

Cash Heterogeneity and the Payout Channel of Monetary Policy*

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Abstract

This paper studies the role of corporate cash holdings in the transmission of monetary policy to equity payouts and risk premia. I document that cash-rich firms have higher equity payouts and higher stock prices in response to expansionary monetary policy surprises. Stock prices rise despite weak cash flow, investment, and credit responses to monetary policy, thus suggesting a tight link between observed firm values and the payout channel. I rationalize the empirical evidence in a New Keynesian model where firms finance investment with cash and equity issuance. Monetary easing weakens precautionary cash demand, leading cash-rich firms to allocate excess funds to shareholders optimally. Since payouts are procyclical, cash-rich firms earn higher returns in expansionary periods. My findings stand against the view that the payout channel is inefficient and undesirable.

Keywords: Monetary policy, Cash Holdings, Equity Payout, Risk Premia, General Equilibrium

JEL: E12, E52, G12, G32

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1 Introduction

Corporate equity payouts have risen substantially in the last few decades. Figure 1 highlights that equity payouts as a share of GDP have roughly quadrupled between 1990 and 2015. There is growing concern that loose monetary policy fuels this surge by stimulating firms to divert resources from productive investment into equity payouts.¹ Moreover, the upward trend in equity payouts coincides with a rise in corporate debt, as seen in Figure 1. By associating these two trends, policymakers also point to excessive borrowing in response to low-interest rates as a culprit behind leveraged payouts (Yellen, 2020). In essence, the policy debate emphasizes an *inefficiency* in the economy through the payout channel of monetary policy, which impedes monetary policy transmission to the real economy, weakens firms' balance sheets through leverage, and thereby increases corporate fragility.

The negative view on the payout channel misses two key points: First, it can be misleading to conclude purely from aggregate macroeconomic trends on the causal link between borrowing, payouts, and monetary policy because firms exhibit significant heterogeneity in how they respond to monetary policy.² Therefore, it is plausible that monetary policy transmission to debt issuance and equity payouts goes through different firms, still giving rise to the observed trends in Figure 1. Second, and more importantly, the standard corporate finance models suggest that equity payouts are an essential part of a firm's excess cash allocation process. By providing better use of surplus cash than poor investments, a payout policy can indeed increase shareholder value and thus *enhance efficiency* in the economy (Cochrane, 2018). This function of equity payouts is even more indispensable under an expansionary monetary policy, which potentially increases excess cash buffers by improving cash flows and decreasing interest burdens. As such, this paper aims to explore such an alternative view on the payout channel of monetary policy by exploiting firm heterogeneity in cash holdings, both empirically and theoretically.

¹For example, Furman (2015), the former chairman of the Council of Economic Advisers, states that underinvestment in the low interest rate environment can be partially explained by increased equity payouts. Financial Times (2014) reports that the Fed's aggressive policy of lowering rates spurs share buybacks, in part by activist investors.

²Examples of the role of firm heterogeneity in the transmission of monetary policy include studies by Gertler and Gilchrist, 1994, Bernanke, Gertler, and Gilchrist, 1996, Kashyap, Lamont, and Stein, 1994, Cloyne, Ferreira, Froemel, and Surico, 2018, Ippolito, Ozdagli, and Perez-Orive, 2018, Ottonello and Winberry, 2020.

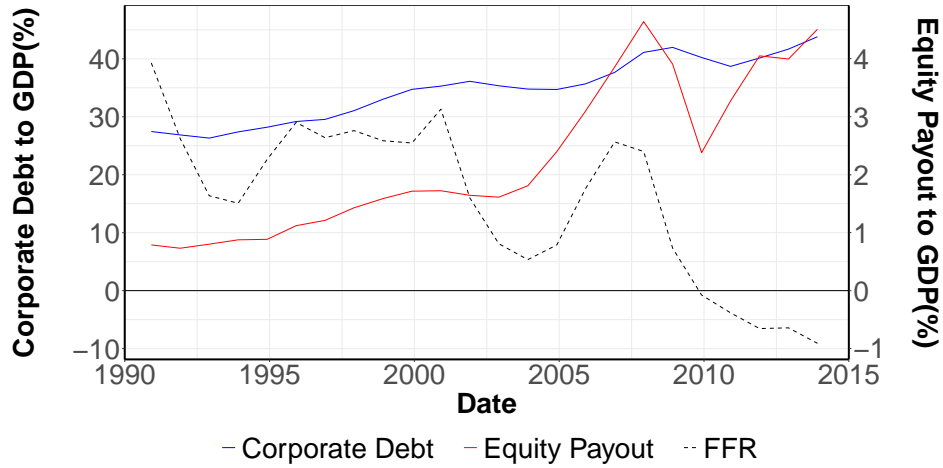


Figure 1: This figure displays trends in corporate borrowing, equity payouts and the stance of monetary policy. Corporate Debt to GDP (blue line, left axis) is computed as Non-financial Corporate Business Debt Securities and Loans from FRED database divided by the real GDP. Equity Payouts to GDP (red line, right axis) is computed as total equity payouts in the Compustat sample divided by the real GDP. The stance of the monetary policy is Fed Fund Rates (including shadow rates below the zero-bound) from [Wu and Xia \(2016\)](#) and displayed on the right axis.

Empirically, I combine the high-frequency monetary policy shocks of [Nakamura and Steinsson \(2018\)](#) with quarterly Compustat data to investigate how cash-rich firms respond to monetary policy. I provide novel empirical evidence that cash-rich firms have higher equity payouts *and* higher stock prices in response to expansionary monetary policy surprises than other firms in the economy. Importantly, higher stock price reactions of cash-rich firms occur *despite* their weak profitability, investment, and credit responses to monetary policy. Weak reactions in all firm outcomes but equity payouts suggest a close link between observed firm values and the payout channel. The rise in stock prices through the payout channel is thereby consistent with the efficiency-enhancing view on equity payouts.

Theoretically, I rationalize the empirical results with a heterogeneous-firm New Keynesian model in which monetary policy drives the discount rate through nominal rigidities. The calibrated model reproduces the observed investment, equity payout, and price responses of firms to monetary policy. In the model, as in the data, cash-rich firms have weak profitability, higher operating leverage, and a stronger precautionary motive to hold cash. By reducing the discount rate, an expansionary monetary policy decreases external financing costs, thus weakens the precautionary cash demand of cash-rich firms. Because weak profitability dampens the effect of nominal rigidities on cash flows, monetary easing does not stimulate the investment of cash-rich firms. As a result, cash-rich firms optimally allocate excess funds to shareholders in

expansionary periods.

My findings challenge the view that the payout channel of monetary policy is undesirable. Instead of weakening firms' balance sheets via leveraged buybacks, monetary easing facilitates the return of idle cash to investors. Although the weak investment channel of cash-rich firms may elicit the idea of "malinvestment" ([Acharya and Plantin, 2019](#)), my model provides an opposing structural interpretation. Firms with higher precautionary motives to hoard cash are also firms with poor cash flows, hence with weak incentives to invest in productive capital when monetary easing lowers the cost of capital. Share prices reflect that it is indeed optimal that cash-rich firms disburse uninvested cash when financial conditions improve ([Bolton, Chen, and Wang, 2013](#)). Notably, monetary policy impacts asset prices because it has real effects on firm activity, not just directly on the real interest rate.

I begin my empirical analysis by providing panel data evidence on how a firm's equity payout responses to a monetary policy shock depend on the firm's cash holdings. I find that one standard deviation higher cash ratio implies that a firm's equity payouts are approximately 20% more responsive to monetary policy.³ Since dividends are sticky, such payout responsiveness is mainly driven by share repurchases.⁴ The repurchase responsiveness is also economically significant, amounting to roughly 15% of average quarterly repurchases in response to a 25 basis point rate cut. Notably, the payout responses of firms persist for up to 2 years after the shock, suggesting a role for the future path of monetary policy captured by high-frequency shocks of [Nakamura and Steinsson \(2018\)](#). Therefore, the persistent payout responses in the data support a central role for Fed promises in affecting firm outcomes and the real economy.⁵

I pin down the economic mechanisms behind the equity payout responses to monetary policy by extending the panel data analysis to other firm outcomes. First, I find that the debt issuance responses of cash-rich firms to monetary policy shocks are statistically and econom-

³In all specifications, I use lagged cash holdings, which are predetermined at the time of the monetary policy shock. This approach alleviates the concern that monetary policy pass-through to cash demand confounds the results. In this regard, my analysis differs from the studies that investigate the interest rate sensitivity of corporate cash balances (e.g., [Azar, Kagi, and Schmalz, 2016](#), [Gao, Whited, and Zhang, 2021](#))

⁴A large body of literature documents the stickiness of dividends. See e.g., [Farre-Mensa, Michaely, and Schmalz \(2014\)](#) for a comprehensive literature review.

⁵[Nakamura and Steinsson \(2018\)](#) show that policy news shocks contain information about both the future path of monetary policy and the future path of economic activity labeled as the information channel. In Appendix B.3, I show that my results are robust to controlling for the information channel of monetary policy using contemporaneous Greenbook forecasts and Greenbook revisions.

ically insignificant. Instead, cash-rich firms reduce their cash savings in response to expansionary shocks. This finding is at odds with the leveraged payouts view, i.e., the payout rally is fueled by credit expansion under an expansionary monetary policy. Second, I show that cash-rich firms also have insignificant cash-flow and investment responses to monetary policy shocks. At first, the weak investment response can be interpreted as equity payouts *non-optimally* crowding out investment. However, the evidence from stock prices suggests otherwise. The cross-sectional asset pricing tests show that expansionary monetary policy shocks lead to higher returns for cash-rich firms than other firms in the economy. Thus, the values of cash-rich firms positively react to expansionary shock despite their weak cash flow and investment responses to monetary policy. Those results are consistent with the idea that monetary policy leads firms to *optimally* allocate excess cash into equity payouts, improving the efficiency in the economy.

Motivated by the empirical evidence, I merge a model of heterogeneous firms with a standard New Keynesian framework. On the firm side, firms with idiosyncratic productivity are subject to operational and investment costs; they invest in capital using either internal profit, cash savings, or equity issuance as a sole source of external financing.⁶ The cost of equity issuance brings about a standard precautionary motive for accumulating cash to finance business operations (e.g., [Riddick and Whited, 2009](#)). On the New Keynesian side, nominal rigidities are separate from the firm block of the model as in [Ottonello and Winberry \(2020\)](#). I model a monetary policy shock as an innovation to a Taylor Rule, enabling the model-data mapping. The monetary policy shock is persistent and the only source of aggregate uncertainty in the model. As usual, sticky prices give rise to a conventional New Keynesian Phillips Curve that specifies the inflation rate. I calibrate and solve the recursive equilibrium of the model using standard parameters and matching investment, cash saving, and life-cycle dynamics of the stationary equilibrium.

Qualitatively, the model provides a unified framework for interpreting the interaction between capital, equity issuance, and cash saving dynamics together with the implications of

⁶The model incorporates equity issuance cost as the sole source of financing for two reasons. First, the model aims to replicate the features of the data by completely isolating from credit channel of monetary policy. Second, debt as an additional decision variable would increase the dimensionality and add significant complexity in solving the recursive equilibrium of the model. I leave the computations of a model that includes debt financing for future research.

monetary policy pass-through. In the model, firms with lower productivity face higher uncertainty to cover their operational costs; they have lower profitability and higher operating leverage. Due to such income uncertainty, those firms hold higher precautionary cash balances to avoid costly external financing. On the one hand, the low income of cash-rich firms dampens the effect of nominal rigidities on their cash flows, muting their investment response to monetary policy. On the other hand, lower external financing costs following an expansionary shock reduce the need to hold precautionary savings, thus leading cash-rich firms to pay out excess cash. An expansionary shock also stimulates the consumption demand of households due to sticky prices. Thus, the model endogenously generates a negative correlation between payouts of cash-rich firms and the marginal utility of consumption (i.e., the real rate). Put differently, cash-rich firms have pro-cyclical and riskier payout claims; their prices thereby respond positively to an expansionary shock. Notably, expansionary monetary policy surprises are good news for shareholders of cash-rich firms even though those firms have lower income and investment responses to monetary policy.

Quantitatively, I simulate a panel of firms from the calibrated model and replicate exercises in the empirical section. The model is successful in reproducing the empirical findings on equity payout price responses to expansionary shocks for cash-rich vs. cash-poor firms. In the simulated model, as in the data, payout responsiveness is persistent, reflecting the impact of the expected path of monetary policy. To demonstrate the role of frictions, I conduct experiments in which I alter one of the frictions in the model. Quantitative analysis implies that issuance and operating costs play principal roles in driving equity payout responses. By contrast, investment costs are more crucial in generating weak investment responses of cash-rich firms. The simulated model is also consistent with the cross-sectional asset pricing dynamics of the data. Expansionary monetary policy induces higher prices for cash-rich firms, as they have higher payouts in good times, that is, the periods of low marginal utility.

Related Literature: My paper is related to several strands of literature. First, it contributes to growing body of work that explores the role of firm heterogeneity in shaping monetary policy transmission. Recent studies mostly focus on the investment response to monetary policy, analyzing how it varies across different firm characteristics such as leverage and default risk

([Ottanello and Winberry, 2020](#)), age ([Cloyne, Ferreira, Froemel, and Surico, 2018](#)), bank debt ([Ippolito, Ozdagli, and Perez-Orive, 2018](#)) and cash ([Jeenas, 2018](#)). By contrast, I provide new evidence for a payout channel of monetary policy that enhances allocative efficiency in the economy by optimally distributing surplus resources. Not only does the existence of the payout channel support the monetary non-neutrality that is consistent with the New Keynesian view, but it also challenges the policy view on the adverse effects of monetary policy, such as leveraged payouts ([Acharya and Plantin, 2019](#)). Unlike much of the literature on debt financed payouts ([Farre-Mensa, Michaely, and Schmalz, 2020](#)), my paper shows that monetary policy shocks transmit to equity payouts and debt issuance through different firm characteristics.⁷

Second, my paper is also related to the literature that provides an integrated discussion of macroeconomics and the cross-sectional differences in cash saving, financing, and payout behavior of heterogeneous firms (e.g., [Covas and Den Haan, 2011](#), [Jermann and Quadrini, 2012](#), [Begenau and Salomao, 2019](#)).⁸ Most studies emphasize productivity and financial shocks as determinants of firm operations. My paper contributes to this literature by rationalizing firms' cash and payout dynamics with a model that features monetary policy shock as a source of aggregate uncertainty. To the best of my knowledge, I provide the first model that builds a bridge between structural corporate finance literature with cash holdings and costly equity issuance as a sole source of external financing (e.g., [Riddick and Whited, 2009](#)) and the New Keynesian literature. As such, my model serves to interpret the causal effects of high-frequency monetary policy shocks on firm dynamics.

My paper differs from recent studies that focus on the interest rate sensitivity of corporate cash holdings, such as [Azar, Kagy, and Schmalz \(2016\)](#) and [Gao, Whited, and Zhang \(2021\)](#). Those studies primarily examine cash balances as outcomes, while my work exploits predetermined cash savings to identify the monetary policy pass-through on equity payouts. In addition, I use high-frequency monetary policy shocks to emphasize the causal effect of monetary

⁷Recently, [Elgouacem and Zago \(2019\)](#) argue that firms with lower corporate bond yields in response to monetary easing tend to repurchase more. Authors interpret this finding as firms issuing more debt for stock buybacks, though my empirical results on debt issuance do not support this interpretation.

⁸The empirical corporate finance literature on stock buybacks essentially focuses on local isolated effects of the asymmetric information and moral hazard frictions on buybacks. However, this literature does not deliver a full assessment of equity payout cyclicalities with a notable exception of [Dittmar and Dittmar \(2008\)](#). By contrast, this paper caters to the macro literature that treats equity payouts as residual internal funds distributed after optimal firm policies are taken and mainly analyzes the cyclical drivers of payouts.

policy, not interest rates. My model of heterogeneous firms shares similar features (e.g., precautionary motive) with [Gao, Whited, and Zhang \(2021\)](#), in which external financing premium also affects cash demand beyond the standard interest cost of holding cash. In [Gao, Whited, and Zhang \(2021\)](#), low discount rates drive down external financing premia through lower default risks. By contrast, my model does not feature debt and default, while it characterizes the dynamics of the discount rate and external financing premium through nominal rigidities. As such, my paper is also quantitatively consistent with the causal effects of high-frequency monetary policy shocks in the data.

Finally, my results also relate to the body of literature that studies the effect of monetary policy on asset prices (e.g., [Bernanke and Kuttner \(2005\)](#), [Gürkaynak, Sack, and Swanson \(2005\)](#)). The recent empirical literature has increasingly focused on cross-sectional differences in response to monetary policy shocks, though the results are mixed.⁹ I contribute to this literature by showing that cash-rich firms are also more exposed to monetary policy shocks through their payout responsiveness despite their muted investment and cash-flow response to monetary policy. The cross-sectional risk premium is consistent with a New Keynesian model, in which monetary policy drives business cycles. My model thereby subscribes to the standpoint held by recent literature that rationalizes cross-sectional monetary policy risk premium with New Keynesian framework, such as [Li and Palomino \(2014\)](#) and [Weber \(2015\)](#). In my model, monetary policy moves stock prices because it has real economic effects on firm activity, not just because it directly drives the real interest rate or risk aversion (e.g., [Pflueger and Rinaldi, 2020](#)).

The rest of the paper is organized as follows. Section 2 presents empirical results on heterogeneous responses of both firm policies and stock returns to monetary policy shocks. Section 3 describes the model, its solution method and its economic intuition. Section 4 provides details on the model calibration. Section 5 discusses the model results. Section 6 concludes.

⁹For example, one strand of the literature shows that firms with poor cash flows ([Ehrmann and Fratzscher, 2004](#)), high bank dependence ([Ippolito, Ozdagli, and Perez-Orive \(2018\)](#)), higher financial constraints ([Chava and Hsu, 2015](#)) react positively to expansionary monetary policy. In contrast to this literature, [Ozdagli and Velikov \(2020\)](#) and [Ai, Han, Pan, and Xu \(2020\)](#) recently construct measures of firm-level monetary policy exposure, which negatively predicts the cross-section of stock returns in response to an expansionary shock.

2 Empirical Results

2.1 Data Description

Compustat Universe I obtain firm-level variables from the quarterly Compustat database of publicly listed U.S. firms. Data construction follows the standard procedures in the literature. I follow [Begenau and Salomao \(2019\)](#) to construct main measures of external financing. *Equity repurchases* are defined as any funds that decrease common and/or preferred stock. Total equity payout represents the sum of equity repurchases and *cash dividends* paid for common capital, preferred capital and other share capital. I construct *debt payouts* as the negative sum of the change in short term and long term debt. The main explanatory variable, corporate cash holdings, is defined as cash and short-term investments. Cash holdings (equity payouts) are normalized by the (lagged) market value of assets.¹⁰

Appendix A provides details of data construction and sample selection procedures. Table 1 reports the summary statistics of the main variables in the final sample selection. The quarterly mean equity repurchases (total equity payouts) rate is 0.34% (0.68%) of total lagged assets with a standard deviation of 1.65% (2.15%). Firms have positive repurchases ($\mathbb{1}_{Rep_{it}}$) and total equity payouts ($\mathbb{1}_{EqOut_{it}}$) in 9% and 17% of all firm-quarters, respectively. The quarterly mean cash ratio is approximately 12% with a standard deviation of 16%.

Cash Heterogeneity: To demonstrate the cross-sectional cash heterogeneity in the data, I sort firms into quintiles based on their cash ratio and form four portfolios. Table 2 highlights crucial differences between high and low cash holding portfolios, which are also discussed in previous literature. First, firms with larger cash holdings are smaller than other firms and have lower leverage, i.e. they rely less on debt as an external financing tool. These statistics are consistent with previous literature, which shows that firms with greater frictions in obtaining external capital accumulate more cash (e.g., [Opler, Pinkowitz, Stulz, and Williamson, 1999](#), [Acharya, Davydenko, and Strebulaev, 2012](#)). Second, cash-rich firms have lower profitability and higher

¹⁰I normalize financial variables by the market value of assets to better incorporate the size of firms' intangibles. Cash ratios are especially normalized by the market value of assets in asset pricing literature (e.g., [Campbell, Hilscher, and Szilagyi, 2008](#), [Ozdagli and Velikov, 2020](#)). Appendix B.7 shows that main results of the paper are robust to normalizing all variables by the book value of assets instead. I also normalize outcome variables by lagged, i.e., predetermined, values to alleviate the concern that contemporaneous effects on asset values confound results.

	Mean	SD	p5	p25	p50	p75	p95
Rep, %	0.34	1.65	0.00	0.00	0.00	0.03	1.72
EqOut, %	0.68	2.15	0.00	0.00	0.00	0.58	2.99
$\mathbb{1}_{Rep}$	0.09	0.28	0.00	0.00	0.00	0.00	1.00
$\mathbb{1}_{Eqout}$	0.17	0.38	0.00	0.00	0.00	0.00	1.00
cash, %	12.05	15.88	0.30	2.09	6.42	15.69	42.73
Asset	3717.92	16019.91	12.81	71.07	324.46	1626.82	15233.42

Table 1: This table reports summary statistics of firm-level variables from the Compustat database. The observations are firm-quarter level. Rep is the ratio of total repurchases to lagged total assets, Eqout is the ratio of total payouts to lagged total assets, $\mathbb{1}_{Rep}$ ($\mathbb{1}_{EqOut}$) indicates whether the firm has distributed any repurchases (repurchases+dividends) in a given quarter, *cash* is the ratio of cash and short-term investments to the market value of assets, Asset is the total book value of assets. Data are used from 1990 to 2014.

operating leverage than relatively cash-poor firms.¹¹ Those statistics suggest that cash saving policies also depend on firms' gross and net income as well as operating expenses, not just external financing frictions. In fact, lower profitability and cash flows, hence higher operating leverage, have been shown one of the key mechanisms of precautionary savings in e.g., [Riddick and Whited \(2009\)](#). Third, cash-rich firms have lower investment rates consistent with their low Tobin's Q ratios as well as higher financial constraints. Yet, those firms also have higher R&D ratios. This statistic is consistent with [Begenau and Palazzo \(2020\)](#), who shows an selection effect of young and less profitable R&D firms on the cash composition in the economy. Finally, cash-rich firms have slightly higher total payout ratios as compared to other firms in the sample. The difference is mostly driven by higher repurchase ratios of cash-rich firms.

Monetary Policy Shocks I employ high-frequency shocks to monetary policy used extensively in the previous event-study literature, such as [Kuttner \(2001\)](#), [Gorodnichenko and Weber \(2016\)](#) and [Nakamura and Steinsson \(2018\)](#). In my main analysis, I use the measure of monetary policy news shocks from [Nakamura and Steinsson \(2018\)](#) (NS). Importantly, these shock series include information from long-term rates, and cover the period after the financial crises. The NS series begins in February 1995 and ends in March 2014. In order to take advantage of a longer time-series, I embed the monetary surprises from [Kuttner \(2001\)](#) from January 1990

¹¹I use flow-based operating leverage measure with revenues as denominator rather than assets. This measure associates operating leverage with fixed and variable costs and cash flows. Therefore, it better reflects the main trade-off in the economic model of Section 3.

	Low	2	3	4	High
Size	8.88	8.94	8.87	8.66	8.24
Leverage	0.32	0.28	0.22	0.16	0.10
Profitability, %	12.31	10.48	10.73	10.52	8.42
Operating Leverage	0.98	0.91	0.97	1.01	1.14
Tobin's Q	3.25	2.26	2.40	2.33	1.76
Investment Rate, %	0.94	0.94	1.02	1.29	2.33
R&D, %	0.31	0.40	0.71	1.17	2.12
EqOut, %	0.41	0.43	0.42	0.43	0.52

Table 2: This table reports summary statistics for quintile portfolios of firms sorted based on their cash holdings. "Low" firms make up quintile 1 and "High" firms make up quintile 5. Size is the logarithm of the market value of assets in millions of dollars. Leverage is total book value of debt divided by the market value of assets. Capex rate is quarterly capital expenditures divided by the market value of assets. Profitability is quarterly gross profits over lagged assets. Tobin's Q is the market value of equity plus the book value of debt and book value of preferred equity minus inventories and deferred taxes divided by the book value of assets. Operating Leverage is computed as cost of goods sold plus selling general and administrative expenses divided by sales. R&D Intensity is research and development expenses in a given quarter divided by market value of assets. EqOut is the ratio of total payouts to lagged assets. Data are used from January 1990 to March 2014.

to January 1995 into the NS series. In the robustness checks, I also obtain results with another high-frequency measure from [Gorodnichenko and Weber \(2016\)](#) (GW) and the raw changes in the Fed Funds rate, including shadow rates during zero lower bound, from [Wu and Xia \(2016\)](#) (WX). I thank all authors for graciously providing their data.

Table 3 provides summary statistics for each monetary policy instrument. The mean is approximately zero for each high frequency shocks. GW and NS high-frequency shocks are qualitatively similar, though NS shocks are available for a longer time-series. The raw changes of interest rate in WX have a larger standard deviation of 20 basis points than two other high-frequency monetary policy instruments.

To combine monetary shocks with firm-level Compustat data, I construct a quarterly measure of monetary shocks by simple summation of the high-frequency shocks within any quarter t . Quarterly shocks display properties similar to monetary policy instruments presented in [Ottonello and Winberry \(2020\)](#). The main instrument of this paper, NS shocks have 97 quarter of observations with a mean of negative 2.6 and a standard deviation of 12.6 basis points. These statistics imply NS shocks as a more conservative instrument than GW and WX shocks with larger means and standard deviations. In Appendix A4, I show that the main empirical results are robust to the inclusion of GW or WX instruments in analysis.

Statistic	High Frequency			Aggregate		
	ΔNS	ΔGW	ΔWX	ΔNS	ΔGW	ΔWX
Mean	0.000	-0.015	-0.038	-0.026	-0.059	-0.115
Median	0.007	0.000	-0.010	0.008	-0.010	-0.030
St. Dev.	0.044	0.091	0.198	0.126	0.156	0.463
Min	-0.243	-0.460	-0.960	-0.590	-0.590	-1.660
Max	0.099	0.150	0.530	0.230	0.260	0.770
N	162	137	291	97	80	97

Table 3: This table reports summary statistics of monetary policy shocks. "High frequency" shocks are obtained from [Nakamura and Steinsson \(2018\)](#) (NS), [Gorodnichenko and Weber \(2016\)](#) (GW) and [Wu and Xia \(2016\)](#) (WX). Aggregate shocks are time-aggregated to quarterly frequency by simply summing all shocks within a quarter. Aggregate shocks of NS (GW) include shocks from [Kuttner \(2001\)](#) for the period 1990-1995 (1990-1994).

2.2 Panel Evidence

In this section, I explore the cross-sectional cash heterogeneity in the responsiveness of firm outcomes to monetary policy. I start with documenting that firms with higher cash holdings are significantly more responsive to monetary policy shocks in their equity payout policy. Then, I use local projections to highlight that heterogeneous payout responses to monetary policy are persistent. Finally, I investigate the monetary policy responsiveness of other firm outcomes, such as investment, debt issuance, cash holdings and profitability.

Heterogeneous Responses of Equity Payouts to Monetary Policy I estimate the following specification for variants of y_i :

$$y_{i,t} = \alpha_i + \alpha_{s,t} + \beta cash_{i,t-1} \varepsilon_t^m + \Gamma'_1 Z_{i,t-1} + \epsilon_{i,t} \quad (1)$$

where $y_{it} \in \{Rep_{it}, EqOut_{it}, \mathbb{1}_{Rep_{it}}, \mathbb{1}_{EqOut_{it}}\}$ is the firm's repurchase ratio, total equity payout ratio, an indicator of positive repurchase policy or an indicator of positive total payout policy at quarter t , ε_t^m is monetary policy shock at quarter t , $cash_{i,t}$ is the firm's cash ratio, and $\epsilon_{i,t}$ is a regression residual. In baseline specification, I include a firm i fixed effect (α_i) to account for unobserved time-invariant differences across firms, and a sector s by quarter t fixed effect (α_{st})

	<i>Rep_{it}</i>			<i>EqOut_{it}</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.207*** (3.772)	0.199*** (3.599)	0.203*** (3.479)	0.147* (1.947)	0.131* (1.708)	0.143* (1.747)
ΔNS			-0.018 (-0.273)			0.050 (0.641)
Firm controls	No	Yes	Yes	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	Yes	Yes	No	Yes	Yes	No
Observations	207,560	206,537	206,537	207,560	206,537	206,537
R ²	0.056	0.058	0.058	0.089	0.092	0.092

Table 4: This table reports the coefficient estimates from the following specification for variants of y_i :

$$y_{i,t} = \alpha_i + \alpha_{s,t} + \beta cash_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Rep_{it}, EqOut_{it}\}$ are the firm's repurchase ratio or the total equity payout ratio, α_i is a firm i fixed effect, α_{st} is a sector s by quarter t fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of leverage, market cap, sales growth, Tobin's Q and ROA. ε_t^m is normalized so that a positive shock is expansionary. All specifications include the the lagged values of cash ratio. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two-way at the firm and quarter level. T-stats are reported in parentheses.

to account for differences in how different industries respond to inter-temporal shocks. I also include a vector of firm-level controls $Z_{i,t}$ that are related to firm operations, such as leverage, market cap, sales growth, Tobin's Q. I lag $cash$ and control variables Z so that they are all set at the time of the monetary shock. All specifications also include the lagged values of cash ratio. The main coefficient of interest is β , which estimates the sensitivity of equity payouts to monetary policy shocks ε_t^m that depends on firms' corporate liquidity. $cash$ is standardized over the entire sample so coefficients reflect standard deviations relative to the mean. I normalize ε_t^m so that a positive shock is expansionary. Standard errors are clustered two-way at the firm and quarter level.

Table 4 reports the results from estimating the specification (1) for repurchases and total equity payouts (i.e. repurchases + dividends). Column (1) and Column (4) presents the results without firm-level controls, implying that firms with higher cash ratios have higher semi-elasticity of equity payout policy. In stock buyback policy, a firm with a one standard deviation higher cash ratio than an average firm is approximately one-fifth a unit as responsive to monetary policy than the average firm. In terms of economic magnitude, such higher responsive-

ness amounts to roughly 15 % of average quarterly repurchases in response to a 25 basis point quarterly rate cut. Adding firm-level controls $Z_{i,t-1}$ in columns (2) and (5) doesn't alter the responsiveness of repurchases and total payouts to monetary shocks. Taken together, columns (2) and (5) suggests that the average responsiveness of repurchases is stronger than that of total equity payouts with "sticky" dividends. Unreported results also show that the dividend policy of firms is not significantly responsive to monetary shocks when firm-level controls are included in regression. Overall, the results indicate that cash-rich firms are more responsive to monetary shocks mostly through their stock buyback policy.

I relax the baseline specification to assess an average effect of monetary policy shock and compare it to the estimated interaction effect β . This second specification removes the industry-time fixed effects, and adds monetary policy shock and additional aggregate controls into the equation as follows:

$$\Delta y_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \gamma \varepsilon_t^m + \Gamma'_1 Z_{i,t-1} + \Gamma'_2 A_{t-1} + \epsilon_{i,t} \quad (2)$$

where A_t is a vector of aggregate controls that include GDP growth, the inflation rate and the unemployment rate. The results in Column (3) and (6) of Table 4 shed some light on the economic significance of the estimated responsiveness to monetary shocks. Both columns indicate that average responsiveness of repurchases and total payouts to monetary policy is almost zero and insignificant. Thus, monetary policy affects payout policies of firms with higher corporate liquidity only. This finding is also supported by Table 6, which highlights that the top cash holding quantile firms have the most responsive payout policies to monetary shocks. The degree of heterogeneity is also high for total payout policies, though the significance of the effect is dampened by the stickiness of dividends.

Another standard way to assess the monetary responsiveness of firms' payout policy is to evaluate whether monetary shocks affect payout decisions at the extensive margin. Table 5 reports the results from estimating the specifications (1) and (2) using $\mathbb{1}_{Rep_{it}}$ and $\mathbb{1}_{EqOut_{it}}$, the indicators for positive gross payouts that are greater than 1% at quarter t , as dependent variables. The evidence suggests that firms with high cash holdings are more responsive to

		$\mathbb{1}_{Rep_{it}}$			$\mathbb{1}_{EqOut_{it}}$	
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	3.810*** (4.109)	3.478*** (3.570)	3.474*** (3.283)	3.937*** (3.748)	3.404*** (3.059)	3.482*** (2.735)
ΔNS			-1.328 (-0.655)			-0.965 (-0.366)
Firm controls	No	Yes	Yes	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	Yes	Yes	No	Yes	Yes	No
Observations	207,560	206,537	206,537	207,560	206,537	206,537
R ²	0.115	0.121	0.119	0.214	0.221	0.219

Table 5: This table reports the coefficient estimates from the following specification for variants of y_i :

$$\Delta y_{i,t} = \alpha_i + \alpha_{s,t} + \beta cash_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{\mathbb{1}_{Rep_{it}}, \mathbb{1}_{EqOut_{it}}\}$ indicates whether the firm has distributed positive repurchases or total equity payouts (repurchases+dividends) in a given quarter, α_i is a firm i fixed effect, α_{st} is a sector s by quarter t fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of leverage, market cap, sales growth, Tobin's Q and ROA. Positive payouts indicate payouts greater than 1% of repurchase ratio in a given quarter t . ε_t^m is normalized so that a positive shock is expansionary. All specifications include the lagged values of cash ratio. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two-way at the firm and quarter level. T-stats are reported in parentheses.

monetary policy in payout decisions. Column (3) shows that firms with one standard deviation higher cash ratio are 3.5% more likely to perform stock buybacks following an expansionary monetary policy shock. The effect of monetary policy on firms repurchase decisions appears as a robust feature of the data at the intensive and the extensive margin.

[Nakamura and Steinsson \(2018\)](#) show that policy news shocks contain information about not only the future path of monetary policy, or monetary policy news, but also the future path of economic activity labeled as the information channel. Therefore, a main concern in my baseline analysis is whether main findings are driven by the information channel of monetary policy, rather than monetary policy news. I control for the information channel of monetary policy using contemporaneous Greenbook forecasts and Greenbook revisions in between FOMC announcements in my baseline specification. [Appendix B.3](#) shows that my main results also hold controlling for the information effects. This finding suggests that the monetary non-neutrality on firms' payout decisions works through Fed news on the future path of monetary policy, rather than the information signaling on the future state of the economy. I will address such

role of policy news by introducing persistent monetary policy shocks in model section.

Appendix B.4 shows that main results also hold with the alternative instruments of monetary policy shocks. The results with GW shocks are qualitatively similar to the main results with NS shocks, however, the magnitude of the interaction coefficient is smaller in the specification with the raw changes in the Fed Funds rate. A plausible interpretation for the dampened coefficient is that the changes in Fed Funds rate is correlated with the real economy, decreasing explanatory power for the causal effect of Fed policy.

Local Projections I further analyze the dynamics of the heterogeneous responses by investigating whether the effect of monetary policy shown in the previous section is just an upon-impact effect or is persistent. Not only can such persistence shed light on the cumulative impact of monetary policy shocks over a longer horizon, but they also provide guidelines for modeling choices. In particular, I study persistence of firm responsiveness to monetary shocks by employing local projections of Jordà (2005). The local projection model is given as:

$$\Delta Rep_{i,t+h} = \alpha_{i,h} + \alpha_{s,t,h} + \beta_h cash_{i,t-1} \epsilon_t^m + \Gamma_h' Z_{i,t-1} + \epsilon_{i,t,h} \quad (3)$$

where $\Delta Rep_{i,t+h}$ is the repurchase growth normalized by assets at quarter $t - 1$ and h is the future horizon. The coefficient β_h captures the cumulative responses of repurchases at quarter $t + h$ to monetary shocks at quarter t conditional on firms' cash holdings at quarter $t - 1$. Panel A in Figure 2 presents the impulse responses estimated from local projections. Firms with high cash holdings are significantly more responsive to a monetary policy shock up to seven quarters after the shock. The statistical significance of the heterogeneity disappears eight quarters after the initial shock. Those findings suggest that heterogeneity in responses is not transitory, but rather long-lived. In the model section, I will address such persistent monetary non-neutrality on firm outcomes by introducing persistent monetary policy shocks.

Time-Series Dynamics of Equity Payouts To analyze the changes in the monetary policy effectiveness over time, I run rolling regressions of the baseline regression specification (1) with

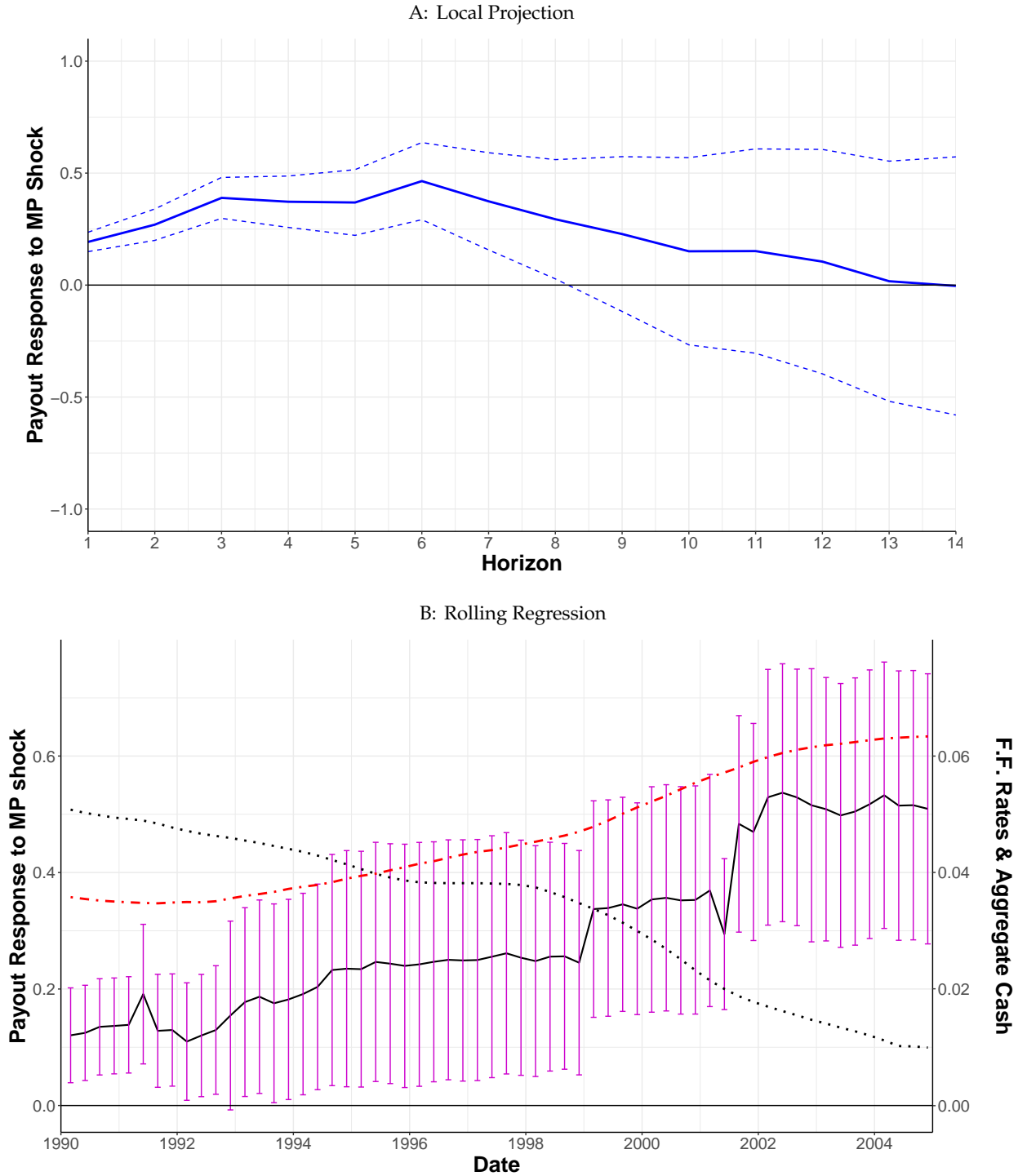


Figure 2: This figure displays the time-series dynamics of the interaction coefficient estimated from local projections and rolling regressions. **Panel A** reports the dynamics of the interaction coefficient estimated from the local projection specification (3) over horizon h . Dashed lines indicate the 90% confidence bands. **Panel B** reports the 90% confidence bands of the interaction coefficient estimated from a rolling regression of the baseline specification (1) with a window length of ten years. Dotted line indicates the average Fed Fund Rates in each rolling window. Dashed line indicates the aggregate cash holdings in each rolling window. Dates represent the beginning quarter-year of each rolling window. In each panel, monetary shocks are normalized so that a positive shock is expansionary.

a window length of 10 years. Panel B in Figure 2 presents the interaction coefficient β as well as the average Fed Fund Rates and aggregate cash holdings of each rolling window. Dates represent the beginning quarter-year of each rolling window. The figure shows that the responsiveness of firms get stronger after 1999. This strength of monetary policy transmission coincides with episodes of declining interest rates and increasing aggregate cash holdings.

It seems monetary policy is more effective on payout policy when the equilibrium interest rates are relatively low and aggregate cash holdings are high. This result is consistent with [Gao, Whited, and Zhang \(2021\)](#), who argue that discount rate channel is more effective than the opportunity cost of cash holding channel in driving corporate cash demand when interest rates are low. As such, policy news appears to become an influential policy tool of monetary policy in a low interest rate environment, i.e. when the marginal impact of a change in future interest rates on the discount rate is high. One could also argue that policy news has become increasingly more effective in recent years when monetary policy stance reflects the equilibrium economic conditions well. (i.e. monetary policy stance as a policy tool actually works.). In this respect, my empirical findings indicate that the information for the future path of interest rates (hence external financing premium) leads firms to time their cash distributions to shareholders optimally

Investment vs. Payout Channels I investigate the role of cash holdings in differential responses of investment to monetary policy. Residual payouts are closely intertwined with the investment, financing and cash saving policies of a firm, hence the responsiveness of investment would shed light on the effects that potentially drive the payout channel. On the one hand, a higher investment response of cash-rich firms would imply cash holdings as a marginal source of financing, as argued in e.g. [Jeenas \(2018\)](#). Since a strong investment channel would deplete cash holdings, a positive payout responsiveness of cash-rich firms to accommodative monetary policy would suggest a strong cash flow effect of nominal rigidities. On the other hand, a weak investment channel of cash-rich firms would leave them ample cash to distribute as payouts. In that case, positive payout responsiveness to expansionary monetary policy is most likely driven by lower precautionary saving needs due to a decline in external financing premium. More importantly, a weak investment channel would imply that policy news may

be good news for investors, not because it will spur further investment and profitability, but because it will allow costly cash buffers to be available to shareholders.

The empirical evidence indicates a weaker investment channel of the monetary policy for cash-rich firms. I show that monetary policy, in fact, affects equity payout and investment decisions through different firm characteristics. Table 6 reports the results estimating the following specification:

$$\Delta y_{i,t} = \alpha_i + \alpha_{s,t} + \beta x_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t} \quad (4)$$

where $y_{i,t} \in \{Rep_{i,t}, \Delta k_{i,t}, \Delta cash_{i,t}\}$ is the firm's repurchase ratio, log investment growth or cash growth at quarter t , $x_{i,t} \in \{Top_cash_{i,t}\}$ is dummy indicators of being in the highest cash ratio or asset quintile at quarter t , and the rest of the variables are as defined in Equation 1. Columns (1) and (3) indicate that firms in the highest cash quintile are the most responsive to monetary policy shocks in repurchase decisions, but not more responsive in their investment decisions. On the other hand, larger firms invest more, while repurchasing less, in response to monetary policy, as seen in Columns (2) and (4). Unreported results from estimating baseline specification (1) with log investment growth as a dependent variable also imply that higher cash ratio has insignificant investment responses to monetary policy shocks. Overall, cash-rich firms do not appear to have a statistically significant investment channel. Instead, Column (5) indicates that cash-rich firms actually use (decrease) their precautionary cash savings in response to monetary policy. Taken together, the results on precautionary cash savings and payout responses suggest that cash-rich firms distribute their excess cash that is not used for further investment growth to shareholders.

Column (9) of Table 6 also reports the results from estimating the specification (4) where $y_{i,t} \in \{\Delta profit_{i,t}\}$ is the profit growth for firm i at quarter t . The results show that cash flows, or profitability, of cash rich-firms are not responsive to expansionary monetary policy shocks. In a New Keynesian framework, those results are also consistent with the convention that poor cash flows render nominal rigidities less effective on the investment channel of cash-rich firms.

	$Rep_{i,t}$		$\Delta k_{i,t}$		$\Delta cash_{i,t}$		$DebtOut_{i,t}$		$\Delta profit_{i,t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Top_cash x ΔNS	0.472*** (5.057)		-0.079 (-0.116)		-0.911* (-1.794)		0.219 (1.091)		0.129 (0.951)	
Top_size x ΔNS		-0.317*** (-4.060)		0.601 (1.088)		0.379* (1.914)		-0.456*** (-3.209)		0.043 (0.341)
Observations	206,537	206,537	205,251	205,251	206,537	206,537	206,537	206,537	205,501	205,501
R ²	0.061	0.062	0.080	0.080	0.053	0.028	0.054	0.055	0.106	0.107

Table 6: This table reports the coefficient estimates from the following specification for variants of $y_{i,t}$, t and $x_{i,t}$:

$$\Delta y_{i,t} = \alpha_i + \alpha_{s,t} + \beta x_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{i,t} \in \{Rep_{i,t}, \Delta k_{i,t}, \Delta cash_{i,t}, DebtOut_{i,t}, \Delta profit_{i,t}\}$ is the firm's repurchase ratio, investment, cash growth, debt payout ratio or profit growth. $x_{i,t} \in \{Top_cash_{i,t}\}$ indicates whether the firm is in the highest cash ratio quintile at quarter t , α_i is a firm i fixed effect, $\alpha_{s,t}$ is a sector s by quarter t fixed effect, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of Top_cash dummy, leverage, market cap, sales growth, operating leverage, Tobin's Q and ROA. ε_t^m is normalized so that a positive shock is expansionary. Standard errors are clustered two-way at the firm and quarter level. t-stats are reported in parentheses.

Debt Issuance vs. Equity Payouts An important concern is that firms may rely on debt markets to finance their payouts. With milder financial conditions following a monetary policy easing, financially constrained firms with higher precautionary cash holdings may tap credit markets to facilitate leveraged payouts (Acharya and Plantin, 2019). A growing body of literature argues that equity payouts are partially financed by debt issuance (e.g. Farre-Mensa, Michaely, and Schmalz, 2020). Here, I show that this is not the case for cash-rich firms through the transmission of monetary policy.

Table 6 reports the results from estimating the specification (4) where $y_{i,t} \in \{DebtOut_{i,t}\}$ is the debt payout ratio for firm i at quarter t . Column (7) indicate that firms in the highest cash quintile are not responsive to monetary policy shocks in their debt issuance. On the other hand, large firms issue more debt, while repurchasing less, in response to monetary policy. The result suggests that large firms have a better response to the credit channel of monetary policy. In contrast, cash-rich firms are not responsive to the credit channel, as payouts or investments aren't financed by debt. Appendix B.2 further demonstrates that the main results for the baseline specification (1) hold when I control for the intensive and extensive margins of debt issuance. Overall, the findings in Table 6 indicate that cash-rich firms don't tap the credit markets while paying out more, but they instead use their cash savings.

Robustness Results I document a number of robustness checks of the main results in Appendix B. First, the results hold controlling the heterogeneity in other observable firm characteristics, such as market capitalization, leverage and Tobin's Q. Second, the results are robust to using alternative instruments of monetary policy shocks. Third, the heterogeneous responses to monetary policy are driven by expansionary shocks. Fourth, the results hold in different sample splits based on firms' labor costs. In light of this evidence, the model in the next section will not focus on the transmission of monetary policy shocks through wages and employment. Last, the results are not driven by R&D intensity. Not only do cash-rich firms in R&D intensive industries display no difference in monetary policy pass-through compared with non-R&D industries, but R&D intensity and cash holdings also capture separate channels through which monetary policy induces firm-level responses.

2.3 The Cross-Section of Stock Returns

The previous section shows that cash-rich firms have higher payout, but weaker investment, cash flow and debt responsiveness to monetary policy. Here, I analyze how such monetary policy pass-through is reflected in firm values. Particularly, I test whether stock price responses to monetary policy surprises support an efficient allocation of cash holdings to shareholders, or indicate that weak investment but strong payout responses are non-optimal, hence deteriorate firm values..

To do so, I explore the FOMC announcement day returns of portfolios of cash-rich vs. cash-poor firms. First, I sort firms based on the quarterly observations of lagged cash ratio quintiles at each FOMC day t within the sample period of NS shocks between February 1994 and March 2014. Then, I compute equal-weighted returns for each cash quintile and examine the effect of each monetary policy shocks on the announcement date and cumulative effect over 2 days after the announcement. I analyze three portfolios, as firms in the second, third and fourth quintiles are combined and designated as middle. I therefore examine the following specification:

$$R_{q,t} = \alpha_q + \beta_q^m \varepsilon_t^m + \beta_q^{Mkt} Mkt_t + \epsilon_{q,t} \quad (5)$$

where $R_{q,t}$ is the (cumulative) return of the cash quintile portfolio on the FOMC announcement day (over 2 days following FOMC announcement), Mkt_t is the excess market return at day t , ε_t^m is the original monetary policy shock at time t , and time t is FOMC announcement day. I include the excess market return into the asset pricing tests to control for the fact that CAPM works well around scheduled macroeconomic news announcements, such as FOMC announcements (e.g., [Savor and Wilson, 2014](#)). Monetary policy shocks are normalized so that a positive shock is expansionary.

Table 7 shows that expansionary shocks lead to higher returns for cash rich firms both on the FOMC announcement day and 2 days post-announcement. Columns (1) and (5) suggests that top quintile portfolio has higher responses to monetary policy surprises, thus earns higher average returns than bottom quintile portfolio. Importantly, cash rich firms still have higher

	Bottom %20		Middle		Top %20	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>A. FOMC day return</i>						
ΔNS	8.866*** (3.339)	-1.103 (-0.623)	12.842*** (4.634)	0.690 (0.635)	14.659*** (4.441)	2.664* (1.717)
Mkt		0.834*** (14.206)		0.960*** (24.883)		0.976*** (26.712)
Adj. R^2 , %	0.09	0.79	0.16	0.88	0.17	0.84
<i>B. FOMC two-day return</i>						
ΔNS	15.237*** (4.008)	5.928 (1.527)	19.917*** (5.582)	9.643*** (2.761)	22.204*** (4.952)	11.908*** (2.952)
Mkt		0.790*** (5.699)		0.872*** (5.968)		0.873*** (6.050)
Adj. R^2 , %	0.11	0.35	0.16	0.41	0.18	0.42

Table 7: This table reports the coefficient estimates from the following portfolio regressions over 162 FOMC announcement days between February 1995 and March 2014:

$$R_{q,t} = \alpha_q + \beta_q^m \varepsilon_t^m + \beta_q^{Mkt} Mkt_t + \epsilon_{q,t}$$

where $R_{q,t}$ is the (cumulative) return of the cash quintile portfolio on the FOMC announcement day (over 2 days following FOMC announcement), Mkt_t is the excess market return at day t , ε_t^m is the original monetary policy shock at time t , and time t is FOMC announcement day. Monetary policy shocks are normalized so that a positive shock is expansionary. Heteroscedasticity-robust standard errors are used to compute t-statistics reported in parentheses.

responses after controlling for the excess market return, whereas the responses drift to negative for cash poor firms on the announcement day. Although CAPM works well around FOMC schedule, it doesn't fully account for the cross section of returns of portfolios sorted on cash ratio on FOMC announcement days. Those results support the efficiency enhancing role of the payout channel of monetary policy: Stock prices respond positively to an expansionary shock despite weak responses in all firm outcomes but equity payouts. The evidence also underscores an existence of cross-sectional monetary policy risk premia due to cash heterogeneity.

Following [Bernanke and Kuttner \(2005\)](#) and [Weber \(2015\)](#), I also provide evidence on the impact of monetary policy at a monthly horizon. I regress monthly excess returns $R_{q,t}$ of quintile portfolios sorted on cash ratio and the CRSP value-weighted index on the aggregate monetary policy shock ε_t^m within month t :

$$R_{q,t} = \alpha_q + \beta_q^m \varepsilon_t^m + \epsilon_{q,t} \quad (6)$$

	Market	Bottom %20	Middle	Top %20	Top – Bottom
	(1)	(2)	(3)	(4)	(5)
alpha	0.011** (2.333)	−0.009 (−1.422)	−0.011 (−1.527)	−0.007 (−1.020)	0.002 (0.759)
Δffr	18.753*** (2.947)	14.655** (2.162)	18.186** (2.269)	24.216*** (2.719)	9.560* (1.868)
Adj. R^2 , %	0.02	0.01	0.01	0.02	0.01

Table 8: This table reports the coefficient estimates from the following monthly portfolio regressions between February 1995 and March 2014:

$$R_{q,t} = \alpha_q + \beta_q^m \varepsilon_t^m + \epsilon_{q,t}$$

where $R_{q,t}$ is the monthly excess returns of quintile portfolios sorted on cash ratio or the monthly excess returns of the CRSP value-weighted index, ε_t^m is the aggregated monetary policy shock within month t . Monetary policy shocks are normalized so that a positive shock is expansionary. Newey-West(1994) standard errors with automatic selection are used to compute t-statistics reported in parentheses.

Table 8 documents the alpha and beta coefficients of three portfolios and the market index. The Market index rises more than 18% following a 1% surprise rate cut in the Fed funds rate. We observe a monotonically increasing pattern in the responses of cash-sorted portfolios. Cash-rich firms are the most responsive to monetary policy surprises with a beta coefficient of 24.2. The portfolio return of cash-rich minus cash-poor firms is also responsive to policy news, rising 9.6% after 1% surprise rate cut. These results highlight cash heterogeneity as a determinant of monetary policy risk premium in the cross-section.¹²

3 Model

I develop a heterogeneous New Keynesian general equilibrium model that interprets the empirical findings and analyze asset pricing implications. Heterogeneous firm environment builds on Riddick and Whited (2009) and Begenau and Palazzo (2020) with addition of labor as a factor of production and a relative wholesale price. New Keynesian block introduces nominal price rigidity that is separate from firms' production decision, as in Ottonello and Winberry (2020). A representative household with log utility closes the model.

¹²Portfolio return responses to monetary policy surprises in both Table 7 and Table 8 are also unaffected after controlling for Fama and French (2015) factors. Results are available upon request.

3.1 Production Firms

Production The production side of the economy contains a continuum of heterogeneous firms that produce undifferentiated goods y_{jt} using a decreasing returns to scale production function: $y_{jt} = z_{jt}k_{jt}^\alpha l_{jt}^\theta$ where z_{jt} is an idiosyncratic productivity shock, k_{jt} and l_{jt} are the firm's capital and labor inputs. Labor market is competitive with a real wage w_t . The logarithm of idiosyncratic productivity shock evolves as an AR(1) process:

$$\log z_{jt} = \rho_z \log z_{jt-1} + \sigma_z \varepsilon_{jt}, \text{ where } \varepsilon_{jt} \sim N(0, 1). \quad (7)$$

The firm accumulates capital with gross investment i_{jt+1} , which yields $k_{jt+1} = (1 - \delta)k_{jt} + i_{jt+1}$ units of capital in period $t + 1$. Investment is subject to a fixed investment costs (e.g. [Riddick and Whited, 2009](#)) and a quadratic adjustment costs function (e.g. [Begenau and Salomao, 2019](#)):

$$g(k_{jt}, k_{jt+1}) = \chi^F \mathbb{1}_{i_{jt+1} > 0} + \frac{\chi_t^C}{2} \left(\frac{i_{jt+1}}{k_{jt}} \right)^2 k_{jt}, \quad (8)$$

The parameter χ_F captures the fixed adjustment costs when investment is greater than zero. The parameter χ_t^C captures convex adjustment costs for both investments and divestitures, hence it is given by $\chi_t^C = \chi_0(1 - \mathbb{1}_{i_{jt+1} > 0}) + \chi_1 \mathbb{1}_{i_{jt+1} > 0}$. When $0 < \chi_1 < \chi_0$, investment is risky and costly to reverse. The firm also incurs an operating expense that is parametrized as $\xi(1 + k)$, which is proportional to firm size as measured by firm's existing capital. Since labor is flexible, the firm's labor demand is implied by the first order condition for labor. Corporate profits are then given by:

$$\pi_{jt} = \max_{l_{jt} \geq 0} (1 - \tau_c) (p_t z_{jt} k_{jt}^\alpha l_{jt}^\theta - w_t l_{jt}) - \xi(1 + k), \quad (9)$$

where p_t is the relative price of the output, w_t is the real wage of labor and l_{jt} is the labor demand of the firm implied by the first-order condition.

Financing: The firm can hold cash via one-period discount bond that earns risk-free rate r_t , as in [Riddick and Whited \(2009\)](#). Interest rate on the bond is taxable interest at a rate τ_c . The firm

is an all equity firm. It can raise external financing through equity issuance, which is costly. The equity issuance cost function captures underwriting fees and adverse selection costs in a reduced form fashion with fixed $\lambda_0 > 0$ and linear issuance costs $\lambda_1 > 0$, (e.g., [Riddick and Whited, 2009](#), [Gao, Whited, and Zhang, 2021](#)):

$$\Psi(d_{jt}) = \mathbb{1}_{d_{jt} < 0}(-\lambda_0 + \lambda_1 d_{jt}), \quad (10)$$

where $\mathbb{1}_{d_{jt} < 0}$ equals 1 if $d_{jt} < 0$ and zero otherwise. There is no payout cost.

Firm Optimization: To introduce the firm optimization problem, I start with the definition of dividends:

$$d_{jt} = \pi_{jt} - i_{jt+1} - g(k_{jt}, k_{jt+1}) + c_{jt} - \frac{c_{t+1}}{(1 - \tau_c)r_t + 1}, \quad (11)$$

where $d_{jt} < 0$ represents equity issuance and $d_{jt} > 0$ represents equity payouts. Equity payout is thus defined as firm profits less investment and investment adjustment cost less the next period of cash carried backward to time t . Let $V_{jt} = V_t(\Omega_{jt}, \mathbf{s}_t)$ be the value of the firm, where $\Omega_{jt} = \{z_{jt}, k_{jt}, c_{jt}\}$ represents the firm-specific state vector, and $\mathbf{s}_t = \{\mu_t, \varepsilon_t^m\}$ represents the aggregate state vector at time t where μ_t is the cross-sectional distribution of firms in terms of individual state vector Ω_{jt} , and ε_t^m is the monetary policy shock. At time t , the firm solves the following problem:

$$V_{jt} = \max_{k_{t+1}, c_{t+1}} d_{jt} + \Psi(d_{jt}) + \mathbb{E}_t [\Lambda_{t+1} (\eta_e(\pi_{jt+1} + (1 - \delta)k_{t+1}) + (1 - \eta_e)V_{jt+1})] \quad (12)$$

where η_e is an exogenous exit probability that each firm faces at each period. The time line for the firm within each period is as follows: At the beginning of the period, firms carry capital for current period production and internally accumulated cash. After observing idiosyncratic productivity shocks, the firm hires labor with the real wage w_t and produces undifferentiated goods y_{jt} using the production function. With probability η_e , the firm receives an i.i.d. exit shock and exit economy after producing. Upon exit, the firm recovers its profits and undepre-

ciated capital stock, but it doesn't divest capital to fund equity payouts. If the firm is allowed to continue to next period, it then decides its equity payout by choosing capital and cash for the next period, incurring fixed operational costs.

Entry Heterogeneous firm entry is modeled following [Begenau and Palazzo \(2020\)](#). Every period, a constant mass M of potential entrants receive a signal q about their future productivity. That is, the distribution of future log-productivity follows $\log z_{t+1} = \rho_z q_t + \sigma_z \varepsilon_{jt}$. The signal q follows a Pareto distribution $q \sim Q(q)$ with a Pareto parameter ω . Firms start operating in the next period after the entry, but they have to determine their next period investment and cash holdings in the current period, given a starting capital k_{priv} . Firms decide to go public if their value at the entry $V_{ent}(q_t, (s_t))$ is positive ($V_{ent} > 0$). The entrant optimization then follows:

$$V_{ent}(q_t, \mathbf{s}_t) = \max_{k_{t+1}, c_{t+1}} -i_{t+1} - g(k_{priv}, k_{t+1}) - \frac{c_{t+1}}{(1 - \tau_c)r_t + 1} + \mathbb{E}_t [\Lambda_{t+1} V(\Omega_{t+1}, \mathbf{s}_{t+1}) / q_t] \quad (13)$$

3.2 New Keynesian Block

I follow [Ottonello and Winberry \(2020\)](#) to design a New Keynesian Phillips Curve that connects real and nominal side of the economy. Nominal rigidities are kept separate from production side of the economy, while the relative price of the output is the key variable to link nominal variables to production environment.

Retailers: There is a continuum of retailers that differentiate the production firms' intermediate goods and set prices. Each retailer produces a differentiated variety \tilde{y}_{jt} using production firms' goods y_{jt} as only inputs. Retailers demand undifferentiated goods of production firms through a simple transformation: $\tilde{y}_{jt} = y_{jt}$

Retailers are monopolistic, risk-neutral and competitive. They set prices \tilde{p}_{jt} subject to demand curve for final good Y_t and the wholesale price index P_t . As in [Rotemberg \(1982\)](#), retailers adjust prices by paying a quadratic menu costs $\frac{\psi}{2} \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right)^2 P_t Y_t$ in terms of the final good Y_t .

Final Good Producer: There is a representative final good producer that produces a final good Y_t using intermediate goods of retailers. the final good producer has a production function as follows:

$$Y_t = \left(\int \tilde{y}_{jt}^{\frac{\gamma-1}{\gamma}} dj \right)^{\frac{\gamma}{\gamma-1}},$$

where \tilde{y}_{jt} are intermediate goods from retailers, γ is the elasticity of substitution over intermediate goods. The profit maximization problem of the final good producer generates the demand curve $\tilde{y}_{jt} = \left(\frac{\tilde{p}_{jt}}{P_t} \right)^{-\gamma} Y_t$, where $P_t = \left(\int \tilde{p}_{jt}^{1-\gamma} dj \right)^{\frac{1}{1-\gamma}}$ is the price index. Final good is the numeraire.

Phillips Curve: Profit maximization of retailers generates the aggregate Phillips Curve. The price setting behavior of retailers is derived in Appendix C.1. Since retailers are risk-neutral, not subject to household intertemporal decisions, their problem can be solved locally. This yields a log-linearized version of New Keynesian Phillips Curve as follows:

$$\log \Pi_t = \left(\frac{\gamma-1}{\psi} \right) \log \frac{p_t}{p^*} + \beta \mathbb{E}_t \log \Pi_{t+1}, \quad (14)$$

where Π_t is the gross inflation rate of the final good, $p^* = \left(\frac{\gamma-1}{\gamma} \right)$ is the steady state price of intermediate good. The Phillips Curve links the nominal variables to the production side of the economy through the relative price of the output.

Monetary Policy The monetary authority sets the short-term nominal interest rate R_t^{nom} according to a Taylor-type rule:

$$\log R_t^{nom} = \Phi_{\Pi} \log \Pi_t + \log \left(\frac{1}{\beta} \right) + \varepsilon_t^m, \quad (15)$$

where β is the discount factor, Π is the gross inflation rate, Φ_{Π} is the parameter that captures the reaction to inflation, and ε_t^m is the monetary policy shock. I model monetary policy shocks as persistent and the only source of aggregate uncertainty, providing information for the future

path of monetary policy. Therefore, the policy shock evolves as an AR(1) process:

$$\varepsilon_t^m = \rho_m \varepsilon_{t-1}^m + \sigma_m \epsilon_t, \quad \epsilon_t \sim N(0, 1), \quad (16)$$

where ρ_m and σ_m are the persistence and volatility of monetary policy shocks.

3.3 Households and Equilibrium

There is a representative household with log utility. To maintain tractability, I assume a simple functional form. The representative agent has additively separable preferences over consumption C_t and labor supply L_t and maximizes

$$\begin{aligned} & \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\log C_t - \zeta L_t) \\ \text{s.t.} \quad & P_t C_t = W_t L_t + R_{t-1}^{nom} B_{t-1} - B_t + D_t + \Xi_t, \end{aligned}$$

where β is the discount factor, ζ captures the disutility of labor supply, W_t is the nominal wage, P_t is the composite price index defined in Section 3.2, B_t denotes nominal bond holdings and D_t denotes aggregate equity payouts to households and Ξ_t is tax transfers to consumers. The household owns all firms in the economy. Household block is cashless, and nominal bonds are in zero net supply. The stochastic discount factor and nominal interest rate are then linked through the Euler equation for bonds. The first-order condition for aggregate consumption yields

$$1 = \beta \mathbb{E}_t \left[\frac{R_t^{nom}}{\Pi_{t+1}} \left(\frac{C_t}{C_{t+1}} \right) \right] \quad (17)$$

which implies the stochastic discount factor as $\Lambda_{t+1} = \beta \left(\frac{C_t}{C_{t+1}} \right)$ where risk-free rate is given by $1 + r_t = \frac{R_t^{nom}}{\Pi_{t+1}}$. The first-order condition for aggregate labor supply yields the equation for the

real wage w_t :

$$w_t = \frac{W_t}{P_t} = \zeta C_t \quad (18)$$

A recursive competitive equilibrium consists of a set of policy functions $(k_{t+1}(\Omega, \mathbf{s}), c_{t+1}(\Omega, \mathbf{s}))$, value functions $(V_t(\Omega, \mathbf{s}), V_{ent}(q_t, \mathbf{s}))$, prices $(\hat{P} = \{\Pi, p_t, w, R_t^{nom}\})$, aggregate capital, production, labor and investment (K, Y, I, L) , the joint distribution of productivity, capital and cash holdings $\mu_t(\Omega)$ such that firms optimize, the Phillips curve and Taylor rule holds, the household optimizes, the distribution of firms and the perceived law of motion (defined below) coincides, and markets clear. Appendix C.2 provides the full characterization of the equilibrium.

3.4 Solution Method

All equilibrium prices and the law of motion for the cross sectional distribution of firms $\mu_t(\Omega)$ depend on the aggregate state, which involves $\mu_t(\Omega)$ itself. The recursive equilibrium is not computable, because $\mu_t(\Omega)$ is an infinite dimensional object and aggregate state space cannot be written in a closed form. To approximate the equilibrium, I follow the literature on computable general equilibrium with heterogeneous agents (e.g. [Krusell and Smith, 1998](#), [Khan and Thomas, 2008](#), [Gilchrist, Sim, and Zakrajšek, 2014](#)) and assume that agents forecast future prices based on a set of finite number of moments. Specifically, I assume that agents use the log-linear rules to predict the current marginal utility of representative household $(u_c(t))$, current relative price of intermediate goods p_t . In addition, I assume agents use a log-linear conjecture to approximate future inflation (Π_{t+1}) . Importantly, I add past consumption as a state variable to allow households condition their expectations on past period's consumption. Consumption better reflects both capital and cash policies of the entire firm distribution (e.g., as in [Gomes and Schmid \(2021\)](#)), thus past consumption as a state variable works more effectively in a model with heterogeneous firms. Formally, agents use the following forecasting rules to predict the

vector of equilibrium quantities:

$$\begin{bmatrix} \log u_c(t) \\ \log p_t \\ \log \Pi_{t+1} \end{bmatrix} = A + B \begin{bmatrix} \log c_{t-1} \\ \varepsilon_t^m \end{bmatrix} \quad (19)$$

where A and B are 3×1 and 3×2 matrix of coefficients, respectively. Given the forecasting rules, the model is solved using inner and outer loop algorithm of [Krusell and Smith \(1998\)](#). In the inner loop, agents solve the firm optimization using a value function iteration conditional on the forecast rules in [19](#).¹³ Having solved for the value and policy functions, I update the forecasting rules using a Monte-Carlo simulation in the outer loop. Each simulation starts with the stationary distribution implied by the model without monetary policy shock, then computes the optimal policies at each period t assuming the agents derive optimal policies under the forecasting rules [19](#) from period $t + 1$ onward. At each period t , I let all markets clear by jointly solving for the marginal utility of consumption $u_c(t)$ and the relative price p_t that is consistent with market clearing. Once the economy is simulated, I re-estimate the forecasting rules via OLS and update the parameters accordingly. I re-iterate the inner and outer loop until full convergence in the forecasting rules.

[Appendix C.3](#) provide details on the numerical implementation and the resulting aggregate behavior of the economy. The posited rules in [19](#) approximates the aggregate economy well, with all R^2 values above 99.7%.

3.5 Economic Intuition

Although an analytical solution for the recursive general equilibrium is not possible, partial equilibrium characterizations can shed light on the intuition behind the model for the link among a firm's investment, financing and liquidity policies and monetary policy. Since optimal payout follows the residual form in [11](#), firm dynamics help us to understand the channels through which monetary policy impacts residual payouts. The economic intuition closely follows [Eisfeldt and Muir \(2016\)](#).

¹³Note that the Taylor-rule [15](#) determines R_t^{nom} given forecasting rules under bounded rationality.

Without aggregate uncertainty, the optimal decisions on k_{t+1} and c_{t+1} satisfy the following Euler equations:

$$E_t \left[\left(\frac{1 + \phi_{t+1}}{1 + \phi_t} \right) \left(\frac{\alpha(1 - \tau_c)p_{t+1}^{\frac{1}{1-\theta}} z_{t+1}^{\frac{1}{1-\theta}} w_{t+1}^{\frac{-\theta}{1-\theta}} k_{t+1}^{\alpha-1} - \xi + (1 - \delta) + g_{k'}(k_t, k_{t+1})}{1 + g_k(k_t, k_{t+1})} \right) \right] = 1 + r_t \quad (20)$$

$$E_t \left[\left(\frac{1 + \phi_{t+1} + \kappa_L}{1 + \phi_t} \right) (1 + (1 - \tau_c)r_t) \right] = 1 + r_t \quad (21)$$

where ϕ_t accounts for the external financing costs at time t ($\phi_t = \mathbb{1}_{d_t < 0} \lambda_1$), κ_L is the multiplier on the non-negativity constraint for cash holdings, and $g_{k'}$ and g_k represents first order conditions of capital adjustment cost with respect to k_{t+1} and k_t . Both equations highlight the various channels through which monetary policy impacts investment and liquidity accumulation decisions. In the first equation (20), the capital in the next period, hence the investment depends on the monetary policy through 1) general equilibrium channels of sticky prices (p_t) and flexible wage (w_t), 2) the external financing premium channel (ϕ_t), 3) the intertemporal substitution channel of real rate (r_t).

The numerator in the second parenthesis of Equation (20) suggests that sticky prices are less effective on investment decisions when future productivity (z_{t+1}) is expected to be low, or the marginal investment costs are expected to be high. In fact, these are also the types of firms in the cross-section that hold cash buffers against costly external financing. First, firms with low productivity (hence low cash flows) have higher precautionary savings as they face higher uncertainty to cover their fixed operational costs. Second, fixed adjustments costs make investment lumpy with a kinked marginal adjustment cost function. Firms with a steeper marginal adjustment cost curve accumulate more cash to finance larger, lumpy investments. Thus, the model suggests that the investment of cash-rich firms would respond less to monetary policy through cash flow effects.

The second equation 21 reflects the precautionary motives for liquidity accumulation to avoid costly external financing costs. Liquidity accumulation is also susceptible to monetary policy through external financing premium and intertemporal substitution channels. An ex-

pansionary monetary policy shock reduces the real rate and the opportunity cost of cash, hence it increases the incentive for cash accumulation. This is the traditional interest rate channel of holding cash. However, there is another channel: the precautionary motive to hold cash against costly external financing. By impacting the real rate, an expansionary shock also reduces (the future path of) external financing premium.

The net effect of monetary policy on cash holdings depends on the relative importance of the interest rate and external financing premium channels. The goal of the calibration exercise is to quantitatively discipline those channels using the model. To the extent that the external financing premium channel dominates the direct effect of interest rates for cash accumulation, cash-rich firms require less cash buffer for precautionary savings following an expansionary shock. Taken together, Equation (20) and (21) would then imply that cash-rich firms have weaker investment responses to monetary easing, hence they don't allocate excess cash for investment, but rather distribute it to shareholders when external financing conditions are improved.

As shareholders transfer funds into and out of the firm in response to investment and liquidity accumulation responses to monetary policy, the residual equity payout series turn out to be volatile for responsive firms. The impact of monetary policy shocks on dividends can be characterized (suppressing the firm subscript i) as follows:

$$\frac{\partial \log d_t}{\partial \varepsilon_t^m} = \frac{1}{(1 - \theta)} \left(\frac{\partial \log p_t}{\partial \varepsilon_t^m} - \theta \frac{\partial \log w_t}{\partial \varepsilon_t^m} \right) \frac{\pi_t}{d_t} - \frac{\partial \log \tilde{I}_t}{\partial \varepsilon_t^m} \frac{\tilde{I}_t}{d_t} - \frac{1}{\tilde{R}_t} \left(\frac{\partial \log c_{t+1}}{\partial \varepsilon_t^m} - \frac{\partial \log r_t}{\partial \varepsilon_t^m} \right) \frac{c_{t+1}}{d_t}$$

where $\tilde{I}_t = i_{t+1} + g(k_t, k_{t+1})$ is the net investment and $\tilde{R}_t = (1 - \tau_c)r_t + 1$ is the gross return on cash savings. The equation shows that monetary policy impacts dividend in three channels. First, monetary policy affects operational income by changing the price level as well as labor costs. This effect is relatively low for cash-rich firms with lower productivity and profits. Second, monetary policy affects investment as discussed above for Equation (20). Weaker investment response of cash-rich firms also makes this investment channel less effective on dividends. Third, monetary policy impacts the next period's cash holdings net of foregone interest rate earnings, in line with the intuition given by Equation (21). Given the weaker investment response of cash-rich firms, this last channel has the most impact on the dividends of cash-rich

firms.

4 Calibration

I calibrate the model in two steps. First, I rely on fixed parameters that are standard values in the literature. Second, I set the remaining parameters to target moments of the data. The time period in the model equals one quarter. All parameters used in the model are summarized in Table 9.

The household's discount factor is set to $\beta = 0.99$, implying a steady-state real interest rate of about 4 percent per year. The quarterly depreciation rate δ is set equal to 0.025. I set the coefficient on labor $\theta = 0.60$ and the coefficient on capital $\alpha = 0.25$ to imply a standard decreasing returns to scale of 85% (e.g. [Gilchrist, Sim, and Zakrajšek, 2014](#), [Ottonello and Winberry, 2020](#)). The persistence and standard deviation of idiosyncratic productivity shocks are from [Begenau and Palazzo \(2020\)](#). Fixed parameters in the New Keynesian Block follow [Ottonello and Winberry \(2020\)](#) for the most part. The Taylor rule coefficient is set to 1.25. The elasticity of substitution is $\gamma = 10$, implying a steady state markup of 11%. The price adjustment cost parameter is set to 90, generating a slope of Phillips curve 0.1, a value within the range of values used in the literature. The disutility of labor ζ is chosen so that the real wage in the steady state is normalized to one.¹⁴ I calibrate the persistence parameter of monetary policy shock process $\rho_m = 0.90$ as in [Weber \(2015\)](#), in line with the estimates of [Coibion and Gorodnichenko \(2012\)](#). The standard deviation of monetary policy shock process is set to match the standard deviation of quarterly monetary policy shocks ΔNS used in the empirical section. Following [Begenau and Salomao \(2019\)](#), corporate tax rate is set to $\tau = 0.3$.

The remaining parameters are calibrated to jointly match key stationary moments in the data. The parameter for the investment adjustment cost $\chi_1 = 1$ is calibrated to match an average investment rate of 3.49% vs. 3.65% reported in [Begenau and Salomao \(2019\)](#). Fixed investment cost $\chi^F = 0.005$ is chosen to generate 12.88% mean cash ratio of firms vs. 12.05% in the Compustat sample. Operating cost is calibrated to $\xi = 0.0375$ to match average payout ratio of firms (0.61% vs. 0.68% reported for Compustat sample in Table 1). I set fixed equity

¹⁴A similar approach is also taken by [Gilchrist, Sim, and Zakrajšek \(2014\)](#).

Parameter	Value	Description	Target
Production Firms			
δ	0.025	Depreciation	Standard Value
α	0.25	Capital coefficient	Returns to scale of 85%
θ	0.60	Labor coefficient	Returns to scale of 85%
ρ_z	0.90	Persistence of id.prod. shock	Begenau and Palazzo (2020)
σ_z	0.121	Std of id.prod. shock (annual)	Begenau and Palazzo (2020)
τ_c	0.3	Corporate tax rate	Begenau and Salomao (2019)
χ^F	0.005	Fixed investment adj.cost	Mean cash rate of 12.05%
χ_0	4	Divestiture adj.cost	Begenau and Salomao (2019)
χ_1	1	Investment adj.cost	Average investment rate of 3.65%
ξ	0.0375	Operating cost	Average payout ratio of 0.68%
λ_1	0.175	Linear equity issuance cost	Average issuance-to-asset ratio of 1.8%
New Keynesian Block			
Φ_{Π}	1.25	Taylor Rule coefficient	Ottonello and Winberry (2020)
γ	10	Elasticity of substitution	Ottonello and Winberry (2020)
ψ	90	Price adjustment cost	Ottonello and Winberry (2020)
ρ_m	0.90	Persistence of monetary shock	Weber (2015)
σ_m	0.000545	Std of monetary shock	Std of Aggregate ΔNS (Table 3)
β	0.99	Discount factor	Standard Value
Entry & Life Cycle			
λ_0	0.005	Fixed equity issuance cost	Average cash at entry within 22 to 40%
ω	10	Pareto: Entrant productivity	Entrants relative size of 66.3%
η_e	2.5%	Exit rate	Age distribution (see below)

Age Distribution with exit rate $\eta_e = 0.025$					
Age bin	1-5	6-10	11-15	16-20	>20
Model	0.253	0.254	0.194	0.120	0.179
Data	0.296	0.206	0.159	0.119	0.221

Table 9: This table provides the calibrated parameters and the age distribution implied by the exit rate $\eta_e = 0.025$. The age distribution of the data is from [Begenau and Palazzo \(2020\)](#). The period is one quarter. See the details in the main text.

issuance cost 0.005 to generate an average cash-to-asset ratio of 28.82% for entrants. This figure is within the range (22.2% to 40%) of average cash holdings of the IPO firms reported in [Bates, Kahle, and Stulz \(2009\)](#). Then, I set linear equity issuance cost 0.175 to generate a quarterly average equity issuance-to-asset ratio of 1.98% (vs. 1.85% in my sample).

The rest of the entry and life cycle dynamics are calibrated following [Begenau and Palazzo \(2020\)](#). I set an exogenous exit rate of 0.025 to match the age distribution in Compustat over the period 1979-2013 reported in [Begenau and Palazzo \(2020\)](#). Table 9 displays that the age distribution generated by the model is close to the distribution in the data. Pareto parameter $\omega = 10$ implies a 61.6% ratio of entrants initial size k_{priv} to average size of incumbents of age 5, close to the ratio 66.3% reported in [Begenau and Palazzo \(2020\)](#).

Cash Heterogeneity in the Model Figure 3 compares the two non-targeted stationary distributions of the model with the data. First, I show that the distribution of operating leverage for cash holdings in the model is comparable to Compustat data. As the key structural driver of precautionary motive to hold cash, operating leverage is the source of cash heterogeneity in the model, as in the data. Panel A in Figure 3 suggests that this mechanism of the model is in line with what we observe in the data. Second, Panel B of Figure 3 shows that the total investment ratio (capital growth + R&D expenditures divided by assets) increases by cash holdings in the model, as in the data. Although the model doesn't differentiate between R&D and capital expenditures, investment ratios in each cash quintile are higher than in the data. Higher investment ratios are not surprising, given that my calibration target for the average investment rate (3.65%) is higher than the mean total investment rate (2.7%) in the data.

5 Model Results

In this section, I analyze the impact of monetary policy shocks in the model. First, I document the impulse responses of key aggregate variables to an expansionary monetary policy shocks. Second, I explore the heterogeneous responses to monetary policy across firms to demonstrate consistency with respect to the empirical findings in Section 2.2. Finally, I explore the monetary transmission to asset prices by performing portfolio regressions with model generated data.

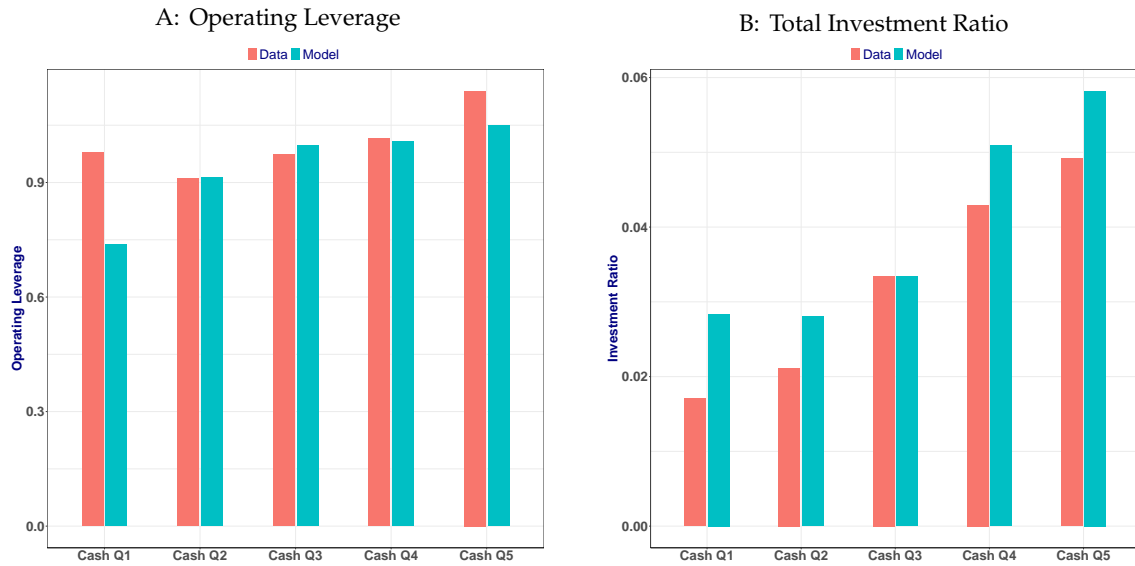


Figure 3: This figure displays the distribution of operating leverage (Panel A) and total investment ratio (Panel B) for cash quintiles in the model vs the data. In the data, total investment ratio is defined as the sum of capital growth and R&D expenses divided by total assets.

5.1 Aggregate Responses to Monetary Policy

I analyze the dynamics of model-implied aggregate variables in response to monetary shocks through impulse-response functions. I compute the impulse response functions by simulating the model twice with and without a single monetary policy shock on the top of the same idiosyncratic shocks and aggregating the responses of endogenous aggregate variables. In computing the model-implied impulse response functions, I follow [Gilchrist, Sim, and Zakrajšek \(2014\)](#) and take into account the nonlinearities in the firms' investment and cash holding policies that arise naturally in an economy with partially irreversible investment. That is, I eliminate sampling bias that may have stemmed from different idiosyncratic shocks via a large number of replications of model simulations. The computation details of impulse-response functions are given in [Appendix C.3](#).

Figure 4 shows aggregate impulse-response functions of aggregate variables to an expansionary shock of 25 basis points (quarterly). Consistent with the New Keynesian framework, expansionary shock lowers nominal and real rates, and stimulate consumption, investment and output. Higher consumption demand also leads to a rise in inflation. The peak effects are comparable to the results of similar heterogeneous-firm New Keynesian models such as

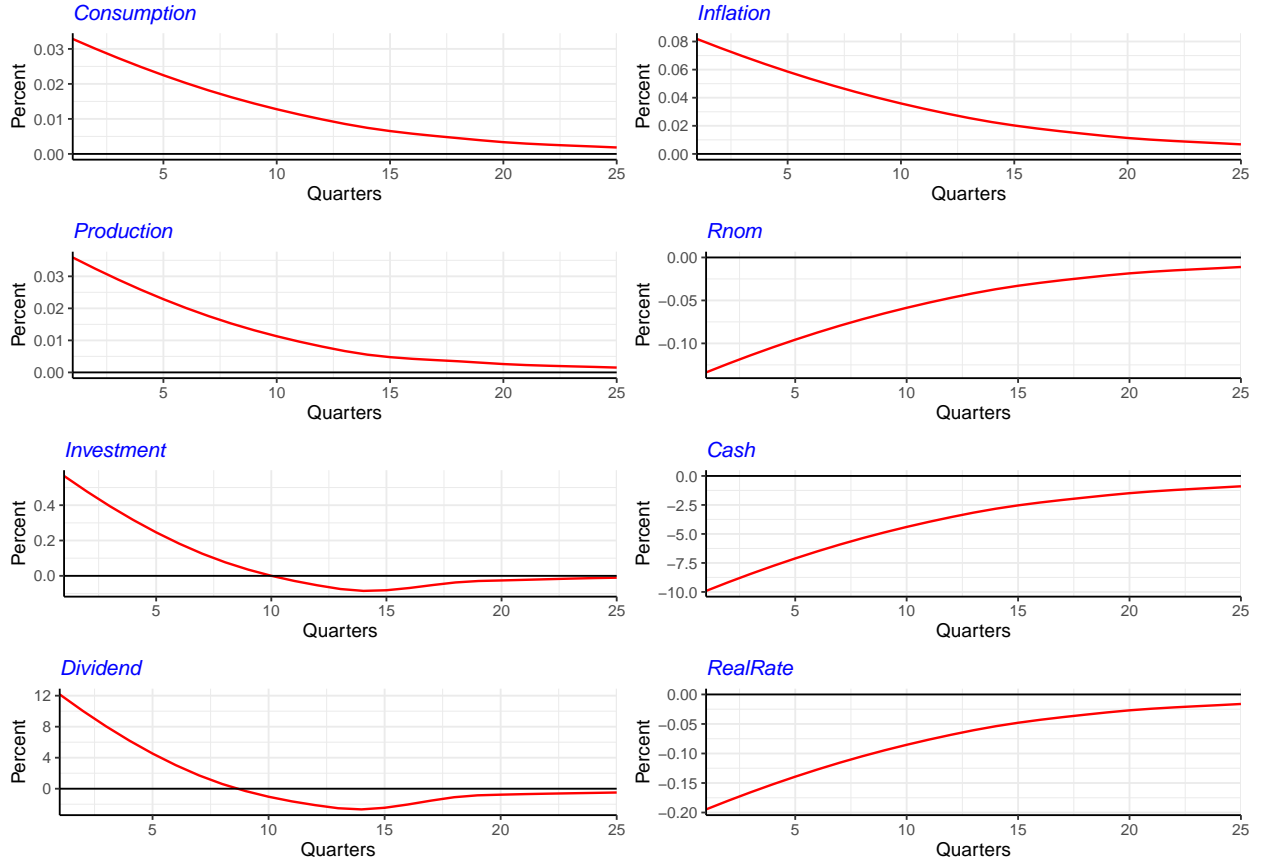


Figure 4: The figure displays model-implied aggregate impulse-responses to 25 basis points expansionary monetary policy shock. The impulse responses are computed as averages of 1,000 simulations, where the impulse responses of 3,000 firms are aggregated in each simulation. The responses are smoothed by polynomial fitting. The computation details of impulse-response functions are given in Appendix C.3.

Luetticke (2021), and Ottonello and Winberry (2020).

5.2 Heterogeneous Responses to Monetary Policy

To estimate the benchmark specification in (1) and (2), I simulate a panel of 3000 firms for 1500 periods, discarding the first 500 periods as burn-in. As in Section 2.2, I condition on firms that survive at least forty quarters, normalize monetary policy shocks so that a positive shock is expansionary. The vector of firm-level controls include the lagged values of cash ratio, firm size and sales growth, which are available in both the data and the model. Since the model doesn't incorporate the dividend stickiness, I report the model's dividend policy as compared to the repurchases policy of the data.

Table 10 shows that the heterogeneous responses to monetary policy in the simulation are

	<i>Rep_{i,t}</i> Data	<i>Div_{i,t}</i> Model	$\mathbb{1}_{Rep_{it}}$ Data	$\mathbb{1}_{Div_{it}}$ Model
	(1)	(2)	(3)	(4)
cash $\times \varepsilon^m$	0.202*** (3.661)	0.279	3.513*** (3.611)	4.659
Firm controls	Yes	Yes	Yes	Yes
Firm - Time FE	Yes	Yes	Yes	Yes
R ²	0.056	0.401	0.116	0.396

Table 10: This table reports the model-implied coefficient estimates vs. the data-implied coefficient estimates from running the following specification for variants of y_i on the model-simulated data :

$$\Delta y_{i,t} = \alpha_i + \alpha_t + \beta cash_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Div_{it}, \mathbb{1}_{Div_{it}}\}$ indicates the firm's model-implied repurchase ratio or the indicator of positive payouts in a given quarter, α_i is a firm i fixed effect, α_t is a quarter t fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include a fiscal quarter dummy and the lagged values of cash ratio, asset size and total sales (total production for the model). Positive payouts indicate payouts greater than 1% of total lagged assets in a given quarter t . ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two-way at the firm and quarter level.

consistent with the data. First, Columns (1) and (2) show that firms with higher cash ratios have higher semi-elasticity of equity payout policy in the simulated model, as in the data. The semi-elasticity of cash-rich firms is slightly higher in the model than in the data. Second, Columns (3) and (4) suggest that the results on the simulation and the data are also comparable at the extensive margin. In the model, firms with one standard deviation higher cash ratio are more likely to payout dividends following an expansionary shock.

I also estimate local projections of the specification 3 on model-simulated data to study the persistence of payout responsiveness to monetary shocks. Figure 5 shows that the heterogeneous responses of equity payouts are persistent in the model, as in the data. The results suggest that the model delivers the key effect of expected path of monetary policy on corporate equity payout dynamics.

Role of Model Ingredients To understand the role of key model ingredients in driving dividend responsiveness of cash-rich firms, I conduct four experiments. In each experiment, I alter one of the ingredients and then estimate empirical specification (??) on the simulated data, where cash-rich firms are captured by a dummy indicator $\{Top_cash_{i,t}\}$ of being in the highest

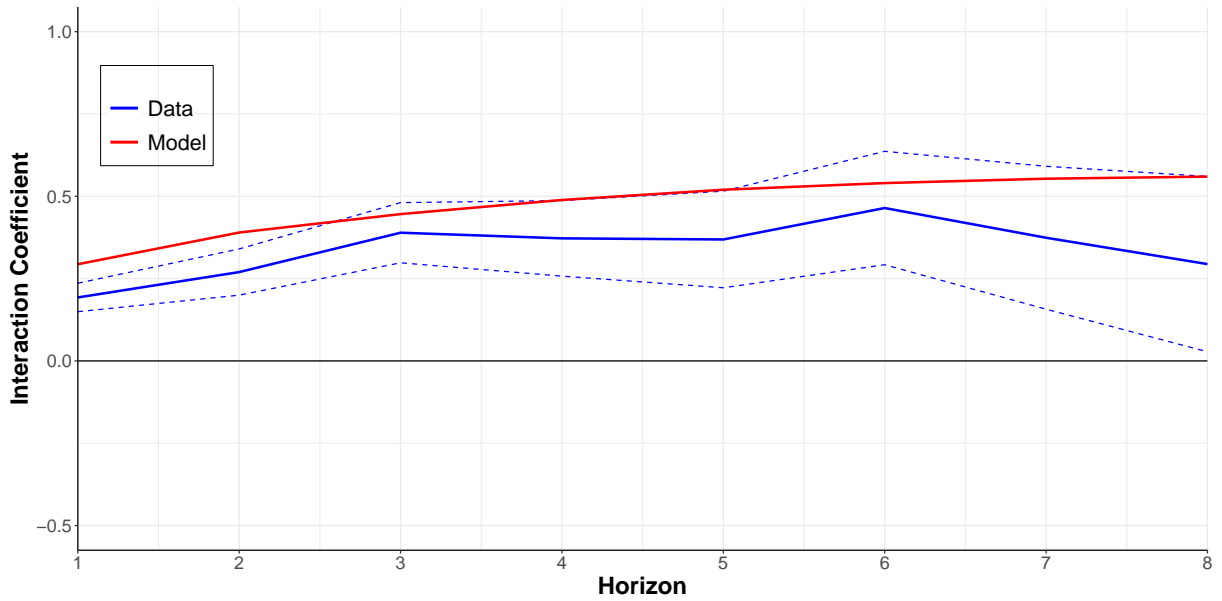


Figure 5: This figure displays reports the dynamics of the interaction coefficient estimated from the local projection specification (3) over horizon h . Dashed lines indicate the 90% confidence bands. Monetary shocks are normalized so that a positive shock is expansionary.

cash ratio quintile at quarter t . Figure 6 displays the coefficients from the regression results.

In the first row of the figure, the baseline calibration indicates that the firms in the highest cash quintile are the most responsive to monetary policy shocks in paying out dividends, as in the data (Table 6). In this baseline calibration, muted investment response and negative cash saving responses of cash-rich firms are also consistent with the data.

The next rows investigate the role of model ingredients in driving baseline results for the responsiveness of payouts, investment and cash holdings for cash-rich firms. First, “Issuance Cost” parametrization shows the importance of equity issuance costs in the model. Decreasing the size of equity issuance cost in half in this parametrization reverses the baseline results for dividends, leading to a negative payout response. With lower external financing costs, firms save less cash on average, and the dispersion of cash holdings in the cross-section of firms decreases. With decreased cash buffers, the cash flow effects of monetary easing, as described in Equation 22, dominate the responsiveness of payouts. As cash-flow channel is relatively low for cash-rich firms, they don’t benefit from improved cash flows like other firms in the economy, hence cash-rich firms relatively payout less in response to monetary policy. since cash-flow effects dominate, the investment response is also stronger for cash rich firms in this

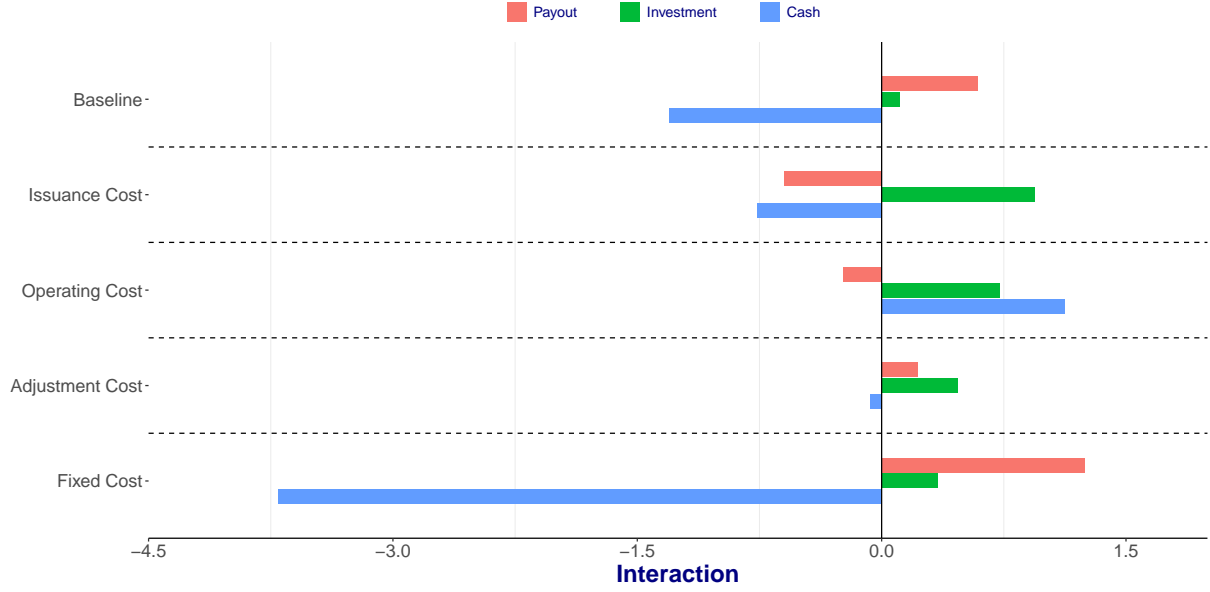


Figure 6: This figure displays estimated Payout, Investment and Cash responses of cash-rich firms to expansionary monetary policy shock using regression specification (4) with different model parametrization. "Baseline" refers to the calibrated model. "Issuance Cost" keeps all parameters the same except decreases the both fixed and linear issuance cost parameters by 50%. "Operating Cost" keeps all parameters the same except decreases the operating cost parameter by 50%. "Adjustment Cost" keeps all parameters the same except decreases the convex adjustment cost parameter by 50%. "Fixed Cost" keeps all parameters the same except decreases the fixed investment cost by 50%. Monetary shocks are normalized so that a positive shock is expansionary.

parametrization.

Second, decreasing the size of operating costs in half in "Operating Cost" parametrization decreases the payout responsiveness of cash-rich firms, which is reasonable given that the operating cost is an important source of uncertainty that affects the issuance vs. payout residual outcomes, as discussed for Equation 20 and 21. With lower operating costs, firms with lower internal cash flows save fewer cash buffers and payout more (or issue less) on average. This is why lower operating costs diminish the state dependency of payouts. Third, decreasing the convex adjustment costs decreases the payout responsiveness of cash-rich firms. This result occurs since the investment response of cash-rich firms relatively strengthens, as seen from statistically significant response of investment. Finally, decreasing fixed costs increases the payout responsiveness of cash-rich firms in the model, but also eliminates the negative semi-elasticity of investment to monetary policy shocks in the baseline calibration. That is, fixed investment costs appear to be more crucial to generate the weak investment response of cash-rich firms as compared to the observed payout responses in the data.

5.3 Asset Pricing Implications

I show the asset pricing implications of the model using the model-simulated data. In the baseline model, an equity is defined to be an unlevered claim on the aggregate dividend stream. Thus, one period holding return on equity of firm i over period $t + 1$ is defined as:

$$R_{i,t+1} = \frac{V_{i,t+1}}{V_{i,t} - D_{i,t}} \quad (22)$$

where $V_{i,t}$ and $D_{i,t}$ are value and payout of firm i at time t . To compare the model with the data, I construct quintile portfolios sorted on cash ratio and analyze the differential responses of returns to monetary policy shocks, as in Section 2.3. Thus, I regress quarterly excess returns $R_{q,t}$ of quintile portfolios on the aggregate monetary policy shocks.

Table 11 presents beta coefficients at the portfolio level. The findings for the baseline calibration in line (1) are qualitatively similar to the portfolio regressions presented in the empirical section 2.3. In this baseline calibration, as in the data, cash-rich firms are the most responsive to monetary policy surprises with a beta coefficient of 27.52. The portfolio return of cash-rich minus cash-poor firms is also significantly responsive to policy news, rising 16% after 1% policy news shock. Overall, the model simulated results demonstrate positive cross-sectional monetary policy risk premium for cash-rich firms. That is, a dynamic New Keynesian model is consistent with the asset pricing dynamics of the data.

Lines (2) to (5) evaluate the role of New Keynesian parameters in driving the asset pricing results. Importantly, all changes in New Keynesian parameters preserve the positive monetary policy beta of cash-rich firms. Lines (2) and (3) check how changes in the monetary policy process affect the findings. In line (2), decreasing the monetary policy persistence has a dampening effect on the beta coefficients for all portfolios. The result is consistent with [Li and Palomino \(2014\)](#) who shows monetary policy rules with a greater weight on interest rate smoothing lead larger expected returns. Intuitively, the lower persistence of the monetary policy diminishes the impact of the expected path of the policy news in driving sdf dynamics, hence the monetary policy risk premium. On the other hand, in line (3) increasing the volatility of monetary policy shocks decreases the heterogeneity in the cross-sectional difference in betas. Taken to-

	β^m			
	Bottom %20 (1)	Middle (2)	Top %20 (3)	Top – Bottom (4)
(1) Baseline Model	11.048	17.490	27.514	16.466
(2) MP Persistence $\rho_m = 0.70$	8.600	16.703	15.301	6.701
(3) MP Volatility $\sigma_m = 0.001$	9.365	9.526	23.214	13.849
(4) Taylor rule $\Phi_\Pi = 1.5$	-7.452	5.994	35.207	42.659
(5) Price Stickiness $\psi = 30$	8.173	-1.121	42.958	34.784

Table 11: This table reports the coefficient estimates from the monthly portfolio regressions using the model simulated data:

$$R_{q,t} = \alpha_q + \beta_q^m \varepsilon_t^m + \epsilon_{q,t}$$

where $R_{q,t}$ is the excess returns of quintile portfolios sorted on cash ratio, ε_t^m is the monetary policy shock at each model period t . Monetary policy shocks are normalized so that a positive shock is expansionary.

gether, lines (2) and (3) demonstrate that different sets of calibration for monetary policy process would still generate the positive cross-sectional risk premium for cash-rich firms. On the other hand, Line (4) shows that a higher slope in the Taylor Rule (i.e. a more aggressive stance on inflation) increases the beta coefficient for the portfolios of cash-rich firms. [Li and Palomino \(2014\)](#) also find a positive link between the stance on inflation and the expected returns.

6 Conclusion

This paper explores the role of cash heterogeneity in the transmission of monetary policy to firm dynamics and asset prices. First, I document that cash-rich firms pay out persistently more in response to expansionary monetary policy shocks that capture the central bank's intentions for the future path of monetary policy. The returns of cash-rich firms command a monetary policy risk premium as they respond more positively to monetary policy shocks. Those results underscore a close relation between firm values and equity payouts, suggesting an efficiency-enhancing role of monetary pass-through. As such, those findings contrast with the long-standing view that the payout channel of monetary policy is inefficient and undesirable. Second, I show that a heterogeneous-firm New Keynesian model with cash holdings

and equity issuance rationalizes payout responses to monetary policy and cross-sectional asset pricing dynamics of the data. In the model, precautionary motive leads firms with poor cash flows and high operating leverage to hold cash. By reducing the discount rate, monetary easing weakens precautionary cash demand, while it doesn't stimulate the investment of cash-rich firms with low profitability. Since payouts are procyclical, cash-rich firms earn higher returns in expansionary periods. Share prices reflect that it is indeed optimal for cash-rich firms to distribute rather than invest surplus cash.

A main contribution of the model is that it rationalizes monetary non-neutrality on corporate decisions as well as asset prices. However, the model is silent on the aggregate impacts of cash distributions from the firm to the investor side of the economy. Against the backdrop of rising corporate cash holdings over the last decade, understanding the aggregate implications of monetary policy through the payout channel becomes even more essential. For example, the impact of cash distributions on asset prices can be linked to how different households choose to utilize such excess cash through risk-sharing and portfolio choice. A heterogeneous firm model without an aggregate productivity shock is not sufficient to match the risk premium dynamics in the economy. Characterizing such dynamics requires a heterogeneous-agent New Keynesian (HANK) framework.

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Appendix

A Panel Data

This section describes the firm-level variables used in this paper. All variables are constructed based on quarterly Compustat data. The definition of the variables follow standard practices in the literature (e.g. [Campbell, Hilscher, and Szilagyi \(2008\)](#), [Almeida, Fos, and Kronlund \(2016\)](#), [Begenau and Salomao \(2019\)](#), [Ottonello and Winberry \(2020\)](#))

A.1 Sample Selection

I follow the sample selection procedures outlined in [Ottonello and Winberry \(2020\)](#). In particular, I exclude:

1. Firms that are not incorporated in the United States.
2. Firms in the financial industry (SIC code between 6000 and 6700) and the utilities sector (SIC code between 4900 and 4999)
3. Firm-quarter observations with acquisitions (*acqy*, item 91) larger than 5% of total assets
4. Firm-quarter observations with extreme observations as follows:
 - (a) Quarterly sales growth above 1 or below -1
 - (b) Cash ratio is in the top and bottom 0.5% of the distribution
 - (c) Total Equity Payout ratio above 1.

After sample selection, I also winsorize all control variables, market capitalization, leverage, Tobin's Q, ROA and sales growth at the top and bottom 0.5% of the observations. Finally, I drop all firms with less than 40 quarters of observations in order to precisely estimate fixed-effects. The results are qualitatively similar without such elimination, and available upon request.

A.2 Data Construction

1. **Equity Payouts:** I follow [Begenau and Salomao \(2019\)](#) to construct equity payout measures of this paper. *Equity Repurchases (Rep)* is the purchase of common and preferred stock (*prstkcy*) less any decrease in total preferred stock (*pstkq*). Variables ending in *y* in Compustat are stated as year-to-date, so I convert *prstkcy* into quarterly frequency by subtracting the past quarter from the current quarter. *Cash dividends (Div)* is defined as the total cash dividends (*dvty*). *Total Equity Payouts (EqOut)* is determined by $Eqout_t = Rep_t + Div_t$. I divide Rep_t and $EqOut_t$ by lagged market value of assets to compute Repurchase and Total Payout Ratios, as in [Almeida, Fos, and Kronlund \(2016\)](#).
2. **Debt Payouts:** *Debt Payout (DebtOut)* is given by the negative change in short term (*dlcq*) and long term (*dlttq*) debt. For robustness, an alternative *DebtOut* measure is defined as the cash payments for long term debt reduction (*dltry*) less the sum of cash proceeds from long term debt issuance (*dltisy*) and the changes in current debt (*dlcchy*). I convert variables ending in *y* into quarterly frequency by subtracting the past quarter from the current quarter. Debt payout ratios are normalized by the lagged market value of assets.
3. *Market Cap (ME)* is given by common Shares Outstanding (*cshoq*) times quarterly closing price of the firm (*prccq*).
4. *Market Value of Assets (MA)* is given by the book value of assets (*atq*) plus the market value of equity ME ($cshoq * prccq$) plus deferred taxes (*txditcq*) less the book value of equity (*ceqq*).
5. *Cash Ratio (cash)* is given by the ratio of cash and short-term investments (*cheq*) to market value of assets as in [Campbell, Hilscher, and Szilagyi \(2008\)](#) and [Ozdagli and Velikov \(2020\)](#).
6. *Investment (Δk)* is given by the log difference of the capital stock *k*. I follow [Ottonello and Winberry \(2020\)](#) to compute capital stock *k*. First, I set *k* as the level of gross plant, property, and equipment (*ppegtq*) in the first period in which this variable is non-missing. Starting from this period, I find cumulative capital stock by adding the changes of net plant, property, and equipment (*ppentq*) to *k* in each period. If an observation is missing,

I use a linear interpolation to approximate a $ppentq$ value in between two non-missing observations.

7. *Leverage (lev)* is defined as the ratio of total book value of debt (the sum of short term ($dlcq$) and long term ($dlttq$) debt) to the market value of assets.
8. *Firm Sales Growth (sales gr.)* is given by the change in log of sales ($saleq$).
9. *Firm Size (Size)* is given by the log of market value of assets.
10. *Tobin's q (Q)* is the ratio of market to book value of assets.
11. *Return on Assets (ROA)* is the ratio of gross profits to lagged book value of assets. Gross profits is given by sales ($saleq$) minus cost of goods sold ($cogsq$).
12. *Sector dummies*: I follow [Ottonello and Winberry \(2020\)](#) to construct sector dummies at 4-digit level. The sectors are given by: (i) agriculture, forestry, and fishing: $SIC < 1000$; (ii) mining: $SIC \in [1000; 1400]$; (iii) construction: $SIC \in [1500; 1700]$; (iv) manufacturing: $SIC \in [2000; 3900]$; (v) transportation, communications, electric, gas, and sanitary services: $SIC \in [4000; 4900]$; (vi) wholesale trade: $SIC \in [5000; 5100]$; (vii) retail trade: $SIC \in [5200; 5900]$; (viii) services: $SIC \in [7000; 8900]$ and public administration: $SIC \in [9100; 9700]$.

B Robustness Checks

This section presents a number of robustness checks for the main empirical results of the paper.

B.1 Heterogeneity in Firm Characteristics

I explore the link between monetary policy and the heterogeneity in firm-level characteristics, such as firm's market cap, Tobin's Q and leverage, other than corporate liquidity. Table [A1](#) shows that none of the firm characteristics drive the heterogeneous responses to monetary shocks. The interaction coefficient on market cap is significant only in the specification without corporate liquidity.¹⁵ The interaction coefficient with cash holdings remains stable after

¹⁵ An alternative measure of firm size as total assets leads to qualitatively similar results.

	$Rep_{i,t}$					
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS		0.182*** (3.053)		0.199*** (3.441)		0.203*** (3.554)
ME x ΔNS	-0.061*** (-2.827)	-0.046** (-2.069)				
TobinQ x ΔNS			-0.085** (-2.209)	-0.016 (-0.453)		
leverage x ΔNS					-0.035 (-1.162)	-0.011 (-0.388)
ΔNS	0.261** (2.469)	0.207** (2.024)	-0.042 (-0.683)	-0.020 (-0.325)	-0.045 (-0.750)	-0.021 (-0.337)
Observations	206,537	206,537	206,537	206,537	206,537	206,537
R ²	0.057	0.058	0.057	0.057	0.057	0.057

Table A1: This table reports the coefficient estimates from the specification 2 for variants of $x_{i,t}$:

$$Rep_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \gamma x_{i,t-1} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t} \quad (B1)$$

where Rep_{it} is the firm's repurchase ratio, $x_{i,t} \in \{ME, TobinQ, leverage\}$ is the firm's market capitalization, Tobin's Q or leverage, α_i is a firm i fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

controlling for other firm-monetary policy shock interactions. Hence, the main results are not driven by the differences in such characteristics.

B.2 Debt Issuance and Monetary Policy

Here, I extend the results reported in Table 6 on the relation between the heterogeneity in debt issuance and equity payouts. Table A2 further demonstrates that main results for the baseline specification (1) hold when I control for heterogeneity in debt issuance. Column (1) and Column (3) shows that debt payout (i.e. debt issuance) is negatively (positively) related to repurchasing activity of firms on average. Though, external financing activity doesn't drive the heterogeneous responses to monetary policy. The semi-elasticity of payout policy is actually positive, but insignificant, for higher debt payout firms in both Column (1) and (3). Importantly, the interaction coefficient with cash holdings remains strong after controlling for external financing in Column (2) and (4). Thus, my main results suggest that firms rely on precautionary cash savings to time their payout activity through monetary policy. Overall, the

	<i>Rep_{i,t}</i>			
	(1)	(2)	(3)	(4)
cash x ΔNS		0.202*** (3.512)		0.200*** (3.432)
Debtout x ΔNS	0.480 (0.284)	0.458 (0.270)		
Debtout	-0.015*** (-3.993)	-0.015*** (-3.994)		
$\mathbb{1}_{DebtIssue} \times \Delta NS$			-0.046 (-0.066)	-0.030 (-0.043)
$\mathbb{1}_{DebtIssue}$			0.009*** (9.356)	0.009*** (9.350)
ΔNS	-0.040 (-0.656)	-0.019 (-0.293)	-0.036 (-0.606)	-0.015 (-0.246)
Observations	207,560	207,560	207,560	207,560
R ²	0.060	0.061	0.065	0.065

Table A2: This table reports the coefficient estimates from the specification 2 variants of $y_{i,t}$ and $x_{i,t}$:

$$y_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \gamma x_{i,t} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Rep_{it}, EqOut_{it}\}$ are the firm's repurchase ratio or the total equity payout ratio, α_i is a firm i fixed effect, $x_{it} \in \{Debtout, \mathbb{1}_{DebtIssue_{it}}\}$ are the firm's debt payout ratio or an indicator of positive debt issuance policy, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include a fiscal quarter dummy and the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

empirical results in this section suggest that the heterogeneity in different characteristics drive the heterogeneous responses of equity and debt payouts to monetary policy.

B.3 Fed Information Effects

Nakamura and Steinsson (2018) show that policy news shocks contain information about not only the future path of monetary policy but also the future path of economic activity. Therefore, a main concern in my baseline analysis is whether main findings are driven by the information channel of monetary policy, rather than monetary policy news. To control for the information channel, I add Greenbook forecasts and forecast revisions between FOMC announcements in baseline specification (1). Table A3 shows that main results are robust to controlling the information effects of monetary policy.

	<i>Rep_{it}</i>			<i>EqOut_{it}</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.189*** (3.477)	0.207*** (3.736)	0.189*** (3.477)	0.133* (1.723)	0.144* (1.844)	0.133* (1.720)
Greenbook controls	Forecast	Revision	Both	Forecast	Revision	Both
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	206,537	206,537	206,537	206,537	206,537	206,537
R ²	0.059	0.058	0.059	0.092	0.092	0.092

Table A3: This table reports the coefficient estimates from the specification that includes Greenbook forecast and revision controls into the baseline specification (1). Monetary shock is normalized so that a positive shock is expansionary. I standardize *cash* over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

B.4 Alternative Instruments of Monetary Policy Shocks

Table A4 reports the robustness checks concerning the measure of monetary policy shocks from Nakamura and Steinsson (2018) (NS) used in the main empirical tests. As alternative measures, I employ the measure of high-frequency shocks from Gorodnichenko and Weber (2016) (GW) as well as the raw changes of Fed Funds rate, together with the estimates of shadow rates at the zero level bound, from Wu and Xia (2016) (WX).

My main results hold with the alternative instruments of monetary policy shocks. Columns (2) and (5) shows that the results with GW shocks are qualitatively similar to the main results with NS shocks. Though, the interaction coefficient of the specification with GW shocks is slightly lower, as the time series of GW shocks is shorter, from 1994-2008, which ends in the midst of the period where the responsiveness gets stronger. The magnitude of the interaction coefficient is much smaller, though significant, in the specification with WX shocks. The dampened coefficient in this case is not surprising, since the changes in Fed Funds rate is correlated with the real economy.

Table A5 further reports the robustness checks concerning the separate measures of expansionary and contractionary monetary policy shocks. The results show that heterogeneous responses of both repurchases and total equity payouts are driven by expansionary shocks.

	<i>Rep_{i,t}</i>			<i>EqOut_{it}</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.202*** (3.522)			0.145* (1.799)		
cash x ΔGW		0.203*** (3.579)			0.184** (2.461)	
cash x ΔWX			0.059*** (4.694)			0.030* (1.707)
ΔNS	-0.021 (-0.329)			0.045 (0.592)		
ΔGW		0.072 (1.117)			0.138* (1.714)	
ΔWX			0.022 (1.164)			0.022 (0.979)
Observations	207,560	173,535	207,560	207,560	173,535	207,560
R ²	0.057	0.058	0.057	0.091	0.097	0.091

Table A4: This table reports the coefficient estimates from the specification 2 for variants of ε_t^m :

$$Rep_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where Rep_{it} is the firm's repurchase ratio, $\varepsilon_t^m \in \{NS, GW, WX\}$ is the monetary shock obtained from [Nakamura and Steinsson \(2018\)](#) (NS), [Gorodnichenko and Weber \(2016\)](#) (GW) or [Wu and Xia \(2016\)](#) (WX), α_i is a firm i fixed effect, $cash_{i,t}$ is the firm's cash ratio, $Z_{i,t}$ is a vector of firm-level controls that include a fiscal quarter dummy and the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

B.5 Firm's Labor Policy and Payouts

Another concern about my main results is that firms' cash holdings might be tightly linked to labor costs. Since holding precautionary liquid assets improve the ability to pay wages, firms may react to financial shocks through employment decisions (e.g. [Bacchetta, Benhima, and Poilly \(2019\)](#)). Hence, I explore whether labor costs drive the heterogeneous responses to monetary policy in the main results. I construct two measures of relative labor costs. The first measure is the labor-capital ratio (LK), which is determined by the ratio of the number of employees (Compustat item *emp*) to the total property, plant and equipment (Compustat item *ppegt*). The second measure is the labor leverage measure (ELS) of [Donangelo, Gourio, Kehrig, and Palacios \(2019\)](#).¹⁶ ELS is defined as by the ratio of imputed labor expenses to the

¹⁶In [Donangelo, Gourio, Kehrig, and Palacios \(2019\)](#), the labor cost measures constructed from Compustat sample have very high correlations with the measures constructed with confidential Census data. The authors also show that empirical findings using Compustat and Census data are qualitatively similar.

	<i>Rep_{it}</i>			<i>EqOut_{it}</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.202*** (3.680)			0.136* (1.799)		
cash x <i>pos</i> ΔNS		0.198*** (2.733)			0.173* (1.849)	
cash x <i>neg</i> ΔNS			0.001 (0.013)			0.531*** (2.766)
Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	206,537	87,949	118,588	206,537	87,949	118,588
R ²	0.058	0.077	0.078	0.092	0.121	0.109

Table A5: This table reports the coefficient estimates from the specification (1) for variants of ε_t^m :

$$Rep_{i,t} = \alpha_i + \alpha_{s,t} + \beta cash_{i,t-1} \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $\{Rep_{it}$ is the firm's repurchase ratio, α_i is a firm i fixed effect, α_{st} is a sector s by quarter t fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two-way at the firm and quarter level. T-stats are reported in parentheses.

value added of labor. Imputed labor expense ($LABEX$) for a firm i is given by:

$$LABEX_{i,t} = \left(\sum_{i=1}^N \frac{xlr_{i,t}}{\left(\frac{emp_{i,t-1} + emp_{i,t}}{2} \right)} \right) * \left(\frac{emp_{i,t-1} + emp_{i,t}}{2} \right) \quad (B2)$$

The first parenthesis in B2 represents the cross-sectional average of wage at time t , while emp is the Compustat item for the number of employees. given $LABEX$, ELS is determined by:

$$ELS_{i,t} = \frac{LABEX_{i,t}}{oibdp_{i,t} + \Delta invfg_{i,t} + xlr_{i,t}}$$

where the denominator represents the value added of labor expense given by the sum of operating income before expenses ($oibdp$), the change in finished goods inventories ($invfg$) and total staff expenses (xlr).

I divide my sample into three terciles of each labor cost measure and run my baseline re-

Panel A: ELS Terciles:						
	$Rep_{i,t}$ ELS1	$Eqout_{i,t}$	$Rep_{i,t}$ ELS2	$Eqout_{i,t}$	$Rep_{i,t}$ ELS3	$Eqout_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.323*** (3.031)	0.193 (1.329)	0.256*** (2.826)	0.178 (1.508)	0.269* (1.731)	0.229 (1.270)
ΔNS	0.032 (0.340)	0.046 (0.425)	0.036 (0.441)	0.104 (1.107)	0.119 (1.214)	0.175 (1.563)
Observations	55,741	55,741	55,800	55,800	55,721	55,721
R ²	0.113	0.137	0.105	0.124	0.097	0.121

Panel B: LK Terciles						
	$Rep_{i,t}$ LK1	$Eqout_{i,t}$	$Rep_{i,t}$ LK2	$Eqout_{i,t}$	$Rep_{i,t}$ LK3	$Eqout_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.216** (2.429)	0.168* (1.661)	0.358*** (4.204)	0.297*** (2.697)	0.213 (1.006)	0.154 (0.696)
ΔNS	0.005 (0.057)	0.060 (0.625)	0.121 (1.379)	0.193* (1.932)	0.029 (0.278)	0.079 (0.736)
Observations	55,020	55,020	54,977	54,977	54,928	54,928
R ²	0.084	0.112	0.095	0.113	0.092	0.119

Table A6: This table reports the coefficient estimates from the specification (2) variants of $y_{i,t}$:

$$y_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Rep_{it}, EqOut_{it}\}$ are the firm's repurchase ratio or the total equity payout ratio, α_i is a firm i fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include a fiscal quarter dummy and the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. The sample data is split into three terciles with respect to two separate relative labor cost measures: (1) Labor leverage (*ELS*) in Panel A. (2) Labor-to-capital ratio (*LK*) (Panel B). ε_t^m is normalized so that a positive shock is expansionary. I standardize *cash* over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

gression specification (2) for each labor tercile.¹⁷ Table A6 shows qualitatively similar heterogeneous responses to monetary policy in different terciles of relative labor costs. Panel (A) display a U-shaped pattern in the strength of interaction coefficient in both repurchases and total payouts. On the other hand, Panel (B) shows that firms with lower relative labor cost have higher semi-elasticity of repurchases to monetary policy. Though, the interaction coefficient is significant in all labor terciles.

¹⁷Both measures of labor costs are constructed with annual data. I run the baseline specification with quarterly data as in the main section, but I update each firm's relative labor costs annually.

	R&D sample		Non-R&D sample	
	$Rep_{i,t}$	$EqOut_{it}$	$Rep_{i,t}$	$EqOut_{it}$
	(1)	(2)	(3)	(4)
cash x ΔNS	0.174* (1.967)	0.124 (1.175)	0.226*** (3.659)	0.178* (1.768)
ΔNS	-0.036 (-0.423)	-0.030 (-0.316)	0.042 (0.693)	0.130 (1.636)
Observations	64,171	64,171	143,389	143,389
R ²	0.066	0.077	0.054	0.097

Table A7: This table reports the coefficient estimates from the specification (2) variants of $y_{i,t}$:

$$y_{i,t} = \alpha_i + \beta cash_{i,t-1} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Rep_{it}, EqOut_{it}\}$ are the firm's repurchase ratio or the total equity payout ratio, α_i is a firm i fixed effect, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q, and ROA. The sample data is split into two samples and R&D sample represents firms that belong to seven R&D specific industries listed in [Begenau and Palazzo \(2020\)](#). ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

B.6 Firm R&D and Payouts

[Begenau and Palazzo \(2020\)](#) relates the increase in cash holdings over the last few decades to the R&D intensive firms. This raises the question whether cash holdings proxy R&D intensity, rather than precautionary savings, as a key driver of heterogeneous responses to monetary policy. To explore this question, I conduct two robustness checks that investigate the link between R&D and firm-level responses to expansionary monetary policy shocks.

First, I divide my Compustat sample into R&D intensive and non-intensive firm samples and run my baseline regression specification (2) for each sample. R&D intensive firms are firms that belong to seven R&D specific industries listed in [Begenau and Palazzo \(2020\)](#).¹⁸ Table A7 shows that main results hold not just in R&D sample, but also in non-R&D sample, as both samples are qualitatively similar in terms of semi-elasticities of payouts. In fact, the payout responsiveness in both extensive and intensive margins are larger for non-R&D firms. Unreported results show that responsiveness in other variables, such as investment, debt issuance and cash growth, are also similar in signs and magnitude.

¹⁸Those industries are based on three-digit SIC code and include Computer and Data Processing Services (SIC 737), Drugs (SIC 283), Medical Instruments and Supplies (SIC 384), Electronic Components and Accessories (SIC 367), Computer and Office Equipment (SIC 357), Measuring and Controlling Devices (SIC 382), and Communications Equipment (SIC 366).

	$Rep_{i,t}$	$\Delta k_{i,t+1}$	$\Delta cash_{i,t}$	$Rnd_{i,t}$	$DebtOut_{i,t}$
	(1)	(2)	(3)	(4)	(5)
Top.Rnd x ΔNS	0.427 (0.888)	-0.821 (-0.241)	-1.732 (-1.242)	1.915* (1.914)	-0.767 (-0.835)
ΔNS	-0.066 (-1.107)	0.287 (0.377)	-0.584** (-2.155)	-0.035*** (-2.643)	0.289* (1.680)
Observations	194,702	193,829	194,702	194,702	194,702
R ²	0.061	0.066	0.077	0.771	0.046

Table A8: This table reports the coefficient estimates from the following specification for variants of $y_{i,t}$ and $x_{i,t}$:

$$\Delta y_{i,t} = \alpha_i + \beta x_{i,t-1} \varepsilon_t^m + \gamma \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{i,t} \in \{Rep_{i,t}, \Delta k_{i,t+1}, \Delta cash_{i,t+1}, Rnd_{i,t}, DebtOut_{i,t}\}$ is the firm's repurchase ratio, investment, cash growth, R&D expense ratio or debt payout ratio, $x_{i,t} \in \{Top_Rnd_{i,t}\}$ indicates whether the firm has a total trailing R&D expense ratio larger than 2% for the past 4 quarters at quarter t , α_i is a firm i fixed effect, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q, ROA and R&D ratio. ε_t^m is normalized so that a positive shock is expansionary. Standard errors are clustered two-way at the firm and quarter level. T-stats are reported in parentheses.

Second, I investigate whether cash holdings is actually a proxy for R&D intensity, rather than precautionary motives. To do so, I replace dummy indicators of cash holdings in specification (4) with an R&D intensity variable and replicate the analysis. The quarterly R&D-intensity variable is a dummy indicator that captures firms with a total trailing R&D expense ratio larger than 2% for the past 4 quarters. The results in Table A8 suggest that R&D intensity does not replace cash richness in terms of monetary policy responsiveness. Payout responses of R&D intense firms are insignificant in both intensive (Column 1) and extensive margins (unreported) as compared to other firms. Moreover, R&D intense firms have positive responsiveness of R&D ratio and debt issuance ratio to expansionary shocks, unlike cash rich-firms in the main analysis of this paper. Interestingly, Column (3) suggests that R&D intense firms still deplete their cash holdings in response to expansionary policy, but not significantly more than other firms combined. Taken together with the results in Column (4), R&D intense firms divert their internal resources to more R&D, not equity payouts. Thus, R&D intensive firms contrast with cash-rich firms, which hold cash for precautionary motives and divert their cash holdings to payouts when precautionary reasons relax.

	<i>Rep_{it}</i>			$\mathbb{1}_{Rep_{it}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
cash x ΔNS	0.319*** (2.755)	0.248** (2.182)	0.249** (2.038)	4.787*** (3.417)	3.066** (2.196)	2.741* (1.836)
ΔNS			-0.083 (-0.663)			-3.331 (-1.315)
Firm controls	No	Yes	Yes	No	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	Yes	Yes	No	Yes	Yes	No
Observations	207,560	206,537	206,537	207,560	206,537	206,537
R ²	0.076	0.079	0.079	0.205	0.215	0.213

Table A9: This table reports the coefficient estimates from the specifications 1 and 2 for variants of $y_{i,t}$ and $x_{i,t}$:

$$y_{i,t} = \alpha_i + \alpha_{s,t} + \beta cash_{i,t-1} \varepsilon_t^m + \gamma x_{i,t} \varepsilon_t^m + \theta \varepsilon_t^m + \Gamma_1' Z_{i,t-1} + \epsilon_{i,t}$$

where $y_{it} \in \{Rep_{it}, \mathbb{1}_{Rep_{it}}\}$ are the firm's repurchase ratio or dummy variable whether the firm has distributed positive repurchases, α_i is a firm i fixed effect, $\alpha_{s,t}$ is industry-quarter fixed effects, $cash_{i,t}$ is the firm's cash ratio, ε_t^m is the monetary shock, $Z_{i,t}$ is a vector of firm-level controls that include the lagged values of cash ratio, leverage, market cap, sales growth, Tobin's Q. ε_t^m is normalized so that a positive shock is expansionary. I standardize $cash$ over the entire sample so coefficients reflect standard deviations relative to the mean. Standard errors are clustered two way at the firm and quarter level.

B.7 Robustness Checks for Cash and Payout Measures

In the main part of the paper, I normalize financial variables by the market value of assets to be consistent with my economic model in Section 3. Table A9 shows that baseline results are robust to normalizing by the book value of assets.

C Model Appendix

C.1 The Price Setting of Retailers and the Phillips Curve:

Here, I provide details in the derivation of the Phillips Curve in Equation 14. The derivations are standard, and follow Rotemberg (1982). There is a continuum of risk-neutral retailers. Each retailer j produces a differentiated good \tilde{y}_{jt} , set prices \tilde{p}_{jt} with a quadratic menu costs $\frac{\psi}{2} \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right)^2 P_t Y_t$ in terms of the final good Y_t , and pays a relative price p_t for the intermediate goods. The profit function of the retailer j is then given as:

$$\tilde{\pi}_{jt} = (\tilde{p}_{jt} - p_t) \tilde{y}_{jt} - \frac{\psi}{2} \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right)^2 P_t Y_t,$$

where P_t denotes the aggregate price index of the final good. We can insert the demand curve into the profit function and divide by P_t to re-arrange it in real terms as follows:

$$\tilde{\pi}_{jt} = (\tilde{p}_{jt} - p_t) \left(\frac{\tilde{p}_{jt}}{P_t} \right)^{-\gamma} \frac{Y_t}{P_t} - \frac{\psi}{2} \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right)^2 Y_t. \quad (C3)$$

The retailer maximizes expected discounted future profits:

$$\max_{\tilde{p}_{jt}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \tilde{\pi}_{jt} \quad (C4)$$

When we substitute the profits equation C3 into C4, the unconstrained maximization problem becomes:

$$\max_{\tilde{p}_{jt}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (\tilde{p}_{jt} - p_t) \left(\frac{\tilde{p}_{jt}}{P_t} \right)^{-\gamma} \frac{Y_t}{P_t} - \frac{\psi}{2} \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right)^2 Y_t. \quad (C5)$$

Solving the maximization problem C5 with respect to \tilde{p}_{jt} yields the following first-order

condition:

$$\begin{aligned}
0 = & (1 - \gamma) \left(\frac{\tilde{p}_{jt}}{P_t} \right)^{-\gamma} \frac{Y_t}{P_t} + \gamma p_t \left(\frac{\tilde{p}_{jt}}{P_t} \right)^{-\gamma-1} \frac{Y_t}{P_t} - \psi \left(\frac{\tilde{p}_{jt}}{\tilde{p}_{jt-1}} - 1 \right) \frac{Y_t}{\tilde{p}_{jt-1}} \\
& + \beta \psi \mathbb{E}_t \left[\left(\frac{\tilde{p}_{jt+1}}{\tilde{p}_{jt}} - 1 \right) \left(\frac{\tilde{p}_{jt+1}}{\tilde{p}_{jt}} \right) \frac{Y_{t+1}}{\tilde{p}_{jt}} \right].
\end{aligned} \tag{C6}$$

Retailers are subject to the same marginal costs p_t and the aggregate demand of the final good Y_t , hence every retailer sets the same price. Then, the price index implies $\tilde{p}_{jt} = P_t$. Making the substitution and re-arranging the terms in C6 yields:

$$\begin{aligned}
0 = & (1 - \gamma) + \gamma p_t - \psi \left(\frac{\Pi_t}{\Pi} - 1 \right) \left(\frac{\Pi_t}{\Pi} \right) \\
& + \beta \psi \mathbb{E}_t \left[\left(\frac{\Pi_{t+1}}{\Pi} - 1 \right) \left(\frac{\Pi_{t+1}}{\Pi} \right) \left(\frac{Y_{t+1}}{Y_t} \right) \right],
\end{aligned} \tag{C7}$$

where $\Pi_t = P_t/P_{t-1}$ and $\Pi = 1$ is the steady state gross inflation rate. At its steady state, equation C7 implies a steady state relative price of the intermediate good $p^* = \frac{\gamma-1}{\gamma}$. Finally, linear approximation of C7 around its steady state yields the log-linearized Phillips Curve in Equation 14.

C.2 Recursive Equilibrium Definition:

A recursive competitive equilibrium consists of an individual firm state vector $\Omega = \{z_t, k_t, c_t\}$, an aggregate state vector $\mathbf{s} = \{\mu_t \Omega, \varepsilon_t^{mon}\}$ a set of policy functions $(k_{t+1}(\Omega, \mathbf{s}), c_{t+1}(\Omega, \mathbf{s}))$, value functions $(V_t(\Omega, \mathbf{s}), V_{ent}(q_t, \mathbf{s}))$, prices $(\hat{P} = \{\Pi, p_t, w, R_t^{nom}\})$, aggregate capital, production, labor and investment (K, Y, I, L) , the joint distribution of productivity, capital and cash holdings $\mu_t(\Omega)$, and a perceived law of motion Γ such that:

1. **Firm optimization:** Given prices \hat{P} and aggregate state vector \mathbf{s} , $V_t(\Omega, \mathbf{s})$ solves the maximization problem (12) with associated policy rules $k_{t+1}(\Omega, \mathbf{s}), c_{t+1}(\Omega, \mathbf{s})$.
2. **Entry:** Given prices \hat{P} and aggregate state vector \mathbf{s} , $V_{ent}(q_t, \mathbf{s})$ solves the entrant problem (13) with associated policy rules $k_{t+1}^*(\Omega, \mathbf{s}), c_{t+1}^*(\Omega, \mathbf{s})$.

3. **New Keynesian Block:** Given aggregate state vector \mathbf{s} , Π_t and p_t satisfy (14). R_t^{nom} evolves according to (15).
4. **Household Optimization:** The stochastic discount factor is given by $\Lambda_{t+1} = \beta \left(\frac{C_t}{C_{t+1}} \right)$. The Euler equation (17) and the real wage equation 18 holds.
5. **Market Clearing:** At each t , aggregate capital is given by $K_t = \int_j k_{tj} d\mu_t(\Omega)$, aggregate investment is given by $I_t = \int_j i_{tj} d\mu_t(\Omega)$. For all \mathbf{s} , aggregate consumption holds for the general equilibrium condition $C_t = Y_t - I_t - N * \xi$, where N is the total number of firms.
6. **Law of Motion:** The actual law of motion for the joint distribution of heterogeneous firms and the perceived law of motion coincide, such that $\mu_{t+1} = \Gamma(\Omega, \mathbf{s})$

C.3 Computational Details:

Model Solution: I solve the model using an extended version of inner and outer loop algorithm of [Krusell and Smith \(1998\)](#) as in [Khan and Thomas \(2008\)](#) and [Gilchrist, Sim, and Zakrajšek \(2014\)](#). In the inner loop, the agents approximate the intractable distribution of firms $\mu_t(\Omega)$ over idiosyncratic productivity, capital and cash holdings with the first moment of the distribution of capital. Given this approximation, agents use the forecasting rules of (19) to form expectations of future inflation as well as market clearing price of marginal utility of consumption and intermediate goods. Under the forecasting rules, agents solve the inner-loop problem using a value function iteration routine. Once the value and policy functions are obtained, the outer loop updates the forecasting rules using a Monte-Carlo simulation.

The inner loop algorithm works as follows: First, I discretize two 5-grid Markov Chains for idiosyncratic productivity z_t and monetary policy shocks ε_t^m using [Tauchen \(1986\)](#) and [Rouwenhorst \(1995\)](#), respectively. Second, I discretize unequally spaced grids for state/policy variables k_t and c_t with more points around lower values and grid sizes of 30 and 15, respectively. I also discretize past consumption state with grid size of 24, but more points around the mean value of the stationary equilibrium. After setting up state/policy grid space, I guess an initial parameters A, B for the forecasting rule in (19). Note that the forecasting rules together with aggregate states allow firms to conjecture the inflation and nominal interest rates in the

firm optimization. Given the forecasting rules, I solve the firm value function 12 subject to 11. Following Khan and Thomas (2008), I simplify the optimization problem 12 by defining $\hat{V}_{jt} = \hat{q}_t * V_{jt}$ where $\hat{q}_t = u_c(t)$ is the marginal utility of consumption. Then, problem 12 can be transformed into the following form :

$$\hat{V}_{jt} = \max_{k_{t+1}, c_{t+1}} \hat{q}_t * (d_{jt} + \Psi(d_{jt})) + \mathbb{E}_t \left[\left(\hat{q}_t \eta_e (\pi_{jt+1} + (1 - \delta)k_{t+1}) + (1 - \eta_e) \beta \hat{V}_{jt+1} \right) \right] \quad (C8)$$

I iterate on the functional equation C8 on a finite grid of state space and compute decision rules for capital and cash. The optimization for the firm entry follows the same steps.

In the outer loop, I update the forecasting rules using a Monte Carlo simulation of the economy with for $N = 3000$ firms and $T = 1500$ quarters, discarding the first 500 quarters. Each simulation starts with the stationary distribution implied by the model without monetary policy shock, then computes the optimal policies at each period t assuming the agents derive optimal policies under the forecasting rules 19 from period $t + 1$ onward. As in the inner loop, this last assumption allows agents to compute expectations, hence equilibrium interest rates and inflation, given aggregate states. In each period t , I solve for the marginal utility of consumption and the relative price of output by clearing the market without reference to the forecast price levels. Given aggregate variables from the simulation, I re-estimate the forecasting rules via OLS and update the parameters accordingly in the next iteration of the inner loop. I re-iterate the inner and outer loop until full convergence of the parameters.

The recursive equilibrium is solved using Armadillo package of C++. Armadillo is a high quality linear algebra library parallelized with OpenMP and has an interface similar to MATLAB. Inner-outer loop takes approximately 2 hours per iteration and requires more than 50 iterations to converge. Though, the number of iterations are dramatically decreased by using good guesses for forecasting rules learned from previous experiments.

I check whether the posited rules in (19) approximate the true aggregate law of motion well. Table A10 displays the parameter estimates implied by the forecasting equations (19) of the agents uses to predict equilibrium quantities in the model. The high R^2 values suggest that agents' forecasting rules are highly accurate, and they are good approximations of the model's

	Dependent Variables		
	$\log u_c(t)$	$\log p_t$	$\log \Pi_{t+1}$
	(1)	(2)	(3)
$\log c_{t-1}$	-0.98*** (0.0003)	-0.093*** (0.00003)	-0.064*** (0.0002)
ε_t^m	0.003* (0.002)	0.0002 (0.0002)	-0.325*** (0.001)
R^2	0.999	0.999	0.997

Table A10: This table reports the converged parameter estimates and R^2 values for the forecasting rules in 19.

true rational expectations equilibrium.

Computing Impulse-Responses: Despite very high R^2 of the forecasting rules, the model's responses to the monetary policy shocks are not reflected by such log-linear rules due to sampling variation in idiosyncratic productivity shocks. To account for the non-linearities of the model, I compute the impulse responses to the monetary policy shock following the algorithm of [Gilchrist, Sim, and Zakrajšek \(2014\)](#).

The algorithm is as follows: Using a set of idiosyncratic productivity shocks for N firms and T periods, I construct two model simulations, one with a monetary policy shock at time t^* and one without a monetary policy shock. Note that the monetary policy shock at time t^* evolves according to its specified law of motion -AR(1) process. Let $y_{m,it}^1$ and $y_{m,it}^0$ denote the output of a model variable (e.g. equity payout) in m^{th} simulation with and without a monetary policy shock, respectively. Given this procedure is repeated M times, the model implied impulse response of an aggregate variable \hat{y}_t is given by:

$$\hat{y}_t = 100 * \log \frac{\sum_{m=1}^M \sum_{t=1}^T y_{m,it}^1}{\sum_{m=1}^M \sum_{t=1}^T y_{m,it}^0} \quad (C9)$$

I set $M = 1000$, $N = 3000$, $T = 150$ and $t^* = 100$ and apply polynomial fitting to generate responses reported in Figure 4 of the main text.