Corporate Cash, Investment, and Uncertainty

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Abstract

This paper utilizes firm-level data to demonstrate the following findings: (1) Investment, cash holdings, and dividend distribution increase in response to a positive cash flow shock. (2) When conditioning on the uncertainty level, investment decreases in response to a positive cash flow shock, while dividends show a positive reaction to such a shock. By employing a general equilibrium model that considers household gains utility from consumption and risk-free asset holdings, the model simulation aligns with the empirical results. Lastly, the welfare analysis indicates that a model with such features results in a welfare loss, and households behaving in a myopic manner is not socially optimal.

JEL classification:
Keywords: Cash flow sensitivity, aggregate uncertainty shock, corporate investment

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1 Introduction

Investment is one of the most critical activities for a firm. Having the proper amount of investment is vital for the firm's health and can significantly contribute to economic development. Fazzari et al. (1988) demonstrated, beyond the q-theory, that cash flow is an important factor in determining a firm's investment. This is commonly referred to as investment-cash flow sensitivity. They pointed out that when a firm is financially constrained, debt and equity financing become costly, leading the firm to rely on internal funds for investment. However, as Chen and Chen (2012) has pointed out, the investment-cash sensitivity has significantly declined over the past 40 years, suggesting that using cash flow to determine investment is no longer as reliable.

On the other hand, it is well-known that firm-level variables fluctuate with the overall condition of the economy and, consequently, should also fluctuate with aggregate uncertainty. A plethora of literature has demonstrated that investments decline in response to the uncertainty level, as shown in works by Basu and Bundick (2017) and Bloom (2009). The decrease in investment can be attributed to two characteristics of investments: their largely irreversible nature and the possibility of delay, as discussed by Pindyck (1991). Simultaneously, corporate cash holdings are positively correlated with uncertainty, primarily due to the precautionary savings effect. When uncertainty increases, firms tend to accumulate cash for future needs, as discussed by Han and Qiu (2007).

As demonstrated by Alfaro et al. (2018), when uncertainty varies over time, lenders may become less likely to assess the credit market, as the cost of lending increases, thereby limiting the firm's ability to secure external funds. In such circumstances, firms may become more "liquidity constrained" as the risk premium that lenders require increases along with the uncertainty. Given that investments are typically financed by corporate cash (or cash flow), firms tend to increase their investments when they have more cash available. Conversely, when uncertainty increases, firms often reduce their investments due to the irreversibility of investment decisions and instead build up cash reserves as a precautionary measure. Therefore, it is natural to investigate whether the impact of cash flow on capital investment becomes stronger or weaker as uncertainty varies over time.

This paper aims to address the core question of how the interaction between cash and uncertainty affects corporate investment. Specifically, it explores the conditional investment-cash sensitivity, a topic that has received limited attention in existing literature. The study begins by utilizing firm-level data to provide empirical evidence regarding the conditional effect of cash flow when conditioned on the level of uncertainty. Subsequently, using a general equilibrium model, it demonstrates that this interaction is not optimal and leads to a welfare loss.

In the first part of the paper, I utilize firm-level data obtained from Compustat, FISE, and TRACE to empirically demonstrate that the unconditional effect of cash flow (shock) on investment is positive, while the conditional effect of cash flow (shock) on investment is negative. This finding aligns with the existing literature on uncertainty. So conditioned on the uncertainty level, cash is not allocated in investment, a natural question arises: where does the cash go? Since cash can either be invested, held, or distributed, I conduct several regression analyses to investigate the conditional effect of cash flow (shock) on corporate cash holdings and cash dividends. The empirical results indicate that the conditional effect of cash flow on corporate cash holdings is insignificant, while it is positive for cash dividends. This suggests a narrative: during periods of high uncertainty, there is an increased substitutability between investment and cash dividends.

Next, in order to explain why this is the case, I employ a general equilibrium model to provide a theoretical explanation for the observed responses of investment and dividends, aligning them with the empirical results. A key element of the model is the household's choice of two assets with differing risk-return profiles each period, as influenced by the work of Fisher (2015) and Krishnamurthy and Vissing-Jorgensen (2012). The utility weight placed on holding the risk-free asset (the safe asset) is time-varying and linked to the level of uncertainty. When households perceive an increase in current uncertainty, they assign greater weight on the safe asset. With this feature incorporated into the model, in response to a sudden increase in uncertainty, investors reallocate their resources from productive (risky) assets to risk-free assets for precautionary motives. Since households are the sole shareholders of the firm and reduce the firm's resources when uncertainty increases, the firm operates suboptimally, leading to a decrease in investment and an increase in dividend distribution. This theoretical response of the responses of investment, cash, and dividends remains robust when employing different parameterizations.

Lastly, I address the question of whether this behavior is beneficial to society. When uncertainty is high, households, who are the shareholders of the firm, tend to hold more resources rather than leaving them in the firm. Since two assets have different risk-return profiles, the expected return on capital (riksy asset) will be much higher if the capital is allocated within the firm rather than held by households. This implies that in the short run, households feel safer by holding more safe assets, but in the long run, capital grows at a slower rate, leading to a reduction in household welfare. By applying the method proposed by Schmitt-Grohe and Uribe (2001) and Schmitt-Grohe and Uribe (2007), I quantitatively demonstrate that households behaving in this manner indeed incur a welfare cost, resulting in a reduction in the expected discounted sum of lifetime utility.

Organization The remainder of the paper is organized as follows: Section 2 reviews relevant research. Section 3 presents empirical evidence regarding the unconditional and conditional effects of cash flow shocks on investment and dividend distribution. Section 4 introduces a theoretical general equilibrium model that offers an interpretation of the empirical evidence and conducts a welfare analysis to demonstrate the incurring of a welfare loss. Finally, Section 5 concludes the paper.

2 Related Literature

The paper aims to combine the firm-level empirical evidence with the quantitative macroeconomic models to illustrate how does the corporate reacts to the uncertainty. In particular, this paper joins and contributes to the following two strands of literature in macroeconomics and corporate finance.

Cash flow sensitivity Two problems matters most in the corporate finance area: how does the financial constraints affect the firm's financial decisions and how does the firm made the financial decisions (Almeida et al., 2004). Keynes argued that liquidity management and financing constraints are fundamentally linked: If financial markets work as well as we typically assume they do, firms' liquidity decisions would be irrelevant. Given the cash is not unlimited supplied, so if the firm wants to finance a new investment project, firm has to turn to the financial market for external financing resource if the internal liquidity is insufficient. If the firm is financially constrained, it is not easy for the firm to access to the external financing and thus firm needs to think about the trade off between the current investment and the future investment. Many studies examine this questions to empirically show if is the case. For example, see Fazzari et al. (1988), Almeida and Campello (2007), Almeida et al. (2004), Han and Qiu (2007), Hovakimian and Hovakimian (2009), Gulen and Ion (2016), Chen and Chen (2012). These studies try to link the financial constraints status with how sensitivity does firm's investment or cash holding with respect to firm's cash flow. These empirical results are the unconditional effects of the cash flow on the firm's investment. My research contribute to this strand of literature by providing a new empirical evidence, the conditional sensitivity of cash flow on investment conditioning on the uncertainty. Since we know the investment and cash are also affected by the uncertainty level (Pindyck, 1991, Leahy and Whited, 1996, Bloom et al., 2018, Bloom et al., 2007, Gulen and Ion, 2016, and Kim and Kung, 2017). Analyzing the conditional effect helps us understand the firm's financial decision and its interact with the uncertainty level. Moreover, this paper is also related to Baum et al. (2010) which also shows the conditional effect of cash flow on the investment and uses the micro level uncertainty not the macro level uncertainty used in this paper.

Beyond provide the empirical evidence on the condition effect of cash flow (shock) on the investment, this paper provides a bigger picture asking if the firm is not investment more, then where does the firm allocate such cash. The paper also related to the firm's dividend policy. Many study shows that the dividend policy reacts to the economic policy uncertainty (Farooq and Ahmed, 2019, Attig et al., 2016, Bliss et al., 2015, Chetty and Saez, 2005). They argue that the firm's dividend policy reacts to event-based uncertainty or economic policy uncertainty. My research contribute to this area by providing the evidence that firm's policy also reacts to the different uncertainty measurements. Economic policy uncertainty differs from aggregate or macroeconomic uncertainty, which relates to uncertainty about macroeconomic fundamentals, as EPU refers to uncertainty about government actions that affect the economic environment (Beckmann and Czudaj, 2017). Since the event-related uncertainty such as tax reform are mostly related to the dividend itself and it will certainty change the amount and the timing of dividend distribution (Korkeamaki et al., 2010, Hanlon and Hoopes, 2014). But the aggregate uncertainty are more likely to change the cash holding and investment simultaneously, and thus will change the dividend policy as a consequence. Because the firm's holding cash is costly, so firm need to either invest some portion or distribute some portion, and only hold for a portion for the daily use or of the precautionary purpose to address the future uncertainty. I empirically shows that the dividend increases to the cash flow unconditional to the aggregate uncertainty level. That also answers the question if the cash are not distributing to the investment conditionally, then where does this amount of money go, or which is replacing the investment. This aligned with the fact that the corporate dividend policy is also related to non-tax conditions, such as the economic setting, high corporate profits, and substantial cash holdings (Brav et al., 2005, Brav et al., 2008). Replacing investment with dividend shows the substitution between investment and dividend increases. So this paper also contributes to the strand of literature studying the relationship between investment and dividend such as Fama (1974), Masulis and Trueman (1988), Smith Jr and Watts (1992), and Pruitt and Gitman (1991).

Uncertainty effect This paper also contribute to this strand of papers by proposing a simple general equilibrium model to match the empirical result. Most studies theoretically show how does the uncertainty affect the investment, cash holding, and dividend distribution. For the investment, given the marginal revenue of investment is convex, higher uncertainty will reduce the investment due to the Jensen's inequality. And for the precautionary purpose of holding cash, increases the uncertainty will create the motive for holding more cash. These can be seen in the study of Alfaro et al. (2018), Basu and Bundick (2017), Bloom et al. (2018), Smietanka et al. (2018), Phan et al. (2019), Baum et al. (2006), Han and Qiu (2007). Since the dividend policy is also an important corporate decision, this paper uses a simple model by introducing the feature of household gain utility from holding safe asset to match the empirical evidence. One the one hand, most researches investigate the effect of cash flow shock and uncertainty shock separately. This paper focuses on the conditional effect which needs two shocks to work together in the model. On the other hand, having the safe asset in the utility function is closely related to Fisher (2015) and Krishnamurthy and Vissing-Jorgensen (2012), where they also work on the utility function with safe asset. The model in this paper generate a feature that during the high uncertainty level, household shift from holding high return but high risk asset with holding low return and low risk asset. This is closely related to the phenomenon called "flight-to-safety". "flight-to-safety" means investors reallocate their resources from productive assets to safe assets for precautionary motives in response to a sudden increase in uncertainty. Many paper studies the economic effect of "flight-to-safety" (Li and Merkel, 2020, Bayer et al., 2019, Brunnermeier et al., 2022b, Brunnermeier et al., 2022a). This paper also contribute to this strand of literature by introducing a simple structure of creating "flight-to-safety" and another economic result of "flight-to-safety".

3 Empirics

In this section, I present firm-level evidence illustrating how firms make financial decisions when facing cash and uncertainty shocks simultaneously. I employ three regressions to demonstrate that when a firm encounters a positive cash shock, it will distribute more cash dividends, invest more, and hold more cash on hand. This is consistent with traditional corporate finance theories. However, I found that, conditional on the uncertainty level, dividends positively respond to the cash shock, whereas investment negatively responds to it. It seems that during periods of high uncertainty, the substitutability between dividends and investment increases.

3.1 Data

Firm level variables The data used in this empirical research are from the Compustat, FISD, and TRACE datasets. Firm-level characteristics are sourced from Compustat, while bond issuance and trading information are retrieved from FISD and TRACE, respectively. The sample period spans from the first quarter of 2007 to the fourth quarter of 2021. The sample excludes financial firms (SIC codes between 6000 and 6999) and utility firms (SIC codes between 4900 and 4999), aligning with common practice in empirical corporate finance literature (Kim and Kung, 2017, Gulen and Ion, 2016, Alfaro et al., 2018).

In the regression analyses, the main dependent variables are capital investment, corporate cash, and cash dividend. I also control several firm characteristics. To ensure that the results are not unduly influenced by large firms and to facilitate comparability among firms of disparate sizes, all variables (except for the zscore, Tobin's Q, from's age) are deflated by the value of lagged total assets (Gulen and Ion, 2016). Investment is defined as capital expenditure (Compustata item CAPXY) divided by lagged total assets (Compustata item ATQ), as suggested by Kim and Kung (2017) and Malmendier and Tate (2005). Cash flow definition sticks to Kim and Kung (2017), where it is defined as the sum of income before extraordinary items (Compustata item IBQ) and depreciation and amortization (Compustata item DPQ), also normalized by lagged total assets. Cash holding is defined as the sum of cash and cash equivalents (Almeida et al., 2004). Tobin's Q is defined as the ratio of a firm's market value to its replacement cost. According to Kim and Kung (2017), it is:

$$Q = \frac{\text{market value of equity + total assets - book value of equity - deferred taxes}}{\text{total assets}}$$

where the market value of equity is calculated as the product of outstanding common shares (Compustata item CSHOQ) and the quarterly end stock price (Compustata item PRCCQ). The book value of equity is directly obtained from item CEQQ, and deferred taxes are derived from item TXBDQ. The age of the firm is determined by subtracting the date of the earliest record of the firm in Compustat from the observation date, with a subsequent log-transformation applied to the difference. Leverage is calculated as the ratio of total liability to total equity, and tangibility is succinctly defined as one minus the ratio of intangible assets (item INTANQ) to total assets. Z-score is constructed follows WRDS's website instruction page[1]

$$\text{z-score}_t = 3.3\,\frac{\text{EBIT}_t}{\text{TA}_t} + 0.99\,\frac{\text{sales}_t}{\text{TA}_t} + 0.6\,\frac{\text{MVE}_t}{\text{L}_t} + 1.2\,\frac{\text{WC}_t}{\text{TA}_t} + 1.4\,\frac{\text{RE}_t}{\text{TA}_t}$$

Lastly, the credit spread is calculate in accordance with Acharya et al. (2012), being calculated as the difference between a corporate bond's yield to maturity and the interpolated yield on the Treasury STRIPS of the same maturity. Given the availability of the yield on the Treasury STRIPS, I utilize the yield on T-bills as the substitute. Specifically, I go to TRACE data set and retrieve all the bond transactions for a particular firm within a given quarter. Bonds with embedded options (callables and putables), ABS, MBS, and those denominated in foreign currencies are excluded from the data. Subsequently, the yield to maturity for each transaction is calculated using the deal price and bond features from FISD by solving a nonlinear equation which equate the present value of the bond future cash flow with the deal price. For each date within the quarter, the corresponding T-bills yield is interpolated. Finally, the difference between the yield to maturity and the corresponding T-bills yield is calculated, and these values are averaged to ascertain the credit spread for a particular firm in a specified quarter.

Uncertainty measurement Economic uncertainty, by its very nature, proves challenging to quantify, and a cohesive consensus among economists regarding its optimal measure remains elusive. I use two popular measures of uncertianty level: macro uncertainty and implied volatility index. Macro uncertainty (MU for short) proposed by Jurado et al. (2015) is widely used in relevant area. Macro uncertainty is as free as possible both from the structure of specific theoretical models, and from dependencies on any single (or small number) of observable economic indicators. Because of this, the MU is (as much as it can be) orthogonal with the current economic conditions. Jurado et al. (2015) showed, this MU is consistent with several narrative evidence and can almost perfectly match the

[1] https://wrds-www.wharton.upenn.edu/pages/wrds-research/applications/risk-and-valuation-measures/tobins-q-altman-z-score-and-companys-age/?algolia-query-id=2e69c77389a8f1df96b030351316634d&algolia-object-id=158&algolia-index-name=main_search_index

different NEBR recession period. Also from the process of constructing the MU, it is exogeneous to the economic condition. The implied volatility index utilize the option price to back-trace the market volatility and is widely used as a proxy for market uncertainty (Basu and Bundick, 2017; Berger et al., 2020). It is calculated by the weighted average of out-of-the-money call and put options on the S&P 500 and by its nature is the 30-day expected volatility of the SP500 index. So VIX is the a forward-looking measure.

An issue remains: the misalignment of frequency between uncertainty measures and firm-level variables. Whereas uncertainty measures present at a monthly frequency, firm characteristics manifest at a quarterly frequency. Consequently, I adhere to the aggregation method advocated by Gulen and Ion (2016): which assigns weights of $1/2$, $1/3$, and $1/6$ to the last month, middle month, and the first month within a given quarter, respectively:

$$U_q = \frac{3U_m + 2U_{m-1} + U_{m-2}}{6}$$

where m denotes the last month in quarter q. This weighting scheme accommodates the prospect that more recent levels of uncertainty may exert a more pronounced impact on a firm's financial decisions.

3.2 Baseline Results

Investment regression Initially, I employ firm-level empirical results to investigate the unconditional and conditional effects of cash shock on investment. Specifically, I conduct a regression of investment, denoted as 'inv' on cash flow, the interaction between cash flow, uncertainty, and several controls. The foundational regression is specified as follows:

$$\text{inv}_{i,t} = \alpha + \theta \text{uncertainty}_t + \delta \text{CF}_{i,t} + \gamma \text{uncertainty}_t \times \text{CF}_{i,t} + X'_{i,t}\beta + \text{FE} + \epsilon_{it}$$

where θ represents the direct effect of uncertainty on investment, and it is anticipated to be negative. This expectation is substantiated by an array of both empirical and theoretical works (see, for example, Basu and Bundick, 2017, Bloom et al., 2018, Bloom et al., 2007, Bloom, 2009, Kim and Kung, 2017, Gulen and Ion, 2016). δ is the unconditional effect of cash on investment and is assumed to be positive, typically this is referred to the cash sensitivity of investment. γ signifies the conditional effect, which is the concern of this paper. I want to examine whether γ is positive or negative. In addition to these variables, I also control for several firm's characteristics including: the credit default risk, firm size, tangibility, age, Tobin's Q, and z-score are integrated. Firm size, tangibility, Q, and z-score are conventional controls in the empirical testing of determinants of corporate investment (Hovakimian and Hovakimian, 2009; Almeida and Campello, 2007; Malmendier and Tate, 2005; Kim and Kung, 2017). Furthermore, control for credit default risk, proxied by the credit default spread, is also incorporated. Using the credit default controls for the cost of debt and the default risk. Both are pivotal in determining investment, for if the cost of debt escalates, the firm encounters constrained funding sources, subsequently diminishing investment. According to Acharya et al. (2012), cash may endogenously accumulate at times due to an increase in default risk, as firms, particularly those with higher risk, typically retain more cash on hand to address future events. Therefore, by controlling for credit default, we exclude the possibility that an increase in cash is attributable to individual default risk. Additionally, I permit the interaction of each control variable with the level of uncertainty within the regression analysis.

Table 1: Investment Panel Regression

Dependent var.	$\text{inv}_{i,t}$	$\text{inv}_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
$\text{CF}_{i,t}$	0.0713^{***} (0.0032)	0.1546^{***} (0.0149)
$\text{U}_t \times \text{CF}_{i,t}$	-0.0740^{***} (0.0117)	-0.1072^{***} (0.0160)
No. Obs	21656	21745
SE type	firm level	firm level

Notes. Above table shows the results for the investment regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

To address the potential endogeneity issue, I control for the industry-times-time fixed effect, and additionally, I cluster the standard error at either the industry or firm levels. Considering the incorporation of all interactions of the controls and the uncertainty level—and given that the uncertainty series is not firm-specific but at an aggregate level—the time fixed effect will absorb the uncertainty effect. Consequently, I abstain from reporting the coefficient on uncertainty. The subsequent table shows the key part of results and full regression results can be found in the appendix

Table 1 shows that the signs on each variable are consistent with expectations. Cash flow ($\text{CF}_{i,t-1}$) is positive and significant at the 1% level, illustrating that cash flow unconditionally boosts the firm's investment as it is a source for the firm. For credit spread ($\text{cds}_{i,t}$), the unconditional effect reduces investment. Given that credit spread is positively correlated with the cost of the firm's borrowing, a higher credit spread results in more expensive firm borrowing, thus lowering the investment level. However, according to Gilchrist and Zakrajšek (2012), the credit spread is correlated with economic conditions and also affects the firm's investment. This issue will be addressed in the robust test section. Leverage ($\text{lev}_{i,t-1}$) is lagged one period and the sign is not consistent with common knowledge. It should be negatively correlated with the investment level (Ahn et al., 2006, Aivazian et al., 2005), but the effect of leverage is assimilated by other variables such as age and Tobin's Q. The unconditional effect of age ($\text{age}_{i,t}$) is positive and consistent with the theory. Tangibility ($\text{tan}_{i,t-1}$) poses an insignificant positive effect on firm's investment; it is significant when MU is used as the uncertainty proxy and the standard error is clustered at the firm's level. A positive effect is consistent with the theory (Almeida and Campello, 2007); having more tangible assets on hand, the firm is more likely to pledge these assets for cash when it is financially constrained. Z-score ($\text{Z}_{i,t-1}$) indicates the firm's potential to go bankrupt. A higher Z-score implies a lower likelihood for the firm to go bankrupt, so it should be positively correlated with investment. Tobin's Q ($\text{Q}_{i,t-1}$) is positive but insignificant, which is consistent with the theory. The insignificance of Q is due to the effect being absorbed by other variables.

The interaction effect of cash flow and uncertainty ($\mathbf{U}_t \times \mathbf{CF}_{i,t}$) is the primary focus of this paper. It is negative and significant at the 1% level, regardless of whether macro uncertainty or implied volatility index is used as the measure, and irrespective of whether the standard error is clustered at the firm's or industry level. This indicates that if the uncertainty level is high, investment-cash sensitivity diminishes. During macroeconomic fluctuations, lenders adjust their loan premiums over the risk-free rate. Elevated loan premia induce firms to exercise more caution in their investment decisions. The reduction of investment-cash sensitivity amidst uncertainty is consistent with Baum et al. (2010) and may provide an answer to the questions posed by Chen and Chen (2012) regarding why investment-cash sensitivity declined and disappeared during the 2007–2009 credit crunch. One possible explanation could be that an increase in the uncertainty level offsets investment-cash sensitivity.

Cash regression In the above section, I empirically shows that uncertainty reduces the investment-cash sensitivity. During the high uncertainty period, firm will not put the resources into the investment as much as the low uncertainty period. So it is naturally to ask how does the firm use the resources during the uncertainty level varies. Normally, firm faces the the trade-off between distributing, holding, or investing. This subsection shows the relationship of cash holding and uncertainty. To do so, I use firm-level empirical results to explore the conditional and unconditional effect of cash shock on cash holding. Specifically, I regress cash holding on cash flow and bunch of controls and focus the interaction of cash flow and uncertainty. The baseline regression is:

$$\text{Cash}_{i,t} = \alpha + \theta \text{uncertainty}_t + \delta \text{CF}_{i,t} + \gamma \text{uncertainty}_t \times \text{CF}_{i,t} + X'_{i,t}\beta + \text{FE} + \epsilon_{it}$$

In the above specification, θ is the direct effect of uncertainty on cash holing. It is expected to be positive due to the precautionary effect of uncertainty (Han and Qiu, 2007, Brianti, 2023, Goodell et al., 2021, Baum et al., 2008, Smietanka et al., 2018). δ is the unconditional effect of cash flow on cash holding. However there is no consensus about the sign (Almeida et al., 2004, Bao et al., 2012, Riddick and Whited, 2009, Han and Qiu, 2007). γ is the conditional effect of cash flow on cash holding and it is what this paper concerns. In this section, I want to address if the γ is positive or negative. Following Han and Qiu (2007), in the cash regression, I controls for lagged cash holding, Tobin's Q, leverage, firm size. Including the lagged cash holding is due to cash holdings is highly persistent among quarters and thus I include lagged one to three quarter cash holdings as explanatory variables.

Table 2: Cash Persistence

Dependent var.	$\text{CF}_{i,t}$
$\text{CF}_{i,t-1}$	00.9825^{***} (0.0009)
intercept	0.0059^{***} (0.0003)
No. Obs	29048

Notes. This pooled OLS regression estimates the correlation between cash holding and lagged cash holding. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Tobin's Q captures the growth opportunities of a firm and normally firms with greater growth opportunities may have higher cash reserves in order to capture future growth opportunities. So the sign on Tobin's Q is expected to be positive. Firm's size is the logarithm of firm's total asset divided by $1,000,000$ and I normally all the monetary items by the lagged asset value. So large firms may have a lower cash-to-assets ratio than small firms due to potential economies of scale in cash management. The sign on firm's size is expected to be negative. Last, firms with higher leverage levels might need to save more cash to meet future debt payments, so leverage is expected to be positive. Like the investment regression, I control the firm times quarter fixed effect and cluster the standard error at the firm level.

Table 3: Cash Panel Regression

Dependent var.	$\text{cash}_{i,t}$	$\text{cash}_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
U_t	0.0189^{***} (0.0068)	0.0182^{***} (0.0038)
$CF_{i,t}$	-0.2602 (0.2338)	0.1298^{***} (0.0398)
$U_t \times CF_{i,t}$	0.4132 (0.2563)	-0.0482 (0.1593)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the results for the cash regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Coefficient on the uncertainty is positive and significant at 1% level. Consistent with the theory, the cash holding increases unconditionally to the uncertainty level no matter which uncertainty measure is used in the regression. The coefficient on cash flow is insignificant when I use the macro uncertainty but it positive significant at 1% level when I use VIX as the proxy as the uncertainty measure. I show in the robust test that coefficient on cash flow when I proxy uncertainty with economic policy uncertainty and financial uncertainty is positive and significant. For the lagged cash holding, coefficient are both positive and significant at 1% level, indicating firm's cash holding is highly persistent and firm may finance the current cash with past cash holding. Also interesting to note that the coefficient on the one period lagged cash holding is greater than the two or three period lagged cash holding, indicating the more recent cash holding is more likely to be carried forward. Coefficient on Tobin's Q and size are consistent with the expectation: positive on Tobin's Q and negative on firm's size, but they are insignificant. Last empirical results shows that coefficient on lagged leverage ($\text{lev}_{i,t-1}$) is negative and significant at 5% level. This may due to the fact, the higher leverage ratio of the firm, the less likely the firm is going to borrow new debt.

We focus on the interaction of the cash and uncertainty, the conditional effect of cash flow on cash holding. The coefficient is insignificant. This indicates that during high uncertainty period, firm will not increase cash-cash flow sensitivity comparing to in the low uncertainty period. This empirical results partially answer the question coming up in the investment subsection. During high uncertainty period, firm will not increase the cash holding and this implies the firm seems to increases the distribution. The substitutibility between investment and distribution increases during the highly uncertain period. So I prove this in the next subsection.

Dividend regression This is the last puzzle to check given the interaction on uncertainty level and cash flow is negative in the investment regression and insignificant in the cash regression. It's naturally to check what is the sign of coefficient on the interaction term in the dividend regression. To do so, I use firm-level empirical results to explore the conditional and unconditional effect of cash shock on dividend. Specifically, I regress dividend on cash flow and bunch of controls and focus the interaction of cash flow and uncertainty. The baseline regression is:

$$\text{div}_{i,t} = \alpha + \theta \text{uncertainty}_t + \delta \text{CF}_{i,t} + \gamma \text{uncertainty}_t \times \text{CF}_{i,t} + X_{i,t}^{'}\beta + \text{FE} + \epsilon_{it}$$

In the above regression, θ is the direct effect on uncertainty on dividend, δ is the unconditional effect of cash flow and γ is the conditional effect of cash flow on uncertainty level. I also controls for lagged dividend, credit spread, leverage, firm age, z-score. The lagged dividend is a proxy for the firm's dividend policies and should be expected to have a positive sign due to firms want to stick to the dividend policy; credit spread indicating how costly the firm borrows the external funds and is expected to be negative.

Table 4: Dividend Panel Regression

Dependent var.	$\text{div}_{i,t}$	$\text{div}_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
$\text{CF}_{i,t}$	-13.631	4.2847^{***}
	(10.151)	(2.1705)
$\text{U}_t \times \text{CF}_{i,t}$	26.171^{**}	31.007^{***}
	(10.830)	(9.7063)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the results for the dividend regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Both leverage and age are expected to have the positive sign on the dividend. Last z-score shows the potential possibility a firm goes to bankruptcy, and thus should be positively correlated with the dividend, due to the fact that bondholder has the priority on claiming the firm's resource. If the firm is on the edge of bankruptcy, it is less likely to distributing dividend. Like the investment regression, I allow the interaction of each controls with the uncertainty level in the regression and I control the firm times quarter fixed effect and cluster the standard error at the firm level. Given I have time fixed effect and I allow the interaction of uncertainty with each controls so I suppress the coefficient on uncertainty level.

Table 4 shows the dividend regression results. First, the lagged dividend is positive and significant at 1% level, indicating firm's dividend policy is persistent and firm would like to stick to the dividend policy. Cash holding in positive and significant at 1% level if I use VIX as the proxy for the uncertainty level but negative and insignificant if I use macro uncertainty in the regression. As I show in the robust test section, using economic policy uncertainty and financial uncertainty in regression yields the positive and significant coefficient on cash flow, I would believe that cash flow positive correlates to dividend. Credit spread is negative and significant at 10% and 1% level and leverage is positive and significant at 5% level. This makes sense because the credit spread and leverage should be negatively correlated. Age is positive but insignificant and Z-score is positive and significant at 1% level, which are consistent with the theory.

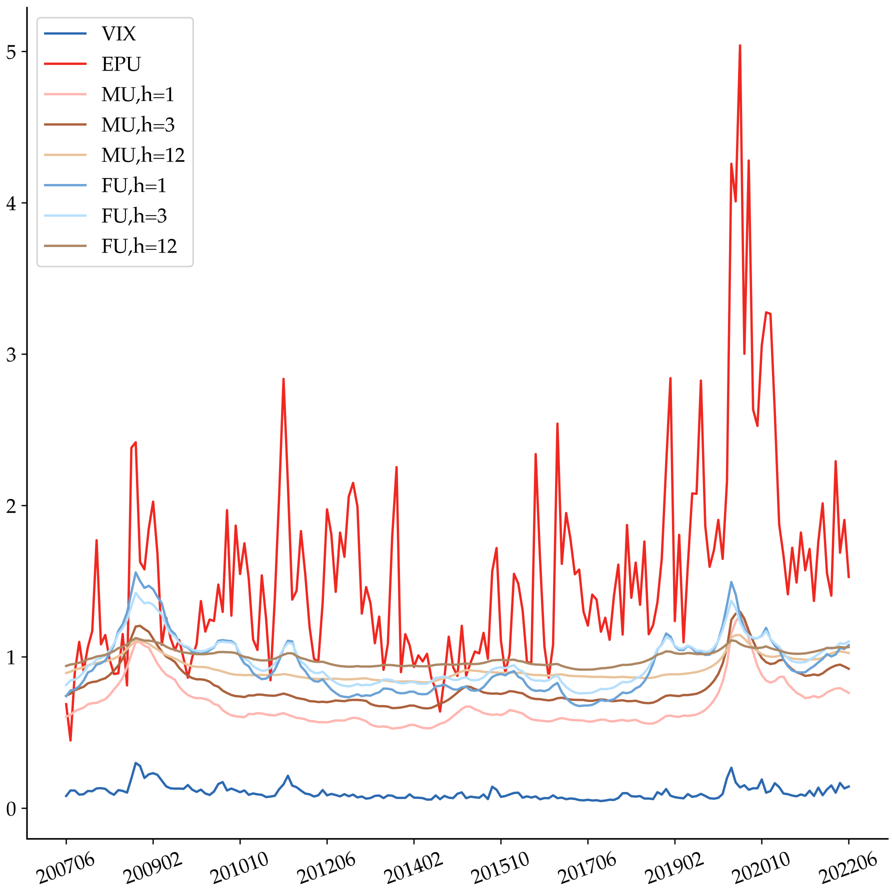
More importantly, the empirical results shows that the conditional effect of cash flow on uncertainty level is positive and significant at 1% for both macro uncertainty and implied volatility index. This results complete the story. Unconditionally, cash flow increases both investment, cash holding, and dividend distribution. But conditional on uncertainty level, investment decreases, cash holding basically hold constant, and dividend increases. Firm increases the substitutibility between dividend and investment when uncertainty level is high. That is during high uncertainty period, if the firm has extra cash, the firm seems to distribute the this amount of cash instead of invest or just simply hold it.

3.3 Robust tests

In this subsection, I consider several robust tests to see if the results are robust. I will present the full empirical results in the appendix.

Using different uncertainty measurement As Caldara et al. (2016) pointed, there is little consensus among economists on what is the best measure of economic uncertainty, rather than taking a stand on any particular indicator. All uncertainty measurements demonstrate co-movements, albeit without perfect correlation, thereby indicating that they share only a particular portion of similarities while also embodying distinct features. I use another two sets of uncertainty measure in the three regressions. The additional uncertainty measures I use are financial uncertainty (Ludvigson et al., 2021) and economic policy uncertainty (Baker et al., 2016). The Economic Policy uncertainty appears to be more volatile compared to other uncertainty measures and seemingly assigns greater weight to the Covid-19 period relative to the 2007-2009 financial crisis, whereas alternative measurements appear to distribute equivalent weight across both periods. Considering that all indicators are correlated to varying degrees, the validity of the robust test is thereby justified.

Figure 1: Various Uncertainty Measurements



Notes. This figure shows the plot of several uncertainty measures. They are all in monthly frequency. And in order to be comparable, I divide the economic policy uncertainty index by 100. The data spans from 2007 April to 2023 January.

Table 5 shows the conditional effect of cash flow on three different firm's financial decisions. The full resultes can be found in the appendix.

Table 5: Robust test: different uncertainty measure

Dependent var.	Uncertainty	$\text{inv}_{i,t}$	$\text{cash}_{i,t}$	$\text{div}_{i,t}$
$\text{CF}_{i,t}$	FU	0.0832^{***}	0.1750^{*}	-1.8663
		(0.0061)	(0.0900)	(3.7262)
	EPU	0.0645^{***}	0.1606^{***}	5.4237^{***}
		(0.0032)	(0.0507)	(2.0740)
$\text{U}_t \times \text{CF}_{i,t}$	FU	-0.0279^{***}	-0.0472	13.452^{***}
		(0.0060)	(0.0928)	(3.8390)
	EPU	-0.0045^{***}	-0.0280	2.8551^{***}
		(0.0014)	(0.0282)	(1.0543)
No. Obs		21656	21656	21656
SE type		firm level	firm level	firm level

Notes. Above table only shows the coefficient on the interaction of cash flow and uncertainty, and unconditional effect of cash flow in three regressions: using investment, cash holding, and dividend as dependent variable respectively. All regression controls for the industry times quarter fixed effect (not reported) and I cluster the standard error at the firm level. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

As we can see using another uncertainty measure, the results are robust. The unconditional effect of cash flow is positive on investment, cash holding, and dividend (for financial uncertainty, cash flow coefficient on dividend is negative but it is not significant). Also the conditional effect of cash flow is positive and significant on dividend, insignificant on cash holding, and negative and significant on investment.

Isolating the economic conditions Because the uncertainty is counter-cyclical, so the uncertainty measure contains the information about the aggregate economic condition. During the period of the high uncertainty, firms' investment opportunity set is shrinking. On the one hand, when uncertainty varies over time, lenders may become less likely to assess the credit market, as the cost of lending increases, thereby limiting the firm's ability to secure external funds (Alfaro et al., 2018). On the other hand, high uncertainty is correlated with the recession and thus fewer investments make money. If that's the case, then managers may increase dividends to shareholders not because of shareholder's flight-to-safety consideration because manager don't have as many positive NPV projects that they can invest in. So it is important to control for the economic condition in the baseline regression.

To do so, I control for the economic conditions and the interaction between economic conditions and cash flow. To measure the economic condition, I use the real GDP data subject to various filters: growth rate, HP filter, Hamiltonian filter, band-pass filter, linear filter. I choose $\lambda = 1600$ in the HP filter (Hodrick and Prescott, 1997), choosing $K = 12$ in band-pass filter (Brianti, 2023), and $h = 8, p = 4$ in Hamiltonian filter (Hamilton, 2018). Using the filters, I filter out the trend of GDP and use the short term economic fluctuation to do the analysis.

Attached is the results of three regression with capital investment, corporate cash, and dividend as the dependent variable. I control the same set of variable as the baseline regressions for the investment, cash and dividend regression and add two additional variables for each regression: economic condition proxy and the interaction of economic condition and cash flow. The following results ignores the control variables to save space. The results for three regression shows that the conclusion is robust even when I control for the economic condition and the interaction of economic condition and the current cash flow. The investment decreases to the cash flow (shock) conditional on the uncertainty level and the dividend increases to the cash flow conditional on the uncertainty level.

Table 6: Robust Test

Filters	growth	linear	quadratic	HP	BP	Hamiltonian
Depen. Var			Cash			
$CF_{i,t}$	0.743^{***}	0.742^{***}	0.618^{***}	0.835^{***}	0.516^{***}	1.028^{***}
	(0.107)	(0.136)	(0.133)	(0.139)	(0.191)	(0.154)
$U_t \times CF_{i,t}$	-0.586^{***}	-0.512^{***}	-0.685^{***}	-0.512^{***}	-0.318^{*}	-0.919^{***}
	(0.151)	(0.149)	(0.146)	(0.151)	(0.174)	(0.169)
Depen. Var			Investment			
$CF_{i,t}$	1.037^{***}	1.032^{***}	0.827^{***}	0.931^{***}	0.882^{***}	0.902^{***}
	(0.008)	(0.161)	(0.171)	(0.174)	(0.286)	(0.178)
$U_t \times CF_{i,t}$	-0.959^{***}	-0.913^{***}	-0.717^{***}	-0.849^{***}	0.796^{**}	-0.809^{***}
	(0.169)	(0.170)	(0.185)	(0.186)	(0.321)	(0.192)
Depen. Var			Dividend			
$CF_{i,t}$	5.920^{***}	8.027^{***}	4.995^{***}	6.529^{***}	6.600^{***}	6.619^{***}
	(2.246)	(2.608)	(2.038)	(2.166)	(2.501)	(2.076)
$U_t \times CF_{i,t}$	30.729^{*}	32.044^{***}	23.673^{***}	16.889^{*}	21.748^{*}	32.513^{***}
	(8.314)	(7.569)	(9.830)	(10.157)	(12.917)	(9.993)

Notes. Above table shows the results for the three regressions, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. For the economic condition, I use the following filters: growth, linear filter, quadratic filter, HP filter, band-pass filter, and hamiltonian filter. I control the firm level fix-effect. I cluster the standard error at the firm level according. I am not reporting the control variables and the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

4 Model

In this section, I introduce a general equilibrium model, based in a real business model, serving two primary objectives: (i) to provide a theoretical foundation for the empirical findings discussed in Section 3; and (ii) to quantify the welfare loss introduced by the flight-to-safety mechanism.

4.1 Model description

In the described economy, their is no price dynamics, exhibiting money neutrality. The economy is inhabited by: (i) a continuum of homogeneous, utility-maximizing households that make choices regarding consumption, c_t and risk-free asset b_{t+1} issued by the central government; (ii) a continuum of value-maximizing firms that determine resource allocation from (after tax) production revenue and benefit from cash holdings, deciding on cash retention, investment magnitude, and dividend distribution levels to maximize the discounted present value of future dividends; and (iii) a central bank, tasked with maintaining equilibrium in government spending through the issuance of risk-free asset and the imposition of corporate taxes.

Household The model contains a continuum of identical households that consume the final good produced by the firm. The preferences of the households are represented by the following utility function.

$$E_t \sum_{j=0}^{\infty} \beta^j \left(\frac{c_{t+j}^{1-\sigma}}{1-\sigma} + f_t \chi \frac{b_{t+j+1}^{1-\rho}}{1-\rho} \right)$$

where $\beta \in (0, 1]$ is the discount factor that governs the level of patience of the household. The utility function is additive separable with the consumption part (CRRA utility functional form). The parameter σ is the coefficient of relative risk aversion for the household, which determines the household's attitude towards risk.

The household also derives utility from holding risk-free asset, with the parameter $\rho > 1$ governing the curvature of the utility derived from holding risk-free asset b_{t+1}. The parameter χ measures the relative importance of consumption and risk-free asset in generating utility. The motivation for including risk-free asset in the utility function is that they serve as a form of savings and that transfers resources from the present to the future. Households need funds to address various uncertainties for precautionary reasons. The introduction of risk-free asset into the utility function aligns with the approach of Krishnamurthy and Vissing-Jorgensen (2012)[2] and Fisher (2015). Thus the household needs to trade off between the two different assets with different risk-return profile and re-balance the portfolio every period.

The utility flow from holding risk-free asset is analogous to the money-in-utility concept pioneered by Sidrauski (1967), which illustrates the benefits associated with the liquidity and safety of the asset. Also, according to Vayanos and Vila (1999) and Rocheteau (2009), investors are likely willing to pay a higher price for an asset if it is liquid, and increases in the holding of such an asset will normally reduce the benefit associated with that asset. Thus, similarly to Krishnamurthy and Vissing-Jorgensen (2012), I assume that the utility derived from holding a bond is a concave function, implying that the marginal value approaches zero as the agent holds a larger amount of risk-free asset.

We can interpret the utility generated from holding risk-free asset as the satisfaction or benefit derived from the convenient yield associated with this safe (and liquid) asset: comparing to risk-free asset, acquisition of information on risky assets is costly. Also the risk-free asset can be used as collateral in many financial transactions and they act as the medium-of-exchange convenience of money via their use by commercial banks and money market funds as backing for checkable deposits.(Krishnamurthy and Vissing-Jorgensen, 2012).

The variable f_t determines the time series variation in utility weight and follow an AR(1) process

$$f_t = \rho_f f_{t-1} + (1-\rho_f) f_{\text{ss}} + \rho_\sigma \left(\ln \frac{\sigma^A_{t-1}}{\sigma^A} - \ln \frac{\sigma^A}{\sigma^A} \right) + \epsilon^b_t$$

The variable f_t captures the idea that the demand for safe and liquid assets fluctuates over time with the aggregate macroeconomic condition. I also posit that past uncertainty levels correlate with the household's preference for holding this risk-free asset. If households perceive the current uncertainty level to be high, they are more inclined to hold the safe asset because of the precautionary motive and thus naturally create the shift from allocating the risky asset $p_t s_{t+1}$ to the risk-free asset b_{t+1}. This aligns with an important empirical characteristic of flight-to-safety known as clustering (Baur and Lucey, 2009). An increase in the

[2] In Krishnamurthy and Vissing-Jorgensen (2012), they assume the representative agent derive utility flow from a comprehensive consumption: $C_t = c_t + \nu(\theta^A_t, \text{GDP}_t; \xi_t)$, where the last term $\nu(\cdot)$ captures the convenience yield associated with holding convenience asset and θ^A_t is the amount of convenience asset.

value of f_t leads to heightened holdings of b_{t+1} because agents assign greater importance to holding bonds, given f_t is autocorrelated.

In addition, the household maximizes the present value of utility subject to the following budget constraint

$$\frac{b_{t+1}}{1+r_t} + p_t s_{t+1} = (p_t + d_t)s_t + b_t + T_t - c_t$$

The household is the shareholder of the firm and thus owns the firm, and d_t represents the cash dividend distributed by the firm. Following Basu and Bundick (2017) and Jermann and Quadrini (2012), p_t stands for the price of the shares held by the household, while s_t represents the shares held by the household. In equilibrium, $s_t = s_{t+1} = 1$. Furthermore, T_t denotes the transfer made by the central government, and this amount will make the following market clear condition hold.

Optimal conditions include the inter-temporal Euler equation for risk-free asset:

$$\frac{\psi_t}{1+r_t} = \beta E_t \psi_{t+1} + f_t \chi b_{t+1}^{-\rho} \tag{1}$$

and inter-temporal Euler equation for shares (risky asset) holding by the household

$$\psi_t p_t = \beta E_t \psi_{t+1}(d_{t+1} + p_{t+1}) \tag{2}$$

In the Euler equations, $\psi = c_t^{-\sigma}$ represents the shadow price of the budget constraints. (2) is the standard asset pricing equation

$$1 = E_t \beta \frac{\psi_{t+1}}{\psi_t} \left(\frac{p_{t+1} + d_{t+1}}{p_t} \right)$$

Regarding the risk-free asset's Euler equation, on an intuitive level, a higher value of f_t indicates that the household assigns greater significance to the utility derived from holding the safe asset. This creates a substitution effect in the decision for period-t, which translates to decreased consumption. Additionally, there is a wealth effect for period-$t+1$, which leads to increased consumption.

Firm The model comprises a continuum of perfectly competitive firms that produce the final goods directly consumed by the household, as described by the following production function:

$$y_t = A_t k_t^{\alpha}$$

A_t represents the (total) factor productivity. Additionally, $\alpha \in (0, 1]$ governs the degree of decreasing returns to scale of the capital input k_t. When $\alpha = 1$, the production function becomes a constant returns to scale production function.

In each period, based on their available resources, firms make decisions regarding investment i_t, corporate cash h_t, and dividends d_t. Following Jermann and Quadrini (2012), there is a quadratic adjustment cost associated with distributing dividends.

$$\phi(d_t) = \frac{\gamma_d}{2}(d_t - d_{\text{ss}})^2$$

The parameter γ_d captures the strength of the adjustment cost. This adjustment cost reflects the preferences of managers for dividend smoothing or dividend policy. Lintner (1965) was the first to show that managers are concerned with maintaining consistent dividends over time, a finding that has been supported by subsequent research. This preference for dividend smoothing may stem from agency problems linked to share issuance or repurchasing, as emphasized by numerous finance studies. However, explicitly modeling these agency conflicts is beyond the scope of this paper.

The firm accumulates capital subject to a capital adjustment cost. I employ the following law of motion as described by Jermann (1998)

$$k_{t+1} = (1 - \delta)k_t + \left[\frac{\delta_1}{1 - \nu}\left(\frac{i_t}{k_t}\right)^{1-\nu} - \delta_2\right]k_t$$

where ν determines the sensitivity of the cost to investment and the parameters $\delta_1 = \delta^\nu$ and $\delta_2 = \delta\nu/(1 - \nu)$ are set by imposing steady state targets $i_{\text{ss}} = \delta k_{\text{ss}}$. The parameter δ is the depreciation rate. The reason of using this capital adjustment cost is there is only one parameters needed to be calibrated ν. In the sensitivity analysis, I consider the more standard and commonly used capital adjustment cost as proposed by Hayashi (1982).

The firm's flow of funds constraint

$$d_t + \phi(d_t) + i_t + h_t = g(h_t) + R^h h_t + (1 - \tau)y_t$$

Here, τ denotes the corporate tax rate imposed on corporate profits, h_t represents end-of-period corporate cash holdings, R^h represents the interest paid on cash saved in the previous period, and $g(\cdot)$ is a positive, increasing, and concave function that captures the benefits of financial flexibility arising from the availability of cash holdings (Brianti, 2023):

$$g(x) = \zeta \frac{x^{1-\iota}}{1-\iota}$$

The parameter ι captures the curvature of the benefit of holding cash. Similarly, holding cash creates a convenience yield and also a cost. With a larger amount of cash holding, the convenience yield decreases, but the cost should increase, whereby the marginal benefit of holding cash increases at a decreasing rate.

The firm's objective is to maximize the expected present value of dividends,

$$\mathbb{E}_t \left[\sum_{k=0}^{\infty} M_{t,t+k} d_{i,t+k} \right]$$

subject to the firm's flow of funds constraint, the production function, and the law of motion of investment. $M_{t,t+k}$ represents the stochastic discount factor determined by the household, with $M_{t,t+1} = \beta \psi_{t+1}/\psi_t$.

Closing the model The government balances its budget by

$$g_t + b_t = \frac{b_{t+1}}{1+r_t} + T_t + \tau y_t$$

Here, g_t represents government spending, which is entirely wasted. The left hand side represents the money inflow and right hand side represents the money outflow. Additionally, for simplicity, I assume that the government transfer to the household T_t includes the capital adjustment costs, as well as benefits and costs associated with cash holdings. This leads to the good market clearing condition given by:

$$c_t + i_t + g_t + \phi(d_t) = y_t$$

Finally, the model incorporates two shocks: a total factor productivity shock affecting future total factor productivity A_t, and an uncertainty shock impacts the second moment of future aggregate productivity A_{t+1}. The corresponding laws of motion for these exogenous processes are as follows:

$$A_t = \rho_a A_{t-1} + (1-\rho_a) A_{\text{ss}} + \sigma^A_{t-1}\epsilon^A_t$$
$$\ln \frac{\sigma^A_t}{\sigma^A} = \rho_u \ln \frac{\sigma^A_{t-1}}{\sigma^A} + \sigma^u \epsilon^u_t$$

where ϵ^A_t and ϵ^u_t are a total factor productivity shock, and an uncertainty shock. In addition, ρ_a and ρ_u govern the persistence of the above two processes, and σ^A and σ^u represent the variance of the two shocks. Here, we can take the total factor productivity shock as the cash shock. An increases in ϵ^A_t will boost A_t and thus the output will also increases accordingly.

4.2 Model Narrative

Given there is no price variation in the model, thus output price can be normalize to 1. Given that, we can take the total factor productivity shock as a cash shock. Specifically, a positive perturbation in total productivity increases the marginal productivity of capital and thus makes the production more efficient, thereby resulting in amplified output levels. Consequently, from the firm's budget constraint, firms find themselves endowed with augmented resources, consequently distribute more, investment more, and an increased propensity to maintain greater liquid reserves.

For the uncertainty effect, please see the following to Euler's equations:

$$\frac{\psi_t}{1+r_t} - f_t \chi b_{t+1}^{-\rho} = \beta E_t \psi_{t+1}$$
$$\psi_t p_t = \beta E_t \psi_{t+1}(d_{t+1} + p_{t+1})$$

The first equation is directly from the risk-free asset Euler equation, and the second equation is from the risky asset Euler equation. For the $\rho_\sigma = 0$ case, increasing the uncertainty level, the future consumption will be more volatile and given $\psi_t = \psi(c_t) = c_t^{-\sigma}$ is a convex function of consumption level, the expectation of ψ_{t+1} increases after a mean-preserving spread. The RHS of the first equation increases. So the current risk-free asset holding will increases accordingly to make the marginal utility of holding risk-free asset decreases. For the $\rho_\sigma > 0$ case, on the one hand, the risk-free asset holding increases according to the above stated mechanism. Also the f_t increases, the marginal cost holding decreases even more and the utility weight on the risk-free asset increases. Agent will consume even less and hold more risk-free asset. Thus the stochastic discount factor increases and agent become very patient. Generally, an exogenous increase in f_t lowers the marginal cost of saving in the risk-free asset thereby increasing the incentive to hold more risk-free asset rather than via risky asset (Fisher, 2015). Intuitively, in response to a sudden increase in uncertainty, investors reallocate their resources from productive (risky) assets to risk-free assets for precautionary motives.

On the other hand, rearrange the firm's first order condition of investment and capital, we have:

$$g_t^{\nu} = E_t \frac{M_{t,t+1}\mu_{t+1}}{\mu_t} \left[(1-\tau)\text{MPK}_{t+1} + f(g_{t+1})\right] \tag{3}$$

where g is the capital growth rate and is defined as i_t/k_t and $f(\cdot)$ is an increasing function of capital growth rate. The above equation means the current capital accumulation rate equals the expected discouned future capital accumulation rate. The derive of this function can be found in the appendix. Given the production function is of decreasing return to scale, thus the marginal product is decreasing in the capital level. After a positive uncertainty shock, current investment decreases and thus the capital decreases. So from the (4), the left hand side decreases makes the discounted factor $M_{t,t+1}\mu_{t+1}/\mu_t$ decreases to equate.

Now from the FOC firm's first order condition of cash

$$1 = E_t \frac{M_{t,t+1}\mu_{t+1}}{\mu_t}(\zeta h_t^{-\iota} + R^x)$$

$\zeta h_t^{-\iota} + R^x$ is the marginal benefit of holding cash. In the model, the agent controls the discount factor of the firm and for the $\rho_\sigma > 0$ case, the agent become extremely patient and want to hold as much risk-free asset as much. From equation (4), the discounted factor decreases and thus the marginal benefit of holding cash increases, causing the cash level to decreases. Becaue the household is patient and $M_{t,t+1}$ increases, then the ratio of shadow price of distributing dividends decreases. The shadow price of distributing dividends in the future decreases more relatively to today: μ_{t+1} decreases more than μ_t to offset the increase in $M_{t,t+1}$ to make the whole $M_{t,t+1}\mu_{t+1}/\mu_t$ decreases. Decreasing in cash and investment makes firm to distribute dividend even more through the market clearing condition. More decreases in μ_{t+1} than in μ_t suggests marginal benefit of distributing dividend in less in the future so firm decreases the investment and cash holding and increases dividend distribution today to prevent move resource from current period to future.

The above discussion suggest that when the uncertainty level is high, the firm conditionally distribute more and invest less and hold less cash for the agent become extremely patient and squeeze the sources from the firm to household. This has three effect. First, firm has less cash at hand meeting the precautionary purpose to address with the future uncertainty, making the allocation sub-optimal. Second, having resources (in form of riskless asset) at the household's hand, the cash is less productive than at the firm's hand. Firm can use the cash either to invest today or put it in cash reserve. Although the latter is costly, it guarantees the enough cash for the future investment. Investment increases the firm's value and thus the risky-asset should have higher return than the risk-free asset. Third, with higher dividend distributing, there incurs a greater equity issuance cost and this cost is purely wasted. That means household holding resource is inefficient and thus the model should create a welfare cost due to the inefficient allocation. Subsequently, I will perform a welfare analysis to show that the model is indeed sub-optimal by having this feature.

4.3 Parametrization and model simulations

In this section, I use Dynare software package (developed by Adjemian et al. (2011)) to numerically solve the model. Suggested by Fernández-Villaverde et al. (2011), I solve the model to a third-order approximation in order to exhibit the time-varying effect of uncertainty. Since the paper want to compare the unconditional and conditional effect of cash shocks, I solve the model twice: in the first time, I shut down the uncertainty shock and only one shock plays in the model; in the second time, I open the uncertainty shock and set the correlation between cash shock and uncertainty shock to be one and let both shocks play in the model. By setting the correlation to be one, I can pin down the conditional effect of the cash shock conditioning on the uncertainty level. The spirit of this setting is that when agent sees a larger cash shock, then the future cash shock will be more scatter distributed and agent is more likely to experience either a larger or smaller cash shock in the future.

I followed Basu and Bundick (2017) to calculate the impulse responses, where the impulse responses is the deviation from the stochastic steady state instead of the deterministic steady state. To do this, I first iterate the third-order approximation until it reaches the stochastic steady state. Then I shock the model with corresponding shock in two cases and record the responses of the each variables. The time varying difference between the responses and stochastic steady state is the impulse responses.

Parameterization I calibrate the model using quarterly US real economy data through steady state relations derived from the equilibrium conditions. In the baseline model, I set $\beta = 0.99$ which is normally used by various literature to match 3% annual interest yield on bonds. Also the net return on corporate cash holding is set to 0 and hold constant for simplicity. For the household utility function, the relative risk averse coefficient σ is set to 2 (Weber, 1975); parameter controls the curvature of bond ρ is simplify set to be 2; and the utility weight is calibrated through the bond Euler equations. In the production sector, the equity issuance cost parameter γ_d is set to 0.292 (Jermann and Quadrini, 2012); the decreasing return to scale parameter in the production function α is set to $1/3$ (Bloom, 2009); the depreciation rate is set to 0.0025 (Jermann and Quadrini, 2012); and the corporate tax rate is set at 0.35 (Jermann and Quadrini, 2012). The persistence parameter ρ_A for technology shock and uncertainty ρ_u are set to 0.95 and 0.9 (Leduc and Liu, 2016); The variance of total factor productivity shock σ^A is 0.01 (Leduc and Liu, 2016), and I set the variance of total factor productivity shock σ^u to 1 to generate significant difference between two cases. In the law of motion for f_t, I set persistent parameter ρ_f to 0.1.

In the law of motion for capital, the parameter ν controls the curvature of the capital adjustment cost and are now set to 0.5 (Jermann and Quadrini, 2012). In the benefit function of holding cash, two parameters needed to be set. ζ is calibrated to match the empirical average of corporate cash holding over output (Brianti, 2023) and $\iota \in (0, 1)$ is set to 0.5. Other values of ν, ι and σ^u will also be considered in the sensitivity analysis.

Table 7: Model's parameter values

Param.	Interpretation	Value	Source
β	Deterministic discount factor	0.99	N.A.
α	DRS parameter	0.33	Bloom (2009)
σ	CRRA in consumption	2	Weber (1975)
ρ	Bond curvature	2	N.A.
χ	Utility weight	1	N.A.
γ_d	Equity issuance cost	0.292	Jermann and Quadrini (2012)
δ	depreciation rate	0.0025	Jermann and Quadrini (2012)
ρ_u	Persistent of TFP variance	0.9	Leduc and Liu (2016)
ρ_A	Persistent of TFP	0.95	Leduc and Liu (2016)
σ^A	Standard deviation of ϵ^A	0.01	Leduc and Liu (2016)
ρ_f	Persistent of f	0.1	N.A.
ζ	Cash benefit parameter 1	0.0150	Steady-state relation
ι	Cash benefit parameter 2	0.5	N.A.
ν	Capital adjustment curvature	0.5	N.A.

Notes. β is the deterministic discount factor; α is the degree of decreasing return to scale in the production function; σ is the constant relative risk aversion coefficient in the consumption bundle; ρ curvature of bond in utility function; χ utility weight on bond holding; γ_d strength of equity issuance cost; δ is depreciation rate; ρ_A and σ^A are the persistence and the variance of total factor productivity shocks ϵ_t^A; ρ_u and σ^u are the persistence and the variance of uncertainty shock ϵ_t^u; ρ_f and ρ_σ are the parameters in the low of motion of f_t; ζ and ι are the parameters in the cash holding benefit function; ν governs the capital adjustment cost.

Results Given the empirical results emphasize how does the variables response to the shock on impact and we do not have the information on the dynamics of the effects, in this section I only present the the impulse responses on impact. I simulate the model three times for every parameterization: the first time I shut down the uncertainty shock and only have the cash shock in the model. Secondly, I include both cash shock and uncertainty both in the model. However this time I set $\rho_\sigma = 0$ to disconnect the f_t with uncertainty level. Lastly, I also include both cash shock and uncertainty both in the model and this time I set $\rho_\sigma = 0.01$ to connect the f_t with uncertainty level. Because the empirical results shows the interaction of cash and uncertainty, so in the second and third simulations I set the correlation between the cash shock and uncertainty shock to be 1. Thus the impulse responses of the second and third simulations are the effect of two shocks together.

The Table 8 shows the simulations when set $\rho_\sigma = 0$, which I shut down the flight-to-safety effect.

Table 8: Percentage deviation from steady state on impact to cash shock

Variables	dividend, d_t	investment, i_t	corporate cash, h_t
no uncertainty	0.762%	4.086%	0.348%
with uncertainty	0.746%	3.982%	0.443%
difference	$-$	$-$	$+$

Notes. Above figures are the percentage deviation from the stochastic steady state on impact. For the "no uncertainty" case, there is only cash shock in the model, and for the "with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the "with uncertainty" case and in the "no uncertainty" case. The baseline parameterization is: $\iota = 0.5$, $\nu = 0.5$, $\sigma^u = 1$, and $\rho_\sigma = 0$.

In this scenario, we can see the positive TFP shock is expansionary, with for both dividend, investment, and cash holding are positively respond to the shock. Also in the appendix, we can found that consumption, output, capital, bond, and firm value are positively responding to this shock. This is consistent with the current literature. Positive TFP shock increases the marginal product of capital then firm would like to increases investment. Also increases the input will boom the output and hence firm has more resource to distribute and all of investment, dividend, and cash holding are increasing. More dividend distributing to the household boost the current consumption and bond holding through the wealth effect. When adding uncertainty shock to the model, cash holding increases but investment and dividend decreases compare to the "no uncertainty" case, indicating the uncertainty is contractionary. Given the capital adjustment is concave for investment, uncertainty reduces the investment. Also from the impulse responses in the appendix, marginal benefit of distributing dividend decrease less compare to the "no uncertainty" case, thus reduces the dividend through the first order condition of dividend. Because of the precautionary purpose, corporate cash increases. The other variables are also consistent with the theory of the uncertainty shock.

The Table 9 shows the simulations when I add the flight-to-safety effect to the model by setting $\rho_\sigma = 0.01$. The "no uncertainty" case are the same, but in the "with uncertainty" case, dividend increases, investment and cash holding decrease to the cash shock compare to the previous case when adding "flight-to-safety" effect. This time, the household, the shareholder of the firm, flight to safety asset by squeezing the source of firm resulting the firm to distribute more dividend and hold less cash and invest less. In the impulses responses, we can see that the benefit of distributing dividend decreases and marginal benefit of holding cash decreases. Thus, firm will not move the resources from current period to the future period. Also firm distributes dividend by holding less cash and invest less.

Table 9: Percentage deviation from steady state on impact to cash shock

Variables	dividend, d_t	investment, i_t	corporate cash, h_t
no uncertainty	0.762%	4.086%	0.348%
with uncertainty	0.843%	3.434%	0.116%
difference	$+$	$-$	$-$

Notes. Above figures are the percentage deviation from the stochastic steady state on impact. For the "no uncertainty" case, there is only cash shock in the model, and for the "with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the "with uncertainty" case and in the "no uncertainty" case. The baseline parameterization is: $\iota = 0.5$, $\nu = 0.5$, $\sigma^u = 1$, and $\rho_\sigma = 0.01$.

The sign of the difference between two cases in Table 9 is the sign of interaction term in the empirical part. One thing to note is the in the empirical result, the interaction between cash and uncertainty in the cash regression is insignificant. However the sign is mostly negative and positive using macro uncertainty (Jurado et al., 2015). This is what the model fails to match, in which the difference is negative.

4.4 Sensitivity Analysis

In this section, I consider a series of sensitive experiments to establish that the qualitative implications presented in above sections are robust to alternative calibrations. I work on the value of four parameters: the curvature in the cash benefit function, ι; the curvature in the capital adjustment function, ν; the variance of uncertainty shock, σ^u; and the curvature of bond in the utility function, ρ.

In each of the sensitivity analysis, I consider the two set of values in both two cases for there is flight-to-safety effect and no flight-to-safety effect in the model. The first experiment, I set the value of $\iota \in (0, 1)$ to be 0.01, 0.5 (baseline calibration), and 0.9. Table 10 shows the results. Setting ι to a large number reduces the cash response to the cash shock, this is because the marginal benefit of the cash is lower compare to the $\iota = 0.01$ case. But for both cases, the difference seems to be less distinct but the sign are consistent with the baseline calibration. The dynamics of the responses can be found in the appendix.

Table 10: Sensitive experiment 1: $\iota = 0.01$ and 0.9

	dividend, d_t	investment, i_t	corporate cash, h_t
	$\iota = 0.01$		
no uncertainty	0.471%	3.404%	1.871%
with uncertainty, FTS off	0.419%	3.249%	2.138%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.733%	3.251%	0.704%
difference, FTS on	$+$	$-$	$-$
	$\iota = 0.9$		
no uncertainty	0.674%	4.143%	0.249%
with uncertainty, FTS off	0.663%	4.050%	0.328%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.729%	3.445%	0.105%
difference, FTS on	$+$	$-$	$-$

Notes. For the “no uncertainty" case, there is only cash shock in the model, and for the “with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the “with uncertainty” case and in the “no uncertainty” case. In this Table, the I use two different calibration for ι: 0.01 and 0.9. For each calibration, I present both cases with FTS on and off.

Table 11: Sensitive experiment 2: $\nu = 0.01$ and 0.99

	dividend, d_t	investment, i_t	corporate cash, h_t
	$\nu = 0.01$		
no uncertainty	0.309%	27.368%	-2.657%
with uncertainty, FTS off	0.307%	26.235%	-2.395%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.467%	23.502%	-2.539%
difference, FTS on	$+$	$-$	$-$
	$\nu = 0.99$		
no uncertainty	0.816%	2.439%	0.458%
with uncertainty, FTS off	0.797%	2.380%	0.557%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.886%	2.056%	0.216%
difference, FTS on	$+$	$-$	$-$

Notes. For the “no uncertainty" case, there is only cash shock in the model, and for the “with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the “with uncertainty” case and in the “no uncertainty” case. In this Table, the I use two different calibration for ν: 0.01 and 0.99. For each calibration, I present both cases with FTS on and off.

The second experiment considers the different set of values of the curvature in the capital adjustment function, ν. We consider the two values for $\nu = 0.01$ and $\nu = 0.99$ against the calibration used in the baseline model $\nu = 0.5$. Table 11 shows the results. For the $\nu = 0.01$ case, the adjustment cost for capital is trivial and it barely affects the investment and capital accumulation. Given that, the uncertainty effect is insignificant. Note that the model is not persistent with the case when I set $\nu = 0.01$, for the response on corporate cash is negative on impact. The reason is that under this case, the capital adjustment cost is very trivial and thus the marginal benefit of investment is larger than the marginal benefit of holding cash. Thus the firm is substituting the cash with investment. But both cases captures the pattern of the empirical results. And full dynamics of variables can be found in appendix.

Given the model is super nonlinear, so the magnitude of the shock does matter for the impulse responses. The third experiment considers the different value for variance of the uncertainty shock, σ^u. I reestimate the model using two values: $\sigma^u = 0.392$ (Leduc and Liu, 2016) and $\sigma^u = 1.5$ against the baseline calibration $\sigma^u = 1$. Table 12 shows that different values of σ^u is able to capture the empirical pattern.

Table 12: Sensitive experiment 3: $\sigma^u = 0.392$ and 1.5

	dividend, d_t	investment, i_t	corporate cash, h_t
no uncertainty	0.762%	4.086%	0.348%
	$\sigma^u = 0.392$		
with uncertainty, FTS off	0.756%	4.045%	0.385%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.794%	3.834%	0.256%
difference, FTS on	$+$	$-$	$-$
	$\sigma^u = 1.5$		
with uncertainty, FTS off	0.738%	3.931%	0.491%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.883%	3.098%	0.003%
difference, FTS on	$+$	$-$	$-$

Notes. For the "no uncertainty" case, there is only cash shock in the model, and for the "with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the "with uncertainty" case and in the "no uncertainty" case. In this Table, the I use two different calibration for σ^u: 0.392 and 1.5. For each calibration, I present both cases with FTS on and off.

Next, we consider the utility functional form. When $\rho \to 1$, the function turns to logarithm. So this experiment analysis the two scenarios where $\rho = 1.01$ and $\rho = 5$ against the baseline calibration $\rho = 2$. Both cases shows the same pattern with the empirical results (Table 13).

Table 13: Sensitive experiment 4: $\rho = 1.01$ and 5

	dividend, d_t	investment, i_t	corporate cash, h_t
$\rho = 1.01$			
no uncertainty	0.754%	4.087%	0.385%
with uncertainty, FTS off	0.738%	3.983%	0.478%
difference, FTS off	−	−	+
with uncertainty, FTS on	0.835%	3.429%	0.152%
difference, FTS on	+	−	−
$\rho = 5$			
no uncertainty	0.768%	4.191%	0.297%
with uncertainty, FTS off	0.750%	4.091%	0.400%
difference, FTS off	−	−	+
with uncertainty, FTS on	0.846%	3.567%	0.073%
difference, FTS on	+	−	−

Notes. For the "no uncertainty" case, there is only cash shock in the model, and for the "with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the "with uncertainty" case and in the "no uncertainty" case. In this Table, the I use two different calibration for ρ: 1.01 and 5. For each calibration, I present both cases with FTS on and off.

Last, in the model, I use a unconventional function form of capital adjustment cost (Jermann and Quadrini, 2012). Does the result speicific to this functional form? In order to examine this question, I change the capital adjustment cost function to a more often used form:

$$k_{t+1} = (1-\delta)k_t + i_t - \frac{\eta}{2}\left(\frac{i_t}{k_t} - \delta\right)^2 k_t$$

This is quadratic adjustment function. Given the investment over capital deviates more from the steady state value δ, more adjustment cost will be incurred. Using the calibration $\eta = 2.09$ (Basu and Bundick, 2017), Table 14 shows the results. Using this capital adjustment cost, the signs are consistent with the baseline model and empirical results. But the response of cash holding is not consistent with the empirical findings and it is very similar to the case when using unconventional capital adjustment cost with $\iota = 0.01$. They share the same reason that the curvature of adjustment cost is small and the firm is substituting the cash with investment for the benefit of investment is greater than cash.

From the sensitive analysis, using different calibartions, the model can match the sign in the empirical result. This suggests that the baseline calibration results are not a by-product of a specific combination of parameters, but are implied by the structure of the economy.

Table 14: Sensitive experiment 5: conventional capital adjustment cost

	dividend, d_t	investment, i_t	corporate cash, h_t
no uncertainty	0.500%	14.882%	-0.804%
with uncertainty, FTS off	0.493%	14.828%	-0.757%
difference, FTS off	$-$	$-$	$+$
with uncertainty, FTS on	0.626%	12.992%	-0.974%
difference, FTS on	$+$	$-$	$-$

Notes. For the “no uncertainty" case, there is only cash shock in the model, and for the “with uncertainty" case, both cash shock and uncertainty shock are in the model. The difference column shows the sign on the difference between the deviation in the “with uncertainty” case and in the “no uncertainty” case. In this Table, I use the conventional capital adjustment cost and the calibration for $\eta = 2.09$ (Basu and Bundick, 2017).

4.5 Welfare Analysis

When I add the FTS effect to the model, the household will extract the resources from the firm and leave the firm suboptimal. Having the sources in the household's hand, resources are not put in its most efficient place. And in the subsequent period, household will not get as much sources as they would have when no FTS in the model. Thus, FTS may create the welfare loss in the economy. So it's important to compare the welfare between two cases. In this section, I use to baseline calibration to address if FTS create welfare loss.

We can check the impulse responses of the welfare W_t and firm value V_t to the cash shock on impact in different cases, where the utility level and firm value are defined recursively as:

$$W_t = U_t + \beta E_t W_{t+1}$$

$$V_t = d_t + E_t M_{t,t+1} V_{t+1}$$

U_t is the period utility function. Since their is no heterogeneity in the model, we can define the social welfare as the discounted expected utility level of household. Table 15 shows both utility level and firm value increases less for the uncertainty case compare to no uncertainty case. Also both utility level and firm value increases even less for the uncertainty case with FTS effect turning on. That indicates uncertainty reduces the welfare and incurs the welfare cost. Also for the uncertainty plus FTS model, the agent squeeze out the resource from the firm making firm operating suboptimally. Thus incurring even larger welfare cost.

Table 15: Response of utility level and firm value on impact to cash shock

	no uncertainty	with uncertainty	with uncertainty and FTS
U_t	0.0017%	0.0016%	0.0003%
V_t	0.0057%	0.0057%	0.0033%

Notes. For the "no uncertainty" case, there is only cash shock in the model, and for the "with uncertainty" case, both cash shock and uncertainty shock are in the model. For the "with uncertainty and FTS" case, I also turn on the FTS effect with the model having two shocks together.

After checking the impulse responses of welfare and firm value on impact, I turn to formal welfare cost measurements developed in Schmitt-Grohe and Uribe (2001) and Schmitt-Grohe and Uribe (2007). These measurements are widely used (Cho et al., 2015, Lester et al., 2014, Epaulard and Pommeret, 2003, Otrok, 2001) to evaluate the welfare cost under different policies or mechanism. These two works uses two different welfare measurements: unconditional welfare cost and conditional welfare cost. I will use both to evaluate welfare changes associating with FTS.

Unconditional welfare cost As in Schmitt-Grohe and Uribe (2001), I measure the welfare costs of FTS as the fraction of non-stochastic steady state consumption that households would be willing to give up in order to be indifferent between the corresponding constant sequences of consumption and risk-free asset holding and the equilibrium stochastic processes for these two variables associated with FTS under consideration. It is calculated with the unconditional mean of welfare W_t where this mean can be interpreted as integrating out initial conditions and future shocks.

Now let c and b be the non-stochastic steady state value of consumption and risk-free asset holding, and Λ be this unconditional welfare costs[3]. Then I can write down the following conditions:

$$\mathbb{E}\sum_{j=0}^{\infty} U(c(1-\Lambda), 1, b) = \mathbb{E}\sum_{j=0}^{\infty} U(c_t, f_t, b_{t+1})$$

[3] If Λ is positive, that means household would like to give up a portion of consumption to be indifferent and indicates the welfare loss. If Λ is negative, this is a welfare gain.

Given the linearity of expectation operator and everything variables are stationary (ergodic) the following equations will be derived

$$\frac{1}{1-\beta}U(c(1-\Lambda),1,b) = \frac{1}{1-\beta}\mathbb{E}[U(c_t, f_t, b_{t+1})]$$

Thus Λ is defined through the following equation:

$$U(c(1-\Lambda),1,b) = \mathbb{E}[U(c_t, f_t, b_{t+1})] \tag{4}$$

Using the above question and solve the model to the third order or second order, I calculate the welfare cost of each case:

Table 16: Unconditional Welfare Cost

	uncertainty	uncertainty plus FTS
Welfare cost (second order approximation), Λ	-0.271%	-0.255%
Welfare cost (third order approximation), Λ	-0.867%	-0.851%

Notes. I use Dynare to solve the model to the second order and third order to get the unconditional welfare cost. To do this, I first simulate with one million iterations to make the model converge. Then I can get the unconditional mean of period utility value. Using the Equation (4), I can calculate the value of Λ.

Given the number of welfare cost is negative, this is the welfare gain. Having the welfare gain is because the model has the two shocks and together and they are perfectly correlated and positive cash shock is expansionary. That is with a larger uncertainty shock, total factor productivity will also be larger, and if the total factor productivity is smaller, the uncertainty is also smaller. Normally, the literatures are solving the model up to the second order to evaluate the welfare loss. However, since my model is solved up to the third, I also evaluate the welfare loss by solving the model up to the third order to be consistent with the impulse reponses on impact. No matther which order I solve for the model, with FTS added to the model, the welfare gain decreases compare to the no FTS cases, indicating that FTS added to the model results a suboptimal equilibrium.

Conditional welfare cost As in Schmitt-Grohe and Uribe (2007), I depart from the usual practice of identifying the welfare measure with the unconditional expectation of lifetime utility. I calculate the conditional welfare cost. I assume that at the initial period, all state variables of the economy equal their respective steady-state values. Using the non-stochastic steady state guarantees that they are the same across all mechanism and ensures that the economy begins from the same initial point under all possible mechanism. So the conditional welfare calculation will take the starting point in the state space at a specific period into account and **only** integrate over future shocks.

Let the subscript r denote the benchmark mechanism and a denote the mechanism we need to consider. Then the welfare associated with benchmark mechanism is

$$V_0^r = \mathbb{E}_0 \sum_{j=0}^{\infty} \beta^j U(c_t^r, b_{t+1}^r)$$

where c_t^r and b_{t+1}^r denote the contingent plans for consumption and bond holding under benchmark mechanism. Also I define the welfare associated with mechanism a (FTS) as

$$W_0^a = \mathbb{E}_0 \sum_{j=0}^{\infty} \beta^j U(c_t^a, b_{t+1}^a)$$

Let Γ denote the welfare cost of the model with FTS instead of without FTS, and measure it as the faction of consumption under FTS mechanism that the household would be willing to give up to be as well off under the model without FTS. Then Γ is defined as

$$W_0^a = \mathbb{E}_0 \sum_{j=0}^{\infty} \beta^j U(c_t^r(1-\Gamma), b_{t+1}^r)$$

Given the utility functional form, we can define solve the Γ explicitly

$$\Gamma = 1 - \left(\frac{W_c^a + W_b^a - W_b^r}{W_c^r}\right)^{\frac{1}{1-\sigma}} \tag{5}$$

where W_k^r (with $k \in c, b$) denotes the corresponding part (consumption and bond holding) of the lifetime sum of expected utility. I use Dynare to solve the model to the second order to get the conditional welfare cost. To do this, I first simulate with one million iterations to make the model converge. Then I can get the conditional mean of period utility value. Using the Equation (5), I can calculate the value of conditional welfare cost $\Gamma = 0.79\%$ of consumption. Although this number is trivial, it still shows that the the model with FTS gains the welfare cost compare to the model with no FTS mechanism.

5 Conclusions

Prior literature has widely studied how does the firm's financial decision responses to the uncertainty level, including the investment behaviors and distribution behavior. But there is not much literature focused on the conditional effect of uncertainty conditioning on the cash level (or the conditional effect of cash shock conditioning on the uncertainty level). Using a sample of the US listed firms from 2007q1 to 2020q4, I empirically showed that cash flow sensitivity of investment is decreasing to the uncertainty and the substitution between the investment and the dividend distribution increases during the high uncertainty period. By guessing this is due to the effect that household squeeze out the sources when the uncertainty level is high to allocate more risk-free asset, I construct a simple DSGE model to match the empirical results. In the DSGE model, household gains the utility from holding the risk-free asset and the utility weight on hoding risk-free asset is time-varying and linked to the uncertainty level. The theoretial results match the empirical results and is robust to several parameterization. Last, I conduct a welfare analysis to show this causes the welfare loss. Given the household is the shareholder of the firm, household squeeze out the resourses from the firm and leave the firm suboptimal. This is a myopic behavior, having more resorses at the household's hand, it is not efficient.

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A Baseline Results

Table 17: Investment Panel Regression

Dependent var.	$\text{inv}_{i,t}$	$\text{inv}_{i,t}$
Uncertainty var.	MU	VIX
$\text{CF}_{i,t}$	0.0713^{***} (0.0032)	0.1546^{***} (0.0149)
$\text{U}_t \times \text{CF}_{i,t}$	-0.0740^{***} (0.0117)	-0.1072^{***} (0.0160)
$\text{cds}_{i,t}$	-0.0711^{***} (0.0223)	-0.2110^{**} (0.0895)
$\text{U}_t \times \text{cds}_{i,t}$	0.2598^{***} (0.0811)	0.2114^{**} (0.0936)
$\text{lev}_{i,t-1}$	0.0002^{*} (0.0001)	0.0007 (0.0005)
$\text{U}_t \times \text{lev}_{i,t-1}$	-0.0014^{***} (0.0005)	-0.0008 (0.0006)
$\text{age}_{i,t}$	-0.0025^{***} (0.0007)	-0.0083^{***} (0.0030)
$\text{U}_t \times \text{age}_{i,t}$	0.0048^{**} (0.0023)	0.0074^{**} (0.0031)
$\text{tan}_{i,t-1}$	0.0051^{**} (0.0021)	0.0057 (0.0098)
$\text{U}_t \times \text{tan}_{i,t-1}$	0.0072 (0.0073)	0.0011 (0.0102)
$\text{Z}_{i,t-1}$	0.0001 (0.0005)	-0.0003 (0.0024)
$\text{U}_t \times \text{Z}_{i,t-1}$	-0.0005 (0.0019)	0.0003 (0.0025)
$\text{Q}_{i,t-1}$	0.0009 (0.0008)	0.0025 (0.0040)
$\text{U}_t \times \text{Q}_{i,t-1}$	0.0030 (0.0030)	-0.0011 (0.0042)

Notes. Above table shows the results for the investment regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Table 18: Cash Panel Regression

Dependent var.	$\text{cash}_{i,t}$	$\text{cash}_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
U_t	0.0189^{***}	0.0182^{***}
	(0.0068)	(0.0038)
$CF_{i,t}$	-0.2602	0.1298^{***}
	(0.2338)	(0.0398)
$U_t \times CF_{i,t}$	0.4132	-0.0482
	(0.2563)	(0.1593)
$\text{cash}_{i,t-1}$	0.6985^{***}	0.6992^{***}
	(0.0143)	(0.0143)
$\text{cash}_{i,t-2}$	0.1133^{***}	0.1128^{***}
	(0.0137)	(0.0137)
$\text{cash}_{i,t-3}$	0.1397^{***}	0.1395^{***}
	(0.0099)	(0.0099)
$\text{size}_{i,t-1}$	-0.0001	-0.0001
	(0.0002)	(0.0002)
$Q_{i,t-1}$	0.0006	0.0006
	(0.0005)	(0.0005)
$\text{lev}_{i,t-1}$	-0.0038^{**}	-0.0038^{**}
	(0.0015)	(0.0015)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the results for the cash regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Table 19: Dividend Panel Regression

Dependent var.	$\text{div}_{i,t}$	$\text{div}_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
$\text{div}_{i,t-1}$	0.5871^{***} (0.0204)	0.5949^{***} (0.0206)
$\text{CF}_{i,t}$	-13.631 (10.151)	4.2847^{***} (2.1705)
$\text{U}_t \times \text{CF}_{i,t}$	26.171^{**} (10.830)	31.007^{***} (9.7063)
$\text{cds}_{i,t-1}$	-9.0011^{*} (5.3166)	-5.9518^{***} (1.4413)
$\text{U}_t \times \text{cds}_{i,t}$	6.3247 (5.5723)	12.721^{**} (5.4354)
$\text{lev}_{i,t-1}$	1.7583^{**} (0.8706)	1.3975^{**} (0.2172)
$\text{U}_t \times \text{lev}_{i,t-1}$	-0.7501 (0.9272)	-1.7913^{**} (0.8413)
$\text{age}_{i,t}$	0.0155 (0.1574)	0.0541 (0.0406)
$\text{U}_t \times \text{age}_{i,t}$	0.0232 (0.1661)	-0.1191 (0.1527)
$\text{Z}_{i,t-1}$	0.4704^{***} (0.1374)	0.2830^{***} (0.0330)
$\text{U}_t \times \text{Z}_{i,t}$	-0.2719^{*} (0.1454)	-0.3394^{***} (0.1278)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the results for the dividend regression, where I use macro uncertainty, MU (Jurado et al., 2015) and implied volatility index, VIX as the proxy for uncertainty measure. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

B Robust Test Result

Table 20: Robust Test: Investment Panel Regression using FU and EPU

Dependent var.	$\text{inv}_{i,t}$	$\text{inv}_{i,t}$
Uncertainty var.	FU	EPU
Column	1	2
$\text{CF}_{i,t}$	0.0832***	0.0645***
	(0.0024)	(0.0032)
$\text{U}_t \times \text{CF}_{i,t}$	−0.0279***	−0.0045***
	(0.0060)	(0.0014)
$\text{cds}_{i,t}$	−0.1001**	−0.0450**
	(0.0405)	(0.0212)
$\text{U}_t \times \text{cds}_{i,t}$	0.0887**	0.0120
	(0.0381)	(0.0100)
$\text{lev}_{i,t-1}$	0.0005**	0.0001
	(0.0003)	(0.0001)
$\text{U}_t \times \text{lev}_{i,t-1}$	−0.0006**	−0.00009
	(0.0002)	(0.00005)
$\text{age}_{i,t}$	−0.0034***	−0.0026***
	(0.00013)	(0.0006)
$\text{U}_t \times \text{age}_{i,t}$	0.0019	0.0006**
	(0.0012)	(0.0003)
$\text{tan}_{i,t-1}$	0.0020	0.0065***
	(0.0041)	(0.0022)
$\text{U}_t \times \text{tan}_{i,t-1}$	0.0047	0.0001
	(0.0039)	(0.0009)
$\text{Z}_{i,t-1}$	0.0007	0.0002
	(0.0010)	(0.0005)
$\text{U}_t \times \text{Z}_{i,t-1}$	−0.0007	−0.0001
	(0.0010)	(0.0002)
$\text{Q}_{i,t-1}$	0.0005	0.0013*
	(0.0016)	(0.0008)
$\text{U}_t \times \text{Q}_{i,t-1}$	0.0011	−0.00004
	(0.0016)	(0.0003)
No. Obs	21745	21745
SE type	firm level	firm level

Notes. Above table shows the robust test results for the investment regression, where I use financial uncertainty, FU (Ludvigson et al., 2021) and economic policy uncertainty, EPU (Baker et al., 2016) as the proxy for uncertainty level. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Table 21: Robust Test: Cash Panel Regression using FU and EPU

Dependent var.	$\text{cash}_{i,t}$	$\text{cash}_{i,t}$
Uncertainty var.	FU	EPU
Column	1	2
U_t	0.0098^{***} (0.0021)	0.0024^{***} (0.0007)
$\text{CF}_{i,t}$	0.1750^{*} (0.0900)	0.1606^{***} (0.03507)
$\text{U}_t \times \text{CF}_{i,t}$	-0.0472 (0.0928)	-0.0280 (0.0282)
$\text{cash}_{i,t-1}$	0.7028^{***} (0.0142)	0.6991^{***} (0.0143)
$\text{cash}_{i,t-2}$	0.1126^{***} (0.0137)	0.1128^{***} (0.0137)
$\text{cash}_{i,t-3}$	0.1317^{***} (0.0097)	0.1393^{***} (0.0099)
$\text{size}_{i,t-1}$	-0.0003^{*} (0.0002)	-0.0001 (0.0002)
$\text{Q}_{i,t-1}$	0.0005 (0.0005)	0.0007 (0.0007)
$\text{lev}_{i,t-1}$	-0.0057^{***} (0.0016)	-0.0034^{**} (0.0015)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the robust test results for the cash regression, where I use financial uncertainty, FU (Ludvigson et al., 2021) and economic policy uncertainty, EPU (Baker et al., 2016) as the proxy for uncertainty level. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

Table 22: Robust Test: Dividend Panel Regression using FU and EPU

Dependent var.	$div_{i,t}$	$div_{i,t}$
Uncertainty var.	MU	VIX
Column	1	2
$div_{i,t-1}$	0.5844^{***} (0.0204)	0.5848^{***} (0.0207)
$CF_{i,t}$	-1.8663 (3.7262)	5.4237^{***} (2.1705)
$U_t \times CF_{i,t}$	13.452^{**} (3.8390)	2.8551^{***} (1.0543)
$cds_{i,t-1}$	-2.1173 (2.4585)	-2.3920^{**} (1.2089)
$U_t \times cds_{i,t}$	-1.2788 (2.3419)	-0.8270 (0.5634)
$lev_{i,t-1}$	1.1174^{***} (0.3360)	1.2548^{***} (0.2003)
$U_t \times lev_{i,t-1}$	-0.0748 (0.3377)	-0.1243 (0.0894)
$age_{i,t}$	0.1304^{**} (0.0636)	0.0547 (0.0378)
$U_t \times age_{i,t}$	-0.1037^{*} (0.0621)	-0.0113 (0.0159)
$Z_{i,t-1}$	0.2963^{***} (0.0546)	0.2861^{***} (0.0320)
$U_t \times Z_{i,t}$	-0.0856 (0.0532)	-0.0402^{***} (0.0132)
No. Obs	21656	21656
SE type	firm level	firm level

Notes. Above table shows the results for the dividend regression, where I use financial uncertainty, FU (Ludvigson et al., 2021) and economic policy uncertainty, EPU (Baker et al., 2016) as the proxy for uncertainty level. I suppress the coefficient on the uncertainty, however the uncertainty level is in the regression. I cluster the standard error at the firm level according. I also not report the fixed effect. $*** = p < 0.01$, $** = p < 0.05$, and $* = p < 0.1$. Standard error in the parenthesis.

C Deriving the Equation (4)

The firm's first order condition with respect to i_t and k_{t+1} are

$$\mu_t = \lambda_t \delta^{\nu} \left(\frac{i_t}{k_t}\right)^{-\nu}$$
$$\lambda_t = E_t M_{t,t+1} \left\{ (1-\tau)\mu_{t+1} \alpha A_{t+1} k_{t+1}^{\alpha-1} + \lambda_{t+1} \left[\frac{1-\nu-\delta}{1-\nu} + \frac{\delta^{\nu}\nu}{1-\nu} \left(\frac{i_{t+1}}{k_{t+1}}\right)^{1-\nu} \right] \right\}$$

Plug the investment FOC into the capital FOC:

$$\mu_t \delta^{-\nu} \left(\frac{i_t}{k_t}\right)^{\nu} = E_t M_{t,t+1} \left\{ (1-\tau)\mu_{t+1} \alpha A_{t+1} k_{t+1}^{\alpha-1} + \mu_{t+1} \delta^{-\nu} \left(\frac{i_{t+1}}{k_{t+1}}\right)^{\nu} \left[\frac{1-\nu-\delta}{1-\nu} + \frac{\delta^{\nu}\nu}{1-\nu} \left(\frac{i_{t+1}}{k_{t+1}}\right)^{1-\nu} \right] \right\}$$

Rearrange, we have

$$\mu_t \delta^{-\nu} \left(\frac{i_t}{k_t}\right)^{\nu} = E_t \frac{M_{t,t+1}\mu_{t+1}}{\mu_t} \left[(1-\tau)\alpha A_{t+1} k_{t+1}^{\alpha-1} + \frac{\delta^{-\nu}(1-\nu-\delta)}{1-\nu} \left(\frac{i_{t+1}}{k_{t+1}}\right)^{\nu} + \frac{\nu}{1-\nu} \left(\frac{i_{t+1}}{k_{t+1}}\right) \right]$$

Given $\nu \in (0,1)$ and $1-\nu-\delta > 0$, we define

$$f(x) = \frac{\delta^{-\nu}(1-\nu-\delta)}{1-\nu} x^{\nu} + \frac{\nu}{1-\nu} x$$

is an increasing function of x. And $\alpha A_{t+1} k_{t+1}^{\alpha-1}$ is the marginal product of capital.