes
Firm fixed effects	Yes	Yes
Observations	53,096	53,096
Adjusted-R^2	0.305	0.305

This panel reports the results of re-estimating Eq. (1). Following Gormley and Matsa (2014), we use the high-dimensional fixed effects model (firm and interacted industry-year fixed effects) to control for unobserved firm characteristics. The sample consists of the US firm-year observations over the sample period 1993–2016 with required data for the regressions. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are IR/FX_t and $Hedging_t$. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

This panel reports the results of re-estimating Eq. (2). Following Gormley and Matsa (2014), we use the high-dimensional fixed effects model (firm and interacted industry-year fixed effects) to control for unobserved firm characteristics. The sample consists of US firm-year observations over the sample period 1993–2016 with required data for the regressions. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. Δ indicates the change in the corresponding variables from year t − 1 to t. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

As discussed in earlier, these three channels have been well documented in previous studies. As for the positive effect of financial hedging on the value of cash, Smith and Stulz (1985) show that corporate financial hedging reduces a firm's cash flow volatility. Therefore, firms using financial derivatives should have a lower precautionary demand for cash holdings. Since the marginal value of cash is negatively related to cash holdings (Faulkender and Wang, 2006), it is intuitive that one direct channel through which financial hedging increases the value of cash is the negative impact

of financial hedging on corporate cash holdings. In this section, we further explore four plausible mechanisms (discussed earlier) of the positive financial hedging effect on the value of cash.

Investment channel

Campello *et al*. (2011) show that derivatives users have higher capital expenditures than non-users. Financial hedging may enable firms to invest cash in positive NPV projects instead of hoarding cash for the precautionary motive, which enhances the value of cash holdings. To further explore the investment channel, we extend the seminal investment-Q framework (Baker, Stein and Wurgler, 2003) by adding our financial hedging proxies and their interactions with Tobin's Q, cash flow and cash holdings:

$$\begin{aligned} &Investment_{i,t+1} \\ &= \alpha + \beta_1 Financial\ hedging\ proxy_{i,t} \\ &\quad + \beta_2 Financial\ hedging\ proxy_{i,t} \times Q_{i,t} \\ &\quad + \beta_3 Financial\ hedging\ proxy_{i,t} \\ &\quad \times CF_{i,t} + \beta_4 Financial\ hedging\ proxy_{i,t} \\ &\quad \times Cash\ holdings_{i,t} + \beta_5 Q_{i,t} \\ &\quad + \beta_6 CF_{i,t} + \beta_7 Cash\ holdings_{i,t} + B \\ &\quad \times Control\ variables_{i,t} \\ &\quad + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \tag{3}$$

where the control variables include *Size*, *Profitability*, *CF volatility*, *Leverage* and *Z-score* (Baker, Stein and Wurgler, 2003; Campello *et al*., 2011). McLean, Zhang and Zhao (2012) show that investment-Q and investment-cash flow sensitivities are associated with *ex-post* investment efficiency. Columns (1) and (2) of Table 7 show that there is a positive relation between financial hedging and firm investment after controlling for firm characteristics. This result is consistent with Campello *et al*.'s (2011) finding that derivatives users tend to invest more than non-users. In columns (3) and (4), we add the interaction terms $IR/FX_t \times Q_t$ and $Hedging_t \times Q_t$, respectively. The coefficients of these two interaction terms are positive and statistically significant at the 5% level, suggesting that financial hedging increases firm-level capital allocation efficiency manifested in investment sensitivity to future growth opportunities. Further, we add the interaction terms between financial hedging and cash flow in columns (5) and (6) and the interaction terms between financial hedging and cash holdings in columns (7) and (8). The coefficients of $IR/FX_t \times Q_t$ and $Hedging_t \times Q_t$ remain positive and statistically significant. More importantly, the coefficients of the interaction terms between financial hedging and cash flow (cash holdings) are positive and statistically significant at the 5% and 1% levels. These results support the notion that financial hedging strengthens the positive relation between investment and internal cash. Overall, our findings confirm the investment mechanism that financial hedging not only increases the investment sensitivity to internal cash, but also has a positive effect on investment efficiency.

Financial constraints

Firms with financial constraints may forgo positive NPV projects when internal funds are in short supply (Fazzari, Hubbard and Petersen, 1988). Campello *et al*. (2011) and Chen and King (2014) find that corporate financial hedging may mitigate the underinvestment problem by alleviating firms' financial constraints and reducing the cost of raising external funds. Therefore, financial hedging may help firms with financial constraints to free cash from serving debt obligations and invest cash into positive NPV projects. We posit that the positive relation between financial hedging and the value of cash is stronger for firms with tighter financial constraints.

We employ two proxies for financial constraints. The first proxy is *KZ-Index*, constructed by Kaplan and Zingales (1997) and Lamont, Polk and Saaá-Requejo (2001). KZ-Index is a relative measure of firms' dependence on external financing. Firms with a higher KZ-Index are more likely to experience difficulties when financial conditions tighten. The second proxy is SA-Index, the size–age index developed by Hadlock and Pierce (2010). By comparing a group of quantitative measures of financial constraints to the related qualitative information from firms' financial reports, Hadlock and Pierce (2010) find that firm age and size have a higher explanatory power in predicting firms' future financial constraint status. A firm is assigned to the financially constrained (unconstrained) sub-sample if its KZ-Index or SA-Index is above (below) the annual median.

Panel A of Table 8 presents the results of

Table 7. Financial hedging, internal cash, and investment efficiency

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IR/FX_t*Q_t			0.002**		0.002*		0.006***	
			[2.38]		[1.78]		[5.57]	
$Hedging_t*Q_t$				0.002**		0.002**		0.006***
				[2.22]		[2.16]		[6.59]
IR/FX_t*CF_t					0.071***		0.024**	
					[4.24]		[2.02]	
$Hedging_t*CF_t$						0.044***		0.055***
						[3.79]		[4.63]
$IR/FX_t*Cash\ holdings_t$							0.015**	
							[2.01]	
$Hedging_t*Cash\ holdings_t$								0.026***
								[3.14]
IR/FX_t	0.005***		0.005***		0.003**		−0.001	
	[2.95]		[3.61]		[2.35]		[−0.84]	
$Hedging_t$		0.008***		0.009***		0.008***		0.001
		[4.90]		[5.80]		[5.36]		[0.27]
$Cash\ holdings_t$	0.069***	0.069***	0.069***	0.069***	0.070***	0.070***	0.064***	0.068***
	[10.58]	[10.58]	[10.53]	[10.53]	[10.78]	[10.72]	[7.53]	[7.78]
Q_t	0.022***	0.022***	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***
	[23.94]	[24.00]	[20.79]	[20.18]	[21.43]	[20.05]	[19.63]	[19.08]
CF_t	0.029***	0.029***	0.029***	0.029***	0.016*	0.009	0.025**	0.010
	[3.40]	[3.41]	[3.40]	[3.38]	[1.69]	[0.81]	[2.32]	[0.92]
$Size_t$	−0.002***	−0.002***	−0.002***	−0.003***	−0.003***	−0.003***	−0.002***	−0.003***
	[−3.41]	[−3.69]	[−3.94]	[−4.12]	[−4.64]	[−4.56]	[−3.99]	[−4.44]

Table 7. (Continued)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Profitability_t$	−0.082***	−0.082***	−0.083***	−0.083***	−0.085***	−0.081***	−0.088***	−0.088***
	[−6.99]	[−7.01]	[−7.16]	[−7.13]	[−7.26]	[−6.98]	[−7.42]	[−7.41]
$CF\ volatility_t$	0.070***	0.070***	0.070***	0.070***	0.066***	0.068***	0.096***	0.094***
	[4.03]	[4.03]	[4.02]	[4.03]	[3.84]	[3.92]	[5.47]	[5.36]
$Leverage_t$	−0.030***	−0.031***	−0.031***	−0.032***	−0.029***	−0.031***	−0.046***	−0.045***
	[−5.67]	[−5.77]	[−5.81]	[−5.89]	[−5.43]	[−5.75]	[−8.63]	[−8.54]
$Z\text{-score}_t$	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.007***	−0.008***	−0.007***
	[−9.24]	[−9.24]	[−9.22]	[−9.25]	[−9.13]	[−9.18]	[−9.28]	[−9.27]
Constant	0.073***	0.071***	0.073***	0.072***	0.074***	0.073***	0.084***	0.082***
	[4.89]	[4.76]	[4.87]	[4.74]	[4.91]	[4.83]	[5.59]	[5.44]
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	46,250	46,250	46,250	46,250	46,250	46,250	46,250	46,250
Adjusted-R^2	0.454	0.454	0.455	0.455	0.456	0.456	0.441	0.444

This table reports the OLS regressions of firm investment on financial hedging proxy variables, Tobin's Q, cash flow, cash holdings, the interaction of financial hedging and Q, the interaction of financial hedging and cash flow, the interaction of financial hedging and cash holdings, and control variables. The sample consists of firm-year observations of US firms over the sample period 1993–2016 with required data for the regressions. The dependent variable is $Investment_{t+1}$, annual capital expenditures plus R&D spending scaled by the lagged total assets. All variables are defined in Appendix A. The coefficients of the year and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 8. Cross-sectional analyses

Panel A: Financial constraints.

	KZ-Index				SA-Index			
Variables	Constr. (1)	Uncon. (2)	Constr. (3)	Uncon. (4)	Constr. (5)	Uncon. (6)	Constr. (7)	Uncon. (8)
$IR/FX_t \times \Delta C_t$	0.042*	0.029			0.045*	0.089		
	[1.70]	[0.68]			[1.93]	[1.32]		
IR/FX_t	0.034***	0.041***			0.040***	0.020***		
	[4.85]	[5.48]			[4.78]	[3.28]		
$Hedging_t \times \Delta C_t$			0.045*	0.028			0.040*	0.097
			[1.78]	[0.67]			[1.75]	[1.38]
$Hedging_t$			0.031***	0.037***			0.035***	0.018***
			[4.14]	[4.94]			[4.16]	[2.88]
ΔC_t	2.183***	2.199***	2.178***	2.198***	2.258***	1.607***	2.258***	1.594***
	[18.79]	[28.18]	[18.59]	[27.94]	[28.18]	[17.15]	[28.08]	[16.43]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,976	26,539	26,976	26,539	25,907	28,229	25,907	28,229
Adjusted-R^2	0.224	0.247	0.224	0.247	0.235	0.204	0.235	0.204

Panel B: Information asymmetry.

	FDIS				ACCM			
Variables	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)
$IR/FX_t \times \Delta C_t$	0.202***	0.024			0.108*	0.051		
	[3.15]	[0.57]			[1.67]	[0.90]		
IR/FX_t	0.014*	0.036***			0.024***	0.032***		
	[1.67]	[3.86]			[3.02]	[3.84]		
$Hedging_t \times \Delta C_t$			0.218***	0.024			0.119*	0.031
			[3.08]	[0.59]			[1.88]	[0.59]
$Hedging_t$			0.009	0.025***			0.016*	0.033***
			[1.05]	[2.59]			[1.96]	[3.85]
ΔC_t	2.033***	2.249***	2.016***	2.252***	2.183***	1.750***	2.167***	1.760***
	[17.49]	[19.17]	[16.89]	[19.15]	[19.41]	[17.79]	[18.87]	[17.78]

Table 8. (Continued)

Panel B: Information asymmetry.

	FDIS				ACCM			
Variables	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,723	17,600	17,723	17,600	20,257	20,814	20,257	20,814
Adjusted-R^2	0.257	0.210	0.257	0.210	0.212	0.227	0.212	0.227

Panel C: Agency problems.

	E-Index				TBLC			
Variables	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)
$IR/FX_t \times \Delta C_t$	0.436**	0.278			0.065**	0.054		
	[2.37]	[1.44]			[2.44]	[1.05]		
IR/FX_t	0.006	0.022*			0.041***	0.032***		
	[0.45]	[1.66]			[5.30]	[4.91]		
$Hedging_t \times \Delta C_t$			0.463**	0.171			0.059**	0.059
			[2.37]	[1.03]			[2.36]	[1.11]

Table 8. (Continued)

Panel C: Agency problems.

	E-Index				TBLC			
Variables	High (1)	Low (2)	High (3)	Low (4)	High (5)	Low (6)	High (7)	Low (8)
$Hedging_t$			-0.002	0.026*			0.038***	0.029***
			[-0.13]	[1.87]			[4.75]	[4.23]
ΔC_t	1.402***	1.762***	1.382***	1.832***	2.236***	1.860***	2.236***	1.853***
	[6.26]	[6.64]	[6.07]	[7.03]	[25.91]	[21.27]	[25.75]	[20.94]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,669	6,039	6,669	6,039	26,131	27,323	26,131	27,323
Adjusted-R^2	0.168	0.210	0.168	0.209	0.229	0.213	0.229	0.212

This panel reports the results of estimating Eq. (2) using two sub-samples classified by firm financial constraints. The main sample consists of the US firm-year observations over the sample period 1993–2016 with required data for the regressions. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. In columns (1)–(4), we divide our main sample into two sub-samples based on the annual median of KZ-Index, a financial constraint index developed by Lamont, Polk and Saaá-Requejo (2001). In columns (4)–(8), we divide our main sample into two sub-samples based on the annual median of SA-Index, a financial constraint index developed by Hadlock and Pierce (2010). The financially constrained (unconstrained) sub-samples include firm-years with above (below) the annual median of the financial constraint index. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects, and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This panel reports the results of estimating Eq. (2) using two sub-samples classified by firm information asymmetry. The main sample consists of the US firm–year observations over the sample period 1993–2016 with required data for the regressions. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. In columns (1)–(4), we divide our main sample into two sub-samples based on the annual median of FDIS, the standard deviation of financial analysts' earnings forecasts measured over a 3-month window before the fiscal year end (Chen and King, 2014). In columns (5)–(8), we divide our main sample into two sub-samples based on the annual median of ACCM, the three-year moving sum of the absolute value of discretionary accruals estimated from the modified Jones model (Dechow, Sloan and Sweeney, 1995; Kim, Li and Zhang, 2011). The high (low) information asymmetry sub-samples include firm-years with above (below) the annual median of FDIS or ACCM. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects, and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This panel reports the results of estimating Eq. (2) using two sub-samples classified by agency conflict. The main sample consists of the US firm–year observations over the sample period 1993–2016 with required data for the regressions. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. In columns (1)–(4), we divide our main sample into two sub-samples based on the annual median of E-Index (Bebchuk, Cohen and Ferrell, 2009). In columns (5)–(8), we divide our main sample into two sub-samples based on the annual median of TBLC, total ownership of blockholders who hold more than 5% of a firm's stocks (Cumming *et al.*, 2019; Edmans, 2014). The high (low) agency conflict sub-samples include firm–years with above (below) the annual median of E-Index or below (above) the annual median of TBLC. All variables are defined in Appendix A. The coefficients of the control variables, year fixed effects, and Fama–French 48-industry fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

estimating Eq. (2) using the sub-samples with financially constrained and unconstrained firms. The estimated coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ are positive but only statistically significant in the sub-samples with financially constrained firms, suggesting that the positive impact of financial hedging on the marginal value of cash only exists among financially constrained firms. This finding supports our conjecture that financial hedging helps financially constrained firms to reduce the cost of raising external funds and enables them to invest cash into positive NPV projects, instead of hoarding cash for debt obligation payments. Through such a channel, the market perceived value of cash for financially constrained firms increases with the use of financial derivatives.

Information asymmetry

The third channel through which financial hedging has a positive effect on the value of cash is via mitigating the information asymmetry between managers and shareholders. Given that the release of financial information is costly and firm managers have an incentive to manipulate or hide unfavourable financial information, shareholders have less information on firms' future cash flows than managers. DeMarzo and Duffie's (1995) theoretical model predicts that financial hedging can reduce information asymmetry between managers and shareholders by eliminating the extraneous noise in firms' future cash flows. Dadalt, Gay and Nam (2002) provide empirical evidence supporting the conjecture of DeMarzo and Duffie (1995) that the use of financial derivatives reduces the noise related to exogenous factors and hence improves the informativeness of corporate earnings. Since the reduction in asymmetric information decreases the monitoring costs of shareholders, managers may use cash more efficiently when they allocate internal capital for positive NPV projects. Therefore, we expect that the positive relation between financial hedging and the value of cash is more pronounced for firms with higher information asymmetry.

We assign firms in sub-samples based on two proxies of asymmetric information. The first proxy for asymmetric information is FDIS, the standard deviation of financial analysts' earnings forecasts over a 3-month window before the fiscal year end (Chen and King, 2014). Dadalt, Gay and Nam (2002) show that the dispersion of analysts' earnings forecasts is positively related to the level of asymmetric information. Chen and King (2014) further find that financial hedging may reduce the dispersion of analysts' earnings forecasts. A firm is assigned to the high (low) information asymmetry sub-sample if its FDIS is above (below) the annual median. Our second proxy for asymmetric information is ACCM, the prior 3 years' moving sum of the absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow, Sloan and Sweeney, 1995; Kim, Li and Zhang, 2011).[11] Firms with a larger absolute value of discretionary accruals are more likely to manipulate earnings, which makes it more difficult for shareholders to accurately assess the disclosed financial information (Dechow, Sloan and Sweeney, 1995; Hutton, Marcus and Tehranian, 2009; Kim, Li and Zhang, 2011). A firm is assigned to the high (low) information asymmetry sub-sample if its ACCM is above (below) the annual median.

Panel B of Table 8 reports the results of estimating Eq. (2) using the sub-samples with high and low information asymmetry. The estimated coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ are positive, but only statistically significant in the sub-sample of firms with high information asymmetry, suggesting that the positive impact of financial hedging on the marginal value of cash only exists among firms with a high level of asymmetric information. This finding is consistent with our expectation that financial hedging improves information transparency between managers and shareholders, subsequently reducing shareholders' monitoring costs. Through this mechanism, financial hedging increases managers' efficiency in using internal cash, and consequently increases the perceived value of corporate cash holdings by the market.

Agency problems

Firms with higher asymmetric information are more prone to agency problems. Previous studies show that firms with poor corporate governance incur agency costs of holding cash (Dittmar and Mahrt-Smith, 2007; Harford, Mansi and Maxwell, 2008). A recent study by You *et al*. (2019) finds that the value of cash decreases during recessions due to investors' concern pertaining to agency conflict, but well-designed investor protection

[11] Discretionary accruals are denoted as OPAQUE in Hutton, Marcus and Tehranian (2009).

may mitigate this effect. Since financial hedging reduces information asymmetry and investor monitoring costs, we conjecture that the positive relation between financial hedging and the value of cash is more pronounced for firms with weaker corporate governance.

We adopt two proxies to separate firms based on agency conflict. The first proxy is E-Index, the anti-takeover index developed by Bebchuk, Cohen and Ferrell (2009). Our second proxy is TBLC, total ownership of blockholders who hold more than 5% of a firm's stocks (Cumming *et al*., 2019; Edmans, 2014). Previous studies show that firms with higher E-Index and lower TBLC are more prone to agency problems. Panel C of Table 8 reports the results of estimating Eq. (2) using the sub-samples with high and low agency conflict. The estimated coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ are positive, but only statistically significant in the sub-sample of firms with high agency conflict. This result supports our conjecture that financial hedging reduces monitoring costs and mitigates the potential agency conflict between managers and shareholders, leading to a higher market perceived value of cash holdings.

Industry-specific analyses

Panel B of Table 1 shows that derivatives use exhibits variations across the Fama–French 10 industries. To provide a full picture of the role played by financial hedging in corporate cash policy, we conduct the following industry-specific analyses. For brevity, we only report the results using IR/FX. Panel A of Table 9 shows that there is a negative relation between derivatives use and cash holdings among the Fama–French 10 industries, except for the Telecommunications industry. These results indicate that the negative relation between financial hedging and cash holdings is not merely driven by the possibility that some industries tend to hold less cash but use more derivatives than others. Panel B of Table 9 shows that the coefficients of $IR/FX_t \times \Delta C_t$ are positive and statistically significant, except for the Consumer Durable, Telecommunications, and Wholesale, Retail and Services industries. However, the firm-year observations in these three industries only account for about 19.4% of our sample firm-year observations.

Discussion of our findings in comparison with previous studies

Using the data on S&P 500 firms in 1994, Opler *et al*. (1999) show that cash holdings are unrelated to whether a firm uses financial derivatives, but positively related to the intensity of derivatives usage. Opler *et al*.'s (1999) findings provide weak evidence that derivatives use is positively related to cash holdings (complementary), which is inconsistent with our findings. Using a sample of S&P 500 manufacturing firms during 1993–1997, Haushalter, Klasa and Maxwell (2007) show that a firm's propensity to use financial derivatives or to hold a large cash balance is highest when it operates in a more competitive industry. Haushalter, Klasa and Maxwell's (2007) findings suggest that in the product market context, derivatives use is negatively related to cash holdings (substitutes), which is consistent with our findings.

Neither of these two studies focus on the relation between financial hedging and cash holdings. The motivation of Opler *et al*. (1999) is to identify a large set of factors driving the change in cash holdings, while Haushalter, Klasa and Maxwell (2007) investigate the impact of product market competition on corporate cash holdings and financial hedging policy. Since the hedging–cash relation is not the main focus in these two papers, their empirical tests do not address the potential endogeneity between cash holdings and financial hedging policy. In addition, their samples may not be comprehensive to reach a solid conclusion on the hedging–cash relation. For each Fama–French 48 industry, we calculate its Herfindahl–Hirschman Index (HHI) based on the firms' annual sales. Then, we divide firms into two sub-samples using the median of the industry HHI. Industries with high HHI have low product market competition. Untabulated results show that financial hedging has a negative impact on cash holdings and a positive effect on the value of cash in both the high and low HHI sub-samples. Our findings suggest that the impact of derivatives use on cash holdings and the value of cash is not conditional on product market competition.

Using the data on 155 US oil and gas producers during 1998-2017, Choi *et al*. (2021) find that financial hedging reduces the value of cash. Panel B of Table 9 shows that financial hedging still has a positive and statistically significant effect on the value of cash in the Energy industry, which

Table 9. Industry-specific analyses

Panel A: Financial hedging and cash holdings.

	Consumer Non-durables	Consumer Durables	Manu facturing	Energy	Business Equipment	Tele communi-cations	Wholesale, Retail and Services	Health	Other
IR/FX_t	−0.007*	−0.011*	−0.008***	−0.012***	−0.020***	−0.006	−0.009***	−0.018***	−0.017***
	[−1.87]	[−1.93]	[−3.66]	[−3.15]	[−6.32]	[−0.91]	[−4.24]	[−3.95]	[−5.79]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,172	1,968	10,221	2,999	14,632	1,511	8,133	7,754	7,406
Adjusted-R^2	0.148	0.200	0.158	0.098	0.162	0.107	0.189	0.165	0.115

Panel B: Financial hedging and marginal value of cash.

	Consumer Non-durables	Consumer Durables	Manu facturing	Energy	Business Equipment	Tele communi-cations	Wholesale, Retail and Services	Health	Other
$IR/FX_t \times \Delta C_t$	0.372***	−0.203	0.173***	0.315***	0.061*	0.060	−0.012	0.095***	0.111***
	[3.83]	[−1.38]	[3.97]	[2.72]	[1.72]	[1.05]	[−0.47]	[2.76]	[3.29]
IR/FX_t	−0.029	−0.053	0.032**	0.042	0.006	0.017	0.037**	0.015	0.026
	[−1.41]	[−1.49]	[2.22]	[1.46]	[0.37]	[0.36]	[2.33]	[0.68]	[1.61]
ΔC_t	1.354***	1.948***	1.683***	1.661***	2.311***	1.473***	1.868***	1.994***	1.669***
	[8.80]	[8.82]	[18.35]	[8.44]	[27.35]	[5.22]	[16.71]	[17.63]	[17.47]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,793	1,852	9,508	2,759	13,045	1,404	7,230	7,065	7,491
Adjusted-R^2	0.143	0.197	0.180	0.256	0.231	0.184	0.207	0.170	0.154

This panel reports the OLS regressions of corporate cash holdings on financial hedging proxy variables and control variables across Fama–French 10 industries. The sample consists of firm-year observations of US firms over the sample period 1993–2016 with required data for the regressions. Firms in the financial (in the 'Other' group) and utility industries are excluded from our sample. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest is IR/FX_t. All variables are defined in Appendix A. For each industry-specific regression, we control for firm and year fixed effects. The coefficients of the control variables and year fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

This table reports the OLS regressions of firm excess returns on the change in cash holdings, financial hedging proxy variables the interaction of the prior two variables, and control variables across Fama–French 10 industries. The sample consists of firm-year observations of US firms over the sample period 1993–2016 with required data for the regressions. Firms in the financial (in the 'Other' group) and utility industries are excluded from our sample. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the 25 Fama and French (1993) size and book-to-market portfolios. Δ indicates the change in the corresponding variables from year $t-1$ to t. All variables are defined in Appendix A. For each industry-specific regression, we control for firm and year fixed effects. The coefficients of the control variables and year fixed effects are suppressed for brevity in the respective columns. t-Statistics based on standard errors clustered at the firm level are reported in brackets. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

is inconsistent with Choi *et al*.'s (2021) findings. To further explore what derives the difference between our results and those of Choi *et al*. (2021), we restrict our sample to firms with SIC codes 1311, 1321, 1381, 1382 and 1389, the same as Choi *et al*. (2021). Over the sample period 1998–2017, Choi *et al*.'s (2021) sample covers 155 unique firms and 1,364 firm-year observations for their value-of-cash tests. However, over the similar sample period 1998–2016, we have 275 unique firms and 1,851 firm-year observations.[12] The average use of IR, COMMD and all types of derivatives is similar between our sample and theirs. However, about 32.1% of our 1,851 sample firm-years use FX derivatives, compared to 18.4% of 1,364 firm-years in their sample. Next, we re-estimate our value of cash baseline regression in the sample of 1,851 firm-year observations. Untabulated results show that apart from IR×ΔC, the coefficients of FX×ΔC, COMMD×ΔC, IR/FX×ΔC and *Hedging*×ΔC are all positive and statistically significant at the 5% and 1% levels.

Supplementary tests

In this section, we examine whether our baseline regression results remain robust after controlling for corporate governance, cash regimes, alternative measures of cash holdings, and the tone of annual financial statements. We also conduct robustness tests using lagged financial hedging variables.[13]

Controlling for corporate governance

Previous studies suggest that corporate governance is related to both cash policy and financial hedging (e.g. Dittmar and Mahrt-Smith, 2007; Jensen and Meckling, 1976; Pinkowitz, Stulz and Williamson, 2006). We choose not to control for corporate governance in our baseline regressions, because the required governance data, especially entrenchment governance indices, substantially reduces our sample size. Nonetheless, to ensure that the effect of financial hedging remains robust to additional corporate governance control variables, we re-estimate our baseline regressions using a sub-sample of firms with available corporate governance proxies, namely G-Index (Gompers, Ishii and Metrick, 2003), E-Index (Bebchuk, Cohen and Ferrell, 2009), motivated monitoring institutional ownership (Fich, Harford and Tran, 2015; Ward, Yin and Zeng, 2018) and blockholder ownership (Cumming *et al*., 2019; Edmans, 2014). Untabulated results show that our baseline regression results remain robust after controlling for these corporate governance proxy variables.

Controlling for cash regimes

As widely discussed in previous studies, corporate cash policy and the marginal value of cash vary considerably across firms within different cash regimes. Halford *et al*. (2017) suggest that failure to control for cash regimes leads to a biased estimation when studying the value of cash in Faulkender and Wang's (2006) framework. We follow Halford *et al*. (2017) and classify firms into three *ex-post* cash regimes: raising cash, distributing cash and servicing debt. Then we re-estimate our baseline regressions in these three cash regimes.

We find that the impact of financial hedging on corporate cash holdings is negative and statistically significant in the raising cash and distributing cash regimes. In addition, we find that the estimated coefficients of $IR/FX_t \times \Delta C_t$ and $Hedging_t \times \Delta C_t$ are positive and statistically significant in the raising cash and distributing cash regimes, but not statistically significant in the servicing debt regime. Our findings indicate that firms' financial hedging activities should have no impact on the value of cash if an extra dollar of cash is claimed by debt-holders instead of stockholders, which is consistent with the theory of maximizing shareholder value (Smith and Stulz, 1985).

Alternative measures of cash holdings

In our baseline analyses, we focus on the total amount of corporate cash holdings, which is the sum of cash and marketable securities. Next, we examine whether our main results are robust to two alternative measures of cash holdings. First, following Dittmar and Mahrt-Smith (2007) and Bates, Kahle and Stulz (2009), we examine the excess cash holdings that are non-essential for

[12]Since Choi *et al*. (2021) do not disclose any data-collection filters besides SIC codes, we cannot identify what derives the difference between our sample observations and theirs.

[13]Untabulated empirical results discussed in this section are reported in our Online Appendix.

corporate operations and investment. We define *Excess cash holdings* as the amount of cash holdings above a predicted optimal level of cash reserves. Second, we adopt industry-adjusted cash holdings as our second alternative measure of cash holdings. Since corporate cash policy may be subject to industry-specific shocks, we follow Haushalter, Klasa and Maxwell (2007) and define *Industry-adjusted cash holdings* as the cash-to-total assets ratio minus the median of the cash-to-total assets ratios of all firms with the same four-digit SIC codes. Untabulated results show that our baseline regression results remain robust to these alternative measures of cash holdings.

Controlling for persistent tone of financial statements

Loughran and McDonald (2011) find that the persistent tone of 10-K statements, measured by a list of negative words, is related to many corporate activities. Bodnaruk, Loughran and McDonald (2015) further show that the frequency of constraining words predicts future liquidity events. To address the concern that negative tone-related textual measures parsed from 10-K reports may affect the impact of financial hedging on corporate cash policy, we adopt four categories (Negative, Uncertainty, Litigious and Constraining) of negative word lists using the sentiment word counts developed by Loughran and McDonald (2011). We scale the number of sentiment word counts by the count of all words appearing in the Loughran–McDonald Master Dictionary (2018). After controlling for the four categories of negative tone-related textual measures, untabulated results show that our main results remain robust, suggesting that our findings are not driven by the persistent tone of 10-K reports.

Long-term benefits of financial hedging

In our empirical tests, the variables of interest and dependent variables are measured in the same year. However, previous financial hedging studies suggest that firms adopt financial derivatives persistently to hedge their risk exposures. To investigate whether firms have any long-term benefits from their hedging strategies, we replace the contemporaneous financial hedging variables in our baseline regressions by their lagged terms: IR/FX_{t-1}, IR/FX_{t-2}, $Hedging_{t-1}$ and $Hedging_{t-2}$. Untabulated results show that our main results are robust to 1-year and 2-year lagged hedging variables. Our finding suggests that the benefits of financial hedging on corporate cash policy are not short-lived. The lead–lag relation between cash variables and financial hedging further mitigates the potential reverse-causality concern.

Additional evidence of the role of financial hedging

In our mechanism analysis, we argue that derivatives use may mitigate financial constraints, information asymmetry and agency problems. Through these mechanisms, financial hedging is positively related to the value of cash holdings. To directly examine the impact of derivatives use on financial constraints, information asymmetry and corporate governance, we regress the proxy variables of financial constraints, asymmetric information, and corporate governance on financial hedging proxy variables and control variables. Consistent with our mechanism analysis, we use KZ-Index and SA-Index as the proxy for financial constraints, FDIS and ACCM as the proxy for information asymmetry, and E-Index and TBLC as the proxy for corporate governance. The control variables are the same as those reported in Eq. (1). Consistent with our argument in the mechanism analysis, our finding suggests that financial hedging is negatively related to financial constraints and information asymmetry, and positively related to corporate governance.

Conclusions

Firm performance is highly dependent on corporate risk management to hedge future financial risk (Ding, Zhang and Duygun, 2019). In this paper, we employ a textual analysis approach to collect the use of financial derivatives data from firms' annual financial reports. We examine an important yet understudied aspect of corporate risk management: the impact of financial hedging on corporate cash holdings and the value of cash. Based on a large sample of US public firms from 1993 to 2016, we find strong evidence that cash holdings are negatively associated with firm financial hedging activities. We also show that the value of corporate cash holdings increases with firms' financial hedging activities. Besides the intuitive channel that the negative impact of financial hedging on cash holdings leads to a

higher value of cash, we provide evidence on four additional mechanisms through which financial hedging increases the value of cash: improving investment efficiency, reducing financial constraints, reducing information asymmetry and mitigating agency problems. Overall, our study suggests that managers should incorporate financial risk management strategies into corporate cash policy, as doing so appears to be valued positively by shareholders when they evaluate a firm's efficiency in using internal cash. Although our findings support the positive effect of financial hedging on the value of cash, one important caveat is that we cannot rule out the possible negative role played by financial hedging in incentivizing managers to misuse internal cash. Our empirical evidence only reflects the net effect of financial hedging on the value of cash.

Appendix

Table A1. Variable definitions

Variable	Definition	Source
$Cash\ holdings_t$	Cash plus marketable securities, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
$r_t - R_t^B$	Excess stock returns with the benchmark portfolios defined as Fama–French 25 portfolios formed on size and book-to-market (Faulkender and Wang, 2006).	CRSP, Compustat and FF
IR/FX_t	An indicator variable, equal to 1 if a firm uses at least one type of interest rate (IR) or foreign currency (FX) derivatives, and 0 otherwise (Campello *et al*., 2011).	EDGAR 10-K
$Hedging_t$	An indicator variable, equal to 1 if a firm uses at least one type of IR, FX or commodity (COMMD) derivatives, and 0 otherwise (Hoberg and Moon, 2017).	EDGAR 10-K
$Size_t$	Natural logarithm of total assets (Bates, Kahle and Stulz, 2009).	Compustat
CF_t	Earnings before interest, tax, depreciation and amortization minus interests, tax and common dividends, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
MTB_t	Ratio of the book value of total assets minus the book value of equity plus the market value of equity to the book value of total assets (Bates, Kahle and Stulz, 2009).	Compustat
NWC_t	Net working capital minus cash and marketable securities, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
$CAPEX_t$	Capital expenditures, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
$R\&D/Sales_t$	Ratio of R&D expenses to total sales. R&D/*Sales* is equal to 0 if R&D expenses are missing (Bates, Kahle and Stulz, 2009).	Compustat
$Acquisitions_t$	Acquisition expenditures, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
$Dividends_t$	Indicator variable, equal to 1 if a firm pays positive common dividend, and 0 otherwise (Bates, Kahle and Stulz, 2009).	Compustat
$Sigma_t$	Average of the standard deviations of CF over 10 years for firms with the same two-digit SIC codes (Bates, Kahle and Stulz, 2009).	Compustat
$Leverage_t$	Total debt, normalized by total assets (Bates, Kahle and Stulz, 2009).	Compustat
MV_t	Market value of equity, defined as the number of shares outstanding multiplied by stock price (Faulkender and Wang, 2006).	Compustat

Table A1. (Continued)

Variable	Definition	Source
C_t	Cash plus marketable securities, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
ΔC_t	Change in cash plus marketable securities from fiscal year t − 1 to year t, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
ΔE_t	Change in earnings from fiscal year t − 1 to year t, normalized by *MV* at the start of fiscal year t. Earnings are calculated as earnings before extraordinary items plus interest, deferred tax credits and investment tax credits (Faulkender and Wang, 2006).	Compustat
ΔNA_t	Change in net assets from fiscal year t − 1 to year t, normalized by MV at the start of fiscal year t. Net assets are calculated as total assets minus cash holdings (Faulkender and Wang, 2006).	Compustat
$\Delta R\&D_t$	Change in R&D expenditure from fiscal year t − 1 to year t, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
ΔI_t	Change in interest expenses from fiscal year t − 1 to year t, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
ΔD_t	Change in total common share dividends from fiscal year t − 1 to year t, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
NF_t	Net financing proceeds defined as equity issuance minus repurchases, plus debt issuance minus debt redemption, normalized by MV at the start of fiscal year t (Faulkender and Wang, 2006).	Compustat
L_t	Total debt divided by the sum of total debt and MV (Faulkender and Wang, 2006).	Compustat
Tax convexity	*Tax convexity* $= 4.88 + 0.019\text{TIVol} - 5.50\text{TICorr} - 1.28D_{ITC} + 7.15D_{SmallNeg} + 1.60D_{SmallPos} + D_{NOL}(3.29 - 4.77D_{SmallNeg} - 1.93D_{SmallPos})$, where TIVol is taxable income volatility; TICorr is the first-order serial correlation in taxable income; D_{ITC} is an indicator variable, equal to 1 if firms have positive investment tax credits, and 0 otherwise; D_{NOL} is an indicator variable, equal to 1 if there are any net operating losses, and 0 otherwise; $D_{SmallNeg}$ is an indicator variable, equal to 1 if firms have small negative taxable income between −$500,000 and $0, and 0 otherwise; and $D_{SmallPos}$ is an indicator variable, equal to 1 if firms have small positive taxable income between $0 and $500,000, and 0 otherwise. We use annual data in Compustat until 2016 to estimate TIVol and TICorr on the basis of a recursive algorithm (Campello *et al*., 2011; Graham and Smith, 1999).	Compustat
$Investment_t$	Annual capital expenditures plus R&D spending, scaled by the lagged total assets (Baker, Stein and Wurgler, 2003; Bhandari and Javakhadze, 2017).	Compustat
Q_t	The market value of equity, minus the book value of equity, plus the book value of assets, divided by the book value of assets (Bhandari and Javakhadze, 2017).	Compustat
Profitability	Earnings before interest, tax, depreciation and amortization, scaled by total assets (Campello *et al*., 2011).	Compustat
CF volatility	The standard deviation of cash flows over 4 years (Campello *et al*., 2011).	Compustat

Table A1. (Continued)

Variable	Definition	Source
Z-score	Z-score $= 1.2 \times Working\ capital + 1.4 \times Retained\ earnings + 3.3 \times$ EBIT $+ 0.999 \times Sales)/Total\ assets$ (Campello *et al*., 2011).	Compustat
KZ-Index$_t$	KZ-Index $= -1.002 \times Cash\ flow + 0.283 \times Tobin's\ Q + 3.139 \times Leverage - 39.368 \times Dividend - 1.315 \times Cash\ holdings$, where all variables are normalized by total assets (Lamont, Polk and Saaá-Requejo, 2001).	Compustat
SA-Index$_t$	SA-Index $= -0.737 \times FSize + 0.043 \times FSize^2 - 0.040 \times Age$, where *FSize* is the natural log of inflation adjusted (to 2004) book assets, and *Age* is the number of years a firm has been on Compustat with a non-missing stock price. The upper limit of *FSize* is ln($4.5 billion) and the upper limit of *Age* is capped at 37 years (Hadlock and Pierce, 2010).	Compustat
FDIS$_t$	The standard deviation of financial analysts' earnings forecasts in the 3-month period before fiscal year end (Chen and King, 2014).	I/B/E/S
ACCM$_t$	Moving sum of the absolute value of discretionary accruals over the prior 3 years, where discretionary accruals are estimated from the modified Jones model (Dechow, Sloan and Sweeney, 1995; Kim, Li and Zhang, 2011).	Compustat
G-Index$_t$	Corporate governance index composed of 24 provisions on investor rights and takeover protections (Gompers, Ishii and Metrick, 2003).	ISS
E-Index$_t$	Corporate governance index composed of the six most important provisions in G-Index (Bebchuk, Cohen and Ferrell, 2009).	ISS
TMI$_t$	Ownership of institutional investors whose holding value in a firm ranked as the top 10% of the stocks in their portfolios (Fich, Harford and Tran, 2015).	s34 files
TBLC$_t$	Total ownership of blockholders who hold more than 5% of a firm's stocks (Cumming *et al*., 2019; Edmans, 2014).	s34 files
Excess cash holdings$_t$	Amount of cash held above a predicted optimal level of cash reserves, which is not needed for a firm's investment or operations (Dittmar and Mahrt-Smith, 2007).	Compustat
Industry-adjusted cash holdings$_t$	Cash-to-total assets ratio minus the median of the cash-to-total assets ratios of firms with the same four-digit SIC codes (Haushalter, Klasa and Maxwell, 2007).	Compustat
Negative$_t$	The count of the sentiment word list of negative in 10-K filings, scaled by the count of all words appearing in the Loughran–McDonald Master Dictionary (2018) (Lamont, Polk and Saaá-Requejo, 2001).	McDonald
Uncertainty$_t$	The count of the sentiment word list of uncertainty in 10-K filings, scaled by the count of all words appearing in the Loughran–McDonald Master Dictionary (2018) (Lamont, Polk and Saaá-Requejo, 2001).	McDonald
Litigious$_t$	The count of the sentiment word list of litigious in 10-K filings, scaled by the count of all words appearing in the Loughran–McDonald Master Dictionary (2018) (Lamont, Polk and Saaá-Requejo, 2001).	McDonald
Constraining$_t$	The count of the sentiment word list of constraining in 10-K filings, scaled by the count of all words appearing in the Loughran–McDonald Master Dictionary (2018) (Lamont, Polk and Saaá-Requejo, 2001).	McDonald

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix Table 1. Controlling for corporate governance
Appendix Table 2. Cash regimes
Appendix Table 3. Alternative cash holdings
Appendix Table 4. Controlling for persistent tone of financial statements
Appendix Table 5. Long-term benefits of financial hedging
Appendix Table 6. Additional evidence on the role of financial hedging
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