Three Essays on Corporate Cash Policy and Productivity

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Abstract

In this thesis, I study corporate cash policy and firm-level productivity through three papers. Specifically, the first paper studies 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. The key finding is that firms with financial hedging programs have smaller cash reserves but a higher value of cash than firms without hedging contracts in place. In addition, financial hedging not only increases the investment sensitivity to internal cash, but also has a positive effect on investment efficiency.

The second paper examines the motive of holding cash by studying the empirical relationship between CEO ownership and corporate cash holdings, using a sample of US firms from 1992 to 2018. Using two proxies for CEO ownership, stock ownership and the ratio of a CEO's stock and option delta to a firm's stock and option delta, the finding shows a monotonic and positive relation between CEO ownership and cash holdings, which is theoretically supported by the precautionary motive for holding cash.

The third paper tests whether firm-specific investor sentiment (FSIS) in the financial markets affects firm-level productivity, using a sample of US public firms from 2010 to 2019. The results show a positive relation between FSIS and total factor productivity, and the positive impact of FSIS on productivity is more pronounced for firms with less exposure to automated production, more managerial ownership, tighter financial constraints, and higher innovative efficiency.

Declaration

The work in this thesis is based on research carried out at the Department of Economics and Finance in Durham University Business School, England. No part of this thesis has been submitted elsewhere for any other degree or qualification and it is my own work unless referenced to the contrary in the text, or where it is otherwise clearly indicated that it is the work of others.

The material presented in Chapter 2 of this thesis was written in collaboration with my supervisor Dr. Yeqin Zeng and Dr. Chao Yin, while the material presented in all other chapters is entirely my own work. I contributed approximately 80% of the work in Chapter 2.

The first paper (Chapter 2) contained in this thesis has been presented at the FMA European Conference, World Finance Conference, and FMA Annual Conference and has been published in the British Journal of Management. The relevant publication is listed below:

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Chapter 1

Introduction

This thesis aims to explore two main topics in corporate finance: corporate cash policy and production efficiency. To study the determinants of corporate cash policy, I focus on two different perspectives, which are risk management, captured by financial hedging, and managerial incentives,characterised by managerial ownership. To contribute to the understanding of productivity drivers at the firm-level, I emphasise the impact of firm-specific investor sentiment (FSIS) on firm production efficiency. A comprehensive review of the existing literature and empirical analysis of three papers are presented in Chapter 2–4, respectively. To provide motivation for the thesis, a brief research background, notable research gaps, and key findings of three individual papers are presented as follows.

The extant literature on financial hedging suggests that firms with financial hedging programs have lower cash flow volatility, lower external financing costs, greater debt capacity, and fewer investment restrictions (e.g., Smith and Stulz 1985; Froot et al. 1993; Campello et al. 2011; Chen and King 2014). However, due to sample limitations, previous hedging studies do not draw a conclusion on the relation between derivatives use and cash holdings. Most previous studies either use a small sample of firms (e.g., Géczy et al. 1997; Haushalter 2000; Graham and Rogers 2002; Guay and Kothari 2003) or focus on a specific industry (e.g., Tufano 1996; Jin and Jorion 2006; Haushalter et al. 2007; Mackay and Moeller 2007; Pérez-González and Yun 2013). To comprehensively understand the impact of financial hedging on corporate cash holdings and the value of cash, I adopt a textual analysis of all U.S. firms' 10-K filings, and provide a full picture of the role played by financial hedging in corporate cash management.

In Chapter 2, I show that firms with financial hedging programs have smaller cash reserves and a higher value of corporate cash holdings. Additionally, financial hedging not only increases a firm's investment sensitivity to internal cash, but also has a positive effect on investment efficiency. More importantly, corporate risk management is positively associated with the value of cash, since the use of derivatives may mitigate financial constraints, information asymmetry, and agency problems.

Although the relationship between managerial characteristics and cash holdings has been widely studied in the empirical literature (e.g., Ozkan and Ozkan 2004; Harford et al. 2008; Tong 2010; Liu and Mauer 2011; Elsilä et al. 2013), the role of CEO ownership in the motives of holding cash is not yet well established. On the one hand, cash holdings as precautionary savings may mitigate the underinvestment problem and enhance firm value, especially when external financing is costly and future cash flows are volatile. Firm ownership may incentivize CEOs to take actions that are beneficial to the firms. On the other hand, CEO ownership is associated with the private benefit motive for holding cash. Previous studies show mixed evidence on the relation between managerial ownership and agency conflicts. Jensen and Meckling (1976) argue that the costs of deviation from maximizing firm value decline as managerial ownership increases. As such, CEOs may holding cash based on precautionary motive or private benefit motive.

In Chapter 3, I present a monotonic and positive relation between CEO ownership and cash holdings, which is supported by the precautionary motive for holding cash. Firms with higher CEO ownership invest more in capital expenditures and R&D expenses with excess cash, and have a higher value of cash. These findings suggest that the precautionary motive for holding cash mainly explains the positive relationship between CEO ownership and cash holdings, while the positive relationship is less likely driven by the private benefit motive for expropriating cash holdings.

The behavioral finance literature defines investor sentiment as optimism or pessimism about firms' future cash flows that are not justified by publicly available fundamental information (De Long et al. 1990; Shleifer and Vishny 1997; Baker and Wurgler 2006; Baker and Wurgler 2007). A recent strand of empirical studies have shown that corporate decision-making activities are responsive to the presence of sentiment-driven investors, including capital investments and external financing (see., Baker et al. 2003; Gilchrist et al. 2005; Dong et al. 2006; Polk and Sapienza 2008; Baker et al. 2009; Dorn 2009; Alimov and Mikkelson 2012; Dong et al. 2012; Arif and Lee 2014; McLean and Zhao 2014). However, the literature has remained largely silent about the role of investor sentiment on corporate outcomes regarding firm productivity. Since productivity is an essential component of all economic activities (Ackerberg et al. 2015; Levine and Warusawitharana 2021), it is important to understand whether sentiment in the financial markets may affect firm productivity, and the channels through which investor sentiment shapes production efficiency and propagates to the real economy.

In Chapter 4, I demonstrate a positive relation between FSIS and total factor productivity. The positive relation is more pronounced for firms with less exposure to automated production, more managerial ownership, tighter financial constraints, and higher innovative efficiency. Taken together, the findings generate the important insight that investors' optimistic expectation has a positive spillover effect on employees and managers' incentives and morale, which ultimately leads to a higher firm production efficiency.

The remainder of the thesis is organized as follows. Chapter 2 presents the full details of the first paper, titled *Financial Hedging, Corporate Cash Policy, and the Value of Cash.* Chapter 3 demonstrates the full content of my second paper, titled *Precautionary motive or private benefit motive for holding cash: Evidence from CEO ownership*. Chapter 4 details my third paper, titled *Firm-specific investor sentiment and productivity.* Chapter 5 concludes and provides implications for future research.

Chapter 2

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

2.1. 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 1984a). Cash holdings can also alleviate underinvestment for firms with tighter financial constraints and greater growth opportunities (Kim et al. 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., Smith and Stulz 1985; Froot et al. 1993; Campello et al. 2011; Chen and King 2014). 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 comparing to non-users, derivatives users are more likely to choose the cash payment method in domestic M&A deals (Alexandridis et al. 2021) and experience higher cross-border M&A deal announcement returns (Chen et al. 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.

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 et al. (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 U.S. firms' annual financial statements between 1993 and 2016. Our textual analysis of U.S. 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 (2006)'s 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 (1978)'s 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 (2014a) 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 one or two 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 et al. 1997; Haushalter 2000; Graham and Rogers 2002; Guay and Kothari 2003) or focus on a specific industry (e.g., Tufano 1996; Jin and Jorion 2006; Haushalter et al. 2007; Mackay and Moeller 2007; Pérez-González and Yun 2013). To comprehensively understand the impact of financial hedging on corporate cash holdings and the value of cash, we adopt a textual analysis of all U.S. 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.

2.2. 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 can not 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 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 et al. (1998) model the positive relation between cash holding and cash flow volatility. In addition, Bates et al. (2009) show that the dramatic increase in U.S. 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 et al. 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 et al. (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 U.S. 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 (DeMarzo and Duffie 1995; Dadalt et al. 2002), 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' concern about managerial misconduct relating to internal cash management, so

[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 et al. 1993; Leland 1998), and reducing underinvestment costs (Carter et al. 2006).

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.*

2.3. Research design and sample

2.3.1. 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:

$$\begin{aligned} \textit{Cash holdings}_{i,t} &= \alpha + \beta_1 \textit{Financial hedging proxy}_{i,t} + B \times \textit{Control variables}_{i,t} \\ &\quad + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \tag{2.1}$$

where i is firm index, t is year index, j is industry index, $\textit{Cash holdings}_{i,t}$ is the ratio of cash and marketable securities to total assets, and $\textit{Financial hedging proxy}_{i,t}$ is an indicator variable measuring the use of financial derivatives. Following previous corporate cash holding studies (e.g., Opler et al. 1999; Acharya et al. 2007; Bates et al. 2009), we control for the variables related to the precautionary explanations for corporate cash holdings. These variables include firm size ($\textit{Size}_{i,t}$), 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 ($\textit{Acquisitions}_{i,t}$), R&D expenses ($R\&D/Sales_{i,t}$), dividends dummy ($\textit{Dividends}_{i,t}$), cash flow volatility ($\textit{Sigma}_{i,t}$), and leverage ($\textit{Leverage}_{i,t}$). 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 Equation (2.1).

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

$$r_{i,t} - R^B_{i,t} = \alpha + \beta_1 \textit{Financial hedging proxy}_{i,t} \times \Delta C_{i,t} + \beta_2 \textit{Financial hedging proxy}_{i,t} + \beta_3 \Delta C_{i,t} + \beta_4 \Delta E_{i,t} + \beta_5 \Delta NA_{i,t} + \beta_6 \Delta R\&D_{i,t} + \beta_7 \Delta I_{i,t} + \beta_8 \Delta D_{i,t} + \beta_9 NF_{i,t} + \beta_{10} C_{i,t-1} + \beta_{11} C_{i,t-1} \times \Delta C_{i,t} + \beta_{12} L_{i,t} + \beta_{13} L_{i,t} \times \Delta C_{i,t} + \mu_t + \theta_j + \epsilon_{i,t} \tag{2.2}$$

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, $\textit{Financial hedging proxy}_{i,t}$ 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 one-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: $\textit{Financial hedging proxy}_{i,t} \times \Delta C_{i,t}$. Since both the dependent and explanatory variables are normalized by the one-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 one-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.1.

2.3.2. 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]

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

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., Guay 1999; Campello et al. 2011; Chen and King 2014; 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 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.

[3] Companies were phased into EDGAR filing over a three-year period, ending May 6, 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 that 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.

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; Graham and Rogers 2002; Bartram et al. 2011; Manconi et al. 2018), we measure financial hedging activities using two indicator variables: *IR/FX* and *Hedging*. *IR/FX* is equal to one if a firm uses at least one type of IR or FX derivatives, and zero otherwise. *Hedging* is equal to one if a firm uses at least one type of IR, FX, or COMMD derivatives, and zero 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 U.S. public firms to report the notional value of their derivatives contracts, as previously required by SFAS No.119. Instead, U.S. 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.

2.3.3. 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 et al. 2011). Owing to the

[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 U.S. 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.

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 Equations (2.1) and (2.2).

Panel A of Table 2.1 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, 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 et al. (2011) report that 65.1% of U.S. firms use at least one type of IR, FX, or COMMD derivatives, which is comparable to 64.3% in our sample. Figure 2.1 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 slightly declines during the stock market crashes observed in 2000 and 2008. Panel B of Table 2.1 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.

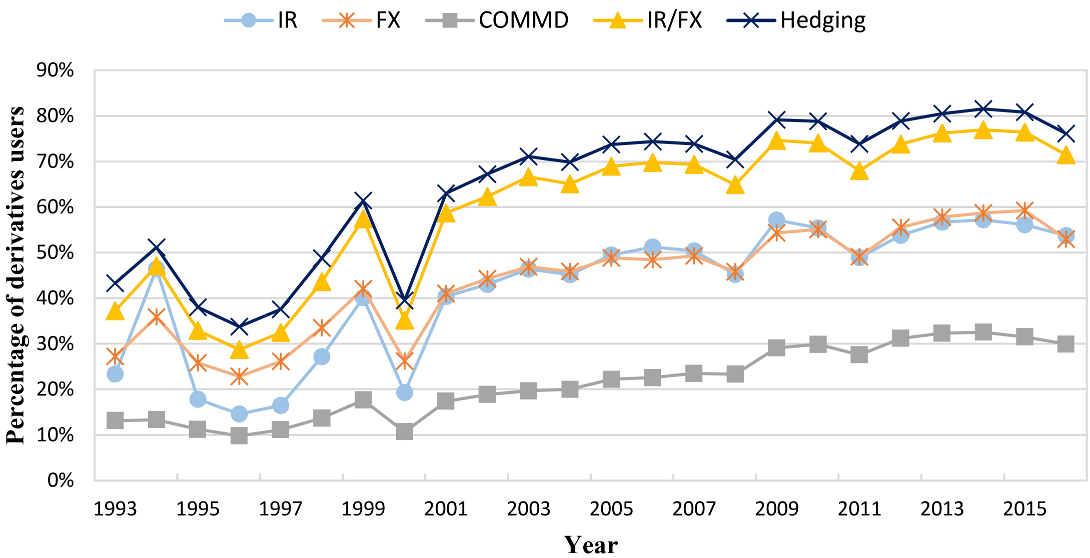

Figure 2.1. Average percentage of the use of derivatives form 1993 to 2016.

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).

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

Table 2.1. Summary statistics

Panel A. Summary statistics of variables. 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.1. 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.

Variable	Obs.	Mean	S.D.	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
$\Delta R\&D_t$	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								
$G\text{-}Index_t$	18,187	8.920	2.617	4	7	9	11	15
$E\text{-}Index_t$	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. 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*).

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

2.4. Main results

2.4.1. Baseline regressions

We begin our empirical analysis by investigating the relation between financial hedging and corporate cash holdings. Table 2.2 presents the results from estimating Equation (2.1). 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 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 et al. (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.

Table 2.2. Baseline regression I: Financial hedging and corporate cash holdings

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 U.S. 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.1. 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.

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

Next, we examine the impact of financial hedging on the value of corporate cash holdings using Faulkender and Wang (2006)'s framework. Table 2.3 presents the results of the 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 (2006)'s 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 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 our hypotheses H1 and H2.

[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 2.3. Baseline regression II: Financial hedging and marginal value of cash

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 U.S. 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 (2006) baseline regression over the their sample period 1972–2001. All variables are defined in Appendix A.1. 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.

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

2.4.2. Endogeneity

One potential endogeneity concern for any corporate financial hedging study is that firms do not make financial hedging decisions randomly (e.g., Campello et al. 2011; Manconi et al. 2018; Bartram 2019). 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 et al. (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 (1978)'s 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 et al. 2012; Chen and King 2014; Manconi et al. 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. Kai and Prabhala (2007) and Huang et al. (2015b) 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 U.S. 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., Smith and Stulz 1985; Nance et al. 1993; Géczy et al. 1997). 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 one-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 et al. 2018). The detailed definition of *Tax convexity* is provided in Appendix A.1. 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 2.4 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 Equation (2.1). 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)

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

report the results of the second-stage 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 2.4 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 Equation (2.2). 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.

Table 2.4. Heckman's treatment effect model

Panel A. Financial hedging and corporate cash holdings. This panel reports Heckman (1978) two-stage regressions of corporate cash holdings on financial hedging proxy variables and control variables. The sample consists of the U.S. 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 2.2. All variables are defined in Appendix A.1. 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.

	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. This panel reports Heckman (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 U.S. 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 2.3. All variables are defined in Appendix A.1. 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.

	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

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 et al. (2011) and use probit models to estimate the propensity scores of firms that use financial derivatives. We include the control variables in regression Equations (2.1) and (2.2) as observable firm characteristics in the probit models to separately estimate the propensity scores. Next, we adopt a nearest-neighbor 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 2.5 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 2.5, we re-estimate Equation (2.1) 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 2.5, we re-estimate Equation (2.2) 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.

Table 2.5. Propensity score matching

Panel A. Differences in firm characteristics between derivatives users and non-users: Cash holding tests. 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 Equation (2.1). We use a one-to-one nearest-neighbor 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.1. $***$, $**$, and $*$ denote statistical significance at the 1%, 5%, and 10% level, respectively.

	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. 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 Equation (2.2). We use a one-to-one nearest-neighbor 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.1. $***$, $**$, and $*$ denote statistical significance at the 1%, 5%, and 10% level, respectively.

	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. This panel reports the results of re-estimating Equation (2.1) 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.1. 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.

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. This panel reports the results of re-estimating Equation (2.2) 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.1. 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.

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]
$Hedging_t$		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

High-dimensional fixed effects

In the third identification method, we follow Gormley and Matsa (2014a) and control for unobserved heterogeneity across firms and time-varying 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 2.6, we re-estimate Equation (2.1) with the firm and industry–year fixed effects. Consistent with the baseline regression results reported in Table 2.2, 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 2.6, we re-estimate Equation (2.2) 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.

Table 2.6. High-dimensional fixed effects

Panel A. Financial hedging and corporate cash holdings. This panel reports the results of re-estimating Equation (2.1). Following Gormley and Matsa (2014a), 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 U.S. 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.1. 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.

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. This panel reports the results of re-estimating Equation (2.2). Following Gormley and Matsa (2014a), 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 U.S. 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.1. 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.

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

2.4.3. 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. As discussed in Section 2.2, 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 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 et al. 2003) by adding our financial hedging proxies and their interactions with Tobin's Q, cash flow, and cash holdings:

$$\begin{aligned}
Investment_{i,t+1} = {} & \alpha + \beta_1 Financial\ hedging\ proxy_{i,t} + \beta_2 Financial\ hedging\ proxy_{i,t} \times Q_{i,t} \\
& + \beta_3 Financial\ hedging\ proxy_{i,t} \times CF_{i,t} + \beta_4 Financial\ hedging\ proxy_{i,t} \times \\
& Cash\ holdings_{i,t} + \beta_5 Q_{i,t} + \beta_6 CF_{i,t} + \beta_7 Cash\ holdings_{i,t} + B \times \\
& Control\ variables_{i,t} + \mu_t + \theta_j + \epsilon_{i,t}
\end{aligned} \tag{2.3}$$

where the control variables include *Size*, *Profitability*, *CF volatility*, *Leverage*, and *Z-score* (Baker et al. 2003; Campello et al. 2011). McLean et al. (2012) show that investment-Q and investment-cash flow sensitivities are associated with *ex-post* investment efficiency. Columns (1) and (2) of Table 2.7 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. (2011)'s 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.

Table 2.7. Financial hedging, internal cash, and investment efficiency

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 U.S. 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.1. 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.

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]
$Profitability_t$	-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

Financial constraints

Firms with financial constraints may forgo positive NPV projects when internal funds are in short supply (Fazzari et al. 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 et al. (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 2.8 presents the results of estimating Equation (2.2) 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 unfavorable financial information, shareholders have less information on firms' future cash flows than managers. DeMarzo and Duffie (1995)'s 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 et al. (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 et al. (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 three years' moving sum of the absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow et al. 1995; Kim et al. 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 et al. 1995; Hutton et al. 2009; Kim

[11] Discretionary accruals are denoted as OPAQUE in Hutton et al. (2009).

et al. 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 2.8 reports the results of estimating Equation (2.2) 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 et al. 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 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 et al. (2009). Our second proxy is *TBLC*, total ownership of blockholders who hold more than 5% of a firm's stocks (Edmans 2014; Cumming et al. 2019). Previous studies show that firms with higher *E-Index* and lower *TBLC* are more prone to agency problems. Panel C of Table 2.8 reports the results of estimating Equation (2.2) 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.

Table 2.8. Cross-sectional analyses

Panel A. Financial constraints. This panel reports the results of estimating Equation (2.2) using two sub-samples classified by firm financial constraints. The main sample consists of the U.S. 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 et al. (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.1. 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.

	KZ-Index				***SA-Index***			
	Constr.	**Uncon.**	**Constr.**	**Uncon.**	**Constr.**	**Uncon.**	**Constr.**	**Uncon.**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(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. This panel reports the results of estimating Equation (2.2) using two sub-samples classified by firm information asymmetry. The main sample consists of the U.S. 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 et al. 1995; Kim et al. 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.1. 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.

	FDIS				***ACCM***			
	High	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(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]
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. This panel reports the results of estimating Equation (2.2) using two sub-samples classified by agency conflict. The main sample consists of the U.S. 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 et al. 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 (Edmans 2014; Cumming et al. 2019). 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.1. 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.

	E-Index				***TBLC***			
	High	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(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]
$Hedging_t$			-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

2.4.4. Industry-specific analyses

Panel B of Table 2.1 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 2.9 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 2.9 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.

Table 2.9. Industry-specific analyses

Panel A. Financial hedging and cash holdings. 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 U.S. 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.1. 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.

	Consumer NonDurables	**Consumer Durables**	**Manu-facturing**	**Energy**	**Business Equipment**	**Tele-communications**	**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. 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 U.S. 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.1. 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.

	Consumer NonDurables	**Consumer Durables**	**Manu-facturing**	**Energy**	**Business Equipment**	**Tele-communications**	**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

2.4.5. 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. (1999)'s 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 et al. (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 et al. (2007)'s 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 et al. (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 U.S. oil and gas producers during 1998-–2017, Choi et al. (2021) find that financial hedging reduces the value of cash. Panel B of 2.9 shows that financial hedging still has a positive and statistically significant effect on the value of cash in the Energy industry, which is inconsistent with Choi et al. (2021)'s 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. (2021)'s 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 are similar between our sample and theirs. However, about 32.1% of 1,851 our 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 $IR \times \Delta C$, the coefficients of $FX \times \Delta C$, $COMMD \times \Delta C$, $IR/FX \times \Delta C$, and $Hedging \times \Delta C$ are all positive and statistically significant at the 5% and 1% levels.

2.5. 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]

2.5.1. Controlling for corporate governance

Previous studies suggest that corporate governance is related to both cash policy and financial hedging (e.g., Jensen and Meckling 1976; Pinkowitz et al. 2006; Dittmar and Mahrt-Smith 2007). We choose not to control for corporate governance in our baseline regressions, because the required governance data, especially entrenchment governance

[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 Appendix A.2.

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 et al. 2003), E-Index (Bebchuk et al. 2009), motivated monitoring institutional ownership (Fich et al. 2015; Ward et al. 2018), and blockholder ownership (Edmans 2014; Cumming et al. 2019). Untabulated results show that our baseline regression results remain robust after controlling for these corporate governance proxy variables.

2.5.2. 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 (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).

2.5.3. 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 et al. (2009), we examine the excess cash holdings that are non-essential for 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 et al. (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.

2.5.4. 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 et al. (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.

2.5.5. 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 one-year and two-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.

2.5.6. 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 Equation (2.1). 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.

2.6. Conclusions

Firm performance is highly dependent on corporate risk management to hedge future financial risk (Ding et al. 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 U.S. 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.

Chapter 3

Precautionary motive or private benefit motive for holding cash: Evidence from CEO ownership

3.1. Introduction

Cash holdings of U.S. public companies consistently increased since the 1990s.[1] Previous theoretical and empirical corporate finance studies have demonstrated two main explanations for a firm's decision to hold cash. First, the precautionary motive for holding cash suggests that a firm keeps cash reserves to hedge the risk of future cash shortfall. Han and Qiu (2007)'s model shows that since future cash flow risk is not fully divisible, the inter-temporal trade-off between current and future investments provides a firm with incentive of precautionary savings. Riddick and Whited (2009) further find a positive relationship between a firm's idiosyncratic risk and cash reserves. Additionally, the precautionary motive suggests that in the presence of asymmetric information, firms may finance future investment opportunities with cash reserves in order to avoid high external financing costs (Opler et al. 1999; Almeida et al. 2004; Acharya et al. 2007). Second, the private benefit motive argues that firms with entrenched managers or weak corporate governance may hold more cash for the managers' interests at the expenses of shareholders. Jensen (1986) notes that due to the separation of ownership and control, managers naturally have incentives to accumulate free cash flows to extract private benefits, such

[1] Bates et al. (2009) report that the listed U.S. non-financial firms's average ratio of cash to total assets increases from 10.5% in 1980 to 23.2% in 2006.

as empire building and perquisite consumption. Harford (1999) also shows that managers tend to use excess cash to make value-decreasing acquisition decisions.

The CEO is the executive who has ultimate responsibility for important corporate strategies. Previous studies have shown that CEO traits, such as risk incentives (Tong 2010; Liu and Mauer 2011), inside debt (Liu et al. 2014), and overconfidence and optimism (Chen et al. 2020; Deshmukh et al. 2021), are associated with corporate cash holdings. However, few studies directly examine the role of CEO ownership in corporate cash management. On the one hand, external financing costs increase with information asymmetry between firms and outside investors, leading to an underinvestment problem. Cash holdings as precautionary savings may mitigate this problem and enhance firm value, especially when future cash flows are volatile. Firm ownership may incentivize CEOs to take actions that are beneficial to both the firms and themselves. Therefore, we should expect a positive relation between CEO ownership and corporate cash holdings. Even though most of the CEOs of U.S. companies hold very small fractions of their firms' common stocks (Jensen and Murphy 1990), these small holdings of "owner-CEOs" usually constitute dominant fractions of the respective CEOs' personal wealth, encouraging them to invest in value-enhancing projects and adopt optimal cash policies (Elsilä et al. 2013; Lilienfeld-Toal and Ruenzi 2014).

On the other hand, CEO ownership is associated with the private benefit motive for holding cash. Previous studies show mixed evidence on the relation between managerial ownership and agency conflicts. Jensen and Meckling (1976) argue that the costs of deviation from maximizing firm value decline as managerial ownership increases. Further studies, such as Demsetz (1983), Morck et al. (1988), and Perrini et al. (2008) indicate that when managerial ownership is low, agency conflicts may be mitigated by external governance mechanisms; but when managerial ownership is high, managers have effective control to indulge their preference for non-value-maximizing behavior. With respect to corporate cash policy, Ozkan and Ozkan (2004) show that, within a sample of U.K. public firms from 1995 to 1999, the relationship between managerial ownership and cash holding is negative when managerial ownership is low. Conversely, the relationship is positive when managerial ownership is high. By contrast, Nikolov and Whited (2014) find that the misalignment of incentives arising from low managerial ownership drives up cash accumulation. Overall, the precautionary motive and private benefit motive have different implications for the role of CEO ownership in corporate cash management. In this paper, we examine how CEO ownership affects the motivation of firms to hold cash. If CEO ownership encourages CEO to act in maximizing shareholder's benefit, precautionary motive for holding cash expects that CEO will save more cash against potential cash flow shortfall and firm risks. As such, the level of cash holdings is expected to increase monotonically with CEO ownership. On the contrary, agency theory argue that high managerial ownership increases the probability that managers pursue private interests at the expense of shareholders. Therefore, private benefit motive of cash holding expects that high level of cash holdings may not be acceptable, leading to a negative relation between managerial ownership and cash holdings.

Our sample covers Standard & Poor's (S&P) 1500 firms from 1992 to 2018. Using two proxies for CEO ownership, stock ownership and the ratio of a CEO's stock and option delta to a firm's stock and option delta, we find that CEO ownership is positively related to cash holdings. On average, a one-standard-deviation increase in CEO ownership is associated with a 3.7% to 4.2% increase in cash holdings, depending on the ownership proxy. Although Ozkan and Ozkan (2004) document a non-monotonic relation between managerial ownership and cash holdings using a sample of listed U.K. firms, we find no evidence of a non-monotonic relation between ownership and cash holdings in our U.S. sample. Specifically, we follow Opler et al. (1999) and Kim and Lu (2011), and separate CEO ownership into three intervals: 0% to 5%, 5% to 25%, and above 25%. We observe a positive relation between CEO ownership and cash holdings over each of the three intervals. Consistent with Harford et al. (2008), we also find that the ownership of the top five executives is positively related to cash holdings. While if we subtract CEO ownership from the ownership of top five executives, the relationship between the ownership of non-CEO top executives and cash holdings is not statistically significant. The monotonic positive relationship between CEO ownership and cash holdings indicates that our baseline finding support for precautionary motive that firm ownership encourages CEO to act in maximizing shareholder's benefits and reserves cash for precautionary demand. Our findings also highlight the important role of CEOs in corporate cash policy.

Since CEO ownership and cash holdings may be jointly determined, we employ PSM and 2SLS identification methods to address the potential endogeneity. In our PSM analysis, we follow Lilienfeld-Toal and Ruenzi (2014) and classify firms into those with high CEO ownership and those with low CEO ownership. We then employ a probit model to estimate the propensity scores of firms with high CEO ownership, using observable firm characteristics. Based on the estimated propensity scores, we match a firm with high CEO ownership to a firm with low CEO ownership. We find that the positive relation between CEO ownership and cash holdings remains robust in our propensity-score-matched sample. In our 2SLS analysis, we follow Kim and Lu (2011) and adopt CEO tenure and CEO tax liability from the sale of vested stock as our instrumental variables (IVs). The instrumented CEO ownership variables are positively related to cash holdings. In the other robustness tests, we show that the positive relation between CEO ownership and cash holdings remains robust, after using alternative measures of cash holdings and controlling for corporate governance and CEO characteristics.

By investigating the mechanism through which CEO ownership affects cash holdings, we find that CEO ownership has a stronger impact on cash holdings when firms have higher firm-specific risk and larger external financing costs. However, we do not find evidence that the positive relation between CEO ownership and cash holdings is stronger among firms with weaker corporate governance. We also find that the positive relation between CEO ownership and cash holdings only exist with sub-samples of recession year but not in boom year. Taken together, the results of mechanism tests suggest that when firms have higher level of firm risks, external financing costs, and a negative macroeconomic shock, CEO ownership encourages CEO to reserves more cash for precautionary demanding. Furthermore, if CEO ownership induces entrenched managerial behaviours, then CEOs are more likely to expropriate cash holdings when firms have weak governance. However, our findings show that the positive relationship between CEO ownership and cash holdings only exists when firms have good corporate governance, which do not support the private benefit motive of cash holdings. In our additional analyses, we show that compared to firms with low CEO ownership, firms with high CEO ownership and excess cash holdings have more capital expenditures and R&D expenses, but do not have significantly higher dividend payments and share repurchases. Finally, we find that CEO ownership has a positive impact on the value of corporate cash holdings. Overall, our empirical evidence supports the view that CEO ownership aligns CEOs' interests to shareholders' benefits with regard to corporate cash policy.

This paper contributes to the growing body of research on cash policy. First, our paper is related to recent contributions that empirically investigate the link between corporate governance and cash holdings. We find that owner-CEOs save cash for firms with precautionary demands and invest excess cash in capital expenditures and R&D, which increase the marginal value of cash holdings. Our finding suggests that CEO ownership acts as an internal governance mechanism in corporate cash policy, which complements the role of the external governance channel in corporate cash policy documented by the previous studies (e.g., Pinkowitz et al. 2006; Dittmar and Mahrt-Smith 2007; Harford et al. 2008). Second, Harford et al. (2008) find a positive relation between the ownership of top five executives and cash holdings in a sample of U.S. public firms, while Ozkan and Ozkan (2004) document a non-monotonic relation between director ownership and cash holding with a sample of U.K. public firms. Our paper shows that CEO ownership has a positive effect on cash holdings and plays a dominant role in corporate cash policy among top executives. Third, by analyzing the impact of CEO ownership on cash policy, our paper extends the literature on the impact of managerial ownership on firm performance (e.g., Morck et al. 1988; Himmelberg et al. 1999; McConnell et al. 2008; Lilienfeld-Toal and Ruenzi 2014) and corporate activities (e.g., Fenn and Liang 2001; Kim and Lu 2011).

The remainder of the paper is organized as follows. Section 3.2 describes the data sources, variable definitions, and summary statistics. Section 3.3 provides empirical evidence on the relation between CEO ownership and cash holdings, and addresses potential endogeneity concerns. Section 3.4 investigates the channels through which CEO ownership affects cash holdings. Section 3.5 documents how CEO ownership affects the use of cash and the value of cash. Section 3.6 concludes.

3.2. Data and variable construction

3.2.1. Sample selection and data sources

Our sample begins with all firms in the S&P ExecuComp database from 1992 to 2018. We require that the firm–year observations in our sample have available data on managerial stock and option holdings. We also require these observations to have accounting data available in Compustat. We obtain managerial entrenchment data from the Institutional Shareholder Service (ISS, formerly RiskMetrics) database and institutional ownership data from the Thomson Reuters s34 files. Since firms in the financial industry (SIC codes 6000–6999) may hold cash to meet capital requirements and firms in the utility industry (SIC codes 4900–4999) are highly regulated, we follow the literature on cash holdings and exclude firms in these two industries (e.g., Opler et al. 1999; Bates et al. 2009). Our main sample consists of 26,409 firm–year observations with the required data for our main empirical analyses.

3.2.2. Independent variables of interest: CEO ownership

We adopt two proxies for CEO ownership. The first measure, *CEO_OWN*, captures a CEO's annual stock ownership. Consistent with the literature on CEO ownership (Cui and Mak 2002; Schiehll and Bellavance 2009; Lilienfeld-Toal and Ruenzi 2014), *CEO_OWN* is defined as the percentage of the common share outstandings held by a CEO. *CEO_OWN* provides us a proxy of a CEO's voting right on corporate policy. The percentage of voting rights owned by CEOs reflects their level of informational advantages (Leland and Pyle 1977; Fahlenbrach and Stulz 2009) and countervailing interest alignment (Jensen and Meckling 1976; Kim and Lu 2011). As such, we use *CEO_OWN* to investigate CEOs' decisions on corporate cash policy and how their decisions impact the shareholder value.

We employ *CEO_OWN_SO* as our second measure of CEO ownership, which is defined as a CEO's stock and option delta divided by the delta of a firm's stocks and options (Kim and Lu 2011). Different from *CEO_OWN*, *CEO_OWN_SO* captures CEOs' incentives from not only stocks but also options. Stock options have no voting rights. Given that each share of stocks has a delta of one, *CEO_OWN_SO* is the fraction of the total delta of all outstanding stocks and options held by a CEO. Specifically, we follow the methodology of Core and Guay (2002) and Edmans et al. (2009) and calculate CEOs' stock options delta and firms' delta of all outstanding stock options. Please refer to Appendix B.1 for detailed calculation of *CEO_OWN_SO*.

3.2.3. Dependent variable and control variables

Following Bates et al. (2009), we measure corporate cash holdings as the ratio of cash and marketable securities to total assets.[2] We also employ three alternative measures of cash ratio in our robustness tests: cash to net assets (Opler et al. 1999), industry-adjusted cash holdings (Haushalter et al. 2007), and excess cash holdings (Dittmar and Mahrt-Smith 2007).

Following previous corporate cash holding studies (e.g., Opler et al. 1999; Acharya et al. 2007; Bates et al. 2009), we control for the following variables: *Size* is the natural logarithm of total assets, capturing the economies of scale of holding cash; *CF* is cash flows normalized by total assets, capturing the source of cash holdings; *MTB* is the market-to-book ratio, which is a proxy for future investment opportunities; *NWC* is net working capital, which is a proxy for the substitutes of liquid assets; *CAPEX* and *Acquisitions* are expenses associated with capital expenditures and acquisitions; *R&D/Sales* is research and development expenses normalized by total sales; *Dividends* is an indicator variable, equal to one if a firm pays common dividends and zero otherwise; *Sigma* is the average of the cash flow volatilities of firms within the same 2-digit SIC industry; *Leverage* is the ratio of total debt to total assets; and *Firm Age* is the natural logarithm of the number of years since the firm was reported in Compustat. The detailed definitions of these variables are provided in Appendix B.2.

[2]Our results are robust to the ratio of cash to net assets and the natural logarithm of cash to total assets. These results are available upon request.

3.2.4. Summary statistics

Table 3.1 presents the summary statistics of the variables used in our main empirical analyses. Our sample contains 26,409 firm–year observations from 1992 to 2018. All variables in dollar values are inflation-adjusted to 2018 dollars using the Consumer Price Index from the Federal Reserve Bank of St. Louis. We winsorize the accounting variables and ownership variables at the 1% and 99% levels. We first start replicating Kim and Lu (2011)'s sample period of 1992–2006 and find that the means (standard deviations) of *CEO_OWN* and *CEO_OWN_SO* are 2.7% (6.5%) and 3.0% (6.5%), which are substantially comparable to 2.8% (6.6%) and 3.2% (6.5%) reported in Kim and Lu (2011). We then extend our sample period to 2018. Consistent with prior studies (Core et al. 1999; Fahlenbrach and Stulz 2009; Kim and Lu 2011), we find that the distribution of CEO stock ownership is right-skewed. The mean and median of *CEO_OWN* are 2.4% and 0.4%, and the mean and median of *CEO_OWN_SO* are 2.6% and 0.6%. On average, the cash holdings of our sample firms account for 14.7% of total assets. Figures 3.1 and 3.2 show that for both CEO ownership measures, cash holdings monotonically increase with CEO ownership from 0% to 40%. Moreover, our sample firms on average generate positive operating cash flows of 8.3% and have a leverage of 21.7%. The average net financing is 8.3% and the average R&D is 4.8%. The distributions of our variables are broadly consistent with those reported in earlier studies.

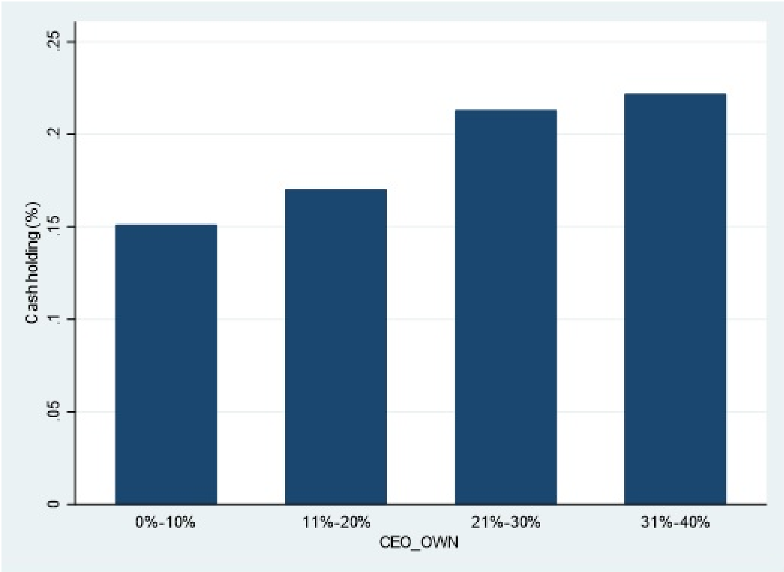

Figure 3.1. Cash holdings and CEO ownership, measured by *CEO_OWN*.

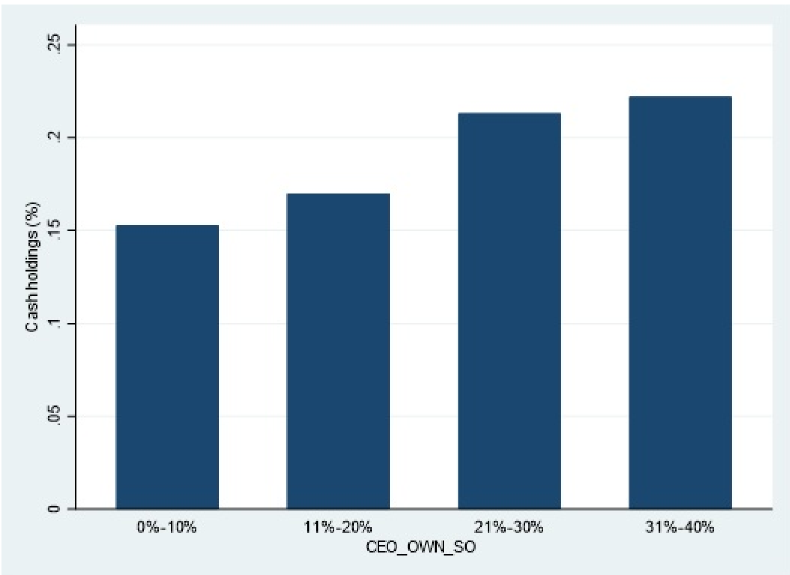

Figure 3.2. Cash holdings and CEO ownership, measured by *CEO_OWN_SO*.

Table 3.1. Summary statistics

This table reports the summary statistics of our main variables. Our sample consists of 26,409 firm–year observations over the fiscal years 1992–2018, with required data for our main empirical analyses. We report the number of observations, mean, standard deviation, 1st percentile, 25th percentile, median, 75th percentile, and 99th percentile. Variable definitions are in Appendix B.2. All accounting variables in dollars are inflation-adjusted to 2018 dollars. All inflation-adjusted accounting variables and stock return variables are winsorized at the 1% and 99% levels.

Variable	Obs.	Mean	S.D.	p1	p25	Median	p75	p99
Dependent variables								
$Cash\ holdings_t$	26,409	0.147	0.166	0.001	0.026	0.082	0.209	0.743
Independent variables of interest								
CEO_OWN_t	26,409	0.024	0.056	0.000	0.001	0.004	0.015	0.325
$CEO\_OWN\_SO_t$	26,409	0.026	0.056	0.000	0.002	0.006	0.018	0.329
Control variables								
$Size_t$	26,409	7.518	1.509	4.333	6.447	7.376	8.481	11.451
CF_t	26,409	0.083	0.078	-0.269	0.055	0.086	0.121	0.265
MTB_t	26,409	1.993	1.244	0.731	1.232	1.612	2.274	7.491
NWC_t	26,409	0.083	0.144	-0.272	-0.011	0.071	0.170	0.463
$CAPEX_t$	26,409	0.057	0.053	0.004	0.022	0.040	0.072	0.298
$R\&D/Sales_t$	26,409	0.048	0.112	0.000	0.000	0.002	0.047	0.724
$Acquisitions_t$	26,409	0.031	0.065	-0.002	0.000	0.001	0.028	0.345
$Dividends_t$	26,409	0.509	0.500	0	0	1	1	1
$Sigma_t$	26,409	0.053	0.022	0.018	0.034	0.052	0.069	0.111
$Leverage_t$	26,409	0.217	0.169	0.000	0.067	0.208	0.328	0.665
$Firm\ age_t$	26,409	3.132	0.649	1.792	2.639	3.178	3.689	4.205
$Vega/TC_t$	25,725	0.025	0.031	0.000	0.006	0.016	0.032	0.195
$CEO\ age_t$	25,769	55.807	7.491	39	51	56	60	76
$CEO\ female_t$	26,409	0.026	0.159	0	0	0	0	1
$CEO\ duality_t$	26,409	0.466	0.499	0	0	0	1	1
$CEO\ tenure_t$	24,833	8.458	7.408	1	3	6	11	35
$CEO\ tax\ burden_t$	22,614	0.040	0.163	-0.833	0.000	0.051	0.129	0.269
Governance variables								
$E\text{-}Index_t$	15,850	3.324	1.370	0	2	3	4	6
TMI_t	26,203	0.187	0.181	0.000	0.036	0.133	0.291	0.674

3.3. Main empirical results

3.3.1. Baseline regression models

To examine the empirical relationship between CEO ownership and corporate cash holdings, we adopt the following baseline regression:

$$Cash\ holdings_{i,t} = \alpha + \beta_1 CEO\ ownership_{i,t} + B\,Control\ variables_{i,t} + \mu_t + \theta_j + \epsilon_{i,t} \quad (3.1)$$

where i is firm index, t is year index and j is industry index. 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.

Table 3.2 reports the results of baseline regressions. In columns (1) and (2), the coefficients of CEO ownership proxy variables are positive and statistically significant at the 1% level, indicating that CEO ownership is positively associated with corporate cash holdings. Column (1) shows that all else being equal, a one-standard-deviation increase in CEO_OWN_t is associated with a 0.55% (= 0.098 × 0.056) increase in *Cash holdings*, which is equivalent to 3.7% of an average firm's cash holdings (= 0.55%/0.147). Column (2) suggests that all else being equal, a one-standard-deviation increase in $CEO\_OWN\_SO_t$ is associated with a 0.62% (= 0.111 × 0.056) increase in *Cash holdings*, which is equivalent to 4.2% of an average firm's cash holdings (= 0.62%/0.147).

The sign and statistical significance of the coefficients of our control variables are generally consistent with those documented in Bates et al. (2009). Table 3.2 shows that cash holdings are positively associated with the market-to-book ratio, research and development expenses, and industry cash flow risk. Conversely, cash holdings are negatively associated with firm size, net working capital, capital expenditures, acquisition expenditures, leverage, dividend payments, and firm age. These findings are consistent with previous studies that the precautionary demand for holding cash increases for firms with smaller size, younger firm age, better investment opportunities, higher external financing costs, and higher firm-specific risk (Opler et al. 1999; Acharya et al. 2007; Bates et al.

2009).

Ozkan and Ozkan (2004) document a non-monotonic relation between cash holdings and managerial ownership using a sample of 839 U.K. firms between 1995 and 1999.[3] To investigate whether there exists a non-linear relation between cash holdings and CEO ownership in our sample, we define three piecewise-linear terms of CEO ownership using cutoff points 5% and 25% (Morck et al. 1988; Opler et al. 1999; Kim and Lu 2011). *CEO_OWN_05* is equal to *CEO_OWN* if $0 <$ *CEO_OWN* $< 5\%$, and 5% otherwise. *CEO_OWN_0525* is equal to 0 if *CEO_OWN* $\leq 5\%$, *CEO_OWN* minus 5% if $5\% <$ *CEO_OWN* $< 25\%$, and 20% otherwise. *CEO_OWN_25* is equal to 0 if *CEO_OWN* $\leq 25\%$, and *CEO_OWN* minus 25% otherwise. Similarly, we also define *CEO_OWN_SO_05*, *CEO_OWN_SO_0525*, and *CEO_OWN_SO_25*. These piecewise-linear terms allow for changes in the slope coefficient at 5% and 25%. We then replace *CEO_OWN* or *CEO_OWN_SO* by the corresponding piecewise-linear terms in the baseline regressions. Columns (3)–(4) of Table 3.2 show that the coefficients of the piecewise-linear terms are all positively significant, indicating that the positive and linear relation between cash holdings and CEO ownership stands between 5% and 25% cutoff points. However, the value of the three coefficients drops from low- to high-CEO ownership, suggesting that the marginal effect of CEO ownership on cash holdings decreases with the increase in CEO ownership.

Harford et al. (2008) show that the equity ownership of the top five executives is positively related to cash holdings. We define *Top5_OWN* and *Top5_OWN_SO* as the proxies for the ownership of the five executives with the highest compensation in the firm. Columns (5)–(6) of Table 3.2 show that the coefficients of *Top5_OWN* and *Top5_OWN_SO* are positive and significant. Next, we subtract CEO ownership from *Top5_OWN* and *Top5_OWN_SO*, and define *Top4_OWN* and *Top4_OWN_SO* as the non-CEO insider ownership. Columns (7) and (8) show that the coefficients of *Top4_OWN* and *Top4_OWN_SO* are insignificant. Our results suggest that CEO ownership plays a more important role in corporate cash policy than the ownership of the other top executives.

[3] In Ozkan and Ozkan (2004)'s empirical analyses, managerial ownership is the total percentage of equity ownership held by company directors.

Table 3.2. Baseline regression: CEO ownership and corporate cash holdings

This table reports the OLS regressions of corporate cash holdings on CEO ownership proxy variables and control variables. The sample consists of 26,409 firm–year observations of U.S. firms over the sample period of 1992–2018 with required data for the regressions. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are CEO ownership (CEO_OWN_t and $CEO\_OWN\_SO_t$), the piecewise-linear terms of CEO ownership ($CEO\_OWN\_05_t$, $CEO\_OWN\_0525_t$, $CEO\_OWN\_25_t$, $CEO\_OWN\_SO\_05_t$, $CEO\_OWN\_SO\_0525_t$, and $CEO\_OWN\_SO\_25_t$), insider ownership ($Top5\_OWN_t$ and $Top5\_OWN\_SO_t$), and non-CEO insider ownership ($Top4\_OWN_t$ and $Top4\_OWN\_SO_t$). All variables are defined in Appendix B.2. 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
CEO_OWN_t	0.098***							
	[2.88]							
$CEO\_OWN\_SO_t$		0.111***						
		[3.09]						
$CEO\_OWN\_05_t$			0.299*					
			[1.76]					
$CEO\_OWN\_0525_t$			0.103**					
			[2.41]					
$CEO\_OWN\_25_t$			0.099**					
			[2.23]					
$CEO\_OWN\_SO\_05_t$				0.284*				
				[1.78]				
$CEO\_OWN\_SO\_0525_t$				0.103**				
				[2.40]				
$CEO\_OWN\_SO\_25_t$				0.126***				
				[2.86]				
$Top5\_OWN_t$					0.066**			
					[2.47]			
$Top5\_OWN\_SO_t$						0.071***		
						[2.61]		

Continued on next page

Table 3.2 - continued from previous page

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$Top4\_OWN_t$							0.061	
							[1.32]	
$Top4\_OWN\_SO_t$								0.068
								[1.40]
$Size_t$	-0.019***	-0.019***	-0.019***	-0.019***	-0.019***	-0.019***	-0.019***	-0.019***
	[-12.13]	[-12.09]	[-11.80]	[-11.81]	[-12.15]	[-12.15]	[-12.33]	[-12.34]
CF_t	-0.037	-0.036	-0.037	-0.037	-0.050**	-0.050**	-0.052**	-0.052**
	[-1.56]	[-1.55]	[-1.56]	[-1.57]	[-2.01]	[-2.00]	[-2.08]	[-2.08]
MTB_t	0.023***	0.023***	0.687***	0.685***	0.024***	0.024***	0.024***	0.024***
	[14.68]	[14.67]	[7.74]	[7.72]	[15.12]	[15.09]	[15.16]	[15.15]
NWC_t	-0.288***	-0.288***	0.023***	0.023***	-0.276***	-0.276***	-0.274***	-0.274***
	[-19.74]	[-19.73]	[14.70]	[14.69]	[-18.93]	[-18.89]	[-18.82]	[-18.81]
$CAPEX_t$	-0.544***	-0.544***	-0.289***	-0.289***	-0.534***	-0.535***	-0.532***	-0.532***
	[-17.58]	[-17.58]	[-19.75]	[-19.73]	[-17.21]	[-17.21]	[-17.19]	[-17.19]
$R\&D/Sales_t$	0.437***	0.437***	-0.545***	-0.545***	0.466***	0.467***	0.463***	0.463***
	[16.23]	[16.25]	[-17.60]	[-17.59]	[15.91]	[15.92]	[15.83]	[15.83]
$Acquisitions_t$	-0.315***	-0.315***	-0.206***	-0.206***	-0.302***	-0.302***	-0.302***	-0.303***
	[-23.94]	[-23.98]	[-18.83]	[-18.86]	[-23.21]	[-23.25]	[-23.28]	[-23.29]
$Dividends_t$	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***	-0.017***
	[-4.59]	[-4.58]	[-4.58]	[-4.57]	[-4.55]	[-4.54]	[-4.45]	[-4.45]
$Sigma_t$	0.687***	0.686***	0.437***	0.437***	0.653***	0.650***	0.658***	0.657***
	[7.74]	[7.72]	[16.22]	[16.23]	[7.34]	[7.31]	[7.39]	[7.38]
$Leverage_t$	-0.205***	-0.205***	-0.315***	-0.316***	-0.195***	-0.195***	-0.197***	-0.197***
	[-18.79]	[-18.81]	[-23.92]	[-23.94]	[-17.34]	[-17.38]	[-17.27]	[-17.28]
$Firm\ age_t$	-0.008***	-0.008***	-0.008***	-0.008***	-0.006**	-0.006**	-0.007**	-0.007**
	[-2.89]	[-2.89]	[-2.85]	[-2.86]	[-2.29]	[-2.31]	[-2.50]	[-2.49]
Constant	0.342***	0.341***	0.338***	0.337***	0.328***	0.328***	0.335***	0.335***
	[14.26]	[14.28]	[13.96]	[14.10]	[12.99]	[13.02]	[12.75]	[12.76]
Industry fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	26,409	26,409	26,409	26,409	24,911	24,911	24,911	24,911
Adjusted-R^2	0.586	0.586	0.587	0.587	0.583	0.583	0.582	0.582

3.3.2. Identification methods

Our baseline regression results show that CEO ownership has a positive impact on corporate cash holdings. Nonetheless, CEOs and firms do not choose each other randomly in the labor market. One potential endogeneity concern is that a CEO may choose to join a firm with better investment prospects and higher financing flexibility. Unobservable characteristics, such as corporate reputation and managerial traits, may also affect both CEO ownership and corporate cash policy. To address the potential endogeneity concerns due to unobservable confounding variables, simultaneity, and reverse causality, we employ the following two identification strategies: a PSM method and a 2SLS model.

Propensity score matching

A firm may appoint a CEO with specific managerial styles according to the firm's specific strategies, including cash policy. CEO ownership and cash holdings may also be jointly determined by firm characteristics, such as firm size. Smaller firms may have more cash holdings and higher CEO ownership. To address the concern about non-random matching between CEOs and firms, we employ a PSM approach to compare the cash holdings of two groups of firms that are similar in terms of observable firm characteristics except CEO ownership. Firms with high CEO ownership are assigned into a treatment group and those with low CEO ownership are assigned into a control group.

Following the setting in Lilienfeld-Toal and Ruenzi (2014), we classify firms into two sub-samples based on the annual median of CEO ownership. Specifically, we define dummy variables *OWN_High* and *OWN_SO_High* which are equal to one if *CEO_OWN* and *CEO_OWN_SO* are above its annual sample median, and zero otherwise. In the first stage of our PSM procedure, we employ a probit model to estimate the probabilities (propensity scores) that firms have a CEO with high ownership. In the probit regressions, the dependent variables are *OWN_High* or *OWN_SO_High* and the independent variables are the control variables in Equation (3.1). In the second stage, we use the calculated propensity scores to conduct a one-to-one nearest neighbor match, requiring that the differences in the propensity scores between firms with high CEO ownership and matched firms with low CEO ownership do not exceed 0.5% in absolute value.

Panel A of Table 3.3 reports the univariate comparisons between firms with high CEO ownership and propensity-score-matched firms with low CEO ownership. Columns (1)–(2) display the mean of firm characteristics for 8,297 paired firms using *CEO_OWN* and columns (4)–(5) present the means for 8,218 paired firms using *CEO_OWN_SO*. The t-statistics in columns (3) and (6) show that all the differences in the mean values of firm characteristics between treatment and control groups are not statistically significant, except for $Firm\ age_t$ in column (3), indicating that firms in the treatment and control groups are comparable in terms of observable firm-level characteristics. In Panel B of Table 3.3, we re-estimate Equation (3.1) using the propensity-score-matched samples. The coefficients of CEO_OWN_t and $CEO\_OWN\_SO_t$ remain positive and statistically significant at the 1% level. On average, a one-standard-deviation increase in CEO_OWN_t is associated with a 0.55% ($= 0.105 \times 0.052$) increase in $Cash\ holdings_t$ and a one-standard-deviation increase in $CEO\_OWN\_SO_t$ is associated with a 0.69% ($= 0.140 \times 0.049$) increase in $Cash\ holdings_t$.[4] These results are consistent with those documented in our baseline regressions.

[4]The mean values of *CEO_OWN* and *CEO_OWN_SO* are 0.052 and 0.049 in the PSM sample.

Table 3.3. Propensity score matching

Panel A. Differences in firm characteristics between CEOs with high and low ownership. This panel reports the univariate comparisons of firm characteristics between firms with high CEO ownership and propensity-score-matched firms with low CEO ownership. We employ a probit model to estimate the propensity scores, in which the dependent variables are OWN_High_t and $OWN\_SO\_High_t$, and the independent variables are the control variables in Equation (3.1). OWN_High_t is equal to one if CEO_OWN_t is above its annual sample median, and zero otherwise. $OWN\_SO\_High_t$ is equal to one if $CEO\_OWN\_SO_t$ is above its annual sample median, and zero otherwise. We conduct a one-to-one nearest neighbor match. The differences in the propensity scores between firms with high CEO ownership and matched firms with low CEO ownership do not exceed 0.5% in absolute value. In columns (1)–(2) and (4)–(5), we report the mean of firm characteristics. In columns (3) and (6), we report the t-statistics of the univariate comparisons between the high and low sub-samples. All variables are defined in Appendix B.2. $***$, $**$, and $*$ denote statistical significance at the 1%, 5%, and 10% level, respectively.

	OWN **matched sample (16,594 Obs.)**			***OWN_SO*** **matched sample (16,436 Obs.)**		
Variables	**High (1)**	**Low (2)**	**t-stat. (3)**	**High (4)**	**Low (5)**	**t-stat. (6)**
$Size_t$	7.379	7.364	0.78	7.372	7.360	0.60
CF_t	0.081	0.083	-1.14	0.080	0.082	-1.37
MTB_t	1.981	1.977	0.22	1.969	1.973	-0.21
NWC_t	0.086	0.087	-0.47	0.086	0.086	0.04
$CAPEX_t$	0.056	0.056	0.54	0.056	0.056	0.04
$R\&D/Sales_t$	0.051	0.052	-0.74	0.051	0.051	0.06
$Acquisitions_t$	0.032	0.032	-0.23	0.031	0.032	-0.57
$Dividends_t$	0.483	0.475	1.06	0.486	0.484	0.30
$Sigma_t$	0.053	0.052	0.79	0.053	0.053	0.02
$Leverage_t$	0.218	0.218	-0.10	0.219	0.219	-0.11
$Firm\ age_t$	3.103	3.086	1.67*	3.106	3.092	1.41

Panel B. CEO ownership and corporate cash holdings using the PSM samples. This panel reports the results of re-estimating Equation (3.1) using the propensity-score-matched samples. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are CEO_OWN_t and $CEO\_OWN\_SO_t$. The control variables are the same as those in Equation (3.1). All variables are defined in Appendix B.2. 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.

Variables	**(1)**	**(2)**
CEO_OWN_t	0.105***	
	[2.66]	
$CEO\_OWN\_SO_t$		0.140***
		[3.19]
$Size_t$	-0.019***	-0.019***
	[-9.89]	[-9.73]
CF_t	-0.010	-0.012
	[-0.40]	[-0.47]
MTB_t	0.023***	0.023***
	[12.93]	[12.65]
NWC_t	-0.283***	-0.275***
	[-16.93]	[-16.42]
$CAPEX_t$	-0.580***	-0.550***
	[-15.82]	[-16.21]
$R\&D/Sales_t$	0.449***	0.434***
	[15.56]	[14.97]
$Acquisitions_t$	-0.320***	-0.315***
	[-20.84]	[-20.04]
$Dividends_t$	-0.021***	-0.021***
	[-5.08]	[-5.08]
$Sigma_t$	0.635***	0.721***
	[6.34]	[7.27]
$Leverage_t$	-0.202***	-0.203***
	[-16.22]	[-16.06]
$Firm\ age_t$	-0.007**	-0.006*
	[-2.09]	[-1.84]
Constant	0.334***	0.338***
	[13.18]	[14.12]
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	16,594	16,436
Adjusted-R^2	0.605	0.595

Two-stage least squares

Our PSM identification method helps to mitigate the endogeneity concern due to the observable firm heterogeneity. However, our PSM identification method can not address the endogeneity due to the unobservable heterogeneity across CEOs and firms, for instance, CEOs' early-life experiences and firm culture. Bernile et al. (2017) find that CEOs with some fatal disaster experiences are associated with risker corporate policies, such as higher leverage and lower cash holdings. To further address the potential endogeneity concerns due to time-variant omitted variables and reverse causality, our second identification strategy is to employ a 2SLS model with IVs.

Following Kim and Lu (2011), we adopt *CEO tenure* and *CEO tax burden* as our IVs for CEO ownership. Gibbons and Murphy (1992) and Palia (2001) show that executives' equity ownership increases with their tenure in the firms. CEO tenure is commonly employed as the IV for managerial equity ownership in previous studies (e.g., Brockman et al. 2010; Liu and Mauer 2011). We define *CEO tenure* as the number of years which a CEO has served in her position. Previous studies also document a positive relation between CEOs' capital gain tax liabilities (tax burdens) and the amount of unrestricted equity ownership, suggesting that greater personal tax burdens significantly discourage CEOs from selling their stocks (Jin and Kothari 2008; Armstrong et al. 2015). In this vein, CEOs with a high capital gain tax rate may choose to hold more unconstrained shares than CEOs with a low capital gain tax rate. Following Jin and Kothari (2008) and Yost (2018), we use the sum of the maximum marginal federal and state individual capital gains tax rates to construct the CEO tax burden.[5] Specifically, *CEO tax burden* is defined as the tax liability arising from selling a CEO's vested stock holdings, scaled by the CEO's total equity holdings (including vested and unvested stock and options):

$$Cash\ tax\ burden_t = \frac{\sum_{k=1}^{t}(P_t - P_k) \times N_k \times t_{cg}}{Total\ equity\ holdings_t} \tag{3.2}$$

where P_t is the stock price at the end of year t, P_k is the stock price at the end of year k,

[5]The data on the federal and state individual maximum marginal capital gains tax rates are from the National Bureau of Economic Research: http://users.nber.org/ taxsim/state-rates/.

N_k is the number of unrestricted shares held by the CEO in year t which were obtained in year k, t_{cg} is the sum of a CEO's maximum marginal federal and state capital gains tax rates in year t, and $Total\ equity\ holdings_t$ is the value of the CEO's stock and options holdings in year t.

Table 3.4 presents the results of our 2SLS regressions. Columns (1) and (2) report the results of the first-stage regressions in which the dependent variables are *CEO_OWN* and *CEO_OWN_SO*. *CEO tenure* and *CEO tax burden* are IVs, and the control variables are the same as those in Equation (3.1). The coefficients of *CEO tax burden* are positive and statistically significant at the 5% and 1% levels, suggesting that CEO ownership is positively associated with tax burden. The coefficients of *CEO tenure* are positive and statistically significant at the 1% level, indicating that CEO ownership increases with CEO tenure. The sign of our IVs are consistent with the evidence documented in previous studies. The Shea's partial R^2 values are above the hurdle of 10% and the F-statistics are higher than 10, which supports the relevance condition that our IVs are important in explaining the variation of the potential endogenous CEO ownership variables. In addition, the under-identification tests (Kleibergen-Paap LM-statistic) and the over-identification tests (Hansen J-statistic) are statistically significant at the 1% and 5% levels, respectively, suggesting that the null hypotheses that our IVs are underidentified or overidentified can be rejected.

Columns (3) and (4) report the results of the second-stage regressions, in which the dependent variable is *Cash holdings* and the independent variables of interest are predicted CEO ownership proxy variables obtained from the first-stage regressions. The control variables in the second-stage regressions are the same as those in Equation (3.1). The coefficients of $CE\widehat{O_OW}N$and $CE\widehat{O\_OW}N\_SO$ are positive and statistically significant at the 1% level, suggesting that the positive impact of CEO ownership on cash holdings remains robust to the 2SLS identification method. Our untabulated results also remain robust if we conduct 2SLS regressions with only one instrumental variable, either *CEO tenure* or *CEO tax burden*. These findings further mitigate the weak instrumentation concern and over-identification issues.

Table 3.4. Two-stage least squares

This table reports the two-stage least squares (2SLS) regression results of corporate cash holdings on predicted CEO ownership proxy variables and control variables. Columns (1) and (2) present the results of the first-stage regressions, in which the dependent variables are CEO_OWN_t and $CEO\_OWN\_SO_t$. Following Kim and Lu (2011) and Yost (2018), the instrumental variables (IVs) in the first-stage regressions are $CEO\ tax\ burden_t$ and $CEO\ tenure_t$. Shea's partial R^2 is a measure of the IV relevance (Shea 1997). F-test is a test of the IV's exclusive condition. The Kleibergen-Paap (KP) LM test is a test of the underidentifying restriction. The Hansen J test is a test of the overidentifying restriction. Columns (3) and (4) present the results of the second-stage regressions, in which the dependent variable is $Cash\ holdings_t$. The independent variables of interest are the predicted CEO ownership proxy variables obtained from the first-stage regressions. The control variables are the same as those in Equation (3.1). All variables are defined in Appendix B.2. 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.

	First-stage		**Second-stage**	
Variables	CEO_OWN_t **(1)**	$CEO\_OWN\_SO_t$ **(2)**	$Cash\ holdings_t$ **(3)**	**(4)**
$\widehat{CEO\_OWN}_t$			0.236***	
			[3.13]	
$\widehat{CEO\_OWN}\_SO_t$				0.274***
				[3.15]
$CEO\ tax\ burden_t$	0.010**	0.011***		
	[2.49]	[2.99]		
$CEO\ tenure_t$	0.003***	0.002***		
	[14.44]	[14.13]		
Constant	0.089***	0.085***	0.327***	0.325***
	[3.90]	[3.69]	[12.86]	[12.73]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Shea partial R^2	0.171	0.155		
F-stat.(IVs)-weakid	111.923***	106.523***		
KP LM-underid	114.568***	111.439***		
Hansen J-overid	5.927**	5.621**		
Observations	21,824	21,824	21,824	21,824
Adjusted-R^2	0.262	0.262	0.589	0.589

3.3.3. Alternative measures of cash holdings

So far, we focus on the total amount of corporate cash holdings, which is the sum of cash and marketable securities. In this section, we examine whether our main results are robust to two alternative measures of cash holdings. First, we examine the excess cash holdings that are non-essential for corporate operations and investment. We define excess cash holdings (*Xcash*) as the amount of cash holdings above a predicted optimal level of cash reserves. Specifically, *Xcash* is the residual estimated from a regression in which the dependent variable is the ratio of cash and marketable securities to total assets, and the independent variables are firm net assets, industry average cash flow volatility, free cash flow, net working capital, market value of equity, and R&D expenses.[6] Following Dittmar and Mahrt-Smith (2007) and Bates et al. (2009), we only focus on the firm–year observations with positive excess cash holdings. 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 et al. (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 sample firms with the same 4-digit SIC codes. Table 3.5 shows that the positive relation between corporate cash holdings and CEO ownership remains positive and statistically significant for the two alternative measures of cash holdings.

[6]Please refer to the Appendix of Dittmar and Mahrt-Smith (2007) for the details of the regression specification.

Table 3.5. Alternative measures of cash holdings

This table reports the OLS regressions of alternative cash holdings on CEO ownership proxy variables and control variables. The sample consists of the S&P1500 firm–year observations over the sample period 1992–2018 with required data for the regressions. In columns (1)–(2), the dependent variable is *Excess cash holdings*$_t$, which is measured as the amount of cash above the predicted optimal level of cash reserves (Dittmar and Mahrt-Smith 2007). We only focus on the firm–year observations with positive excess cash holdings. In columns (3)–(4), the dependent variable is *Industry-adjusted cash holdings*$_t$, which is measured as a firm's cash to total assets ratio minus the median of the cash to total assets ratios of all firms with the same 4-digit SIC industry codes (Haushalter et al. 2007). The independent variables of interest are CEO_OWN_t and $CEO\_OWN\_SO_t$. The control variables are the same as those reported in Equation (3.1). All variables are defined in Appendix B.2. The coefficients of the control variables, 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.

	Excess cash holdings$_t$		***Industry-adjusted cash holdings***$_t$	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
CEO_OWN_t	0.087**		0.116***	
	[2.46]		[3.47]	
$CEO\_OWN\_SO_t$		0.098**		0.127***
		[2.52]		[3.61]
Constant	0.268***	0.267***	0.218***	0.217***
	[6.31]	[6.30]	[7.74]	[7.69]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	11,271	11,271	25,408	25,408
Adjusted-R^2	0.238	0.238	0.239	0.239

3.3.4. Additional controls for corporate governance and CEO characteristics

The previous literature documents that managerial entrenchment is related to corporate cash policy. For instance, Harford et al. (2008) show that firms with weaker shareholder rights have lower cash reserves. Nikolov and Whited (2014) also find that agency problems affect corporate cash policy, while institutional investors may mitigate these agency problems. To control the effect of corporate governance on cash holdings, we include two governance proxy variables as our additional control variables. The first one is *E-index*, the accumulated number of the six important anti-takeover provisions developed by Bebchuk et al. (2009). Firms with more anti-takeover provisions have more entrenched managers and poorer corporate governance. The second one is *TMI*, the ownership of motivated monitoring institutional investors whose holding value in a firm ranks among the top 10% of the stocks in their portfolios (Fich et al. 2015; Ward et al. 2018). Firms with a larger motivated monitoring institutional ownership have better corporate governance. The results in columns (1) and (2) of Table 3.6 show that after controlling for corporate governance, firms with higher CEO ownership tend to hold more cash. Consistent with the evidence documented in Harford et al. (2008) and Nikolov and Whited (2014), we find that firms' cash holdings increase when they have lower managerial entrenchment and higher institutional monitoring ownership.

Apart from controlling for corporate governance, we control for the heterogeneity of CEO-level characteristics: *CEO age*, *CEO gender*, the sensitivity of a CEO's stock options to stock price volatility (*Vega/TC*), and a CEO's managerial power within the firm (*CEO duality*). Columns (3) and (4) of Table 3.6 report that corporate cash holdings increase with CEO ownership. In columns (5) and (6), we add all the additional control variables in our baseline equation. Our main finding remains robust.

Table 3.6. Additional controls for corporate governance and CEO characteristics

This table reports the OLS regressions of corporate cash holdings on CEO ownership proxy variables and additional control variables. The dependent variable is *Cash holdings*$_t$ and the independent variables of interest are OWN_SO_t and OWN_t. In columns (1) and (2), we add two corporate governance control variables: *E-Index*$_t$ and TMI_t. In columns (3) and (4), we add four control variables related to CEO: $Vega/TC_t$, *CEO age*$_t$, *CEO female*$_t$, and *CEO duality*$_t$. In columns (5) and (6), we add all six additional control variables. The other control variables are the same as those reported in Equation (3.1). All variables are defined in Appendix B.2. 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
CEO_OWN_t	0.109**		0.114***		0.136**	
	[2.32]		[3.14]		[2.51]	
$CEO\_OWN\_SO_t$		0.129***		0.124***		0.148**
		[2.61]		[3.17]		[2.52]
E-Index$_t$	-0.004**	-0.004**			-0.004**	-0.004**
	[-2.55]	[-2.53]			[-2.44]	[-2.44]
TMI_t	0.042***	0.042***			0.046***	0.046***
	[2.94]	[2.94]			[3.30]	[3.26]
$Vega/TC_t$			0.005	0.008	-0.015	-0.010
			[0.12]	[0.19]	[-0.26]	[-0.17]
CEO age$_t$			-0.006	-0.005	0.004	0.006
			[-0.48]	[-0.44]	[0.26]	[0.34]
CEO female$_t$			0.016*	0.016*	0.015	0.015
			[1.70]	[1.69]	[1.46]	[1.43]
CEO duality$_t$			-0.004	-0.004	-0.004	-0.004
			[-1.52]	[-1.49]	[-1.13]	[-1.10]
Constant	0.368***	0.366***	0.363***	0.360***	0.330***	0.324***
	[10.38]	[10.44]	[7.03]	[6.97]	[4.64]	[4.54]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,726	15,726	25,103	25,103	15,042	15,042
Adjusted-R^2	0.568	0.568	0.588	0.588	0.569	0.569

3.4. Mechanisms

Our analysis has shown that firms with higher CEO ownership hold more cash. In this section, we examine the plausible mechanisms for our finding.

3.4.1. Firm-specific risk

The precautionary motive for holding cash suggests that firms with riskier cash flows, higher external financing costs, and better investment opportunities, tend to hold more cash to hedge future cash flow uncertainty and reduce financial distress costs (Opler et al. 1999; Acharya et al. 2007; Bates et al. 2009). A survey study conducted by Graham and Harvey (2001) finds that corporate financial decisions are related to the evaluation of new investments, and firms are more likely to use firm-specific risk rather than individual project risk to evaluate new projects. The theoretical model of Riddick and Whited (2009) also shows a positive relation between a firm's idiosyncratic risks and cash holdings. If firm ownership helps to align the interests between shareholders and CEOs by incentivizing CEOs to improve firm performance and mitigate firm-specific risk, CEOs with high firm ownership may choose to adopt a cash policy based on precautionary reasons. Following this vein, we expect that the impact of CEO ownership on cash holdings is more pronounced among firms with higher firm-specific risk.

Our first proxy for firm-specific risk is stock return volatility, *Return_Vol*, which captures a firm's idiosyncratic risk in the financial market. *Return_Vol* is defined as a firm's average monthly standard deviations of stock returns over a year, where the monthly standard deviation of stock returns is the sample standard deviation of daily stock returns within a month, multiplied by the number of trading days in the month (Rajgopal and Venkatachalam 2011).[7] Our second proxy for firm-specific risk is cash flow volatility, *CF_Vol*, which captures a firm's operation uncertainty. *CF_Vol* is calculated as the standard deviation of operating margin ratio, which is equal to operating cash flow divided by

[7] Our results remain robust to the volatility of stock returns adjusted by the Fama and French (1993) three-factor model.

total sales, using annual data over three years (Bartram et al. 2011).[8] Similar to Bustamante and Frésard (2020), we define an indicator variable *D_high* which is equal to one if *Return_Vol* or *CF_Vol* is greater than its annual sample median, and zero otherwise, and an indicator variable *D_low* which is equal to one if *Return_Vol* or *CF_Vol* is less than its annual sample median, and zero otherwise. We then modify our baseline regression by replacing *CEO ownership proxy* with the interaction terms between *CEO ownership proxy* and two indicator variables:

$$\begin{aligned} Cash\ holdings_{i,t} = \alpha + \beta_1 CEO\ ownership_{i,t} * D\_high_t + \beta_1 CEO\ ownership_{i,t} * D\_low_t \\ + B\,Control\ variables_{i,t} + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \tag{3.3}$$

Panel A of Table 3.7 reports the regression results. Columns (1)–(4) show that the estimated coefficients of interaction terms with *D_high* are positive and statistically significant, while the estimated coefficients of interaction terms with *D_low* are statistically insignificant. Our findings suggest that CEO ownership has a stronger impact on cash holdings when firms have higher firm-specific risk, supporting the precautionary motive for holding cash.

3.4.2. External financing costs

According to the pecking order theory (Myers and Majluf 1984b; Myers 1984), outside investors have less information on the value of a firm's assets and investment opportunities than the firm's managers. The asymmetric information between managers and outside investors leads to a higher cost of external financing, therefore firms prefer internal cash to costly external financing. Firms may forgo projects with positive net present value (NPV) if their internal funds are not sufficient. To mitigate the underinvestment problem in the future, firms may stockpile cash from operating revenue (Harford et al. 2008). If the precautionary motive drives the positive relation between CEO ownership and cash

[8] Alternatively, we use five years of annual operating margins to calculate cash flow volatility; the results are the same. We also calculate cash flow volatility using the ratio of annual operating cash flows to total assets; the results remain robust.

holdings, then we expect to find a stronger relation when external financing costs are higher.

We employ two proxies to measure a firm's external financing costs. The first one is the S&P credit rating of a firm, *Issuer Rating*, which indicates a forward-looking opinion about the credit quality of a firm's debt issue. Firms with a higher *Issuer Rating* have a lower debt financing cost. The second one is Whited and Wu (2006)'s index, *WW-Index*, which measures a firm's external finance constraints. Firms with a higher *WW-Index* are expected to have a higher external financing cost. Same as in Equation (3.3), we interact CEO ownership variables with *D_high* and *D_low*, which indicate whether *Issuer Rating* is above or below a BBB credit rating, or whether *WW-Index* is above or below its annual sample median.

Columns (1) and (2) in Panel B of Table 3.7 show that the coefficients of the interaction terms between the CEO ownership variables and low *Issuer Rating* indicator variable are positive and statistically significant, while the coefficients of the interaction terms between the CEO ownership variables and high *Issuer Rating* indicator variables are statistically insignificant. Columns (3) and (4) show that the coefficients of the interaction terms between the CEO ownership variables and high *WW-Index* indicator variable are positive and statistically significant, while the coefficients of the interaction terms between the CEO ownership variables and low *WW-Index* indicator variables are statistically insignificant. Our findings suggest that the positive relation between CEO ownership and cash holdings is stronger when firms have higher external financing costs. CEOs with higher firm ownership have higher incentives to improve shareholders' value, therefore they prefer to hold more precautionary cash reserves for financing positive NPV projects and preventing the underinvestment problem.

3.4.3. Agency conflicts

Jensen (1986) argues that in the present of agency costs of managerial entrenchment, managers have greater preference for increasing firms' cash holdings so that they may pursue empire building and perquisite consumption at the expense of shareholders. Consistent with agency theory, Dittmar et al. (2003) show that firms hold more cash in countries with weaker corporate governance. Kalcheva and Lins (2007) also find that internationally firms with weaker shareholder protection hold more cash; however, they find no evidence that managerial agency costs outweigh the costs of underinvestment when country-level shareholder protection is weak. In Section 3.3.4, we have controlled for corporate governance using the *E-index* and the monitoring ownership of institutional investors, and the results show that the positive relation between CEO ownership and cash holdings remains robust. In this section, we conduct a cross-sectional analysis and examine whether the positive relation between CEO ownership and cash holdings is driven by the motive for managerial expropriation of cash holdings.

Previous studies suggest that firms with a higher *E-index* and lower institutional monitoring ownership are associated with weaker corporate governance and more agency problems (Gompers et al. 2003; Bebchuk et al. 2009). Similar to Equation (3.3), we interact CEO ownership variables with *D_high* and *D_low* which indicate whether *E-Index* and *TMI* are above or below their annual sample medians.[9] The results in Panel C of Table 3.7 show that the coefficients of the interaction terms between the CEO ownership variables and low *E-Index* indicator variable are positive and statistically significant, while the coefficients of the interaction terms between the CEO ownership variables and high *E-Index* indicator variable are statistically insignificant. In addition, the coefficients of the interaction terms between the CEO ownership variables and both high and low *TMI* indicator variables are positive and statistically significant. Consistent with Bates et al. (2009), we do not find evidence that the positive relation between CEO ownership and cash holdings is stronger among firms with weaker corporate governance.

3.4.4. Business cycle

A cash–cash flow sensitivity model proposed by (Almeida et al. 2004) implies that cash holding patterns should vary over the business cycle, since the aggregated corpo-

[9] To be consistent with our tests in Table 3.6, we adopt *E-Index* and *TMI* as corporate governance proxies. We also use *G-Index*, *blockholder ownership*, and *institutional ownership* (Harford et al. 2008; Nikolov and Whited 2014) as the alternative corporate governance proxies. Untabulated tests show that our results remain robust.

rate liquidity demand fluctuates over the business cycle and works as exogenous shock, which affects both the size of current cash flows and the relative attractiveness of future investment. Particularly, financially constrained firms should increase their propensity to retain cash following negative macroeconomic shocks. In the same vein, if CEO ownership provide strong incentive to hold cash to mitigate the possibility of having forego good investment opportunities due to fund shortage, firm with high level of CEO ownership are more likely to save more cash against the recessions.

To test this conjecture, we collect the recession data from National Bureau of Economic Research (NBER) U.S. business cycle contractions and expansion[10] and construct two indicator variables, *Recession* and *Boom*. The variable *Recession* equals to one if at least one month in year t within the contraction (peak to trough) and zero otherwise (Bao et al. 2012). The variable *Boom* equals to one if year t is not a recession year and zero otherwise. We then replicate the Equation 3.1 using sub-samples of firms within recession and boom year. The results in Panel D of Table 3.7 show that the coefficients of *CEO_OWN* and *CEO_OWN_SO* are positive and statistically significant over the recession year, but insignificant during the boom year. This finding supports the conjecture that CEO ownership plays an important role in internal governance mechanism that aligns shareholders and managers' interests and encourages firms to retain cash for preventing potential underinvestment issues during the recessions.

Overall, our four cross-sectional analyses suggest that the positive relation between CEO ownership and cash holdings is more likely driven by the precautionary motive, rather than the private benefit motive for expropriating cash holdings.

[10] NBER website: https://www.nber.org/research/business-cycle-dating.

Table 3.7. Differential impact of CEO ownership on cash holdings

This table reports the OLS regressions of cash holdings on the interactions between CEO ownership proxy variables and two indicator variables, *D_high* and *D_low*. *D_high* (*D_low*) is equal to one if the corresponding variable is greater than (less than) its annual sample median and zero otherwise. In Panel A, we employ stock return volatility (*Return_Vol*) and operating cash flow volatility (*CF_Vol*) as the proxies for firm-specific risk. In Panel B, we use a firm's credit rating, $Issuer\ Rating_t$, and Whited and Wu (2006)'s external finance constraint index, $WW\text{-}Index_t$, as proxies for external financing costs. In Panel C, we adopt $E\text{-}Index_t$ and TMI_t as proxies for corporate governance. In Panel D, we adopt $Recession_t$ and $Boom_t$ as proxies for business cycle. We only report the coefficients on the interaction terms, and the F-statistic corresponding to a test of equality between interacted coefficients. The control variables are the same as those reported in Equation (3.1). All variables are defined in Appendix B.2. 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.

Panel A. Firm-specific risk.				
	$Return\_Vol_t$		CF_Vol_t	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
$CEO\_OWN_t \times D\_high$	0.133***		0.202***	
	[3.05]		[4.42]	
$CEO\_OWN_t \times D\_low$	0.044		0.011	
	[1.05]		[0.32]	
$CEO\_OWN\_SO_t \times D\_high$		0.165***		0.229***
		[3.42]		[4.64]
$CEO\_OWN\_SO_t \times D\_low$		0.042		0.013
		[0.94]		[0.34]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Test coefficient F-stat.	3.41*	4.24**	16.12***	18.80***
Observations	21,754	21,754	26,387	26,387
Adjusted-R^2	0.599	0.599	0.587	0.587
Panel B. External financing costs.				
	$Issuer\ Rating_t$		$WW\text{-}Index_t$	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
$CEO\_OWN_t \times D\_high$	0.134		0.088**	
	[1.31]		[2.50]	
$CEO\_OWN_t \times D\_low$	0.094**		0.078	
	[1.99]		[1.61]	

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Table 3.7 - continued from previous page

$CEO\_OWN\_SO_t \times D\_high$		0.104		0.112***
		[1.19]		[2.70]
$CEO\_OWN\_SO_t \times D\_low$		0.105**		0.096
		[2.08]		[1.62]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Test coefficient F-stat.	16.12***	13.94***	42.98***	48.28***
Observations	5,459	5,459	26,226	26,226
Adjusted-R^2	0.429	0.429	0.577	0.587

Panel C. Agency costs of managerial entrenchment.

	E-Index$_t$		***TMI$_t$***	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
$CEO\_OWN_t \times D\_high$	0.040		0.138**	
	[0.62]		[2.51]	
$CEO\_OWN_t \times D\_low$	0.132**		0.084**	
	[2.11]		[2.37]	
$CEO\_OWN\_SO_t \times D\_high$		0.026		0.153**
		[0.36]		[2.56]
$CEO\_OWN\_SO_t \times D\_low$		0.166***		0.099***
		[2.60]		[2.61]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Test coefficient F-stat.	19.61***	25.31***	50.95***	55.48***
Observations	10,400	10,400	26,203	26,203
Adjusted-R^2	0.581	0.581	0.587	0.587

Panel D. Business cycle.

	Recession$_t$		***Boom$_t$***	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
CEO_OWN_t	0.104***		0.030	
	[3.07]		[0.59]	
$CEO\_OWN\_SO_t$		0.118***		0.047
		[3.24]		[0.88]
Constant	0.335***	0.333***	0.348***	0.346***
	[14.54]	[14.55]	[7.85]	[7.86]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	2,198	2,198	24,211	24,211
Adjusted-R^2	0.585	0.585	0.596	0.596

3.5. Additional analyses

3.5.1. CEO ownership, firm investment, and payout decisions

To help us further distinguish the role of CEO ownership in corporate cash policy, we examine how managerial ownership affects the use of cash, specifically firm investment and payout decisions. Following Dittmar and Mahrt-Smith (2007), we adopt excess cash holdings (*Xcash*) as the amount of cash holdings above a predicted optimal level of cash reserves, and focus on firms with positive excess cash holdings that are not essential for corporate operations and investment. Similar to Harford et al. (2008), we measure a firm's investment decisions using the changes in capital expenditures ($\Delta Capex$) and R&D expenses (Δ*R&D/Sales*), and measure a firm's payout policy using the changes in cash dividends per share of common stocks (ΔDiv) and open market repurchases of common stock ($\Delta Repurchases$). We regress the changes in investment or payout variables on CEO ownership, excess cash holdings, their interactions, and control variables. The control variables are the same as those in Equation (3.1).[11]

Panel A of Table 3.8 shows that the interactions of CEO ownership and excess cash holdings are positively related to $\Delta Capex$ and Δ*R&D/Sales*, indicating that firms with high CEO ownership tend to invest more on capital expenditures and R&D when firms have more excess cash holdings. Our findings support the view that CEOs are incentivized to invest more cash in future growth opportunities. Our result is consistent with Hobdari (2008) who finds that investment of employee-owned firms is positively associated with internal funds. Panel B of Table 3.8 shows that the coefficients of the interaction terms between CEO ownership and excess cash holdings are all statistically insignificant, suggesting that firms with high CEO ownership do not have a higher payout ratio when excess cash holding is high. These findings indicate that CEO ownership aligns CEOs interests to shareholders' interests and encourages CEOs to retain large cash reserves as precautionary savings, rather than distributing cash to shareholders.

[11] We drop *CAPEX*, *R&D/Sales*, or *Dividends* from the control variables, if it is the dependent variable in the regressions.

Table 3.8. CEO ownership, investment decisions, and payout policy

This table reports the OLS regressions of the changes in firm investment or payout variables on CEO ownership, excess cash holdings, the interactions of the two variables, and control variables. We only report the coefficients on the interaction terms. The control variables in Panel A are the same as those reported in Equation (3.1) without $CAPEX_t$ in columns (1) and (2) and without $R\&D/Sales_t$ in columns (3) and (4). The control variables in Panel B are the same as those reported in Equation (3.1) without $Dividends_t$. All variables are defined in Appendix B.2. 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.

Panel A. Investment decisions.				
	Δ $Capex_t$		**Δ $R\&D/Sales_t$**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
$CEO\_OWN_t \times Xcash_t$	0.079**		0.167***	
	[2.03]		[3.53]	
CEO_OWN_t	-0.012		-0.003	
	[-1.14]		[-0.54]	
$CEO\_OWN\_SO_t \times Xcash_t$		0.096**		0.154***
		[2.36]		[3.12]
$CEO\_OWN\_SO_t$		-0.013		0.000
		[-1.16]		[0.08]
$Xcash_t$	0.012***	0.012***	-0.018**	-0.018**
	[3.65]	[3.53]	[-2.53]	[-2.43]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	10,558	10,558	10,569	10,569
Adjusted-R^2	0.146	0.147	0.065	0.064
Panel B. Payout decisions.				
	Δ $Dividends_t$		**Δ $Repurchases_t$**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
$CEO\_OWN_t \times Xcash_t$	-0.057		0.015	
	[-1.44]		[0.19]	
CEO_OWN_t	0.011		-0.012	
	[1.45]		[-0.97]	
$CEO\_OWN\_SO_t \times Xcash_t$		-0.063		-0.004
		[-1.52]		[-0.05]
$CEO\_OWN\_SO_t$		0.012		-0.014
		[1.41]		[-1.10]
$Xcash_t$	0.001	0.001	-0.014	-0.013
	[0.27]	[0.31]	[-1.53]	[-1.45]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	10,563	10,563	9,707	9,707
Adjusted-R^2	0.032	0.032	0.025	0.025

3.5.2. CEO ownership and the value of cash

Our cross-sectional analyses in Section 3.4 suggest that CEOs with higher firm ownership hold more cash as a precautionary strategy to hedge against potential firm risks and mitigate the underinvestment problem. However, firms also incur costs of holding cash, such as a low rate of return on these liquid assets (Opler et al. 1999) and high capital gain tax on the interest of cash reserves (Faulkender and Wang 2006). To understand the impact of CEO ownership on the cost-benefit trade-offs, we further investigate how CEO ownership affects the market perceived value of cash holdings. When CEO ownership enhances the alignment of CEOs' and shareholders' interests, a firm's cash hoarding behavior driven by the precautionary motive should improve the efficiency of the firm's cash policy and create value for shareholders. As such, the marginal value of cash should be positively associated with CEO ownership.

To estimate the value of one additional dollar of cash holdings associated with CEO ownership, we extend Faulkender and Wang (2006)'s valuation model by adding the interactions between CEO ownership proxies and the change in cash holdings:

$$\begin{aligned} r_{i,t} - R^B_{i,t} = {} & \alpha + \beta_1 CEO\ ownership_{i,t} \times \Delta C_{i,t} + \beta_2 CEO\ ownerhsip_{i,t} \\ & + \beta_3 \Delta C_{i,t} + \beta_4 \Delta E_{i,t} + \beta_5 \Delta NA_{i,t} + \beta_6 \Delta R\&D_{i,t} + \beta_7 \Delta I_{i,t} + \beta_8 \Delta D_{i,t} + \beta_9 NF_{i,t} \\ & + \beta_{10} C_{i,t-1} + \beta_{11} C_{i,t-1} \times \Delta C_{i,t} + \beta_{12} L_{i,t} + \beta_{13} L_{i,t} \times \Delta C_{i,t} + \mu_t + \theta_j + \epsilon_{i,t} \end{aligned} \tag{3.4}$$

where i is firm index, t is year index, j is industry index; $r_{i,t}$ is firm i's stock return during fiscal year t; $R^B_{i,t}$ is firm i's 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; $CEO\ ownership_{i,t}$ is either CEO_OWN or CEO_OWN_SO; Δ indicates a change in the corresponding variables over fiscal year t; and $C_{i,t}$ is cash and marketable securities. Our control variables include earnings before interest and extraordinary items ($E_{i,t}$), total assets net of cash ($NA_{i,t}$), research and development expenses ($R\&D_{i,t}$), interest expenses ($I_{i,t}$), common dividends ($D_{i,t}$), net financing proceeds ($NF_{i,t}$), and market leverage ($L_{i,t}$). We normalize all the accounting variables in Equation (3.4) by the one-year lagged market value of equity, apart from $L_{i,t}$. μ_t is the year fixed effect and θ_j is the Fama–French 48 industry fixed effect. The independent variable of interest is the interaction of CEO ownership proxy with the change in cash holdings: $\mathit{CEO\ ownership}_{i,t} \times \Delta C_{i,t}$. Since both the dependent and independent variables are normalized by the one-year lagged market value of equity, the estimated coefficient β_3 can be interpreted as the marginal value of cash, the dollar change in shareholder wealth for a one-dollar increase in corporate cash holdings. The estimated coefficient β_1 represents the direct effect of CEO ownership on the value of corporate cash holdings.

Columns (1) and (2) of Table 3.9 show that the coefficients of the interaction terms are positive and statistically significant at the 10% and 5% levels. β_3 is equal to 1.241 in column (1) and 1.655 in column (2). The results report that a one-standard-deviation increase in *CEO_OWN* is associated with a \$0.07 ($= 0.056 * 1.241$) increase in the marginal value of cash, and a one-standard-deviation increase in *CEO_OWN_SO* is associated with a \$0.09 (=0.056*1.655) increase in the marginal value of cash. These results suggest that CEO ownership has a positive impact on the value of cash.

Next, we examine the impact of CEO ownership on the value of cash across firms within different cash regimes. We follow Halford et al. (2017) and classify firms into three *ex-post* cash regimes. Firms are classified into the raising cash regime if they issue equity and do not pay dividends in fiscal year t. Contrarily, firms are classified into the distributing cash regime if they distribute cash to shareholders and do not issue equity in fiscal year t. Finally, firms are classified into the servicing debt regime if their market leverage ratios are in the top decile distribution of firms at the beginning of fiscal year t and do not have cash raising or distributing activities in fiscal year t. Columns (3)–(8) of Table 3.9 show that the impact of CEO ownership on the value of cash remains positive and statistically significant for firms in the raising cash regime only. In the raising cash regime, CEOs with high firm ownership are motivated to increase shareholder value by increasing cash reserves for maintaining the ability to finance positive NPV projects and avoiding the underinvestment problem due to the costly external financing. As shown in Section 3.5.1, CEOs with high ownership choose to hold cash for the precautionary motive rather than distributing cash as dividends, share repurchases, or debt payments. Consequently, CEO ownership is not positively related to the value of cash in the distributing cash and serving debt regimes. Our findings are consistent with the view that firms with high CEO ownership accumulate cash for the precautionary demand of future investment.

Table 3.9. CEO ownership and the value of cash

This table reports the OLS regressions of firm excess returns on the change in cash holdings, CEO ownership proxy variables, the interaction of the prior two variables, and control variables. The main sample consists of the S&P1500 firm–year observations over the sample period 1992–2018 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 B.2. 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.

	Total sample		**Raising cash**		**Distributing cash**		**Servicing debt**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$CEO\_OWN_t \times \Delta C_t$	1.241*		2.920***		-0.040		-1.818	
	[1.92]		[3.85]		[-0.05]		[-0.68]	
CEO_OWN_t	-0.139***		0.057		-0.076		-0.203	
	[-2.66]		[0.22]		[-1.55]		[-0.26]	
$CEO\_OWN\_SO_t \times \Delta C_t$		1.655**		2.823***		0.356		-3.034
		[2.45]		[3.78]		[0.40]		[-1.12]
$CEO\_OWN\_SO_t$		-0.117**		0.288		-0.071		0.168
		[-2.02]		[0.99]		[-1.31]		[0.21]
ΔC_t	2.170***	2.162***	2.286***	2.277***	1.429***	1.417***	1.042	1.087
	[20.31]	[20.30]	[9.01]	[8.97]	[12.07]	[12.01]	[1.11]	[1.15]
ΔE_t	0.663***	0.663***	0.594***	0.596***	0.609***	0.609***	0.332***	0.331***
	[20.26]	[20.25]	[6.04]	[6.05]	[15.56]	[15.56]	[2.64]	[2.64]
ΔNA_t	0.192***	0.192***	0.254***	0.254***	0.204***	0.204***	0.118	0.118
	[10.84]	[10.87]	[4.30]	[4.30]	[10.28]	[10.27]	[1.50]	[1.48]
$\Delta R\&D_t$	1.445***	1.438***	1.162	1.173	0.671	0.668	5.190	5.278
	[3.71]	[3.69]	[1.16]	[1.17]	[1.38]	[1.38]	[1.55]	[1.59]
ΔI_t	-3.193***	-3.191***	-2.233*	-2.208*	-3.425***	-3.428***	-1.462	-1.437
	[-7.17]	[-7.16]	[-1.68]	[-1.66]	[-6.98]	[-6.98]	[-0.81]	[-0.79]

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	Total sample		**Raising cash**		**Distributing cash**		**Servicing debt**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
ΔD_t	0.793*	0.791*	-2.206	-2.197	1.648***	1.649***	-1.344	-1.402
	[1.72]	[1.72]	[-0.90]	[-0.89]	[3.95]	[3.95]	[-0.33]	[-0.35]
NF_t	0.432***	0.431***	0.792***	0.790***	0.248***	0.248***	0.477***	0.466***
	[14.66]	[14.65]	[7.60]	[7.56]	[7.71]	[7.70]	[3.17]	[3.12]
C_{t-1}	-0.503***	-0.502***	-1.042***	-1.039***	-0.338***	-0.337***	-3.652***	-3.659***
	[-25.54]	[-25.51]	[-11.84]	[-11.78]	[-18.30]	[-18.31]	[-8.30]	[-8.33]
$C_{t-1}\times\Delta C_t$	-0.134***	-0.135***	0.097	0.094	-0.280***	-0.280***	-0.127	-0.126
	[-3.57]	[-3.60]	[0.80]	[0.78]	[-6.91]	[-6.90]	[-0.67]	[-0.67]
L_t	-1.113***	-1.117***	-1.484**	-1.469**	-0.344	-0.349	-2.097	-2.062
	[-4.35]	[-4.37]	[-1.99]	[-1.97]	[-1.18]	[-1.21]	[-1.49]	[-1.48]
$L_t\times\Delta C_t$	-2.936***	-2.937***	-2.868***	-2.838***	-1.616***	-1.605***	0.912	0.857
	[-10.73]	[-10.75]	[-4.20]	[-4.15]	[-5.22]	[-5.19]	[0.57]	[0.54]
Constant	0.014	0.012	0.413***	0.409***	-0.040	-0.041	1.847***	1.851***
	[0.36]	[0.30]	[2.94]	[2.92]	[-1.06]	[-1.08]	[8.41]	[8.43]
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	23,215	23,215	2,356	2,356	18,520	18,520	306	306
Adjusted-R^2	0.212	0.212	0.295	0.295	0.168	0.168	0.533	0.533

3.6. Conclusions

This paper examines whether the equity ownership of a CEO affects corporate cash policy. Using a sample of S&P 1500 firms from 1992 to 2018, we document a positive relationship between CEO ownership on corporate cash holdings. Our finding is robust after mitigating the endogeneity concerns by PSM and 2SLS identification methods. After investigating the potential mechanisms through which CEO ownership affects corporate cash holdings, we find that the positive relation between CEO ownership and cash holdings is more pronounced for firms with higher firm-specific risk and larger external financing costs, suggesting that equity-based ownership provides CEOs an incentive to hoard cash as precautionary savings. Conversely, we do not find evidence that agency issues play an important role in the relation between CEO ownership and cash holdings. Firms with higher CEO ownership are more likely to spend excess cash on investment and less likely to distribute excess cash to shareholders, which in turn generate a higher market perceived value of cash. Overall, these findings imply that firm ownership provides strong incentives for CEOs to increase shareholder value by holding cash for the precautionary motive and investing cash on value-enhancing projects, as opposed to the private benefit motive.

Chapter 4

Firm-specific investor sentiment and productivity

4.1. Introduction

The behavioral finance literature defines investor sentiment as optimism or pessimism about firms' future cash flows that are not justified by publicly available fundamental information (De Long et al. 1990; Shleifer and Vishny 1997; Baker and Wurgler 2006; Baker and Wurgler 2007). A recent strand of empirical studies has shown that corporate decision-making activities are responsive to the presence of sentiment-driven investors, including capital investments and external financing (see., Baker et al. 2003; Gilchrist et al. 2005; Dong et al. 2006; Polk and Sapienza 2008; Baker et al. 2009; Dorn 2009; Alimov and Mikkelson 2012; Dong et al. 2012; Arif and Lee 2014; McLean and Zhao 2014). There is also a growing research interest in firm productivity, and existing studies document that firm productivity increases with hiring rate, capital investments, and better access to external finance (Butler and Cornaggia 2011; İmrohoroğlu and Tüzel 2014; Levine and Warusawitharana 2021).

However, the literature has remained largely silent about the role of investor sentiment on corporate outcomes regarding firm productivity. Since productivity is an essential component of all economic activities (Ackerberg et al. 2015; Levine and Warusawitharana 2021), it is important to understand whether sentiment in the financial market may affect firm productivity, the channels through which investor sentiment shapes production efficiency and propagates to the real economy. In this study, we attempt to fill this gap by assessing the direct effect of firm-specific investor sentiment (FSIS) on firm-level productivity. Given that sentiment-driven investors possess optimistic or pessimistic expectations of a firm's future growth opportunities (Lamont and Stein 2004; Baker and Wurgler 2006; Stambaugh et al. 2012), investor sentiment may have a spillover effect on managers and employees' incentives and morale, which ultimately influences a firm's production efficiency.

A major challenge in the sentiment literature is to identify and quantify investor sentiment. Baker and Wurgler (2006) propose a composite market-based investor sentiment index to measure investor sentiment. Previous studies use this proxy of market-wide sentiment to study how investor sentiment affects firm-level policies and disclosures (e.g., Bergman and Roychowdhury 2008; Hribar and McInnis 2012; Mian and Sankaraguruswamy 2012; Walther and Willis 2013; Li and Luo 2017; Dang and Xu 2018). However, Baker and Wurgler (2006)'s sentiment index is mainly driven by business-cycle and contemporaneous risk components (Sibley et al. 2016) and is partially explained by rational models (Pástor and Pietro 2003; Pástor and Veronesi 2005; Pástor and Veronesi 2006). Furthermore, Aboody et al. (2018) argue that market-wide sentiment may not provide a full picture of how sentiment in the financial market influences firm-level issues, given that it only varies over time but does not have any cross-sectional variations.

Therefore, to better identify and understand the direct effect of investor sentiment on productivity at the firm level, we employ three measures of FSIS: stock overnight (close-to-open) returns proposed by Aboody et al. (2018), retail investor order imbalance developed by Boehmer et al. (2021), and non-political sentiment derived from the transcripts of earnings conference calls by Hassan et al. (2019). We also adopt total factor productivity (TFP) developed by İmrohoroğlu and Tüzel (2014) as our main proxy for firm productivity, and two alternative measures of productivity proposed by Ackerberg et al. (2015) and Jacob (2021) in our robustness tests. Using a sample of U.S. public firms from the CRSP/Compustat Merged database between 2010 and 2019, we examine the empirical relation between investor sentiment and firm productivity. We find that FSIS is positively related to TFP. A one-standard-deviation increase in investor sentiment is associated with 1.6% to 7.0% increase in firm productivity. Our result strongly supports the view that a firm is more productive when investors in the financial market are optimistic about the firm's future performance and growth opportunities.

To assert the causal interpretation of our main finding, we adopt three tests to address potential endogeneity due to reverse causality and omitted variables. First, we take advantage of quasi-natural experiments provided by stocks' additions to the S&P 500 index and the Russell 1000 index, and conduct difference-in-differences (DID) tests. We verify that FSIS increases after the firms' stocks are added to the indices, while there is no evidence that the index addition significantly changes how firms operate. After matching the treated firms that are added to the index with the control firms that are not in the index, we show that the treated and control firms do not have significant difference in their productivity three years before the addition event. More importantly, the TFP of treated firms are significantly higher than the TFP of control firms up to three years after the addition event. Second, we follow Gormley and Matsa (2014a) and mitigate the potential estimation bias due to time-invariant and firm-specific omitted variables by controlling for the firm fixed effects and the Fama-French 48 industry × year fixed effects in our baseline regression. Third, we alleviate simultaneity and reverse causality concerns by replacing the level of FSIS in our baseline regression with the change in FSIS over a year or one-year lagged FSIS. Our main finding remains robust to the second and third identification tests. We also assess whether our results are influenced by the bias of our productivity estimation. Our main finding is unaffected by using two alternative proxies for TFP.

We next investigate the mechanisms through which FSIS influences firm productivity. First we show that the positive effect of FSIS on TFP is more pronounced for firms with a lower exposure of automation technology. This finding indicates that investors' optimistic view on firms spill over to firms' employees, and subsequently incentivizes the employees to enhance the productivity of labor input in the production process. Our result is consistent with Dang and Xu (2018) who also document the spillover channel between market-wide sentiment and firm managers. Meanwhile, we extend the spillover channel to a wider range of a firm's human labor. Second we find that the positive relation between FSIS and TFP is stronger among firms with higher managerial ownership. This evidence complements the catering channel identified by Polk and Sapienza (2008) and Dong et al. (2012), in which managers are more likely to invest when the market is optimistic about their firms. In the same vein, we find that managers with higher firm ownership may improve firm productivity for the purpose of catering current investor sentiment and maintaining overvalued equity prices. At last, we find that the positive effect of FSIS on TFP is more prominent for firms with tighter financial constraints and higher innovation efficiency, indicating that high investor sentiment helps to raise cheaper equity capital and encourage firms to innovate production technology.

In our supplementary tests, we first assess whether our results are influenced by the bias of our productivity estimation. The result shows that our finding is unaffected when we replace TFP with alternative proxies. We then test the persistence of the impact of FSIS on TFP and find that FSIS has a positive impact on TFP in the following three years but the impact shrinks over time. We also extend our sample period to 1992–2019 and 2002–2019 for individual FSIS proxy, respectively. Our main findings remains robust. Lastly, we explore the relationship between firm operational efficiency and FSIS. We find that a firm's operating efficiency and profitability increase with the FSIS, and a firm's operating income loss is negatively related to FSIS.

Our paper contributes to the literature in several ways. First, to our knowledge, we are the first to document that investor sentiment at the firm level can exert a significant economic impact on firm productivity. Existing literature in behavioral finance mainly focuses on the role of market-wide investor sentiment in asset pricing (see., Baker and Wurgler 2006; Baker and Wurgler 2007; Barber et al. 2009; Yu and Yuan 2011; Baker et al. 2012; Stambaugh et al. 2012; Da et al. 2015; Huang et al. 2015a; Yuan 2015) and corporate finance (e.g., Gilchrist et al. 2005; Polk and Sapienza 2008; Baker et al. 2009; Dorn 2009; Alimov and Mikkelson 2012; Dong et al. 2012; Arif and Lee 2014; McLean and Zhao 2014; Dang and Xu 2018). However, the literature pays far less attention to the impact of FSIS on corporate outcomes that are fundamental for economic growth. Our paper extends this strand of literature by exploring the direct linkage between investor sentiment and firm productivity.

Second, prior literature mainly focuses on using market-wide sentiment to examine firm-level activities and try to draw a causal relation, whereas we explore the new strand by focusing on firm-specific sentiment. Since market-based sentiment only reflects the time-series variations across all stocks while FSIS captures cross-sectional variation, FSIS has more power than market-level sentiment to explain the cross-sectional differences in corporate activities (Aboody et al. 2018). Kim and Kim (2014) argue that excessive optimism may neutralize excessive pessimism at the market level. Confounding macroeconomic factors, such as business cycles and monetary policy, may be associated with both market-level sentiment and corporate activities (Sibley et al. 2016). To avoid the concern of a spurious relation, we investigate the relation between investor sentiment and firm productivity using three firm-specific sentiment measures proposed by most recent sentiment studies (Aboody et al. 2018; Hassan et al. 2019; Boehmer et al. 2021).

Third, this paper adds to the literature on the determinants of firm productivity. We show that besides well-documented firm-specific characteristics and corporate policy, the sentiment of investors in the financial market plays an important role in explaining a firm's production efficiency. We also uncover evidence that the impact of FSIS on firm productivity is through the mechanisms of sentiment spillover, managers catering, external financing, and innovation efficiency. A practical implication of our findings is that sentiment-driven investors may place excessively optimistic valuations on future expected cash flows associated with corporate production inputs, which influence firm productivity through these four mechanisms. Our paper offers a new perspective on the behavioral role of investor sentiment in corporate policy and outcomes.

The remainder of the paper is organized as follows. Section 4.2 presents a brief literature review. Section 4.3 describes the sample, variables, and research design. Section 4.4 presents the summary statistics and main empirical results. Section 4.5 explores the plausible mechanisms through which FSIS affects TFP and provides supplementary test results. Section 4.6 concludes.

4.2. Literature review

4.2.1. Firm productivity

Firm productivity refers to a firm's efficiency in transforming its capital inputs and labor inputs into outputs. The literature has devoted much attention to address the potential endogeneity in the estimation of production functions (e.g., Marschak and Andrews 1944; Hoch 1955; Mundlak and Hoch 1965; Christensen et al. 1973; McElroy 1987), whereas the production functions proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) have been widely used in empirical studies. For example, İmrohoroğlu and Tüzel (2014) use Olley and Pakes (1996)'s method and estimate the firm-level total factor productivity (TFP) for U.S. public firms. They find that TFP is positively related to contemporaneous monthly stock returns but negatively associated with future excess returns. In addition, they show that firms with lower TFP tend to be firms with smaller size, less investment, lower hiring rates, larger book-to-market ratios, and more firm risk.

A recent strand of studies investigate how market factors and firm-level characteristics improve firm productivity. Krishnan et al. (2015) show that firms' TFP increases after their local states deregulate the state banking system and their access to external finance is improved. Levine and Warusawitharana (2021)'s theoretical model demonstrates that the increase in financial frictions strengthens the sensitivity of productivity growth to the use of external finance. Furthermore, Balasubramanian and Sivadasan (2011) use the patent data from the National Bureau of Economic Research (NBER) and production data from U.S. Census Business Register and find that firm productivity increases with new patent grants. Moran and Queralto (2018) develop a model to identify the dynamic effects of innovation on firm productivity dynamics and prove that the increase in aggregate private R&D expenditures induces gradual and persistent increases in firm productivity. Jacob (2021) find that capital investment and employment levels are positively related to firm-level productivity, and the increase in productivity is shared between shareholders and employees.

4.2.2. Investor sentiment

The classical finance theory, in which rational arbitrageurs always drive asset prices to the present value of expected cash flows associated with the assets, leaves no role for investor sentiment. Keynes (1936) argues that investor behaviours can affect the market and decouple asset prices from their associated fundamental values, due to the well-known psychological fact that investors with high (low) sentiment are more likely to make overly optimistic (pessimistic) judgements. Many years later, researchers in behavioral finance formalize the role of investor sentiment in financial markets. De Long et al. (1990) document that investors are subject to sentiment and the change in investor sentiment leads to more noise trading, greater asset mispricing, and excess volatility. There is also a growing consensus in the literature that investor sentiment helps to explain stock returns (Kothari and Shanken 1997; Neal and Wheatley 1998; Nicholas et al. 1998; Baker and Wurgler 2000; Brown and Cliff 2005). A key finding of these studies is that when investor sentiment is high, investors tend to engage in speculative trading and overvalue asset prices.

More recent studies examine the relationship between investor sentiment and corporate decisions, such as capital investment, dividend policy, equity issuance, and innovation (Baker and Wurgler 2007; Stambaugh et al. 2012; Alimov and Mikkelson 2012; Dong et al. 2012; Arif and Lee 2014; McLean and Zhao 2014; Dang and Xu 2018). Previous studies also show that firm-level disclosures are responsive to investor sentiment (Hribar and McInnis 2012; Mian and Sankaraguruswamy 2012; Walther and Willis 2013; Livnat and Petrovits 2019). For example, during low-sentiment periods, managers increase long-horizon earnings forecasts to maintain current investor optimism (Bergman and Roychowdhury 2008), while during high-sentiment periods, managers are more likely to disclose adjusted earnings metrics (Brown et al. 2012).

However, most of these empirical studies rely on Baker and Wurgler (2006)'s market-based investor sentiment index, in which sentiment is considered as a market-wide phenomenon. Aboody et al. (2018) also argue that market-wide sentiment varies over time but is invariant in the cross section, which may not be well suited to address firm-level issues. As such, subsequent studies focus on firm-level measures of investor sentiment by observing retail investors behaviour and by extracting sentiment from news media. For instance, Cornelli et al. (2006) use pre-IPO prices of 486 European companies to proxy for retail investors' sentiment and Kumar and Lee (2006) measure FSIS using buy-sell order imbalance of retail investors. Tetlock (2007) extracts investor sentiment from the Wall Street Journal and Danbolt et al. (2015) proxy FSIS based on Facebook status updates. Our paper is closely related to Aboody et al. (2018), Hassan et al. (2019), and Boehmer et al. (2021), who develop firm-level sentiment measures which enable us to proxy for investor sentiment with respect to specific firms. We also go beyond the conventional relation between investor sentiment and stock returns and explore how FSIS impacts firm productivity.

4.3. Sample, variables, and research design

4.3.1. Data sources and sample

Our sample consists of all U.S. firms listed in the New York Stock Exchanges (NYSE), American Stock Exchange (AMEX), and NASDAQ from the Center for Research in Security Prices (CRSP). Our sample period starts in 2010, the earliest year with data available for one of our three FSIS measures, and ends in 2019, the latest year with complete data on our main measure of TFP. Following İmrohoroğlu and Tüzel (2014), we exclude firms in financial and utility industries (SIC codes 6000–6999 and 4900–4999, respectively). We retrieve firm accounting data from the Compustat database, data on daily stock prices and S&P 500 index constituents from the CRSP database, data on Russell 1000 index constituents from the FTSE/Russell database, and stock transaction data from the Trade and Quote (TAQ) database. We also collect the firm-level TFP data from Şelale Tüzel's website, sentiment data based on the tone of earnings conference call transcripts from Tarek A. Hassan's website, market-level investor sentiment index data from Jeffrey Wurgler's website, data on the Consumer Price Index (CPI) from the Federal Reserve Bank of St. Louis' website, data on the price index for Gross Domestic Product (GDP) and the price index for private fixed investment from the Bureau of Economic Analysis' website, automation patent data from Lukas Püttmann's website, and corporate patent data from the United States Patent and Trademark Office's website. All accounting data in dollars are inflation-adjusted to 2019 dollars using the CPI. Our final sample includes 18,107 firm–year observations with 3,332 unique firms.

4.3.2. Measures of firm productivity

We follow recent research on firm productivity (e.g., Kogan et al. 2017; Jacob 2021) and adopt İmrohoroğlu and Tüzel (2014)'s measure of firm-level TFP as our main proxy. *TFP* is constructed from the following production function:

$$y_{i,t} = \beta_0 + \beta_k k_{i,t} + \beta_l l_{i,t} + \omega_{i,t} + \varepsilon_{i,t} \tag{4.1}$$

where i is firm index, t is year index, $y_{i,t}$ is the natural logarithm of output, $k_{i,t}$ is the natural logarithm of capital, and $l_{i,t}$ is the natural logarithm of labor, $\omega_{i,t}$ is *TFP* observed by firm i before making its factor input decisions, and $\varepsilon_{i,t}$ is the residual term which is not known by firm i or econometricians. The detailed definitions of $y_{i,t}$, $k_{i,t}$, and $l_{i,t}$ are described summarized in Appendix C.1. İmrohoroğlu and Tüzel (2014) adopt Olley and Pakes (1996)'s semi-parametric methodology to estimate $\widehat{\beta}_0$, $\widehat{\beta}_k$, and $\widehat{\beta}_l$, which helps to reduce selection and simultaneity biases and controls for productivity's within firm serial correlation.[1] The firm-level TFP, $\omega_{i,t}$, can be abstracted from the three estimated production function parameters:

$$\omega_{i,t} = y_{i,t} - \widehat{\beta}_0 - \widehat{\beta}_k k_{i,t} - \widehat{\beta}_l l_{i,t} \tag{4.2}$$

As such, TFP captures the overall efficiency and effectiveness of how factor inputs are used in a firm's production process.

Ackerberg et al. (2015) argue that the earlier production function estimation tech-

[1] İmrohoroğlu and Tüzel (2014) also include industry-specific time dummies to the estimation, which attenuates the effect of industry or aggregate TFP in any given year. Please refer to the online appendix of İmrohoroğlu and Tüzel 2014 for the estimation procedure.

niques are subject to functional dependence concerns. In our robustness tests, we adopt two alternative measures of firm productivity and show that our main results are not driven by İmrohoroğlu and Tüzel (2014)'s production function specification. Our first alternative measure of TFP, *TFP_Alt1*, follows Bennett et al. (2020) which applies Ackerberg et al. (2015)'s conditional input demand function to address potential endogeneity issues. Different from İmrohoroğlu and Tüzel (2014)'s measure, Bennett et al. (2020) adopt the Cobb-Douglas production function and calculate *TFP* as the sum of the intercept and residual from the regression of firm output on capital and labor. Our second alternative measure of *TFP*, *TFP_Alt2*, follows Jacob 2021 which employs an alternative measure for firm output and regresses it on labor and capital separately for each industry-year. A firm's overall productivity is computed as the residuals of these regressions. The detailed descriptions of our two alternative measures of firm productivity are provided in Appendix C.2.

4.3.3. Measures of firm-specific investor sentiment

For our empirical tests, we adopt three measures of FSIS, which are based on overnight stock returns, retail investor order imbalance, and the tone of earnings conference call transcripts.

Overnight returns

Our first measure of FSIS is stock overnight return. Aboody et al. (2018) show that overnight returns possess four characteristics of a sentiment measure. First, overnight returns have time-series persistence, which is consistent with Barber et al. (2009)'s evidence of short-term persistence in the share demand of sentiment-influenced investors. Second, the persistence of overnight returns is stronger for harder-to-value firms, which is in line with the previous empirical evidence that market-level investor sentiment has a greater impact on the prices of harder-to-value firms (e.g., Baker and Wurgler 2006; Berkman et al. 2009; Hribar and McInnis 2012; Mian and Sankaraguruswamy 2012; Seybert and Yang 2012). Third, the persistence of overnight returns is stronger for firms with lower institutional ownership, which is consistent with Yu and Yuan (2011)'s finding that compared to institutional investors, the trading of retail investors is more likely to be affected by sentiment. Fourth, overnight returns are negatively associated with stock long-term performance, consistent with the view that return anomalies driven by investor sentiment are temporary (Hvidkjaer 2008) and retail investor demand is negatively related to stock returns.

Following Aboody et al. (2018), we require that the end-of-prior-year prices of all stocks in the CRSP database are greater than \$5 per share and the market capitalization of each stock is more than \$10 million. The overnight return on stock i on day j is defined as:

$$OR_{i,j} = \frac{Open_{i,j} - Close_{i,j-1}}{Close_{i,j-1}} \tag{4.3}$$

where $Open_{i,j}$ is the opening price of stock i on day j, and $Close_{i,j-1}$ is the closing price of stock i on day $j-1$. Both opening prices and closing prices are adjusted for stock split, stock dividends, and cash dividends. $OR_{i,j}$ is treated as missing if either $Open_{i,j}$ or $Close_{i,j-1}$ is missing in the CRSP database. We further annualize the overnight return as $FSIS\_OR_{i,j}$ using the following equation:

$$FSIS\_OR_{i,t} = 250 \times \frac{\sum_{j=1}^{N} OR_{i,j}}{N} \tag{4.4}$$

where 250 is the approximate number of trading days within a fiscal year and N is the number of non-missing $OR_{i,j}$ in year t. $FSIS\_OR_{i,j}$ is treated as missing if N is less than 100.

Retail investor order imbalance

Previous studies suggest that retail investor order imbalance is an eligible measure of investor sentiment. For example, Kumar and Lee (2006) find that retail investor sentiment, measured by buy-sell order imbalance of retail investors, have a strong ability to explain the return co-movements of stocks with high concentration of retail investor ownership and high arbitrage costs. Barber et al. (2009) further confirm Kumar and

Lee (2006)'s findings that collective annual small trade order imbalance predicts future stock returns, and stocks heavily bought by retail investors underperform those heavily sold by retail investors by 4.4% in the following year. In other word, stocks with high retail investor demand earn relatively low future returns, consistent with the empirical evidence of investor sentiment measures (e.g., Baker and Wurgler 2006; Baker and Wurgler 2007; Stambaugh et al. 2012). A recent study by Boehmer et al. (2021) further provides empirical evidence that retail order imbalance is significantly and positively related to contemporaneous firm-level public news, suggesting that retail investor order imbalance captures the characteristics of investor sentiment.

Following Boehmer et al. (2021), we focus on trades that occur off-exchange. We first identify trades that initiated by retail investors using exchange code "D" in the TAQ database.[2] We only keep common stocks with share code 10 or 11 listed on NYSE, Amex, and NASDAQ, and require that stock prices are above \$1 at the previous month end. We then calculate the daily retail order imbalance of stock i on day j, $OIB_{i,j}$ as follows:

$$OIB_{i,j} = \frac{Buy_{i,j} - Sell_{i,j}}{Buy_{i,j} + Sell_{i,j}} \tag{4.5}$$

where $Buy_{i,j}$ ($Sell_{i,j}$) is the aggregate retail buyer-initiated (seller-initiated) number of shares of stock i on day j. According to Regulation National Market System in 2005, retail investors' orders receive sub-penny price improvement, but institutional investor orders do not. Based on these institutional arrangements, retail buyer (seller) orders tend to be executed slightly above (below) the round penny. In contrast, institutional investors' orders often are executed in the midpoint of the prevailing bid and ask prices. If the bid-ask spread is an odd (even) number of pennies, the resulting midpoint trade price ends in a half-penny (round penny). For all trades with an exchange code "D" in the TAQ, let $P_{i,j}$ be the transaction price of stock i in dollars on day j and let $Z_{i,t} \equiv 100 * mod(P_{i,t}, 0.01)$,

[2] In U.S., most marketable equity trades initiated by retail investors are executed by wholesalers or via internalization. In other words, these orders are filled from a broker's own inventory. According to Financial Industry Regulatory Authority (FINRA) rules, broker-dealers must publicly report these price-improved off-exchange transactions to a Trade Reporting Facility (TRF). These TRF executions are then included in the TAQ "consolidated tape" of all reported transactions with exchange code "D" (Boehmer et al. 2021).

where $Z_{i,t} \in [0, 1)$ be the fraction of a penny associated with that transaction price. A trade is defined as a retail buy transaction if $Z_{i,t}$ is in the interval $(0.6, 1)$, and the trade is defined as a retail sell transaction if $Z_{i,t}$ is in the interval $(0, 0.4)$. Boehmer et al. (2021) show that the identification of retail investor trading using this method is valid after 2009.

We then calculate annualized retail investors order imbalance ($FSIS\_OIB_{i,j}$) using the following equation:

$$FSIS\_OIB_{i,t} = 250 \times \frac{\sum_{j=1}^{N} OIB_{i,j}}{N} \tag{4.6}$$

where 250 is the approximate number of trading days within a fiscal year and N is the number of non-missing $OIB_{i,j}$ over the year. $FSIS\_OIB_{i,j}$ is treated as missing if N is less than 100.

Tone of earnings conference call transcripts

Prior literature ascertains that conference calls have become increasingly important as a venue for firm-specific information dissemination, allowing managers to provide supplementary information on their firms' earnings announcements and granting investors an opportunity to ask questions on both disclosed financial results and expected future performance (e.g., Price et al. 2012; Blau et al. 2015; Brochet et al. 2018). Price et al. (2012) report that the tone of earnings conference call discussion is significantly related to abnormal returns and trading volume over 2004–2007. Jiang et al. (2019) pinpoint that the sentiment measure based on the tone of earnings conference calls is complementary to the existing measures of investor sentiment.

Our third proxy for FSIS is based on quarterly non-political sentiment ($NPSentiment_{i,q}$) from Hassan et al. (2019) who apply a pattern-based sequence-classification method of computational linguistics to analyze firms' earnings conference call transcripts. Hassan et al. (2019) first construct a non-political training library for the topics related to "performance", "ownership changes", or "corporate actions" to identify two-word combinations (bigrams), using newspaper articles published in the Wall Street Journal, New York Times, UAS Today, and Washington Post from Factiva. They then count the number of instances of bigrams indicating the discussions of a given non-political topic in earnings conference call transcripts, in conjunction with positive and negative words as defined by Loughran and McDonald (2011). We define the third proxy for FSIS ($FSIS\_ECS_{i,j}$) as the sum of $NPSentiment_{i,q}$ over a fiscal year:

$$FSIS\_ECS_{i,t} = \sum_{q=1}^{4} NPSentiment_{i,q} \tag{4.7}$$

4.3.4. Baseline regression

To investigate the empirical relation between FSIS and firm productivity, we estimate the following baseline regression:

$$TFP_{i,t} = \beta_0 + \beta_1 FSIS_{i,t} + B\,Controls_{i,t} + \mu_t + \theta_j + \varepsilon_{i,t} \tag{4.8}$$

where i is firm index, t is year index, and j is industry index. TFP is measured by İmrohoroğlu and Tüzel (2014)'s total factor productivity, $FSIS$ is proxied by one of the three sentiment measures ($FSIS\_OR$, $FSIS\_OIB$, and $FSIS\_ECS$).

The first control variable in $Controls_{i,t}$ is Baker and Wurgler (2006)'s sentiment index (BWI), which controls for the potential impact of market-level investor sentiment on firm productivity. Following Bennett et al. (2020), we also include the natural logarithm of total assets ($Assets$), Tobin's Q (Q), cash scaled by $Assets$ ($Cash$), debt scaled by $Assets$ ($Debt$), research and development expenses scaled by $Assets$ (*R&D*), and capital expenditure scaled by $Assets$ ($Capex$) in $Controls_{i,t}$. Since TFP may be associated with other observable firm characteristics, such as firm age, business risk, and diversification (e.g., İmrohoroğlu and Tüzel 2014; Loderer et al. 2016; Bennett et al. 2020), we further include $Firm\_Age$, $Business\_Risk$, and $Diversified$ in $Controls_{i,t}$. To control for the variations of firm productivity across different industries and over time, we include the year fixed effects (μ_t) and Fama-French 48 industry fixed effects (θ_j) in the baseline regression.

All accounting variables in dollars are inflation-adjusted to 2019 dollars. All variables are winsorized at the top and bottom one percent of their distributions, except for $Firm\_Age$ and indicator variable $Diversified$. To facilitate comparability among sentiment proxies derived from different methodologies and the interpretation of estimated results, we standardize the three FSIS proxies by subtracting mean and dividing by standard deviation. Therefore, the coefficient on *FSIS* can be interpreted as the change in a firm's productivity in respond to a one-standard-deviation change in *FSIS*. The detailed definition of all variables is provided in Appendix C.1.

4.4. Main results

4.4.1. Descriptive statistics

Table 4.1 present the descriptive statistics of the variables used in our baseline regression. The mean value of *TFP*, measured by the natural logarithm of total factor productivity, is −0.318, with a standard deviation of 54.4%. All investor sentiment variables are standardized with a mean of zero and a standard deviation of one. The medians of the FSIS measures, *FSIS_OR*, *FSIS_OIB*, and *FSIS_ECS*, are 0.017, 0.098, and -0.025, respectively. The median value of market-level investor sentiment, *BWI*, is 0.108. The average of firm size, measured by the natural logarithm of total assets is 6.922. On average, our sample firms have an average *Q* of 1.955, indicating that an average firm's market value is approximately two times higher than its book value of assets. The average cash holdings of our sample firms account for 17.9% of total assets. Moreover, the mean values of *Debt*, *R&D*, and *Capex* are 23.1%, 5.0%, and 4.8%, respectively. The average age of our sample firms is 24 and 53.7% of our sample firms have multiple segments. The distributions of these variables are generally comparable to those reported in previous studies.

Table 4.1. Summary statistics

This table reports the summary statistics of the variables used in our baseline regression. Our sample consists of 18,107 firm–year observations over the fiscal years 2010–2019, 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. The three FSIS variables are standardized between zero and one. All accounting variables in dollars are inflation-adjusted to 2019 dollars. All control variables are winsorized at the 1% and 99% levels, apart from *Firm_Age* and *Diversified*. All variables are defined in Appendix C.1.

Variable	Obs.	Mean	S.D.	p1	p25	Median	p75	p99
Dependent variables								
TFP_t	18107	-0.318	0.544	-2.097	-0.576	-0.306	-0.030	1.003
Independent variables of interest								
$FSIS\_OR_t$	15206	0.000	1.000	-4.379	-0.424	0.017	0.474	3.476
$FSIS\_OIB_t$	14835	0.000	1.000	-2.994	-0.539	0.098	0.610	2.511
$FSIS\_ECS_t$	15786	0.000	1.000	-3.165	-0.541	-0.025	0.549	2.866
Control variables								
BWI_t	18107	0.000	1.000	-2.770	-0.245	0.108	0.568	1.289
$Assets_t$	18107	6.922	1.893	3.044	5.570	6.848	8.188	11.349
Q_t	18107	1.955	1.313	0.610	1.157	1.536	2.226	8.054
$Cash_t$	18107	0.179	0.171	0.001	0.047	0.123	0.260	0.720
$Debt_t$	18107	0.231	0.212	0.000	0.031	0.200	0.357	0.926
$R\&D_t$	18107	0.050	0.079	0.000	0.000	0.007	0.075	0.347
$Capex_t$	18107	0.048	0.050	0.003	0.016	0.031	0.060	0.262
$Firm\_Age_t$	18107	23.709	16.345	4.000	11.000	20.000	31.000	68.000
$Business\_Risk_t$	18107	0.068	0.154	0.011	0.019	0.025	0.035	0.899
$Diversified_t$	18107	0.537	0.499	0.000	0.000	1.000	1.000	1.000

4.4.2. Baseline regression results

Table 4.2 presents the estimated coefficients of our baseline regression (Equation (4.8)). Columns (1)–(3) show that the coefficients of the three FSIS proxies are all positive and statistically significant at the 1% level, after controlling for firm characteristics that may influence firm productivity as well as the year and industry fixed effects. Beyond their statistically significance, our baseline regression results are also economically meaningful, reporting that a one-standard-deviation increase in *FSIS_OR*, *FSIS_OIB*, and *FSIS_ECS* is associated with a 2.8%, 1.6%, and 7.1% increase in firm productivity, respectively. In terms of the control variables, the coefficients of *BWI* are statistically insignificant, indicating that market-level investor sentiment is lack of power to explain firm-level productivity in our regression specification. The coefficients of *Assets*, *Q*, and *Cash* are positive and statistically significant. The positive coefficients of these three control variables are consistent with the notion that firms with larger size, greater future growth opportunities, and higher cash holdings have higher total factor productivity. The coefficients of *R&D*, *Firm_Age*, and *Diversified* are all negative and statistically significant, indicating that firms with more R&D investment, older firm age, and more diversified business segments tend to have lower total factor productivity. The signs of our control variables are generally in line with the findings in İmrohoroğlu and Tüzel (2014) and Bennett et al. (2020).

Table 4.2. Baseline regression: FSIS and productivity

This table reports the panel regressions of total factor productivity (TFP) on firm-specific investor sentiment (FSIS) and control variables. The sample consists of U.S. firm–year observations over the sample period 2010–2019, with required data for the regressions. The dependent variable is TFP_t and the independent variables of interest are $FSIS\_OR_t$, $FSIS\_OIB_t$ and $FSIS\_ECS_t$. All variables are defined in Appendix C.1. The coefficients of the Fama–French 48 industry 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.

Variables	**(1)**	**(2)**	**(3)**
$FSIS\_OR_t$	0.028***		
	[5.93]		
$FSIS\_OIB_t$		0.016***	
		[3.49]	
$FSIS\_ECS_t$			0.071***
			[11.92]
BWI_t	0.006	0.015	0.017
	[0.46]	[1.13]	[1.24]
$Assets_t$	0.144***	0.166***	0.152***
	[26.81]	[29.88]	[28.99]
Q_t	0.075***	0.079***	0.077***
	[10.00]	[10.20]	[10.22]
$Cash_t$	0.177***	0.130**	0.105*
	[2.94]	[2.04]	[1.79]
$Debt_t$	0.001	-0.089**	-0.034
	[0.03]	[-2.06]	[-0.79]
$R\&D_t$	-1.433***	-1.666***	-1.448***
	[-9.04]	[-10.31]	[-9.63]
$Capex_t$	-0.061	0.044	-0.188
	[-0.32]	[0.23]	[-0.94]
$Firm\_Age_t$	-0.002***	-0.002***	-0.002***
	[-4.45]	[-5.09]	[-5.51]
$Business\_Risk_t$	-0.067	0.005	-0.016
	[-1.43]	[0.11]	[-0.35]
$Diversified_t$	-0.074***	-0.054***	-0.067***
	[-4.92]	[-3.61]	[-4.42]
Constant	-1.209***	-1.395***	-1.353***
	[-12.43]	[-14.97]	[-12.63]
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	15,206	14,835	15,786
Adjusted-R^2	0.276	0.334	0.321

4.4.3. Endogeneity

The aforementioned baseline regression results show that investor sentiment and firm productivity are positively related. However, our estimation potentially involves endogeneity concerns due to reverse causality that firms with high productivity are likely to attract investors' attention, leading to higher FSIS. Endogeneity concerns also rise if high FSIS during time t simultaneously facilitates firms' inputs in their production processes and enhances production efficiency. Moreover, unobservable firm characteristics may have a confounding effect on both investor sentiment and firm productivity. To address the potential endogeneity concerns, we adopt the following three identification strategies: a difference-in-differences (DID) model, a high-dimensional fixed effect model, and FSIS measured at time $t-1$ and as its change form.

Difference-in-Differences analysis

Previous studies treat a firm's addition to the S&P 500 index as an exogenous event and examine the impact of S&P 500 index addition on the firm's stock returns (e.g., Shleifer 1986; Harris and Gurel 1986; Beneish and Whaley 1996; Chen et al. 2005) and corporate policies (e.g., Brisker et al. 2013; Huseynov et al. 2017). More recent studies use the Russell 1000 index reconstitution as a source of exogenous variation in firms' ownership structure (e.g., Chang et al. 2015; Boone and White 2015; Fich et al. 2015) and explore the impact of the index reconstitution on corporate payout policy (Crane et al. 2016), corporate tax planning (Chen et al. 2019), and small firm financing (Cao et al. 2019). Since the selection of both the S&P and the Russell indices' constituents is at the discretion of the Index Committees and based on several eligibility factors, such as market capitalization, firms selected in the indices have little control on the selection process.[3] When a firm is added into an index, index tracking funds are obligated to purchase the firm's stock, leading to a positive drift of the firm's stock return around the addition announcement event. Such a positive drift may attract investor awareness (Chen

[3] Please refer to S&P U.S. Indices Methodology and Russell U.S. Equity Indices for the detailed discussions on the construction methodologies of these two indices.

et al. 2005), especially the attention-triggered retail investors. Given that the addition to the S&P 500 index or the Russell 1000 index does not change a firm's production and operation, we argue that the index addition has a positive impact on the firm's FSIS but does not affect its productivity.

Following Bennett et al. (2020)'s research design, we first verify the effect of index additions on FSIS. We define two indicator variables, *Addition_S&P* and *Addition_Russell*, which are equal to one if a firm is added into the corresponding S&P 500 index or Russell 1000 index in the previous three years including the year of the addition and zero otherwise. We then regress our FSIS proxy variables on these two indicator variables and control for *BWI*, *Assets*, *Q*, and *Firm_Age*. We only focus on firms with above the annual median of total assets in this test, because it is unlikely that small firms are added into the two indices due to the market capitalization eligibility factor (Bennett et al. 2020). The estimation results are presented in Table 4.3. The dependent variables are *FSIS_OR* in columns (1) and (4), *FSIS_OIB* in columns (2) and (5), and *FSIS_ECS* in columns (3) and (6), respectively. The coefficients of *Addition_S&P* and *Addition_Russell* are all positive and statistically significantly, apart from column (5), indicating that FSIS increases when firms have been added into the S&P 500 index or Russell 1000 index during the previous three years.

Table 4.3. S&P 500 index additions and FSIS

This table shows the effect of index additions on FSIS. The sample includes firms with above annual median of total assets. The dependent variables are $FSIS\_OR_t$ in columns (1) and (4), $FSIS\_OIB_t$ in columns (2) and (5), and $FSIS\_ECS_t$ in columns (3) and (6). In columns (1)–(3), the independent variable of interest is $Addition\_S\&P_t$, an indicator variable equal to one if a firm is added to the S&P 500 index in previous three years including the year of the addition, and zero otherwise. In columns (4)–(6), the independent variable of interest is $Addition\_Russell_t$, an indicator variable equal to one if a firm is added to the Russell 1000 index in previous three years including the year of the addition, and zero otherwise. All variables are defined in Appendix C.1. The coefficients of the Fama–French 48 industry 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$Addition\_S\&P_t$	0.027*	0.105**	0.033*			
	[1.80]	[2.24]	[1.70]			
$Addition\_Russell_t$				0.002*	-0.024	0.092**
				[1.73]	[-1.22]	[2.39]
BWI_t	0.012	0.170**	-0.034	0.011***	0.015	0.063
	[0.50]	[2.24]	[-1.34]	[5.67]	[0.61]	[1.42]
$Assets_t$	-0.003	0.106***	0.030***	0.000	0.060***	0.042***
	[-0.91]	[6.91]	[5.99]	[0.21]	[7.80]	[3.55]
Q_t	0.021***	0.099***	0.028***	0.001***	0.024***	0.071***
	[5.53]	[8.14]	[4.72]	[2.58]	[3.90]	[5.27]
$Firm\_Age_t$	-0.001***	0.001	0.001***	-0.000***	0.000	0.004***
	[-4.00]	[0.71]	[3.73]	[-3.49]	[1.00]	[4.99]
Constant	0.070	-0.721***	-0.457***	0.078***	0.064	-0.387***
	[1.31]	[-4.10]	[-5.82]	[28.06]	[1.02]	[-3.60]
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,384	6,879	8,493	8,384	6,879	8,493
Adjusted-R^2	0.110	0.127	0.079	0.033	0.059	0.038

Next, we conduct a DID analysis and investigate whether the increase in FSIS due to index additions is associated with any increase in total factor productivity. To construct our DID sample for the S&P 500 index additions, we employ a propensity score matching (PSM) technique to find the control firms that are comparable to the treated firms which are newly included in the S&P 500 index over our sample period. Following Bennett et al. (2020), we require that control firms have Compustat data available and have never been included in the S&P 500 index during our sample period. Using the firm characteristics controlled in our baseline regression (*Assets*, *Q*, *Cash*, *Debt*, *R&D*, *Capex*, *Firm_Age*, *Business_Risk*, and *Diversified*) as the matching criteria and the minimum Mahalanobis distance matching method, we match treated firms to control firms within the same two-digit SIC industries. Similarly, we construct our DID sample for the Russell 1000 index additions. Our DID samples cover firm-year observations three years before and three years after a firm's index addition, including the year of the addition. We require that the firms in this test have three years of financial data before and after the index addition.

Using these two DID samples, we first conduct parallel trend analyses of the relation between index additions and TFP:

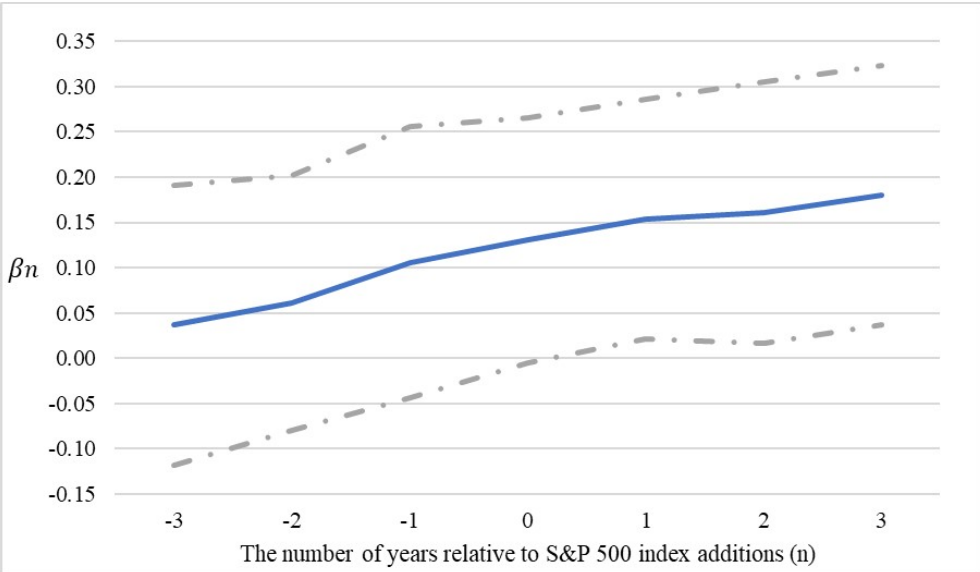
$$TFP_{i,t} = \alpha + \beta_{-3} * Addition\_{-3}Y_{i,t} + \beta_{-2} * Addition\_{-2}Y_{i,t} + \beta_{-1} * Addition\_{-1}Y_{i,t} + \beta_0 * Addition\_0Y_{i,t} + \beta_1 * Addition\_1Y_{i,t} + \beta_2 * Addition\_2Y_{i,t} + \beta_3 * Addition\_3Y_{i,t} + \mu_t + \varepsilon_{i,t} \quad (4.9)$$

where the dependent variable is $TFP_{i,t}$ and the independent variables are seven dummy variables indicating the time relative to the index addition. $Addition\_nY_{i,t}$ is equal to one if firm i is a treated firm and year t is n years away from firm i's index addition year, and zero otherwise. For example, $Addition\_0Y_{i,t}$ refers to the index addition year and $Addition\_{-3}Y_{i,t}$ refers to the third year before the index addition year. If firm i is a control firm, these seven dummy variables are equal to zero. Following Bennett et al. (2020), we control for the year fixed effects.

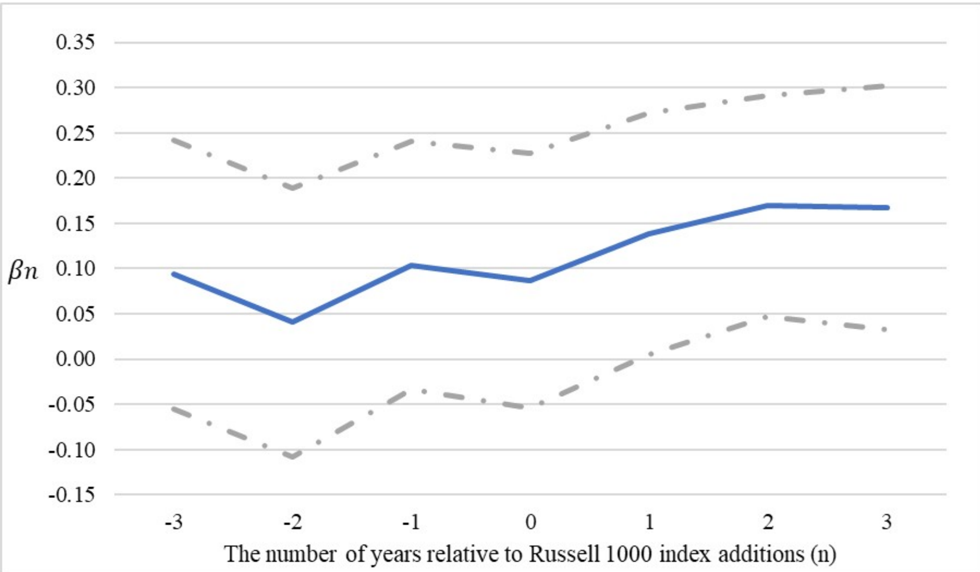
Panels A and B of Figure 4.1 display the results of our parallel trend analyses in Equation (4.9). The vertical axis plots the estimated coefficients (β_n) and the horizontal axis shows the number of years relative to the index addition events (n). The dashed lines are for the 90% confidence intervals of the estimated coefficients, and the confidence intervals are constructed based on standard errors clustered at the firm level. Panels A and B show that β_{-3}, β_{-2}, and β_{-1} are statistically insignificant at the 10% level, suggesting that there is not a statistically significant difference in *TFP* between the treated and control firms over a three-year window before the index additions. The parallel trend condition is satisfied in our two DID samples. Panels A and B also show that β_1, β_2, and β_3 are positive and statistically significant at the 10% level, implying that treated firms' TFP is significantly higher than control firms' TFP over a three-year window after the index additions.

Figure 4.1. Parallel trend analyses of the effect of index additions on TFP.

This figure shows the parallel trend analyses of the effect of index additions on TFP. The sample includes treated firms that are added to the S&P 500 index or Russell 1000 index and control firms matched by firm characteristics which are included as control variables in Equation (4.8) within the same two-digit SIC industries. The y-axis plots the coefficients estimated by Equation (4.9) which regresses TFP on dummy variables indicating the year relative to an index addition, controlling for the year fixed effects. The x-axis plots the time relative to the index addition. The dash lines indicate the 90% confidence intervals for the estimated coefficients, and the confidence intervals are based on standard errors clustered at the firm level.



Panel A. S&P 500 index additions



Panel B. Russell 1000 index additions

We further use the DID sample to estimate the following specification:

$$TFP_{i,t} = \beta_0 + \beta_1 Treat_i \times Post_{i,(t,t+3)} + \beta_2 Post_{i,(t,t+3)} + B\,Controls_{i,t} + \mu_t + \gamma_i + \varepsilon_{i,t} \quad (4.10)$$

where i is firm index, t is year index, $Treat\_S\&P_i$ ($Treat\_Russell_i$) is equal to one if firm i is added in the S&P 500 (Russell 1000) index and zero otherwise, $Post_{i,t}$ is equal to one if year t is either an index addition year or after the index addition and zero otherwise, $Controls_{i,t}$ are the control variables in Table 4.2, μ_t is the year fixed effects, and γ_i is the firm fixed effects. Table 4.4 shows the estimation results of Equation (4.10). In columns (1) and (2), the coefficients of the interaction terms, $Treat\_S\&P_i \times Post_{i,t}$ and $Treat\_Russell_i \times Post_{i,t}$, are all positive and statistically significant at the 5% level, indicating that firms become more productive after being added to the S&P 500 index or Russell 1000 index. Since we have shown that the index additions place a positive and exogenous shock on FSIS, our findings in Table 4.4 justify a causal relation between FSIS and TFP.

Table 4.4. DID analyses: Index additions and productivity

This table reports the results of difference-in-differences (DID) tests. The sample includes treated firms added to the S&P 500 index or Russell 1000 index and control firms matched by firm characteristics in the same two-digit SIC industries. For both treated and control firms, the sample covers firm–year observations three years before and after the index additions, including the addition years. The dependent variable is TFP_t. The independent variable of interest is $Treat\_S\&P_i \times Post_{i,t}$ in column (1) and $Treat\_Russell_i \times Post_{i,t}$ in column (2). $Treat\_S\&P_i$ ($Treat\_Russell_i$) is an indicator variable that is equal to one if firm i is added to the S&P 500 (Russell 1000) index and zero otherwise. $Post_{i,t}$ is an indicator variable that is equal to one if year t is either an index addition year or after the index addition and zero otherwise. All variables are defined in Appendix C.1. The coefficients of the year and firm 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.

Variables	**(1)**	**(2)**
$Treat\_S\&P \times Post_t$	0.048**	
	[2.03]	
$Treat\_Russell \times Post_t$		0.075**
		[2.40]
$Post_t$	0.005	-0.016
	[0.36]	[-1.26]
BWI_t	0.095***	0.084***
	[3.18]	[3.12]
$Assets_t$	0.024***	0.052***
	[3.74]	[5.42]
Q_t	0.106	0.174
	[0.92]	[1.28]
$Cash_t$	-0.061	-0.104
	[-0.85]	[-1.24]
$Debt_t$	-3.570***	-1.486**
	[-5.00]	[-2.09]
$R\&D_t$	0.442	0.571**
	[1.44]	[2.12]
$Capex_t$	-0.033	-0.045
	[-1.16]	[-1.19]
$Firm\_Age_t$	0.116	-0.118
	[1.13]	[-0.85]
$Business\_Risk_t$	-0.014	0.020
	[-0.51]	[0.86]
$Diversified_t$	0.028	-0.003
	[0.92]	[-0.10]
Constant	0.369	0.590
	[0.36]	[0.51]
Firm fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	1,341	1,403
Adjusted-R^2	0.210	0.134

High-dimensional fixed effects

Confounding variables, correlated with investor FSIS and TFP but unobservable to the econometrician, may lead to estimation bias and precludes causal inference in our study. To address the endogeneity concerns due to omitted variables, we follow Gormley and Matsa (2014b)'s advice and adopt a high-dimensional fixed effects model. Specifically, we control for unobservable heterogeneity across firms and time-varying heterogeneity across industries in our baseline regressions. Table 4.5 presents the estimation results after controlling for firm fixed effects and the Fama-French 48 Industry × Year fixed effects. In columns (1)–(3), the coefficients of our three FSIS proxy variables are all positive and statistically significant at the 1% level, suggesting that a one-standard-deviation increase in *FSIS_OR*, *FSIS_OIB*, and *FSIS_ECS* leads to 1.8%, 1.2%, and 6% increase in firm productivity, respectively. The positive relation between FSIS and TFP remains robust after controlling for unobserved heterogeneity.

Table 4.5. High-dimensional fixed effects

This table reports the high-dimensional fixed effects regressions of TFP on FSIS, and control variables. Following Gormley and Matsa (2014a), 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 U.S. firm–year observations over the sample period 2010–2019, with required data for the regressions. The dependent variable is TFP_t and the independent variables of interest are standardized $FSIS\_OR_t$, $FSIS\_OIB_t$ and $FSIS\_ECS_t$. All variables are defined in Appendix C.1. The coefficients of the Fama–French 48 industry × Year fixed effects, and firm 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.

Variables	**(1)**	**(2)**	**(3)**
$FSIS\_OR_t$	0.018***		
	[5.78]		
$FSIS\_OIB_t$		0.012***	
		[4.37]	
$FSIS\_ECS_t$			0.060***
			[14.41]
BWI_t	0.008	0.005	0.018*
	[0.89]	[0.52]	[1.87]
$Assets_t$	0.218***	0.228***	0.215***
	[13.78]	[14.86]	[14.19]
Q_t	0.072***	0.077***	0.073***
	[10.72]	[11.14]	[11.07]
$Cash_t$	0.214***	0.162***	0.174***
	[4.30]	[3.33]	[3.41]
$Debt_t$	-0.079	-0.060	-0.040
	[-1.38]	[-1.32]	[-0.74]
$R\&D_t$	-5.052***	-5.026***	-4.921***
	[-13.01]	[-10.91]	[-11.98]
$Capex_t$	0.821***	0.814***	0.803***
	[5.42]	[4.93]	[4.51]
$Firm\_Age_t$	-0.041*	-0.008	0.005
	[-1.91]	[-0.39]	[0.26]
$Business\_Risk_t$	-0.063*	-0.118***	-0.114***
	[-1.89]	[-3.69]	[-3.03]
$Diversified_t$	-0.034*	-0.029	-0.035**
	[-1.82]	[-1.61]	[-2.03]
Constant	-0.736	-1.595***	-1.860***
	[-1.37]	[-2.93]	[-3.86]
Industry × year fixed effects	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes
Observations	14,748	14,464	15,352
Adjusted-R^2	0.795	0.798	0.797

Changes in FSIS and lagged FSIS

Using both level of FSIS and TFP measured in year t, we have documented a contemporaneously positive relation between sentiment and productivity. However, investors may pay more attention to firms with a higher productivity, subsequently resulting in a higher contemporaneous investor sentiment. As such, our baseline regression result may suffer the concerns of reverse causality and simultaneity. To mitigate these two concerns, we investigate the responsiveness of the change in TFP to the change in FSIS and the impact of lagged FSIS on TFP. Panel A of Table 4.6 shows that the estimated coefficients of the change in FSIS proxy variables are all positive and statistically significant, suggesting that the change in FSIS is positively related to the change in TFP. Panel B of Table 4.6 shows that the estimated coefficients of the lagged FSIS proxy variables are all statistically significant, which mitigate the concern that FSIS and TFP are contemporaneously measured.

Table 4.6. Changes in FSIS and lagged FSIS

Panel A. Changes in firm-specific investor sentiment. This table reports the panel regressions of the change in total factor productivity (ΔTFP_t) on the change in firm-specific investor sentiment (ΔFSIS_t), and the changes in control variables. All firm-specific investor sentiment variables are standardized. All variables are defined in Appendix C.1. 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.

Variables	**(1)**	**(2)**	**(3)**
$\Delta FSIS\_OR_t$	0.012***		
	[4.44]		
$\Delta FSIS\_OIB_t$		0.006***	
		[2.60]	
$\Delta FSIS\_ECS_t$			0.036***
			[11.34]
ΔBWI_t	0.001	0.001	0.005
	[0.10]	[0.08]	[0.73]
$\Delta Assets_t$	0.218***	0.230***	0.213***
	[12.71]	[13.62]	[13.43]
ΔQ_t	0.040***	0.047***	0.044***
	[8.29]	[9.27]	[8.93]
$\Delta Cash_t$	0.147***	0.101**	0.087**
	[3.51]	[2.35]	[1.97]
$\Delta Debt_t$	-0.209***	-0.189***	-0.189***
	[-4.69]	[-4.59]	[-4.60]
$\Delta R\&D_t$	-5.463***	-5.940***	-5.577***
	[-13.90]	[-14.86]	[-14.46]
$\Delta Capex_t$	0.661***	0.601***	0.481***
	[4.40]	[4.13]	[2.99]
$\Delta Firm\_Age_t$	-0.010	0.021	0.020
	[-0.62]	[1.16]	[1.21]
$\Delta Business\_Risk_t$	-0.058*	-0.097***	-0.096***
	[-1.70]	[-3.31]	[-2.86]
$\Delta Diversified_t$	-0.033**	-0.031*	-0.032**
	[-1.97]	[-1.89]	[-2.00]
Constant	0.026	-0.022	-0.033
	[1.01]	[-0.71]	[-1.03]
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	12,002	11,904	12,391
Adjusted-R^2	0.150	0.163	0.169

Panel B. Lagged firm-specific investor sentiment. This table shows the panel regressions of TFP_t on the lagged firm-specific investor sentiment ($FSIS_{t-1}$), and control variables. All firm-specific investor sentiment variables are standardized. All variables are defined in Appendix C.1. 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.

Variables	**(1)**	**(2)**	**(3)**
$FSIS\_OR_{t-1}$	0.024***		
	[4.68]		
$FSIS\_OIB_{t-1}$		0.011**	
		[2.32]	
$FSIS\_ECS_{t-1}$			0.054***
			[8.73]
BWI_t	-0.000	0.001	-0.002
	[-0.03]	[0.11]	[-0.18]
$Assets_t$	0.144***	0.163***	0.151***
	[26.19]	[28.59]	[27.96]
Q_t	0.089***	0.088***	0.087***
	[11.24]	[10.83]	[10.81]
$Cash_t$	0.197***	0.160**	0.118*
	[3.14]	[2.39]	[1.91]
$Debt_t$	0.038	-0.047	-0.006
	[0.79]	[-1.04]	[-0.13]
$R\&D_t$	-1.208***	-1.425***	-1.210***
	[-7.38]	[-8.41]	[-7.74]
$Capex_t$	-0.135	-0.035	-0.312
	[-0.67]	[-0.18]	[-1.48]
$Firm\_Age_t$	-0.002***	-0.002***	-0.002***
	[-3.72]	[-4.39]	[-4.85]
$Business\_Risk_t$	-0.062	0.002	-0.007
	[-1.28]	[0.05]	[-0.15]
$Diversified_t$	-0.071***	-0.062***	-0.069***
	[-4.53]	[-3.99]	[-4.31]
Constant	-1.301***	-1.420***	-1.411***
	[-13.11]	[-15.54]	[-13.35]
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Observations	12,507	12,051	12,769
Adjusted-R^2	0.303	0.358	0.333

4.5. Supplementary test results

4.5.1. Mechanisms

In this section, we explore the following four potential mechanisms through which FSIS affects TFP: sentiment spillover, managers catering, external financing, and innovation efficiency.

Sentiment spillover

One potential mechanism through which FSIS affects TFP is that high FSIS may increase employees' morale, which influences their perceptions of future firm growth, their own incentives, and ultimately their labor production efficiency. McLean and Zhao (2014) provide empirical evidence that a firm's employment is less sensitive to the firm's future growth opportunities during low investor sentiment periods. Recent studies show that the adoption of automation technology not only reduces workers' wage bargaining power and incentives, but also affects firms' finance policy (David and Dorn 2013; Graetz and Michaels 2017; Acemoglu and Restrepo 2020). Since it is unlikely that FSIS affects firms' automation production process, we expect that the positive effect of FSIS on TFP is more pronounced for firms having a lower exposure to automation technology and relying more on human labor in their production process.

Mann and Püttmann (2018) classify an automation patent as "a device that carries out a process independently", where the "device" refers to a physical machine, a combination of machines, an algorithm or a computer program that automates a production process without human intervention except for supervision. Based on the data from automation patent textual analysis in Mann and Püttmann (2018), we follow Qiu et al. (2020) and measure the automation exposure, *Auto_Expo*, as a logarithm of the segment-sales-weighted sum of the stock of automation patents across all four-digit SIC industries. Given that the data of automation patents are only available to us until 2014, the sample period for our cross-sectional analysis spans 2010 to 2014.

We define two dummy variables, *D_High* and *D_Low*, which indicate whether $Auto\_Expo_t$

is above or below the annual sample median. Then we extend our baseline regression by interacting our FSIS proxy variables with *D_High* and *D_Low*. The estimated regression coefficients are presented in columns (1)–(3) of Table 4.7. The coefficients of the interaction terms with *D_Low* are all positively significant at the 1% level and larger than those of the interaction terms with *D_High*. The F-statistics of our equality tests on the coefficients show that the positive effect of FSIS on TFP is statistically more pronounced for firms with a lower automation exposure in columns (2) and (3). Overall, these results are consistent with our expectation that high FSIS has a spillover over effect on employees' morale, leading to higher productivity for firms with less automated production.

Managers catering

When investors show optimism on firms, managers with higher firm ownership have an incentive to cater for investors' expectation and improve firms' productivity. Better firm operating performance may help maintain high stock returns so that managers' wealth tied with the firms will also increase. Previous studies show that managers tend to undertake ambitious programs of investment that cater to optimistic market expectations of future firm growth opportunities (Polk and Sapienza 2008; Dong et al. 2012). In addition, managers become more optimistic about their firms' prospects when market sentiment is higher (Dang and Xu 2018). Grundy and Li (2010) find that managers with higher firm ownership are more incentivized to over-invest when investors are optimistic about their firms. Based on these findings, we conjecture that the positive relation between FSIS and TFP is stronger among firms with higher managerial ownership.

To test this possibility, we measure managerial ownership, *Top5_Own*, as the common stock ownership of the five executives with the highest compensation, including chief executive officers (Kim and Lu 2011). We assign the value one or zero to *D_High* and *D_Low* based on the annual median of $Top5\_Own_t$. Similarly, we extend our baseline regression by interacting our FSIS proxy variables with the two indicators of managerial ownership. Columns (4)–(6) of Table 4.7 show that the coefficients of the interaction terms with *D_High* are larger than those of the interaction terms with *D_Low*. The F-statistics of equality tests indicate that the difference in the coefficients of the interaction terms is statistically significant in columns (4)–(6). Our findings suggest that managers with higher firm ownership have a stronger incentive to enhance firm productivity in response to higher FSIS.

External financing

With the increase in FSIS, the market has a more optimistic expectation about a firm's future cash flows, which may consequently reduce the cost of external financing and help the firm improve its productivity. Dang and Xu (2018) find that financially constrained firms are more likely to issue equity when the market sentiment is high, which secures funding for their innovation activities. In the same vein, when sentiment-driven investors are more optimistic about firms' financing policy, equity capital provided by these optimistic investors may help firms with financial constraints to increase their productivity. If FSIS affects TFP through an external financing mechanism, we would expect the positive relation between FSIS and TFP to be more pronounced among financially constrained firms.

To examine the external financial mechanism, we use the *KZ*-index developed by Kaplan and Zingales (1997) as a measure of financial constraint. Firms with a higher *KZ*-index are more likely to experience difficulties when financial conditions tighten. We define *D_High* and *D_Low* indicating whether a firm's *KZ*-index is above or below the annual median. As shown in columns (7)–(9) of Table 4.7, the coefficients of the interaction terms between FSIS proxy variables and *D_High* are positive and statistically significant. The coefficients of the interaction terms with *D_High* are larger than those of the interaction terms with *D_Low*. The F-statistics of equality tests show that the difference in the coefficients of the interaction terms is statistically significant in columns (7)–(9). These results support the external financing mechanism through which sentiment-driven investors enable financially constrained firms to improve productivity.

Innovation efficiency

Sentiment-driven investors may encourage firms to engage in innovation activities and improve productivity. On the one hand, Kogan et al. (2017) find that firms with more innovative outputs experience an increase in their productivity. On the other hand, Dang and Xu (2018) show that market sentiment tends to induce higher efficiency in patent production, resulting in larger quantity and better quality of patents. If sentiment-driven investors incentivize firms to achieve higher productivity through the innovation mechanism, we predict that the positive relation between FSIS and TFP is more pronounced among firms with higher innovation efficiency.

Following the prior literature (Shea 1999; Dang and Xu 2018), we construct a measure of innovation efficiency using the ratio of patents to R&D spending, *Patent/R&D*. We then assign the value of one to *D_High* (*D_Low*) if *Patent/R&D* is above (below) the annual median, and zero otherwise. Columns (10)–(12) of Table 4.7 show that the coefficients of the interaction terms with *D_High* are positive and statistically significant. The coefficients of the interaction terms with *D_High* are larger than those of the interaction terms with *D_Low*. The F-statistics of equality tests indicate that the difference in the coefficients of the interaction terms is statistically significant in columns (10) and (12), which supports our prediction that innovation stimulated by FSIS further leads to an increase in firm productivity.

Table 4.7. Cross-sectional analyses

This table reports the panel regressions of *TFP* on the interactions between *FSIS* proxy variables and two indicator variables, D_High_t and D_Low_t. We employ $Auto\_Expo_t$ in columns (1)–(3) as the proxy for automation exposure, $TOP5\_Own_t$ in columns (4)–(6) as the proxy for managerial ownership, $KZ\text{-}Index_t$ in columns (7)–(9) as the proxy for financial constraints, and $Patent/R\&D_t$ in columns (10)–(12) as the proxy for innovation. D_High_t (D_Low_t) is equal to one if the corresponding proxy variable is greater than (less than) its annual sample median, and zero otherwise. Control variables are the same as those in Table 4.2. We only report the coefficients on the interaction terms, and the F-statistic corresponding to a test of equality between interacted coefficients. All firm-specific investor sentiment variables are standardized. All variables are defined in Appendix C.1. The coefficients of the control variables, the Fama–French 48 industry 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.

	Auto_Expo			***TOP5_Own***			***KZ-Index***			***Patent/R&D***		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
$FSIS\_OR_t \times D\_High_t$	0.027***			0.023***			0.038***			0.066***		
	[3.07]			[3.43]			[5.60]			[5.86]		
$FSIS\_OR_t \times D\_Low_t$	0.035***			0.002			0.023***			0.021**		
	[3.48]			[0.37]			[3.60]			[2.13]		
$FSIS\_OIB_t \times D\_High_t$		0.005			0.014**			0.031***			0.021**	
		[0.64]			[2.36]			[4.76]			[2.07]	
$FSIS\_OIB_t \times D\_Low_t$		0.036***			0.001			0.005			0.008	
		[3.62]			[0.29]			[0.77]			[0.82]	
$FSIS\_ECS_t \times D\_High_t$			0.050***			0.049***			0.101***			0.111***
			[4.63]			[7.61]			[12.49]			[10.08]
$FSIS\_ECS_t \times D\_Low_t$			0.096***			0.033***			0.028***			0.042***
			[6.92]			[6.02]			[3.58]			[3.94]
Constant	-1.502***	-1.643***	-1.503***	-0.737***	-0.818***	-0.821***	-1.230***	-1.399***	-1.344***	-1.147***	-1.377***	-1.362***
	[-20.64]	[-25.15]	[-21.00]	[-11.60]	[-13.66]	[-14.02]	[-12.49]	[-14.74]	[-12.13]	[-8.30]	[-11.72]	[-10.99]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F-statistics	0.39	5.60**	7.22***	5.35**	3.08*	3.92**	3.00*	8.10***	47.71***	10.37***	1.04	23.87***
Observations	5,986	5,904	6,213	7,672	7,834	7,843	14,195	13,760	14,682	7,572	7,377	7,997
Adjusted-R^2	0.277	0.337	0.331	0.249	0.267	0.292	0.284	0.341	0.327	0.312	0.350	0.362

4.5.2. Alternative measures of productivity

Ackerberg et al. (2015) argue that the OLS production function estimation proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) may involve a functional dependence problem and the estimated coefficients of the observed capital and labor inputs would be biased. To evaluate whether our finding is sensitive to the measure of firm productivity, we use two alternative proxies for total factor productivity and replicate our baseline regression. The first alternative measure of TFP, *TFP_Alt1*, is constructed by the productivity estimation method of Ackerberg et al. (2015) and Bennett et al. (2020) that address the potential endogeneity issue in estimating the production function. The second alternative measure of TFP, *TFP_Alt2*, is estimated by Jacob (2021)'s specification. The detailed estimation process of these two proxies for productivity is provided in Appendix Appendix C.2.

Table 4.8 presents the estimation results. In columns (1)–(3), the dependent variable is TFP_Alt1_t. The estimated coefficients of three FSIS proxy variables are positive and statistically significant. In columns (4)–(6), the dependent variable is TFP_Alt2_t. The estimated coefficients of three FSIS proxy variables are all positive and statistically significant at the 1% level. Overall, these results confirm that our main finding is robust to alternative estimation of firm productivity.

Table 4.8. Alternative measures of productivity

This table reports the panel regressions of alternative measures of productivity on *FSIS* and control variables. The dependent variables are TFP_Alt1_t in columns (1)–(3) and TFP_Alt2_t in columns (4)–(6). The independent variables of interest are standardized $FSIS\_OR_t$, $FSIS\_OIB_t$ and $FSIS\_ECS_t$. The control variables are the same as those in Table 4.2. All variables are defined in Appendix C.1. The coefficients of the control variables, year and the 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.

	TFP_Alt1			***TFP_Alt2***		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$FSIS\_OR_t$	0.018***			0.027***		
	[4.18]			[6.45]		
$FSIS\_OIB_t$		0.008**			0.015***	
		[1.97]			[3.44]	
$FSIS\_ECS_t$			0.060***			0.058***
			[11.49]			[10.76]
Constant	-0.168	-0.220**	-0.143	-0.644***	-0.310**	-0.301**
	[-1.60]	[-2.33]	[-1.56]	[-9.97]	[-2.27]	[-2.22]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,902	14,531	15,451	14,110	13,608	14,733
Adjusted-R^2	0.465	0.460	0.459	0.122	0.159	0.147

4.5.3. Persistence of FSIS

Previous studies suggest that the impact of sentiment-driven transactions on stock returns is not persistent (e.g., Barber et al. 2009; Dorn 2009; Aboody et al. 2018). In this section, we examine whether FSIS has a permanent impact on TFP or the positive relation between FSIS and TFP decreases over time. If the positive relation between FSIS and TFP is driven by confounding firm fundamentals, then it is unlikely that the positive relation gradually diminish over time. We replace the contemporaneous TFP_t in our baseline regression by one of the three forward terms: TFP_{t+1}, TFP_{t+2}, and TFP_{t+3}. The estimated coefficients are reported in Table 4.9. The coefficients of *FSIS_OR* and *FSIS_ECS* are all positive and statistically significant in columns (1)–(3) and columns (7)–(9). The coefficients of *FSIS_OIB* are all positive in columns (4)–(6), but only statistically significant in column (4). There exists evidence that the positive impact of FSIS on TFP is persistent in the long term. However, combining the results reported in Table 4.2 and Table 4.9, we find that the positive impact of FSIS on TFP decreases over time. The coefficients of *FSIS_OR* monotonically decrease from 0.028 in column (1) of Table 4.2 to 0.014 in column (3) in Table 4.9. The coefficients of *FSIS_ECS* also monotonically decrease from 0.071 to 0.034 over four years. The coefficients of *FSIS_OIB* become statistically insignificant in year $t + 2$ and $t + 3$.

Table 4.9. Persistence of the effect of FSIS on TFP

This table reports the panel regressions of foward *TFP* on *FSIS* and control variables. The dependent variables are TFP_{t+1} in columns (1), (4), and (7). The dependent variables are TFP_{t+2} in columns (2), (5), and (8). The dependent variables are TFP_{t+3} in columns (3), (6), and (9). The independent variables of interest are standardized $FSIS\_OR_t$, $FSIS\_OIB_t$ and $FSIS\_ECS_t$. The control variables are the same as those in Table 4.2. All variables are defined in Appendix C.1. The coefficients of the control variables, year and the 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.

	TFP_{t+1}	TFP_{t+2}	TFP_{t+3}	TFP_{t+1}	TFP_{t+2}	TFP_{t+3}	TFP_{t+1}	TFP_{t+2}	TFP_{t+3}
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
$FSIS\_OR_t$	0.025***	0.015***	0.014**						
	[5.05]	[2.77]	[2.38]						
$FSIS\_OIB_t$				0.010**	0.007	0.004			
				[1.98]	[1.35]	[0.79]			
$FSIS\_ECS_t$							0.056***	0.044***	0.034***
							[9.12]	[6.64]	[4.54]
Constant	-1.203***	-1.201***	-1.274***	-1.367***	-1.346***	-1.409***	-1.387***	-1.360***	-1.407***
	[-11.54]	[-10.58]	[-9.45]	[-14.69]	[-14.34]	[-12.45]	[-12.32]	[-11.59]	[-10.36]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,740	11,428	9,422	13,163	10,864	8,955	14,104	11,596	9,516
Adjusted-R^2	0.282	0.277	0.278	0.334	0.323	0.320	0.311	0.297	0.291

4.5.4. Extended sample period

The sample period of our empirical analyses is 2010–2019, because one of our three FSIS proxy variables, *FSIS_OIB*, is available to us after 2010. In this section, we extend our sample period based on the data availability of *FSIS_OR* and *FSIS_ECS*. Specifically, our extended sample period for *FSIS_OR* starts from 1992 when the CRSP started to provide daily opening stock price data, and our extended sample period for *FSIS_ECS* starts from 2002 when Hassan et al. (2019)'s data on the transcripts of earnings conference calls becomes available. Using the extended samples, we re-estimate our baseline regression reported in Table 4.2 and the regression specifications reported in Panels A and B of Table 4.6. The estimated regression results are tabulated in Table 4.10. All the coefficients of FSIS proxy variables are positive and statistically significant at the 1% level. Our main finding remains robust in the extended samples.

Table 4.10. Extended sample period

This table reports the panel regressions of *TFP* on *FSIS* and control variables, using extended sample periods. The sample period is 1992–2019 in columns (1)–(3) and 2002–2019 in columns (4)–(6). Columns (1) and (4) report the results of the baseline regressions in Table 4.2, where the dependent variable is TFP_t and the independent variables of interest are $FSIS\_OR_t$ and $FSIS\_ECS_t$. Columns (2) and (5) report the results of the regressions in Panel A of Table 4.6, where the dependent variable is ΔTFP_t and the independent variables of interest are $\Delta FSIS\_OR_t$ and $\Delta FSIS\_ECS_t$. Columns (3) and (6) report the results of the regressions in Panel B of Table 4.6, where the dependent variable is TFP_t and the independent variables of interest are $FSIS\_OR_{t-1}$ and $FSIS\_ECS_{t-1}$. All variables are defined in Appendix C.1. The coefficients of the control variables, year and the 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$FSIS\_OR_t$	0.008***					
	[3.39]					
$\Delta FSIS\_OR_t$		0.006***				
		[3.76]				
$FSIS\_OR_{t-1}$			0.006***			
			[2.89]			
$FSIS\_ECS_t$				0.073***		
				[16.89]		
$\Delta FSIS\_ECS_t$					0.039***	
					[17.16]	
$FSIS\_ECS_{t-1}$						0.048***
						[11.45]
Constant	-1.132***	0.017	-1.222***	-1.362***	-0.012	-1.441***
	[-15.45]	[1.04]	[-16.59]	[-17.38]	[-0.64]	[-18.21]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	55,972	46,134	48,580	29,911	25,000	25,639
Adjusted-R^2	0.269	0.157	0.305	0.324	0.185	0.337

4.5.5. FSIS and operational efficiency

In this section, we investigate the impact of FSIS on alternative efficiency measures. Following previous studies on firm operating efficiency and profitability (Alimov and Mikkelson 2012; Loderer et al. 2016), we employ operating cost ratio (*Sale/Cost*) and asset turnover ratio (*Asset_Turnover*) as the proxies for operating efficiency, return on asset (*ROA*) and net income dummy (*Negative_NI*) as the proxies for operating performance. *Sale/Cost* is defined as the ratio of sale to total costs. *Asset_Turnover* is measured by the ratio of sales to the lagged net assets. *ROA* is calculated by the ratio of operating income before depreciation to the lagged total assets. *Negative_NI* is defined as a dummy variable that equals one if a firm's net income is negative, and zero otherwise. We replicate the the baseline regressions in Table 4.2 by replacing the TFP with the alternative efficiency measures, and further control for the lagged of efficiency measures to eliminate the potential effect of reverse caution.

Table 4.11 shows the estimation results. In columns (1)–(3), the dependent variable is $Sale/Cost_t$, and the estimated coefficients of three FSIS proxy variables are all positive and statistically significant at the 1% level. The dependent variable in columns (4)–(6) is *Asset_Turnover*, and the estimated coefficients are positive and statistically significant. ROA_t is employed as dependent variable in columns (7)–(9), and the coefficients on FSIS proxy variables are all positive and statistically significant at the 1% level. Columns (10)–(12) use the loss dummy, $Negative\_NI_t$ as the dependent variable. The coefficients are all negative and statistically significant at the 1% level. Overall, these findings indicate that a firm's operating efficiency and profitability increase with firm-level investor sentiment.

Table 4.11. Firm-specific investor sentiment and operational efficiency

This table reports the panel regressions of firm operational efficiency on *FSIS* and control variables. The dependent variables are $Sale/Cost_t$ in columns (1)–(3), $Asset\_Turnover_t$ in columns (4)–(6), ROA_t in columns (7)–(9), and $Negative\_NI_t$ in columns (10)–(12). The independent variables of interest are standardized $FSIS\_OR_t$, $FSIS\_OIB_t$ and $FSIS\_ECS_t$. The control variables are the same as those in Table 4.2. All variables are defined in Appendix C.1. The coefficients of the control variables, year and the 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.

	Sale/Cost			***Asset_Turnover***			***ROA***			***Negative_NI***		
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
$FSIS\_OR_t$	0.012***			0.034***			0.007***			-0.026***		
	[5.10]			[4.08]			[7.50]			[-6.63]		
$FSIS\_OIB_t$		0.009***			0.015*			0.003***			-0.011***	
		[4.23]			[1.73]			[3.64]			[-2.64]	
$FSIS\_ECS_t$			0.017***			0.024**			0.016***			-0.092***
			[5.98]			[2.23]			[15.14]			[-22.00]
Constant	0.856***	0.798***	0.769***	1.811***	1.884***	1.786***	0.047**	-0.009	-0.009	0.507***	0.768***	0.758***
	[18.12]	[19.73]	[17.29]	[9.97]	[12.49]	[11.94]	[2.34]	[-0.45]	[-0.44]	[7.36]	[10.23]	[10.93]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,206	14,835	15,786	12,841	12,090	12,890	12,841	12,090	12,890	15,206	14,835	15,786
Adjusted-R^2	0.370	0.414	0.383	0.454	0.427	0.455	0.340	0.359	0.364	0.165	0.200	0.232

4.6. Conclusions

At the corporate level, productivity is a measure of the efficiency of a company's production process. Previous studies have investigated the determinants of productivity from the perspectives of external finance, capital investment, employment rates, and employees' wages (Butler and Cornaggia 2011; İmrohoroğlu and Tüzel 2014; Krishnan et al. 2015; Moran and Queralto 2018; Levine and Warusawitharana 2021; Jacob 2021). Firm productivity is also positively related to employees' morale and managers' incentives (Lazear 2000; Hamilton et al. 2003). However, it remains unknown whether high sentiment of investors in the financial market has any spillover effect on employees' morale and managers' incentives, which in turn may improve firm productivity. Our study closes this gap by providing new empirical evidence to both literature of investor sentiment and firm productivity.

Using three proxies for firm-level investor sentiment, we document a positive relation between FSIS and firm productivity. The positive relation is robust to identification tests that mitigate potential endogeneity, different model specifications, and alternative measures of firm productivity. These findings support the view that when the sentiment is high, investors tend to hold optimistic expectations on firm future performance, which encourages firms to be more productive. In addition, we find that the positive impact of FSIS on firm productivity is stronger for firms with less exposure to automated production, more managerial ownership, tighter financial constraints, and higher innovative efficiency. Moreover, we find that increases in firm-specific investor sentiment facilitate the increases in firms' operating efficiency and profitability. Overall, our findings highlight that investor sentiment, a behavioral bias in the financial market, may serve as a positive driver of firm productivity. Our evidence provides a new perspective on the behavioral role of investors in corporate activities and outcomes.

Chapter 5

Conclusions

This thesis seeks to contribute to the literature on corporate cash holdings, by examining the impacts of financial hedging and managerial ownership on the level of cash holdings, and their impacts on the value of cash holdings. In addition, this thesis expands the empirical evidence on firm productivity by studying the relationship between investor sentiment on firm production efficiency. Chapter 2– 4 in this thesis, present the three individual papers in which aim to answer the following important yet understudied research questions:

1. How does financial risk management affect corporate cash policy, and what is the value implication of financial hedging on corporate cash holdings?

2. What are the motives for a firm to hold cash, and which motive plays a dominating role in corporate cash management? How does CEO ownership affect the motivation of firms to hold cash?

3. To what extent does investor sentiment matter for firm productivity, and how does firm-specific investor sentiment influence the firm-level production efficiency?

In Chapter 2, we examine the impact of financial hedging on corporate cash holdings and the value of cash by employing a textual analysis approach to collect the use of financial derivatives data from firms' annual financial reports. Using a large sample of U.S. public firms from 1993 to 2016, we find a negative relationship between cash holdings and firms' financial hedging activities, but a positive relationship between the value of corporate cash holdings and firms' financial hedging activities. We further uncover the 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.

In Chapter 3, we investigate whether CEO ownership affects corporate cash management. Based on a sample of S&P 1500 firms from 1992 to 2018, we document a positive relationship between CEO ownership and corporate cash holdings. Moreover, CEO's with high equity-based ownership encourages firms with higher firm-specific risk and larger external financing costs to holding more cash as precautionary savings. Conversely, we do not find evidence that agency issues play a significant role in the relation between CEO ownership and cash holdings. Overall, these findings imply that equity ownership provides strong incentives for CEOs to increase shareholder value by holding cash for the precautionary motive and investing cash on value-enhancing projects, as opposed to the private benefit motive.

In Chapter 4, we study the relationship between firm-specific investor sentiment (FSIS) and firm-level productivity. Within a sample of all U.S. public firms covered by the CRSP/Compustat Merged database, we find that FSIS is positively associated with firm productivity, operational efficiency and profitability. Furthermore, investors' optimistic expectations have a positive spillover effect on employees and managers' incentives and morale, which ultimately leads to a higher firm production efficiency. Overall, these findings highlight that investor sentiment, a behavioral bias in the financial market, may serve as a positive driver of firm productivity. Our study closes the research gap by providing new empirical evidence to investor sentiment and firm productivity literature, and offers a new perspective on the behavioral role of investors in corporate activities and outcomes.

For future work, there are many different adaptations, methods, and tests can be conducted. First, due to the data availability, all three papers in this thesis focus on the sample of U.S. firms. Given that textual analysis can be widely used in many different types of report, it could be interesting to consider the regions with different regulation setting and reexamine the impact of financial derivatives adoption on corporate cash policy. Second, to address the potential endogeneity issues, various identification tests have been conducted, such as the Heckman treatment model, a two-stage least squares method, and a difference-in-differences analysis, the instruments and exogenous experiments used in these robustness tests can be modified to adapt to different samples.

Appendix A

Appendices to Chapter 2

Appendix A.1

Table A1. Variable definitions

This table provides variable definitions and corresponding data sources. CRSP refers to the Centre for Research in Security Prices, FF refers to Kenneth R. French's data library, EDGAR refers to the Electronic Data Gathering, Analysis, and Retrieval database, ISS refers to the Institutional Shareholder Services (formerly RiskMetrics), s34 files refer to the Thomson Reuters 13F Database, and McDonald refers to Bill McDonald's personal site.

Variable	**Definition**	**Source**
$Cash\ holdings_t$	Cash plus marketable securities, normalized by total assets (Bates et al. 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 one if a firm uses at least one type of interest rate (IR) or foreign currency (FX) derivatives, and zero otherwise (Campello et al. 2011).	EDGAR 10-K
$Hedging_t$	An indicator variable, equal to one if a firm uses at least one type of IR, FX, or commodity (COMMD) derivatives, and zero otherwise (Hoberg and Moon 2017).	EDGAR 10-K
$Size_t$	Natural logarithm of total assets (Bates et al. 2009).	Compustat
CF_t	Earnings before interest, tax, depreciation and amortization minus interests, tax, and common dividends, normalized by total assets (Bates et al. 2009).	Compustat

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Table A.1 - continued from previous page

Variable	Definition	Source
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 et al. 2009).	Compustat
NWC_t	Net working capital minus cash and marketable securities, normalized by total assets (Bates et al. 2009).	Compustat
$CAPEX_t$	Capital expenditures, normalized by total assets (Bates et al. 2009).	Compustat
$R\&D/Sales_t$	Ratio of R&D expenses to total sales. *R&D/Sales* is equal to zero if R&D expenses are missing (Bates et al. 2009).	Compustat
$Acquisitions_t$	Acquisition expenditures, normalized by total assets (Bates et al. 2009).	Compustat
$Dividends_t$	Indicator variable, equal to one if a firm pays positive common dividend, and zero otherwise (Bates et al. 2009).	Compustat
$Sigma_t$	Average of the standard deviations of *CF* over ten years for firms with the same two-digit SIC codes (Bates et al. 2009).	Compustat
$Leverage_t$	Total debt, normalized by total assets (Bates et al. 2009).	Compustat
MV_t	Market value of equity, defined as the number of shares outstanding multiplied by stock price (Faulkender and Wang 2006).	Compustat
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

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Table A.1 - continued from previous page

Variable	Definition	Source
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	$Tax\ convexity = 4.88 + 0.019 TIVol - 5.50 TICorr - 1.28 D_{ITC} + 7.15 D_{SmallNeg} + 1.60 D_{SmallPos} + D_{NOL}(3.29 - 4.77 D_{SmallNeg} - 1.93 D_{SmallPos})$, where *TIVol* is taxable income volatility; *TICorr* is the first-order serial correlation in taxable income; D_{ITC} is an indicator variable, equal to one if firms have positive investment tax credits, and zero otherwise; D_{NOL} is an indicator variable, equal to one if there are any net operating losses, and zero otherwise; $D_{SmallNeg}$ is an indicator variable, equal to one if firms have small negative taxable income between $-\$500,000$ and \$0, and zero otherwise; and $D_{SmallPos}$ is an indicator variable, equal to one if firms have small positive taxable income between \$0 and $\$500,000$ and zero otherwise. We use annual data in Compustat until 2016 to estimate *TIVol* and *TICorr* on the basis of a recursive algorithm (Graham and Smith 1999; Campello et al. 2011).	Compustat
$Investment_t$	Annual capital expenditures plus R&D spending, scaled by the lagged total assets (Baker et al. 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 four years (Campello et al. 2011).	Compustat

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Table A.1 - continued from previous page

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
$KZ\text{-}Index_t$	*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 et al. 2001).	Compustat
$SA\text{-}Index_t$	*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 $ln(\$4.5billion)$ 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 three years, where discretionary accruals are estimated from the modified Jones model (Dechow et al. 1995; Kim et al. 2011).	Compustat
$G\text{-}Index_t$	Corporate governance index composed of 24 provisions on investor rights and takeover protections (Gompers et al. 2003).	ISS
$E\text{-}Index_t$	Corporate governance index composed of the six most important provisions in *G-Index* (Bebchuk et al. 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 et al. 2015).	s34 files
$TBLC_t$	Total ownership of blockholders who hold more than 5% of a firm's stocks (Edmans 2014; Cumming et al. 2019).	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 et al. 2007).	Compustat

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Table A.1 - continued from previous page

Variable	Definition	Source
$Negative_t$	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 et al. 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 et al. 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 et al. 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 et al. 2001).	McDonald

Appendix A.2

Table A2. Controlling for corporate governance

Panel A. Corporate cash holdings. This panel reports the OLS regressions of corporate cash holdings on financial hedging proxy variables, corporate governance 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. The dependent variable is $\textit{Cash holdings}_t$ and the independent variables of interest are IR/FX_t and $\textit{Hedging}_t$. We control for corporate governance proxy variables: $\textit{G-Index}_t$, $\textit{E-Index}_t$, TMI_t, and $TBLC_t$. The other control variables are the same as those in Equation (1). 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
IR/FX_t	-0.009**	-0.008*	-0.007**	-0.008***				
	[-2.00]	[-1.76]	[-2.52]	[-2.91]				
$\textit{Hedging}_t$					-0.010**	-0.008	-0.006**	-0.007**
					[-1.99]	[-1.56]	[-2.14]	[-2.51]
$\textit{G-Index}_t$	-0.003***				-0.003***			
	[-3.53]				[-3.53]			
$\textit{E-Index}_t$		-0.007***				-0.007***		
		[-3.66]				[-3.66]		
TMI_t			-0.016				-0.016	
			[-1.54]				[-1.54]	
$TBLC_t$				0.092***				0.092***
				[9.91]				[9.89]
Constant	0.435***	0.438***	0.266***	0.258***	0.436***	0.438***	0.266***	0.259***
	[12.79]	[11.30]	[13.27]	[13.14]	[12.80]	[11.30]	[13.30]	[13.17]
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	16,626	17,985	57,966	57,966	16,626	17,985	57,966	57,966
Adjusted-R^2	0.550	0.538	0.531	0.535	0.550	0.538	0.531	0.535

Panel B. Marginal value of cash. This panel 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, corporate governance proxy variables, and control variables. 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*. We control for four corporate governance proxy variables: $G\text{-}Index_t$, $E\text{-}Index_t$, TMI_t, and $TBLC_t$. The other control variables are the same as those in Equation (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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
$IR/FX_t \times \Delta C_t$	0.163*	0.244***	0.051**	0.077***				
	[1.79]	[3.14]	[2.39]	[2.82]				
IR/FX_t	0.011	0.021***	0.009*	0.039***				
	[1.35]	[2.79]	[1.77]	[7.65]				
$Hedging_t \times \Delta C_t$					0.126	0.192**	0.051**	0.075***
					[1.22]	[2.30]	[2.39]	[2.83]
$Hedging_t$					0.013	0.021***	0.008	0.036***
					[1.55]	[2.60]	[1.57]	[6.84]
$G\text{-}Index_t \times \Delta C_t$	0.007				0.009			
	[0.47]				[0.56]			
$G\text{-}Index_t$	0.003**				0.003**			
	[2.21]				[2.19]			
$E\text{-}Index_t \times \Delta C_t$		-0.003				0.001		
		[-0.10]				[0.04]		
$E\text{-}Index_t$		0.000				0.000		
		[0.13]				[0.14]		
$TMI_t \times \Delta C_t$			0.037				0.038	
			[0.15]				[0.16]	
TMI_t			0.419***				0.421***	
			[26.84]				[26.97]	
$TBLC_t \times \Delta C_t$				-0.119				-0.116
				[-0.97]				[-0.95]
$TBLC_t$				-0.126***				-0.125***
				[-7.98]				[-7.86]
ΔC_t	1.756***	1.764***	2.045***	2.089***	1.758***	1.781***	2.042***	2.085***
	[11.08]	[12.19]	[32.49]	[33.35]	[11.12]	[12.38]	[32.25]	[33.10]
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	17,516	18,775	53,454	53,454	17,516	18,775	53,454	53,454
Adjusted-R^2	0.189	0.192	0.230	0.220	0.188	0.191	0.230	0.220

Table A3. Cash regimes

Panel A. Financial hedging and corporate cash holdings. This panel reports the OLS 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. We follow Halford et al. (2017) and divide our main sample into three cash regimes. Firms in the raising cash regime issue equity and do not pay dividends, firms in the distributing cash regime do not issue equity but pay dividends or repurchase stocks, and firms in the servicing debt regime have a market leverage ratio in the top decile of all firms and do not raise or distribute cash. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are IR/FX_t and $Hedging_t$. The control variables are the same as those in Equation (1). 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.

	Raising cash		**Distributing cash**		**Servicing debt**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
IR/FX_t	-0.013**		-0.009***		0.004	
	[-2.33]		[-2.76]		[1.16]	
$Hedging_t$		-0.011*		-0.010***		0.004
		[-1.84]		[-2.82]		[1.10]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,200	9,200	26,617	26,617	1,429	1,429
Adjusted-R^2	0.591	0.591	0.434	0.434	0.273	0.273

Panel B. Financial hedging and marginal value of cash. This panel 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 US firm–year observations over the sample period 1993–2016 with required data for the regressions. We follow Halford et al. (2017) and divide our main sample into three cash regimes. Firms in the raising cash regime issue equity and do not pay dividends, firms in the distributing cash regime do not issue equity but pay dividends or repurchase stocks, and firms in the servicing debt regime have a market leverage ratio in the top decile of all firms and do not raise or distribute cash. 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. The control variables are the same as those in Equation (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.

	Raising cash		**Distributing cash**		**Servicing debt**	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$IR/FX_t \times \Delta C_t$	0.111***		0.125*		0.035	
	[3.27]		[1.65]		[0.91]	
IR/FX_t	0.058***		0.026***		0.024	
	[3.15]		[4.58]		[0.67]	
$Hedging_t \times \Delta C_t$		0.097***		0.142**		0.032
		[2.83]		[1.98]		[0.80]
$Hedging_t$		0.050***		0.025***		0.053
		[2.60]		[4.21]		[1.42]
ΔC_t	2.223***	2.223***	1.264***	1.246***	0.468	0.468
	[16.66]	[16.61]	[13.50]	[13.13]	[1.21]	[1.20]
Constant	-0.099	-0.098	-0.032	-0.031	1.939***	1.913***
	[-0.61]	[-0.61]	[-0.95]	[-0.92]	[5.96]	[5.97]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,861	7,861	25,987	25,987	1,331	1,331
Adjusted-R^2	0.293	0.292	0.179	0.179	0.530	0.531

Table A4. Alternative cash holdings

Panel A. Financial hedging and alternative cash holdings. This panel reports the OLS regressions of alternative 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. In columns (1)–(2), the dependent variable is *Excess cash holdings*$_t$, which is measured as the amount of cash held above a predicted optimal level of cash reserves (Dittmar and Mahrt-Smith 2007). We only focus on the firm–year observations with positive excess cash holdings. In columns (3)–(4), the dependent variable is *Industry-adjusted cash holdings*$_t$, which is measured as a firm's cash to total assets ratio minus the median of the cash to total assets ratios of all firms with the same 4-digit SIC industry codes (Haushalter et al. 2007). The independent variables of interest are IR/FX_t and $Hedging_t$. The control variables are the same as those in Equation (1). 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.

	Excess cash holdings$_t$		***Industry-adjusted cash holdings***$_t$	
Variables	**(1)**	**(2)**	**(3)**	**(4)**
IR/FX_t	-0.009***		-0.013***	
	[-4.93]		[-4.91]	
$Hedging_t$		-0.007***		-0.011***
		[-3.91]		[-3.91]
Constant	0.140***	0.140***	0.140***	0.140***
	[12.56]	[12.49]	[7.31]	[7.33]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	25,712	25,712	58,796	58,796
Adjusted-R^2	0.370	0.370	0.198	0.198

Panel B. Financial hedging and the marginal value of cash. This panel reports the OLS regressions of firm excess returns on the change in alternative 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. The dependent variable is $r_{i,t} - R^B_{i,t}$, the annual excess stock return relative to the Fama and French (1993) 25 size and book-to-market portfolios. Δ indicates the change in the corresponding variables from year *t-1* to *t*. *Excess cash holdings*$_t$ is measured as the amount of cash held above a predicted optimal level of cash reserves (Dittmar and Mahrt-Smith 2007). We only focus on the firm–year observations with positive excess cash holdings. *Industry-adjusted cash holdings*$_t$ is measured as a firm's cash to total assets ratio minus the median of the cash to total assets ratios of all firms with the same 4-digit SIC industry codes (Haushalter et al. 2007). The control variables are the same as those in Equation (2). We replace ΔC_t by the corresponding alternative change in cash holdings in the control variables. 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**
$IR/FX_t \times \Delta$*Excess cash holdings*$_t$	0.051*			
	[1.87]			
IR/FX_t	0.048***			
	[5.42]			
Hedging$_t \times \Delta$*Excess cash holdings*$_t$		0.058**		
		[2.28]		
Hedging$_t$		0.041***		
		[4.24]		
$IR/FX_t \times \Delta$*Industry-adjusted cash holdings*$_t$			0.056*	
			[1.80]	
IR/FX_t			0.035***	
			[6.81]	
Hedging$_t \times \Delta$*Industry-adjusted cash holdings*$_t$				0.071**
				[2.39]
Hedging$_t$				0.032***
				[6.03]
Δ*Excess cash holdings*$_t$	1.349***	1.341***		
	[8.83]	[8.78]		
Δ*Industry-adjusted cash holdings*$_t$			0.804***	0.790***
			[14.05]	[13.74]
Constant	-0.056	-0.049	0.063*	0.064*
	[-0.59]	[-0.52]	[1.72]	[1.77]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	19,315	19,315	54,147	54,147
Adjusted-R^2	0.170	0.169	0.158	0.158

Table A5. Controlling for persistent tone of financial statements

Panel A. Corporate cash holdings. This panel reports the OLS regressions of corporate cash holdings on financial hedging proxy variables, negative tone-related variables, and control variables. The sample consists of 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 $Hedging_t$. We control for four negative tone proxy variables: $Negative_t$, $Uncertainty_t$, $Litigious_t$, and $Constraining_t$ (Loughran and McDonald 2011). The other control variables are the same as those in Equation (1). 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.

Variables	**(1)**	**(2)**
IR/FX_t	-0.009***	
	[-3.49]	
$Hedging_t$		-0.008***
		[-3.07]
$Negative_t$	4.910***	4.911***
	[12.98]	[12.98]
$Uncertainty_t$	6.952***	6.945***
	[11.91]	[11.88]
$Litigious_t$	-0.469***	-0.471***
	[-2.66]	[-2.67]
$Constraining_t$	-6.773***	-6.777***
	[-9.77]	[-9.77]
Constant	0.132***	0.133***
	[5.45]	[5.48]
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	58,394	58,394
Adjusted-R^2	0.544	0.544

Panel B. Marginal value of cash. This panel 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, negative tone-related variables, and control variables. 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. We control for four negative tone proxy variables: $Negative_t$, $Uncertainty_t$, $Litigious_t$, and $Constraining_t$ (Loughran and McDonald 2011). The other control variables are the same as those in Equation (2). 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.

Variables	**(1)**	**(2)**
$IR/FX_t \times \Delta C_t$	0.058**	
	[2.29]	
IR/FX_t	0.039***	
	[7.50]	
$Hedging_t \times \Delta C_t$		0.057**
		[2.25]
$Hedging_t$		0.036***
		[6.65]
$Negative_t$	-7.892***	-7.892***
	[-10.04]	[-10.04]
$Uncertainty_t$	-1.133	-1.095
	[-1.03]	[-1.00]
$Litigious_t$	1.243***	1.270***
	[3.06]	[3.13]
$Constraining_t$	9.921***	9.877***
	[6.36]	[6.33]
ΔC_t	2.071***	2.069***
	[33.89]	[33.57]
Constant	0.039	0.040
	[0.85]	[0.87]
Control variables	Yes	Yes
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	53,884	53,884
Adjusted-R^2	0.220	0.220

Table A6. Long-term benefits of financial hedging

Panel A. Corporate cash holdings. This panel reports the OLS regressions of corporate cash holdings on lagged 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. The dependent variable is $Cash\ holdings_t$ and the independent variables of interest are IR/FX_{t-1}, IR/FX_{t-2}, $Hedging_{t-1}$ and $Hedging_{t-2}$. The control variables are the same as those reported in Equation (1). 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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**
IR/FX_{t-1}	-0.007**			
	[-2.26]			
IR/FX_{t-2}		-0.007**		
		[-2.31]		
$Hedging_{t-1}$			-0.006*	
			[-1.85]	
$Hedging_{t-2}$				-0.006*
				[-1.76]
Constant	0.269***	0.271***	0.269***	0.271***
	[12.84]	[12.01]	[12.84]	[12.00]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	50,094	43,495	50,094	43,495
Adjusted-R^2	0.526	0.524	0.526	0.524

Panel B. Marginal value of cash. This table reports the OLS regressions of firm excess returns on the change in cash holdings, lagged financial hedging proxy variables, the interaction of the prior two 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. 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*. The control variables are the same as those reported in Equation (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.

Variables	**(1)**	**(2)**	**(3)**	**(4)**
$IR/FX_{t-1} \times \Delta C_t$	0.056***			
	[3.98]			
IR/FX_{t-1}	0.030***			
	[5.98]			
$IR/FX_{t-2} \times \Delta C_t$		0.052***		
		[3.26]		
IR/FX_{t-2}		0.031***		
		[6.01]		
$Hedging_{t-1} \times \Delta C_t$			0.055***	
			[3.94]	
$Hedging_{t-1}$			0.023***	
			[4.45]	
$Hedging_{t-2} \times \Delta C_t$				0.043***
				[2.70]
$Hedging_{t-2}$				0.028***
				[5.20]
ΔC_t	2.072***	1.999***	2.069***	2.001***
	[55.18]	[49.70]	[54.80]	[49.48]
Constant	-0.011	0.010	-0.006	0.012
	[-0.30]	[0.25]	[-0.16]	[0.31]
Control variables	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	54,147	46,191	54,147	46,191
Adjusted-R^2	0.217	0.212	0.217	0.212

Table A7. Additional evidence on the role of financial hedging

This table reports the OLS regressions of the proxy variables of financial constraints, asymmetric information, and corporate governance 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. The dependent variables are *KZ-Index*, *SA-Index*, *FDIS*, *ACCM*, *E-Index*, and *TBLC*. The independent variables of interest are *IR/FX* and *Hedging*. The control variables are the same as those reported in Equation (1). 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.

	KZ-Index		***SA-Index***		***FDIS***		***ACCM***		***E-Index***		***TBLC***	
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
IR/FX	-0.085*		-0.037***		-0.0004***		-0.012**		0.014		0.012***	
	[-1.87]		[-3.87]		[-2.76]		[-2.54]		[0.52]		[5.08]	
Hedging		-0.022		-0.044***		-0.0003**		-0.010**		0.033		0.012***
		[-0.47]		[-4.60]		[-2.12]		[-2.01]		[1.17]		[5.02]
Constant	-2.347***	-2.347***	-1.885***	-1.883***	0.012***	0.012***	0.388***	0.388***	2.010***	1.997***	0.141***	0.140***
	[-17.57]	[-17.56]	[-63.07]	[-63.00]	[24.19]	[24.14]	[15.48]	[15.46]	[7.66]	[7.59]	[6.19]	[6.14]
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	58,205	58,205	58,796	58,796	37,663	37,663	39,440	39,440	17,836	17,836	57,966	57,966
Adjusted-R^2	0.310	0.310	0.622	0.623	0.0576	0.0575	0.537	0.537	0.783	0.783	0.119	0.119

Appendix B

Appendices to Chapter 3

Appendix B.1

CEO_OWN_SO is the fraction of stock and options deltas held by a CEO to the firm's total delta associated with all outstanding common stocks and stock options. Since the delta of one share of stocks is equal to one:

$$CEO\_OWN\_SO = \frac{CEO\ Shares + CEO\ Option\ Delta}{Total\ Outstanding\ Shares + Total\ Option\ Delta}$$

where *CEO Shares* is the number of common stocks held by a CEO; *CEO Option Delta* is the delta of all stock options held by a CEO, estimated by the procedure outlined in Appendix B of Edmans et al. (2009); *Total Outstanding Shares* is the number of outstanding common shares issued by a firm; and *Total Option Delta* is the delta of a firm's outstanding stock options, calculated by the following equation:

$$Totat\ Option\ Delta = deltaEX\_avg \times optex + deltaUnex\_abe \times optosey$$

where $deltaEX\_avg$ is the annual average delta of exercisable stock options across all executives (including the CEO) covered by ExecuComp, estimated by the method in Appendix B of Edmans et al. (2009); *optex* is the number of exercisable stock options at the year end, and zero if missing; $deltaUnex\_avg$ is the annual average delta of non-exercisable stock options across all executives (including the CEO) covered by ExecuComp, estimated by the method in Appendix B of Edmans et al. (2009); and *optosey* is the number of stock options granted to date that has not been exercised or cancelled, and are non-exercisable at the year end, and zero if missing. Following Kim and Lu (2011) and Edmans et al. (2009), *Total Option Delta* is equal to $max\{Total\ Option\ Delta, Firm\ Exercisable\ Option\ Delta\}$.

Appendix B.2

Table B1. Variable definitions

This table provides variable definitions and corresponding data sources. CRSP refers to the Centre for Research in Security Prices, ISS refers to the Institutional Shareholder Services (formerly RiskMetrics), s34 files refer to the Thomson Reuters 13F Database, FF refers to Kenneth R. French's data library, and NBER refers to National Bureau of Economic Research U.S. business cycle contractions and expansion.

Variable	Definition	Source
Cash holdings	Cash plus marketable securities, normalized by total assets (Bates et al. 2009).	Compustat
CEO_OWN	The ratio of outstanding common stocks held by a CEO to the firm's total outstanding common stocks (Kim and Lu 2011).	ExecuComp
CEO_OWN_SO	The ratio of delta of common stocks and stock options held by a CEO to the firm's total delta associated with all outstanding common stocks and stock options (Kim and Lu 2011).	ExecuComp
CEO_OWN_05	Equals *CEO_OWN* if $0 <$ *CEO_OWN* $< 5\%$, and equals 5% if *CEO_OWN* $\geq 5\%$ (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
CEO_OWN_0525	Equals 0 if *CEO_OWN* $\leq 5\%$, equals *CEO_OWN* minus 5% if $5\% <$ *CEO_OWN* $< 25\%$, and equals 20% if *CEO_OWN* $\geq 25\%$ (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
CEO_OWN_25	Equals 0 if *CEO_OWN* $\leq 25\%$, and equals *CEO_OWN* minus 25% if *CEO_OWN* $> 25\%$ (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
CEO_OWN_SO_05	Equals *CEO_OWN_SO* if $0 <$ *CEO_OWN_SO* $<$ 5%, and equals 5% if *CEO_OWN_SO* $\geq 5\%$ (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
CEO_OWN_SO_0525	Equals 0 if *CEO_OWN_SO* $\leq 5\%$, equals *CEO_OWN_SO* minus 5% if $5\% <$ *CEO_OWN_SO* $< 25\%$, and equals 20% if *CEO_OWN_SO* $\geq 25\%$ (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
CEO_OWN_SO_25	Equals 0 if *CEO_OWN_SO* $\leq 25\%$, and equals *CEO_OWN_SO* minus 25% if *CEO_OWN_SO* $>$ 25% (Opler et al. 1999; Kim and Lu 2011).	ExecuComp
Top5_OWN	The common stock ownership of the five executives with the highest compensation.	ExecuComp
Top5_OWN_SO	The ownership of the five executives with the highest compensation, where the ownership is defined the same as *CEO_OWN_SO*.	ExecuComp

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Table B.1 - continued from previous page

Variable	Definition	Source
Top4_OWN	The common stock ownership of the four executives (excluding CEOs) with the highest compensation.	ExecuComp
Top4_OWN_SO	The ownership of the four executives (excluding CEOs) with the highest compensation, where the ownership is defined the same as *CEO_OWN_SO*.	ExecuComp
Size	The natural logarithm of total assets (Bates et al. 2009).	Compustat
CF	Earnings before interest, tax, depreciation and amortization minus interests, tax, and common dividends, normalized by total assets (Bates et al. 2009).	Compustat
MTB	A 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 et al. 2009).	Compustat
NWC	Net working capital minus cash and marketable securities, normalized by total assets (Bates et al. 2009).	Compustat
CAPEX	Capital expenditures, normalized by total assets (Bates et al. 2009).	Compustat
R&D/Sales	A ratio of research and development expenses to total sales. *R&D/Sales* is equal to zero if research and development expenses are missing (Bates et al. 2009).	Compustat
Acquisitions	Acquisition expenditures, normalized by total assets (Bates et al. 2009).	Compustat
Dividends	An indicator variable, equals to one if a firm pays a positive common dividend, and zero otherwise (Bates et al. 2009).	Compustat
Sigma	The average of the standard deviations of *CF* over ten years for firms with the same 2-digit SIC codes (Bates et al. 2009).	Compustat
Leverage	Total debt, normalized by total assets (Bates et al. 2009).	Compustat
Firm age	The natural logarithm of the number of years since a firm's IPO as reported in CRSP (Kim and Lu 2011).	CRSP
Vega/TC	The ratio of vega of shares and stock options held by a CEO to total compensation, where total compensation includes salary, bonus, restricted stock and option grants, long-term incentive payouts, and any other compensation (Liu and Mauer 2011).	ExecuComp
CEO age	The age of a CEO as reported in the ExecuComp database (Liu and Mauer 2011).	ExecuComp
CEO female	An indicator variable, equals to one if a CEO is female, and zero otherwise.	ExecuComp

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Table B.1 - continued from previous page

Variable	Definition	Source
CEO duality	An indicator variable, equals to one if a CEO is the chairman of the board, and zero otherwise (Jenter and Lewellen 2015).	BoardEx
CEO tenure	The number of years that a CEO has served in the position as reported in the ExecuComp database (Liu and Mauer 2011).	ExecuComp
CEO tax burden	A CEO's tax liability arising from the sale of the vested stock holdings, scaled by the stock equivalent value from the CEO's holdings of stocks and stock options (Yost 2018).	ExecuComp
E-Index	A corporate governance index, composed of the six most important provisions in *G-index* (Bebchuk et al. 2009).	ISS
TMI	The ownership of institutional investors whose holding value in a firm ranked as the top 10% of the stocks in their portfolios (Fich et al. 2015).	s34 files
Xcash	The 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	Cash to total assets ratio minus the median of the ratios across the firms with the same 4-digit SIC codes (Haushalter et al. 2007).	Compustat
Return_Vol	The average monthly standard deviation of a firm's stock returns over one year, where the monthly standard deviation of the stock returns refers to the sample standard deviation of daily stock returns within a month, multiplied by the number of trading days in the month (Rajgopal and Venkatachalam 2011).	CRSP
CF_Vol	Operating cash flow volatility, defined as the standard deviation of operating margins (operating cash flow divided by total assets) using 3 years of annual data (Bartram et al. 2011).	Compustat
Issuer Rating	The Standard and Poor's credit rating of a firm.	Compustat
WW-Index	$WW\text{-}Index = -0.091 * CF - 0.062 * Dividends$ +0.021*(Lont-term debt/total assets) −0.044*Size+0.102*(3-digit industry sales growth) − 0.035*(sales growth) (Whited and Wu 2006).	Compustat
D_high	An indicator variable, equals to one if *Return_Vol*, *CF_Vol*, *WW-Index*, *E-Index*, or *TMI* is higher than the corresponding annual sample median, and zero otherwise. *D_high* is also equal to one if *Issuer Rating* is BBB or higher (investment grade), and zero otherwise (Saretto and Tookes 2013).	

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Table B.1 - continued from previous page

Variable	Definition	Source
D_low	An indicator variable, equals to one when *Return_Vol*, *CF_Vol*, *WW-Index*, *E-Index*, or *TMI* is lower than the corresponding annual sample median, and zero otherwise. *D_low* is also equal to one if *Issuer Rating* is lower than BBB, and zero otherwise (Saretto and Tookes 2013).	
Recession	An indicator variable, equals to one if at least one month in year *t* within the contraction (peak to trough) and zero otherwise.	NBER
Boom	An indicator variable, equals to one if year *t* is not a recession year and zero otherwise.	NBER
$\Delta Capex_t$	Change in *CAPEX* from fiscal year $t-1$ to year t (Harford et al. 2008).	Compustat
$\Delta R\&D/Sales_t$	Change in *R&D/Sales* from fiscal year $t-1$ to year t (Harford et al. 2008).	Compustat
ΔDiv_t	Change in the ratio of cash dividend payment to total assets from fiscal year $t-1$ to year t (Harford et al. 2008).	CRSP
$\Delta Repurchases_t$	Change in the ratio of stock repurchases to total assets from fiscal year $t-1$ to year t (Harford et al. 2008).	CRSP
$r_t - R_t^B$	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
MV_t	Market value of equity, defined as the number of shares outstanding multiplied by stock price (Faulkender and Wang 2006).	Compustat
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

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Table B.1 - continued from previous page

Variable	**Definition**	**Source**
$\Delta R\&D_t$	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

Appendix C

Appendices to Chapter 4

Appendix C.1

Table C1. Variable definitions

This table provides variable definitions and corresponding data sources. CRSP refers to the Centre for Research in Security Prices, TAQ refers to the Trade and Quote database, IMTU refers to İmrohoroğlu and Tüzel (2014)'s website, HHLT refers to Hassan et al. (2019)'s website, KMLP refers to Mann and Püttmann (2018)'s website, USPTO refers to United States Patent and Trademark Office website, BW refers to Baker and Wurgler 2006 website, and BEA refers to the Bureau of Economic Analysis.

Variable	Definition	Source
$y_{i,t}$	Sales minus materials, deflated by the Gross Domestic Product (GDP) price deflator from the Bureau of Economic Analysis. Sales is Compustat item SALE. Materials is total expenses minus labor expenses, where total expenses is sales minus operating income before depreciation and amortization (Compustat item OIBDP) and labor expenses is the number of employees (Compustat item EMP) multiplying average wages from the Social Security Administration (İmrohoroğlu and Tüzel 2014).	IMTU
$l_{i,t}$	The stock of labor, measured by the number of employees (Compustat item EMP) (İmrohoroğlu and Tüzel 2014).	IMTU

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Table C.1 - continued from previous page

Variable	Definition	Source
$k_{i,t}$	The stock of capital, measured by gross property, plant, and equipment (Compustat item PPEGT), deflated by the price deflator for private fixed investment, following the methods of Hall (1990) and Brynjolfsson and Hitt (2003). Average age of capital stock is calculated as the ratio of accumulated depreciation (PPEGT-Net PPE, Compustat item DPACT) to current depreciation (Compustat item DP). Age is smoothed by taking a 3-year moving average. The capital stock is lagged by one period to measure the available capital stock at the beginning of the period (İmrohoroğlu and Tüzel 2014).	IMTU
TFP_t	Total factor productivity, a measure of firm-level overall effectiveness and efficiency of using capital and labor in the production process (İmrohoroğlu and Tüzel 2014).	IMTU
$FSIS\_OR_t$	Firm-specific investor sentiment measured by overnight return, defined as 250 × the average daily overnight returns over fiscal year t (Aboody et al. 2018). *FSIS_OR* is standardized to have zero mean and standard deviation of one.	CRSP
$FSIS\_OIB_t$	Firm-specific investor sentiment measured by retail investors' order imbalance, defined as $\frac{250}{N} \times \sum_{i=1}^{N} \frac{\text{num. of buyer initiated trades}_i - \text{num. of seller-initiated trades}_i}{\text{num. of buyer-initiated trades}_i + \text{num. of seller-initiated trades}_i}$, where N is the number of non-missing data in one fiscal year (Boehmer et al. 2021). *FSIS_OIB* is standardized to have zero mean and standard deviation of one.	TAQ
$FSIS\_ECS_t$	Firm-specific investor sentiment measured by non-political sentiment, defined as the sum of quarterly non-political sentiment in a firm's earnings conference call transcripts over fiscal year t (Hassan et al. 2019). *FSIS_ECS* is standardized to have a mean of zero and standard deviation of one.	HHLT
BWI_t	The sum of Baker and Wurgler (2006)'s monthly market sentiment index over fiscal year t. *BWI* is standardized to have a mean of zero and standard deviation of one.	BW
$Assets_t$	The natural logarithm of total assets (Bennett et al. 2020).	Compustat
Q_t	Tobin's Q, defined as book value of total assets plus market value of equity minus book value of equity divided by book value of total assets (Bennett et al. 2020).	Compustat

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Table C.1 - continued from previous page

Variable	Definition	Source
$Cash_t$	Cash and cash equivalent, scaled by total assets (Bennett et al. 2020).	Compustat
$Debt_t$	Total debt, scaled by total assets (Bennett et al. 2020).	Compustat
$R\&D_t$	R&D expenses, scaled by total assets. *R&D* is equal to zero if an observation is missing (Bennett et al. 2020).	Compustat
$Capex_t$	Capital expenditures, scaled by total assets.	Compustat
$Firm\_Age_t$	The number of years since a firm is recorded for the first time in Compustat.	Compustat
$Business\_Risk_t$	The standard deviation of the firm's daily stock returns over previous year (Bennett et al. 2020).	CRSP
$Diversified_t$	An indicator variable, equal to one if a firm has multiple segments reported in the Compustat Historical Segment database, and zero otherwise (Bennett et al. 2020).	Compustat
$Addition\_S\&P_t$	An indicator variable, which is equal to one if a firm is added to the S&P 500 index in previous three years including the year of addition and zero otherwise.	CRSP
$Addition\_Russell_t$	An indicator variable, which is equal to one if a firm is added to the Russell 1000 index in previous three years including the year of addition and zero otherwise.	FTSE/Russell
$Addition\_Year_t$	An indicator variable, which is equal to one if a firm is added to the S&P 500 index or Russell 1000 index in fiscal year t and zero otherwise.	CRSP and FTSE/Russell
TFP_Alt1_t	Firm-level TFP define by Bennett et al. (2020).	BEA and Compustat
TFP_Alt2_t	Firm-level TFP defined by Jacob (2021).	BEA and Compustat
$Auto\_Expo_t$	Automation patents used in production process without human intervention classifised by Mann and Püttmann (2018).	KMLP
$Top5\_Own_t$	Managerial ownership, measured by the common stock ownership of the five executives with the highest compensation, including CEO (Kim and Lu 2011).	ExecuComp
$KZ\text{-}Index_t$	Kaplan and Zingales (1997)'s index of financial constraints.	CRSP and Compustat
$Patent/R\&D_t$	Innovation efficiency, defined as the ratio of the number of patents to R&D expenses (Shea 1999).	USPTO
$Sale/Cost_t$	Operating efficiency, defined as the ratio of net sales to total costs, where total costs equal sales minus EBITDA (Alimov and Mikkelson 2012).	Compustat

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Table C.1 - continued from previous page

Variable	Definition	Source
$Asset\_Turnover_t$	Asset turnover, defined as the ratio of sales to the lagged net assets, where net assets equal total assets minus cash (Alimov and Mikkelson 2012).	Compustat
ROA_t	Return on assets, defined as the ratio of operating income before depreciation to the lagged total assets (Loderer et al. 2016).	Compustat
$Negative\_NI_t$	An indicator variable, equal to one if a firm's net income is negative, and zero otherwise (Loderer et al. 2016).	Compustat

Appendix C.2

In this appendix, we present the definitions of two alternative measures of firm productivity used in our robustness tests.

We construct our first alternative measure of firm productivity, *TFP_Alt1*, based on Bennett et al. (2020)'s setting. Bennett et al. (2020) employ the method in Ackerberg et al. (2015) and estimate the part of firm output that is not explained by capital and labor inputs. We start from the Cobb-Douglas production function:

$$Y = A \cdot K^{\alpha} \cdot L^{\beta} \qquad (C1)$$

where Y is firm output, K is capital,L is labor, and A is firm productivity. Taking the natural logarithm on both sides of Equation (C1), we get:

$$\ln(Y) = \alpha \cdot \ln(K) + \beta \cdot \ln(L) + \ln(A) \qquad (C2)$$

To calculate a firm's TFP (*ln(A)*), we estimate the following specification:

$$\ln(Y) = \beta_0 + \alpha \cdot \ln(K) + \beta \cdot \ln(L) + \epsilon \qquad (C3)$$

where β_0 is the intercept and ϵ is the residual. Comparing Equation (C2) to (C3), a firm's TFP is the sum of the intercept and residual from Equation (C3):

$$\ln(A) = \beta_0 + \epsilon \qquad (C4)$$

In Equation (C3), Y is firm output or value added, defined as *Sales* minus *Materials* deflated by the GDP deflator from BEA. *Sales* is revenues (Compustat item REVT) and *Materials* is *Total expense* minus *Labor expense*. *Total expense* is defined as the difference between revenues and operating income before depreciation and amortization (Compustat item OIBDP). Different from İmrohoroğlu and Tüzel (2014), *Labor expense* is measured by employee wages (Compustat item XLR). If XLR is missing, we replace it by the product of a firm's employee number (Compustat item EMP) and the average wage per employee in the firm's Fama-French 12 industry. K is capital, defined as the gross property, plant, and equipment (Compustat item PPEGT) deflated by the price deflator for private fixed investment from BEA, followed by the adjustment of the average age of capital (Hall 1990; Brynjolfsson and Hitt 2003). L is labor, defined as the number of employees from Compustat.

We construct our second alternative measure of firm productivity, *TFP_Alt2*, based on Jacob (2021)'s method to estimate production functions. Specifically, *TFP_Alt2* is measured as the residuals from the regressions of value added (firm output) on labor and capital inputs for each industry-year:

$$\ln(Value\_Added)_{i,t} = \alpha_0 + \alpha_1 \ln(Total\_Wages)_{i,t} + \alpha_2 \ln(Fixed\_Assets)_{i,t} + \varepsilon_{i,t} \qquad (C5)$$

where *Value_Added* is defined as earnings before taxed (Compustat items REVT - COGS - XSGA - DP) plus depreciation (Compustat Item DP) and *Total_Wages* (Compustat item XLR). If XLR is missing, we replace it by the product of a firm's employee number (Compustat item EMP) and the average wage per employee in the firm's Fama-French 12 industry. Same as İmrohoroğlu and Tüzel (2014) and Bennett et al. (2020), *Fixed_Assets* is measured by the gross property, plant, and equipment (Compustat item PPEGT) deflated by the price deflator for private fixed investment from the BEA. We follow Hall (1990) and Brynjolfsson and Hitt (2003) to adjust the average age of capital.

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