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# Firm Financial Conditions and the Transmission of Monetary Policy*

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February 10, 2023

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# 1 Introduction

How does a firm's investment response to monetary policy depend on its financial conditions? Most of the large literature addressing this question is informed by theories in which firms' access to external funds is subject to financial market frictions (e.g., Bernanke and Gertler, 1989 and Kiyotaki and Moore, 1997). On the empirical front, the literature has then proxied for the severity of firms' financial frictions using various firm characteristics, such as size (Gertler and Gilchrist, 1994), default risk (Ottonello and Winberry, 2020), age (Cloyne et al., 2019), and liability structure (Gürkaynak et al., 2022). The general message of this research is that financial frictions, reflected in firms' marginal cost curves (Bernanke et al., 1999), play an important role in shaping firms' responses to monetary policy.

In this paper, we document that a firm's excess bond premium (EBP)—the component of its credit spread in excess of its default risk (Gilchrist and Zakrajšek, 2012)—is a major determinant of its responsiveness to monetary policy. Importantly, our results indicate that a firm's EBP conveys information about the slope of its marginal benefit curve for capital and is distinct from firm characteristics associated with financial frictions. We show that while monetary policy easings compress credit spreads more for firms with ex-ante higher EBPs, it is firms with lower EBPs that invest more. We rationalize these findings using a model in which firms with flatter marginal benefit curves have lower EBPs in equilibrium, reflecting the relative resilience of their marginal productivity to further capital accumulation. We provide further support for this economic mechanism by showing that two key implications of our model hold empirically: (i) lower-EBP firms' investment is more sensitive to changes in their credit spreads; and (ii) the effect of monetary policy on aggregate investment depends on the moments, in particular the skewness, of the cross-sectional EBP distribution, which vary over time.

We begin by studying the heterogeneous responses of firms' credit spreads and investment to monetary policy shocks using a database that paints a comprehensive picture of firms' financial conditions. Specifically, we combine data on bond-level credit spreads and firm-level balance sheets from 1973 to 2021 with monetary policy shocks identified using high-frequency data. We find, on the one hand, that easing monetary policy shocks compress credit spreads more for firms with ex-ante higher EBPs, that is, for firms with tighter ex-ante financial conditions. On the other hand, we find that easing monetary policy shocks induce larger investment responses from firms with ex-ante lower EBPs. In both cases, the heterogeneity is economically significant: the peak response of investment and credit spreads for a firm with an EBP one standard deviation from the mean is about twice the size of the mean firm's response. We also show that, as a state variable for the transmission of monetary policy, a firm's EBP plays a larger role than its default risk, measured both by "distance to default" (Merton, 1974) and leverage, and is statistically distinct from other firm-level characteristics such as size, liquid assets, and age.

We rationalize our empirical results using a model in which a firm's EBP conveys the slope of its marginal benefit curve for capital. A flatter marginal benefit curve implies that the firm's marginal product of capital (MPK) diminishes relatively slowly as it invests. The model also features an upward-sloping marginal cost curve for financing investment, which arises due to financial intermediaries' leverage constraints (Gertler and Kiyotaki, 2010, Gertler and Karadi, 2011 and Anderson and Cesa-Bianchi, 2021). In equilibrium, we show that the financial sector affords lower EBPs to firms with more-resilient investment prospects. This firm-level result is consistent with the interpretation of aggregate EBP as representing investors' views regarding the economic outlook for firms as a whole (Favara et al., 2016 and López-Salido et al., 2017).

We shed light on the importance of the slope of firms' marginal benefit curves for the transmission of monetary policy using a comparative statics exercise. A monetary easing, by increasing financial intermediaries' net worth, leads to an outward shift in the marginal cost curve that traces along firms' marginal benefit curves. Thus, a monetary easing engenders a relatively large increase in investment by low-EBP firms—those with flatter marginal benefit curves—despite a relatively mild fall in their credit spreads. Conversely, high-EBP firms increase investment relatively little despite a larger fall in their credit spreads. These results match our empirical findings and highlight the salience of the slope of firms' marginal benefit curves for shaping the response of firms' investment and spreads to monetary policy, a mechanism overlooked by the literature.

We then further inspect our model's mechanism by testing two of its central implications, one of which is at the firm level and the other in the aggregate. First, the model's emphasis on the slope of firms' marginal benefit curves is relevant not just for monetary policy shocks, but applies for any shift in the marginal cost curve. Thus, in addition to the inverse relationship between firms-level credit spreads and investment documented in many studies (e.g., Gilchrist and Zakrajšek, 2007), one should observe that firms with lower EBPs invest more following a reduction in their credit spreads, due to their flatter marginal benefit curves. We find strong evidence of this in the data.

The second implication of our model is that the aggregate effectiveness of monetary policy should depend on the cross-sectional distribution of firm EBPs. Specifically, when a larger mass of firms have lower EBPs, that is, flatter marginal benefit curves, monetary policy should be more potent. We test this using moments of the cross-sectional EBP distribution as aggregate state variables and interact them with our monetary policy shocks. Consistent with our model, we find that in times when the EBP distribution is more left-skewed, reflecting a greater concentration of firms with flatter marginal benefit curves, expansionary monetary policy shocks induce larger increases in aggregate investment growth.

**Literature Review:** Our paper relates to three strands in the literature.

The first strand investigates firms' heterogeneous responses to monetary policy. Much of this literature builds on theories in which firms' access to external funds is subject to financial frictions, such as agency costs (Bernanke and Gertler, 1989, and Bernanke et al., 1999), collateral constraints tied to firms' physical capital (Kiyotaki and Moore, 1997) and earnings (Lian and Ma, 2021), as well as frictions in financial intermediation (e.g., Gertler and Kiyotaki, 2010, and Gertler and Karadi, 2011). Importantly, as highlighted by Ottonello and Winberry (2020), for example, financial frictions influence the shape of the marginal cost curve faced by firms. On the empirical front, the literature has used many firm-level characteristics to proxy for the severity of these financial frictions, such as liability structure (Ippolito et al., 2018; Gürkaynak et al., 2022), age and dividends (Cloyne et al., 2019), size (Gertler and Gilchrist, 1994; Crouzet and Mehrotra, 2020), leverage (Anderson and Cesa-Bianchi, 2021; Caglio et al., 2021; Wu, 2018; Lakdawala and Moreland, 2021), credit default swap spreads (Palazzo and Yamarthy, 2022), liquid assets (Jeenas, 2019; Jeenas and Lagos, 2022), liquidity-constraints (Kashyap et al., 1994), marginal productivity (González et al., 2021), and information frictions (Ozdagli, 2018; Chava and Hsu, 2020).[1] We contribute to this literature by showing that a firm's EBP is an important determinant of its responsiveness to monetary policy. Moreover, we provide evidence that firm EBPs convey information about the slope of firms' marginal benefit curves for capital, making it distinct from financial frictions that are summarized by firms' marginal cost curves.

Second, our paper adds to the longstanding literature on the determinants of investment, especially the user cost of capital theory (Jorgenson, 1963) and the q theory (Tobin, 1969).[2] To address the empirical weakness of q theory when assessed using equity prices, Philippon (2009) builds a model in which the "bond market's q" is captured (predominantly) by firm credit spreads, which he finds to be a strong predictor of U.S. aggregate investment.[3] Relatedly, Gilchrist and Zakrajšek (2007) and Gilchrist et al. (2014) find similar results for firm-level credit spreads, which are the main source of variation in firms' user-cost of capital. Gilchrist and Zakrajšek (2012) clarify that it is the non-default-risk component of credit spreads, the EBP, that best predicts aggregate economic activity. Our contribution to this literature is twofold: (i) we show that the sensitivity of firms' investment to changes in credit spreads depends on their ex-ante EBP; and (ii) we provide evidence that firms' EBPs convey information about the slope of their marginal benefit curves for capital, or MPK in our setup, which is tied to the user cost and q in equilibrium.

Third, our paper contributes to the literature investigating the time-varying aggregate effects of monetary policy, especially its weaker effects during recessions. Vavra (2014) and McKay and Wieland (2021) build models in which monetary policy is less effective

[1]Focusing on firm cyclicality, Crouzet and Mehrotra (2020) highlight that as a state variable, firm size may not be capturing the extent of firms' financial frictions, but rather their industry scope. Jeenas and Lagos, 2022 also focus on a non-financial-frictions channel by studying the effects of an instrumented Tobin's q on firm equity issuance and investment conditional on firms' asset liquidity.

[2]These literatures have their roots in the prima facie incompatibility between the stock and flow theories of capital and investment, respectively (e.g. Clark, 1899, Fisher, 1930, Keynes, 1936, Hayek, 1941). Beginning with Lerner (1953), q-theory has appealed to adjustment costs to resolve this incompatibility (see e.g. Lucas and Prescott, 1971, Abel, 1979 and Hayashi, 1982).

[3]Lin et al. (2018) extend the model to stochastic interest rates and empirically support their theory.

in recessions due to cyclicality in the cross-sectional distribution of price adjustments and durable expenditures, respectively. Tenreyro and Thwaites (2016) document that the decreased power of U.S. monetary policy in recessions is particularly evident for durables expenditure and business investment, while Jordà et al. (2020) show this pattern holds internationally. Our paper contributes to this literature by providing a new mechanism for monetary policy's time-varying effects and its weaker transmission in recessions: cyclicality in the slope (around equilibrium) of firms' marginal benefit curves for capital, as reflected in the moments of the cross-sectional distribution of firm EBPs.

# 2 Data and Descriptive Statistics

In this section, we discuss the baseline monetary policy shock series (Section 2.1); describe the EBP calculation (Section 2.2); document how the cross-sectional EBP distribution evolves over time and relates to other firm characteristics (Section 2.3); and report the common elements of our regression specifications (Section 2.4).

## 2.1 Monetary Policy Shocks

As a baseline, we use the monetary policy shocks proposed by Bu et al. (2021). These shocks combine three appealing features, which together distinguish them from other monetary policy shocks in the literature. First, by extracting high-frequency interest-rate movements from the entire U.S. Treasury yield curve, these shocks stably bridge periods of conventional and unconventional monetary policy. Second, these shocks are devoid of the central bank information effect: the idea that monetary policy announcements, in addition to providing a pure monetary policy surprise, may also reveal information about the central bank's views on the macroeconomy. Third, these monetary policy shocks are not predicted ex-ante by available information, such as Blue Chip forecasts, "big data" measures of economic activity, news releases, and consumer sentiment.[4]

[4]For critiques of earlier monetary policy shocks that exhibited predictability, see, for example, Ramey (2016), Miranda-Agrippino (2016) and Bauer and Swanson (2020).

We calculate these shocks for the period between January 1985 and December 2021, and normalize their sign so that positive values refer to monetary policy easings. Additionally, for regressions at a quarterly frequency, we aggregate the shocks by summing them within the quarter. See Appendix A.1 for more details on the monetary policy shocks. Appendix B.5 shows that our results are robust to using alternative monetary policy shocks.

## 2.2 Data Sources and EBP Calculation

To provide a comprehensive picture of the firm, we use four databases: CRSP for stock market returns, Compustat for balance sheet information, and Lehman-Warga and Merrill-Lynch for corporate bond yields quoted in secondary markets. Our dataset allows us to explore the effects of monetary policy on both firm quantities (investment) and prices (credit spreads). The sample period is October 1973 to December 2021. For more details about our dataset, including variable definitions and sample selection, see Appendix A.2.

To calculate the excess bond premium, we follow an approach similar to Gilchrist and Zakrajšek (2012). We first compute the credit spread $S_{ikt}$ on the bond $k$ issued by firm $i$ at time $t$ as the difference between the bond's yield and the yield on a U.S. Treasury that shares the same maturity, with the latter calculated by Gürkaynak et al. (2007). Then, we decompose each bond's credit spread $S_{ikt}$ into two components. The first is driven by the firm's default risk, as well as a vector of bond characteristics, and is termed the predicted spread $\hat{S}_{ikt}$. The second, and residual, component is the excess bond premium, $EBP_{ikt}$.

More precisely, we assume the following decomposition for bond-level credit spreads:

$$\log S_{ikt} = \beta DD_{it} + \gamma^{'}\mathbf{Z}_{ikt} + \upsilon_{ikt}, \tag{1}$$

where $DD_{it}$ is firm $i$'s distance to default, which captures firm $i$'s expected default probability (Merton, 1974); $\mathbf{Z}_{ikt}$ is a vector of the bond's characteristics, including its duration, coupon rate and age as well as firm and credit rating fixed effects; and $\upsilon_{ikt}$ is the error term. We estimate regression (1) by ordinary least squares (OLS) and compute the predicted credit spread $\hat{S}_{ikt}$ as

$$\hat{S}_{ikt} = exp\Big[\hat{\beta} DD_{it} + \hat{\gamma}' \mathbf{Z}_{ikt} + \frac{\hat{\sigma}^2}{2}\Big], \tag{2}$$

where $\hat{\beta}$ and $\hat{\gamma}$ denote the OLS estimates from regression (1) and $\hat{\sigma}^2$ denotes the estimated variance of the error term, which we assume to be normally distributed. While the model is simple, it explains a significant share of variation in credit spreads—the $R^2$ is 0.68—driven largely by the firm's default risk.

We define the excess bond premium (EBP) of firm $i$'s bond $k$ at time $t$ as

$$EBP_{ikt} = S_{ikt} - \hat{S}_{ikt}. \tag{3}$$

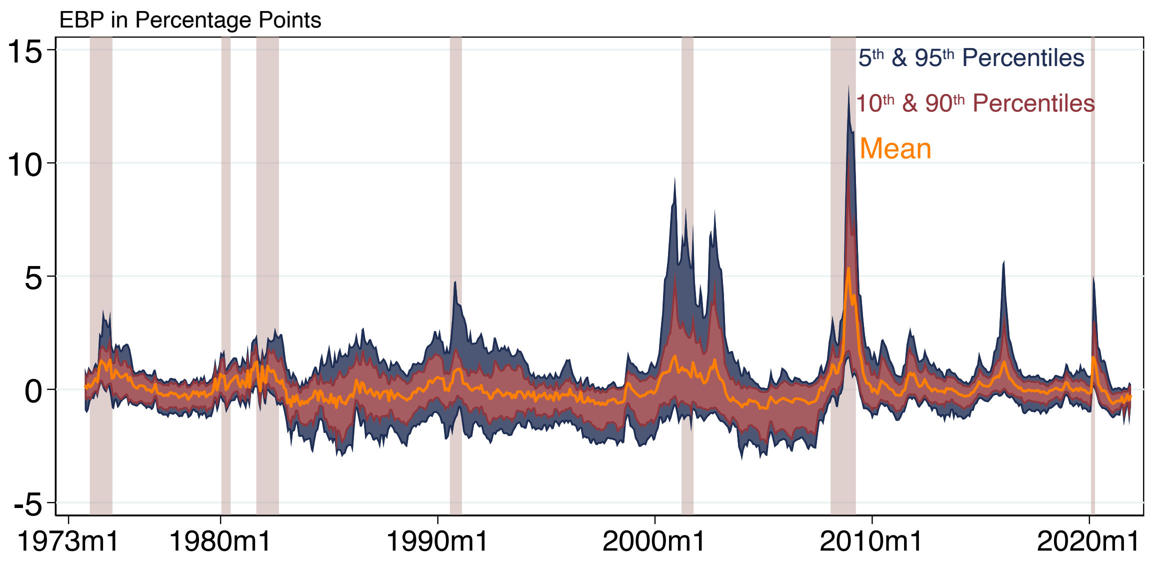
Thus, the $EBP_{ikt}$ is the component of the bond's credit spread that is unexplained by the firm's default risk and the bond's salient characteristics.[5] A higher $EBP_{ikt}$ implies that, controlling for its default risk, the firm faces a higher marginal borrowing rate on its debt, and, thus, faces tighter financial conditions. See Appendix A.3 for more details on the EBP calculation. Appendix B.6 shows that our results in the subsequent sections are robust to using a modified $EBP_{ikt}$ that accounts for a potential nonlinear relationship between spreads and distance to default.

After implementing this procedure for the bonds in Merrill-Lynch and Lehman-Warga databases whose firm's balance sheet information and equity prices are available in Compustat and CRSP, respectively, our dataset contains 11,319 bonds from 1,913 firms for the period 1973–2021.[6] Owing to our use of the Lehman-Warga database and a monetary policy shock series that spans periods of conventional and unconventional policy, we obtain either a longer sample and/or more bonds and firms than used in the existing literature (e.g., Ottonello and Winberry, 2020, Anderson and Cesa-Bianchi, 2021).

[5] In Appendix A.3, we document that the correlation between our mean credit spreads and that of Gilchrist and Zakrajšek (2012) is 96%. The correlation is 86% between our two mean EBPs.

[6] We clean the data as in Gilchrist and Zakrajšek (2012); see Appendix A.2 for details.

FIGURE 1
Cross-Sectional Distribution of Bond-Level EBPs over Time




*Note*. Figure 1 shows the mean and selected percentiles (5th, 10th, 90th, and 95th) of the cross-sectional distribution of bond-level EBPs. Shaded columns correspond to periods classified as recessions by the National Bureau of Economic Research.

## 2.3 The Cross-Sectional EBP Distribution

We document that the cross-sectional EBP distribution displays considerable heterogeneity and contains important information beyond what is reflected by the mean EBP (Gilchrist and Zakrajšek, 2012). Figure 1 plots the bond-level cross-sectional EBP distribution over the period 1973–2021. For most of this period, the left-tail percentiles are below zero, indicating that an appreciable segment of bonds receive a discount on their credit spreads relative to their default risk. Left-tail percentiles also have more muted cyclical fluctuations than the mean EBP, with a noticeable rise above zero only during the 2008 crisis. In contrast, right-tail percentiles are not only more volatile than the mean, but are also generally greater than zero. Thus, right-tail firms usually pay a premium on their borrowing costs relative to their default risk, especially in recessions. In what follows, we show that firm EBPs contain firm-specific information related to their economic prospects.

Although the percentiles of the EBP distribution vary considerably over time, a bond's place within the EBP distribution is persistent. Table 1 displays the Markov transition

Table 1
Transition Matrix for Monthly Bond-Level EBPs

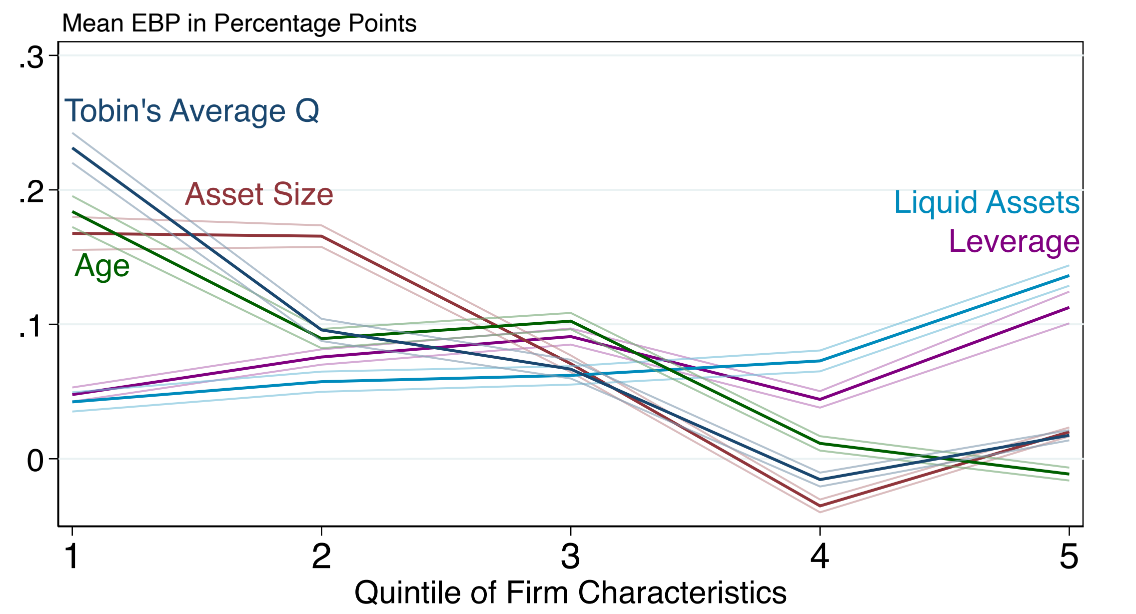
| | | $EBP_{ik,t+1}$ Quintiles | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| $EBP_{ik,t}$ Quintiles | 1 | 0.85 | 0.11 | 0.02 | 0.01 | 0.01 |
| | 2 | 0.13 | 0.67 | 0.16 | 0.03 | 0.02 |
| | 3 | 0.02 | 0.18 | 0.62 | 0.16 | 0.02 |
| | 4 | 0.01 | 0.04 | 0.18 | 0.66 | 0.11 |
| | 5 | 0.01 | 0.01 | 0.02 | 0.13 | 0.83 |

*Note.* Table 1 provides transition probabilities for monthly bond-level EBPs based on 5 states. Entry in row i and column j refers to the probability of transitioning from state (quintile) i to state (quintile) j in the subsequent month. Probabilities are calculated as an average over the sample.

matrix for bond-level EBPs. The table shows that the probability of a bond's EBP staying in its quintile in the next month (diagonal entries) is much higher than transitioning to any other quintile, with this result being particularly strong in the lowest and highest quintiles of the distribution. This result is necessary, but not sufficient, for firm-level EBPs to encode important information about the economic state of firms.

We also document the cross-sectional relationship between firm EBPs and other firm characteristics (Figure 2). Specifically, we focus on the average relationship between the EBP and the following variables: leverage (debt over assets), liquid assets (cash over assets), age (time since IPO), size (asset value), and average Tobin's Q (market over book value of assets). We observe a mildly increasing association between firms' EBP and both their leverage and liquid assets, with firms in the highest quintile tending to have higher EBPs. In contrast, younger and smaller firms tend to have higher average EBPs, although this relation is non-monotonic. Finally, we see that firms with higher average Tobin's Q are prone to lower EBPs. Despite these cross-sectional correlations, the results that follow highlight that the information contained in firms' EBPs are statistically and economically distinct from these other variables.

FIGURE 2
Firm EBPs vs. Firm Characteristics in the Cross-Section




*Note.* Figure 2 reports firms' average EBP (y-axis) in each quintile of the following firm characteristics (x-axis): leverage (debt over assets), liquid assets (cash over assets), age (months since IPO), size (assets), and Tobin's average Q (market over book value of assets). Lines of lighter colors correspond to 90% confidence intervals. For each firm characteristic, (i) we sort firms into quintiles using the historical average of the characteristic, then (ii) we calculate the average EBP (and associated confidence interval) for the firms in each quintile.

## 2.4 Common Features of Regression Specifications

To estimate the effects of monetary policy conditional on a firm's characteristic, we follow Jeenas (2019) by averaging the characteristic's value over the previous year. For example, $EBP^{ma}_{ikt}$ denotes the average EBP of firm $i$'s bond $k$ at time $t$ over the previous year.[7] This helps purge uninformative high-frequency variation in our conditioning variables, as well as possible seasonality. Our conclusions, however, are not tied to this particular functional form. In Appendix B.2, we show that our results are robust to conditioning on a dummy variable for if the value of a firm's characteristic is above or below the associated median value across all firms in a given period (Cloyne et al., 2019, Anderson and Cesa-Bianchi, 2021). For interpretability, we also standardize the conditioning variables to have zero mean and unit variance over the entire sample.

[7]This corresponds to the previous 12 months for monthly data and 4 quarters for quarterly data.

Throughout the paper, our specifications include both firm-level and aggregate controls, which we denote by $\mathbf{Z}_{it}$. Firm-level controls are leverage, size, sales growth, age, liquid assets, short-term asset share (current over total assets), and Tobin's average Q. Aggregate controls focus on economic and financial conditions using three lags of the following variables: Chicago Fed's national activity index for monthly regressions and GDP growth for quarterly regressions, the economic policy uncertainty index of Baker et al. (2016), and the first three principal components of the U.S. Treasury yield curve. Our baseline regressions use macro-financial controls because they allow us to compare the unconditional effect of monetary policy shocks with the effects conditional on firms' characteristics. That said, our results for the effects of monetary policy conditional on a firm's EBP are robust to including sector-time fixed effects, as shown in Appendix B.1. Finally, for all panel regressions, inference is conducted using standard errors that are two-way clustered by firm and time.

# 3 Monetary Policy and Bond-Level Credit Spreads

In this section, we document that expansionary monetary policy shocks decrease credit spreads more for high-EBP bonds than for low-EBP bonds. We also show that the sensitivity of credit spreads to monetary policy shocks is primarily determined by a bond's EBP, rather its firm's default risk.

Our baseline specification estimates the transmission of monetary policy to bond-level credit spreads both unconditionally and conditional on a bond's *ex-ante* EBP. Specifically, we estimate the following local projections (Jordà, 2005) at a monthly frequency for a series of horizons $h$:

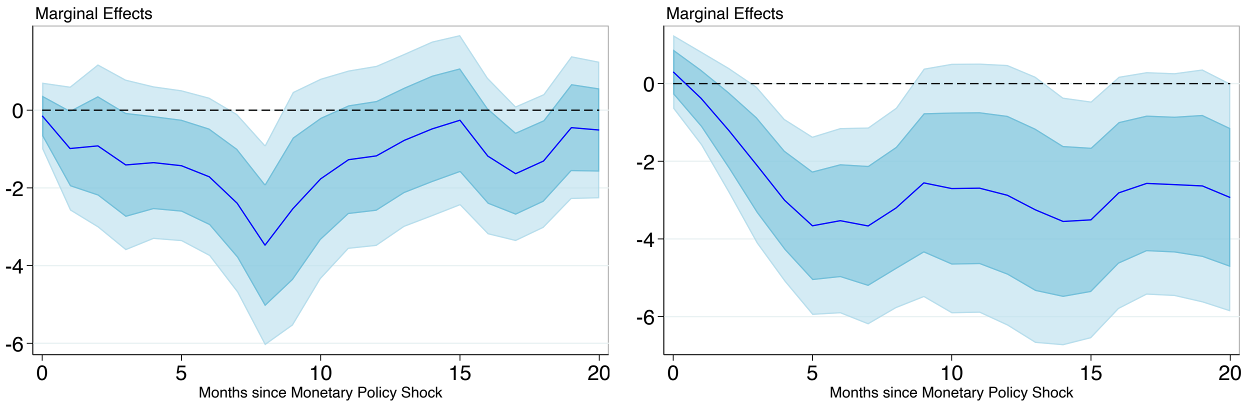
$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{4}$$

where $S_{ikt}$ denotes firm i's bond k credit spread; $\varepsilon_t^m$ refers to the monetary policy shock; $EBP_{ikt-1}^{ma}$ represents firm i's standardized EBP as conveyed by its bond $k$; $\beta_k^h$ is a bond fixed effect; and $\mathbf{Z}_{it-1}$ is the vector of control variables described in Section 2.4, plus $EBP_{ikt-1}^{ma}$. Importantly, $EBP_{ikt-1}^{ma}$ is lagged, as are the controls, to ensure they are not influenced by

FIGURE 3

Monetary Policy's Effect on Bond-Level Credit Spreads

(A) Unconditional (B) Conditional on EBP




*Note.* Figure 3 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on the h-month change in bond credit spreads, $S_{ikt+h} - S_{ikt-1}$, which we estimate using regression (4). Panel 3a shows the unconditional effects, $\beta_1^h$. Panel 3b shows the effects conditional on $EBP_{ik,t-1}^{ma}$, $\beta_2^h$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and month.

the contemporaneous monetary policy shock.

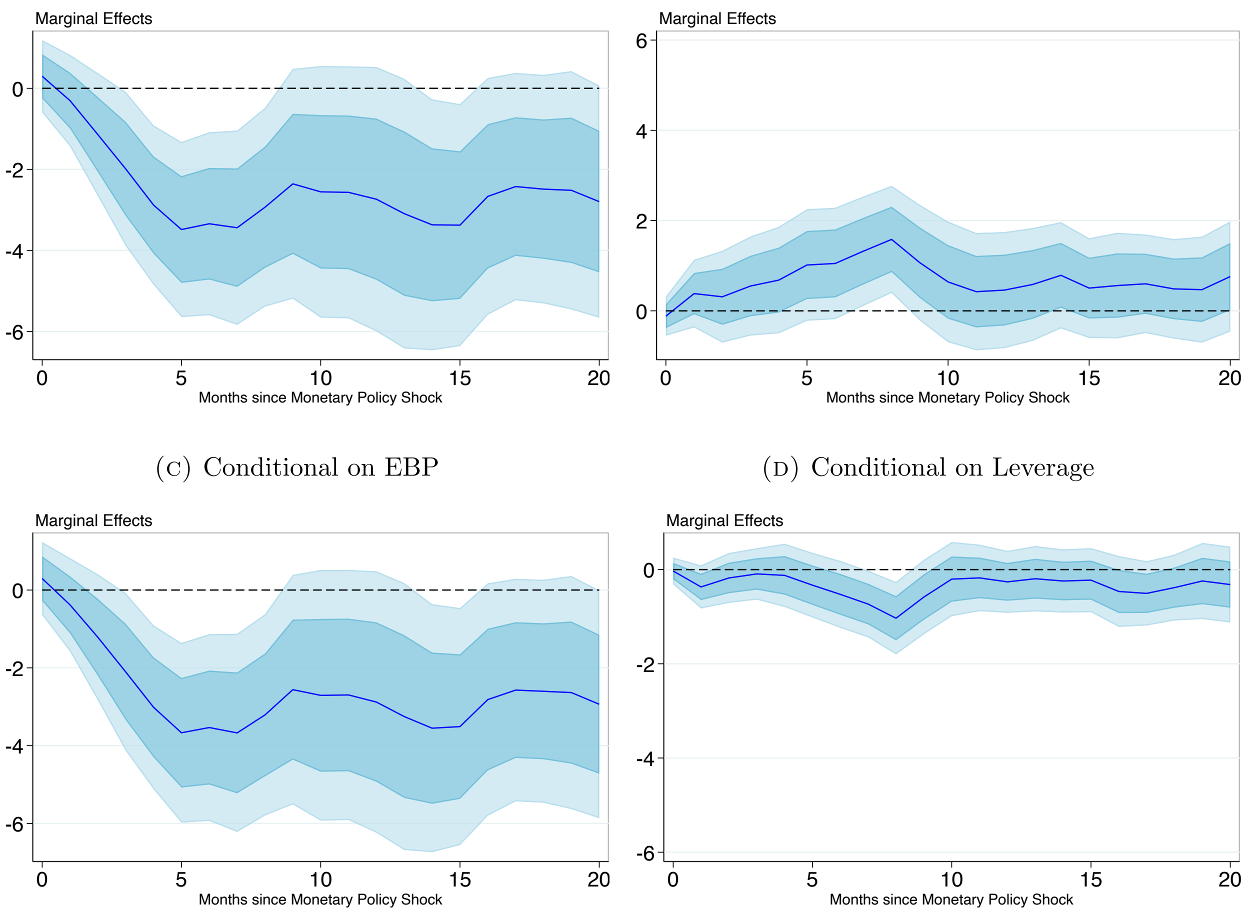
Figure 3 shows that monetary policy has quantitatively important effects on credit spreads. Panel 3a traces the average response of credit spreads to a surprise monetary easing ($\beta_1^h$). We find that a one percentage point easing shock induces a decline in the average bond's credit spreads of nearly four percentage points, which occurs eight months after the shock. This result points to a delayed peak effect of monetary policy on firms' marginal borrowing rates, an issue overlooked by high-frequency studies.

Panel 3b shows that the effect of a monetary policy easing on credit spreads is larger for high-EBP bonds, that is, for firms facing tighter ex-ante financial conditions. In particular, firms whose bonds carry an EBP one standard deviation above the mean face an additional decline in their credit spreads of nearly 4 percentage points. Similar to the unconditional effects, this EBP-dependent decline in credit spreads builds up over time, reaching its maximum effect between five and seven months after the shock.

We also show that it is mainly the EBP, rather than default risk, that regulates the response of credit spreads to monetary policy. To demonstrate this, we run a "horse-race"

FIGURE 4

Monetary Policy's Effect on Bond Credit Spreads: EBP vs. Default Risk




(A) Conditional on EBP

(B) Conditional on Distance to Default

(C) Conditional on EBP

(D) Conditional on Leverage

*Note.* Figure 4 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on the h-month change in bond credit spreads, $S_{ikt+h} - S_{ikt-1}$, which we estimate using two versions of regression (5). First, panels 4a and 4b report, respectively, the interaction coefficients on $EBP_{ikt-1}^{ma}$ ($\beta_2^h$) and our first proxy for default risk $x_{it}^{ma}$, the distance to default, ($\beta_3^h$). Second, panels 4c and 4d report, respectively, the interaction coefficients on $EBP_{ikt-1}^{ma}$ ($\beta_2^h$) and our second proxy for default risk $x_{it}^{ma}$, leverage, ($\beta_3^h$). Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and month.

between our EBP interaction, $EBP_{ikt-1}^{ma} \times \varepsilon_t^m$, and a default-risk interaction, $x_{it-1}^{ma} \times \varepsilon_t^m$:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^m + \beta_3^h x_{it-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \quad (5)$$

where $x_{it-1}^{ma}$ is the yearly moving-average of firm i's default risk, which we measure two ways: (i) firm i's distance to default; and (ii) firm i's leverage.[8] Panels 4a and 4b report

[8]Note that, in this case, both $EBP_{ikt-1}^{ma}$ and $x_{it-1}^{ma}$ are also included in $\mathbf{Z}_{it-1}$.

the EBP and default-risk interaction coefficients, respectively, when $x^{ma}_{it-1}$ is measured by distance to default, while Panels 4c and 4d do the same for leverage. In both cases, we find that the sensitivity of firms' credit spreads to monetary policy is primarily a function of their EBPs, rather than their default risk.[9] Moreover, the conditional effects by EBP are largely unchanged relative to our baseline results in Figure 3b.

**Robustness:** In Appendix B, we show that our results are robust to many variants of our empirical approach, including: (i) controlling for time-sector fixed effects (Appendix B.1); (ii) conditioning on the EBP using dummy variables (Appendix B.2); (iii) conditioning on other state variables emphasized in the literature, namely age, liquidity, credit rating, Tobin's average Q, size, and sales growth (Appendix B.4); (iv) using alternative monetary policy shocks (Appendix B.5); and (v) conditioning on an EBP purged of its potential higher-order dependence on distance to default (Appendix B.6).

# 4 Monetary Policy and Firm-Level Investment

In this section, we document that expansionary monetary policy shocks increase investment more for low-EBP firms than for high-EBP ones. Thus, conditional on EBP, firms whose investment is more responsive to monetary policy issue bonds whose credit spreads are less responsive. Moreover, we again highlight that the sensitivity of firms' investment to monetary policy is mainly a function of their EBP, rather than their default risk.

To evaluate the dynamic response of firm-level investment to monetary policy, our baseline specification measures both the unconditional effect of a monetary policy shock, as well as the effect conditional on firms' ex-ante EBP. Specifically, we estimate the following local projections at a quarterly frequency for a series of horizons $h$:

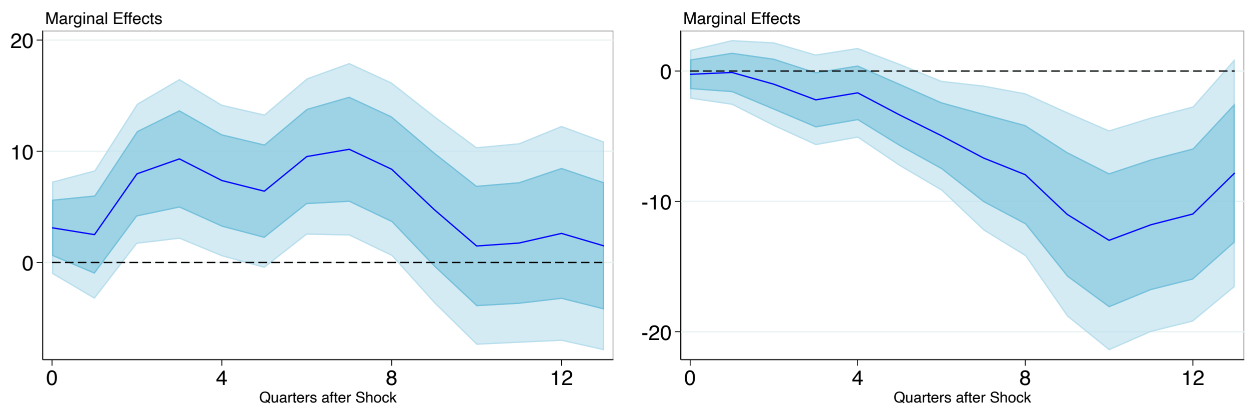
$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta^h_i + \beta^h_1 \varepsilon^m_t + \beta^h_2 EBP^{ma}_{it-1} \times \varepsilon^m_t + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{6}$$

where $K_{it}$ is the real book value of firm $i$'s tangible capital stock (as in Ottonello and

[9]To provide comparability with other studies, we also establish that default-risk is a statistically significant state variable for the transmission of monetary policy to credit spread when the EBP is not included as a competing state variable (Appendix B.3).

Figure 5
Monetary Policy's Effect on Firm-Level Investment

(a) Unconditional (b) Conditional on EBP




*Note.* Figure 5 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on the h-quarter cumulative investment of firm i, $\log(K_{it+h}/K_{it-1})$, which we estimate using regression (6). Panel 5a shows the unconditional effects, $\beta_1^h$. Panel 5b shows the effects conditional on $EBP_{it-1}^{ma}$, $\beta_2^h$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and quarter.

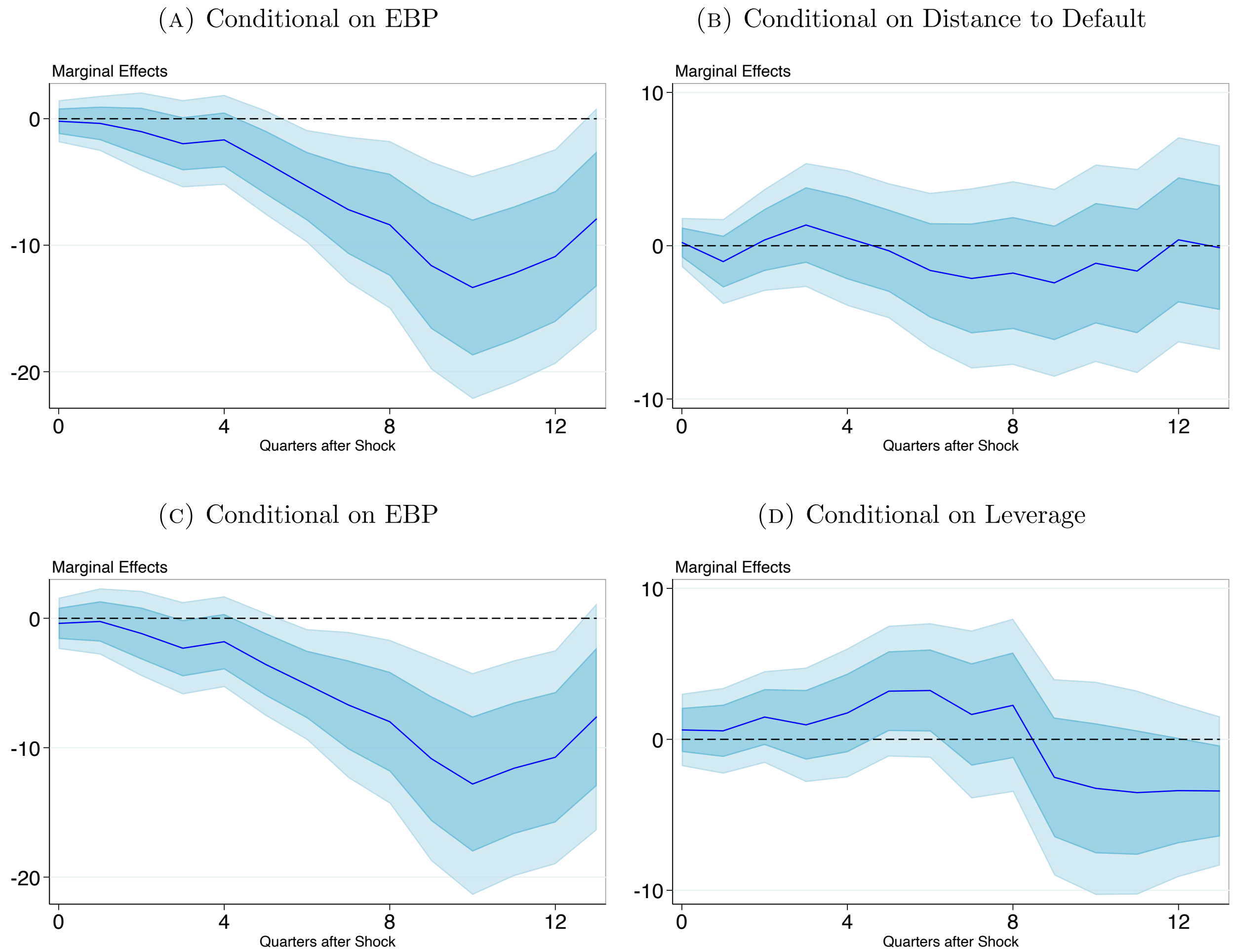
Winberry, 2020), $EBP_{it-1}^{ma}$ is the average $EBP_{ikt-1}^{ma}$ on firm i's bonds within a given quarter; $\beta_i^h$ are firm fixed effects; and $\mathbf{Z}_{it-1}$ is the vector of control variables described in Section 2.4 plus $EBP_{it-1}^{ma}$.

Figure 5 displays firms' investment responses to monetary policy shocks. The unconditional response, displayed in Panel 5a, is hump-shaped. Quantitatively, a one percentage point monetary easing induces a 10 percentage point increase in investment for the average firm, with a peak-effect 7 quarters after the shock. The negative marginal effects in Panel 5b imply that the increase in investment is diminished for firms with higher ex-ante EBPs. This dampened response for higher-EBP firms is economically significant and reaches its largest magnitude 10 quarters after the shock.[10]

We find once more that a firm's EBP supersedes its default risk as a state-variable for the transmission of monetary policy, this time for investment. As in the previous section, we do so by running a horse-race between the interactions of these two firm characteristics

[10] Appendix B.2 presents separate impulse responses for low- and high-EBP firms, and shows they are always either statistically greater than or equal to zero.

FIGURE 6
Monetary Policy's Effect on Firm Investment: EBP vs. Default Risk




*Note.* Figure 6 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on the h-quarter cumulative investment of firm i, $\log(K_{it+h}/\log K_{it-1})$, which we estimate using 2 versions of regression (7). First, Panels 6a and 6b report, respectively, the interaction coefficients on $EBP_{it-1}^{ma}$ $(\beta_2^h)$ and our first proxy for default risk $x_{it-1}^{ma}$, the distance to default, $(\beta_3^h)$. Second, panels 6c and 6d report, respectively, the interaction coefficients on $EBP_{it-1}^{ma}$ $(\beta_2^h)$ and our second proxy for default risk $x_{it-1}^{ma}$, leverage, $(\beta_3^h)$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and quarter.

with a monetary policy shock:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{it-1}^{ma} \times \varepsilon_t^m + \beta_3^h x_{it-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \quad (7)$$

where default risk $x_{it-1}^{ma}$ is again measured in two ways: distance to default and leverage.[11] As shown in Figure 6, the sensitivity of firms' investment response to monetary policy is

[11] Again, both $EBP_{it-1}^{ma}$ and $x_{it-1}^{ma}$ are included in $\mathbf{Z}_{it-1}$.

primarily a function of their EBPs (Panels 6a and 6c) rather than their default risk (Panels 6b and 6d).[12] And, once again, the conditional effects by firm EBP are largely unchanged relative to our baseline results.

When viewed through the lens of the financial accelerator mechanism present in the models of, for example, Bernanke et al. (1999) and Ottonello and Winberry (2020), our results from this section seem at odds with our findings from Section 3. Specifically, we have shown that while firms facing tight financial conditions—high EBPs—experience large decreases in their credit spreads in response to monetary easings, these high-EBP firms increase investment only modestly. Conversely, low-EBP firms experience mild declines in their marginal borrowing costs, and, nevertheless, increase investment considerably.[13] The discrepancy between these results and the predictions of financial accelerator models owes to the latter's emphasis on differences in firms' default risk and hence the slope of their marginal cost of capital curves. Instead, in the next section, we rationalize our findings with a model in which firms' differential responses to monetary policy arise due to differences in their investment prospects, which are reflected in their marginal benefit curves.

**Robustness:** In Appendix B, we show that our results are robust to: (i) controlling for time-sector fixed effects (Appendix B.1); (ii) conditioning on EBP using dummy variables (Appendix B.2); (iii) conditioning on other state variables emphasized in the literature: age, liquidity, credit rating, Tobin's average Q, size, and sales growth (Appendix B.4); (iv) using alternative monetary policy shocks (Appendix B.5); and (v) conditioning on an EBP purged of potential higher-order dependence on distance to default (Appendix B.6).

# 5 Interpretation of Empirical Results

In this section, we build a stylized model in which a firm's EBP conveys the slope its marginal benefit curve for capital (Section 5.1), and determines the responsiveness of its

[12] To provide comparability with other studies, we again establish that default-risk is a statistically significant state variable for the transmission of monetary policy to investment when the EBP is not included as a competing state variable (Appendix B.3).

[13] In Appendix B.7, we show that low-EBP firms also borrow more via debt financing than do high-EBP firms in response to a monetary easing, despite the smaller fall in their marginal borrowing costs.

investment and credit spreads to monetary policy in a manner consistent with our empirical results (Section 5.2).

### 5.1 Theoretical Framework

Our framework focuses on two agents: firms who demand capital for production and financial intermediaries who, subject to financial frictions similar to those proposed by Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Anderson and Cesa-Bianchi (2021), supply capital to firms. Different from these papers, we highlight the salience of firms' capital demand for the transmission of the monetary policy.

Financial intermediaries are endowed with net worth $N$ and issue deposits $D$ to households (not explicitly modeled here) at an exogenous interest rate $R$.[14] These intermediaries have access to a capital producing technology that can transform $N$ and $D$ on a one-to-one basis into capital $K_S$, which they supply to firms for a return $R_K$. As long as this return on capital exceeds the deposit rate ($R_K > R$), intermediaries have an incentive to leverage-up to increase the return on their equity. Motivated by real-world regulatory capital requirements and risk-management practices, we assume that intermediaries face a constraint that requires them to have sufficient skin-in-the-game when lending to firms. This is modelled as an agency friction in which intermediaries can abscond with a fraction $\theta$ of their revenue $R_K K_S$. Similar to Gabaix and Maggiori (2015), we assume that this fraction is increasing in the size of intermediaries' balance sheet: $\theta = \theta(K_S)$ and $\theta^{'}(K_S) > 0$. In turn, households only fund intermediaries that satisfy an incentive compatibility constraint: $R_K K_S - RD \geq \theta R_K K_S$. The optimization problem of the intermediaries becomes:

$$\max_{K_S} \; R_K K_S - RD \quad \text{s.t.} \quad R_K K_S - RD \geq \theta R_K K_S \quad \text{and} \quad K_S = D + N.$$

The solution to the problem above determines how much capital intermediaries supply to firms. We focus on equilibria in which $R_K \geq R$. When $R_K > R$, intermediaries leverage-up until the point in which the skin-in-the-game constraint binds. Additionally, when $R_K =$

[14]For simplicity, we set $R = 1$.

$R$, financial intermediaries are indifferent between any level of deposits satisfying the skin-in-the-game constraint. Thus, we obtain the following capital supply curve:

$$\frac{R_K}{R} = \begin{cases} \frac{K_S - N}{K_S(1-\theta)} & K_S \geq \frac{N}{\theta} \\ 1 & K_S < \frac{N}{\theta} \end{cases} \tag{8}$$

where $R_K/R$ is the model credit spread, and $K_S = N/\theta$ is the cutoff value of capital supply for which the intermediaries' constraint binds. Importantly, in the region where $K_S \geq N/\theta$, the capital supply curve is upward sloping in credit spreads. Of note, this capital supply curve is also the marginal cost of capital curve face by firms.

Next, we arrive at a firm's marginal benefit curve for capital by solving its profit maximization problem:

$$\max_{K_D} \ K_D^{\alpha} - R_K K_D,$$

where the production function has decreasing returns to scale, $\alpha \in (0,1)$. As in Gertler and Karadi (2011), firms borrow at an interest rate $R_K$ because we assume there are no frictions on their end for obtaining intermediary funds. From the first order condition, we get the following marginal benefit curve:

$$\frac{R_K}{R} = \frac{1}{R}\alpha K_D^{\alpha-1}. \tag{9}$$

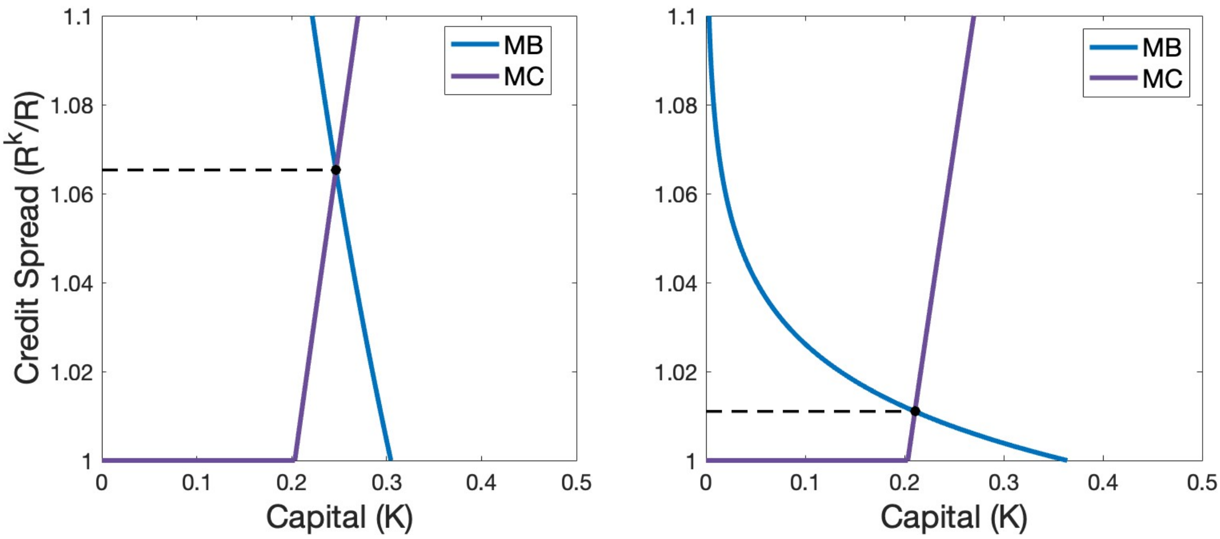
Given that $\alpha \in (0,1)$, firms' marginal benefit curves are downward sloping in credit spreads. For simplicity, in what follows, we vary the slope of firms' marginal benefit curves by changing $\alpha$, focusing on the implications of this for the equilibrium credit spread.

This model allows us to link the level of firms' ex-ante EBPs with the slope of their marginal benefit curves near their respective capital market equilibria. Figure 7 displays two different capital market equilibria, which differ only by the slope of firms' marginal benefit curves. Firms with flatter marginal benefit curves near the equilibrium face lower credit spreads (Panel 7b), while those with steeper curves face higher spreads (Panel 7a).[15]

[15] This result is quite general; the exception is if intermediary net worth is very high (see Appendix C.2).

FIGURE 7
Slope of Firms' Marginal Benefit for Capital Curves and their EBPs

(A) High-EBP Firm (B) Low-EBP Firm




*Note.* Figure 7 displays two different capital market equilibria that differ only by the slope of the firm's marginal benefit curve $K^D$. We change this slope by varying the parameter $\alpha$ of firms' production function. Panel 7a (7b) shows that the firm with a steeper (flatter) marginal benefit curve has a higher (lower) EBP in equilibrium. We describe the calibration of the parameters in Appendix C.1.

Given that firms carry no default risk in our framework, credit spreads may be interpreted as firms' EBPs, which arise from intermediaries' shadow cost of leverage.[16] Thus, in our model, firms with flatter marginal benefit curves for capital have lower EBPs. These flatter marginal benefit curves reflect the relative resilience of these firms' marginal product of capital to further investment i.e. the relative resilience of their investment prospects.

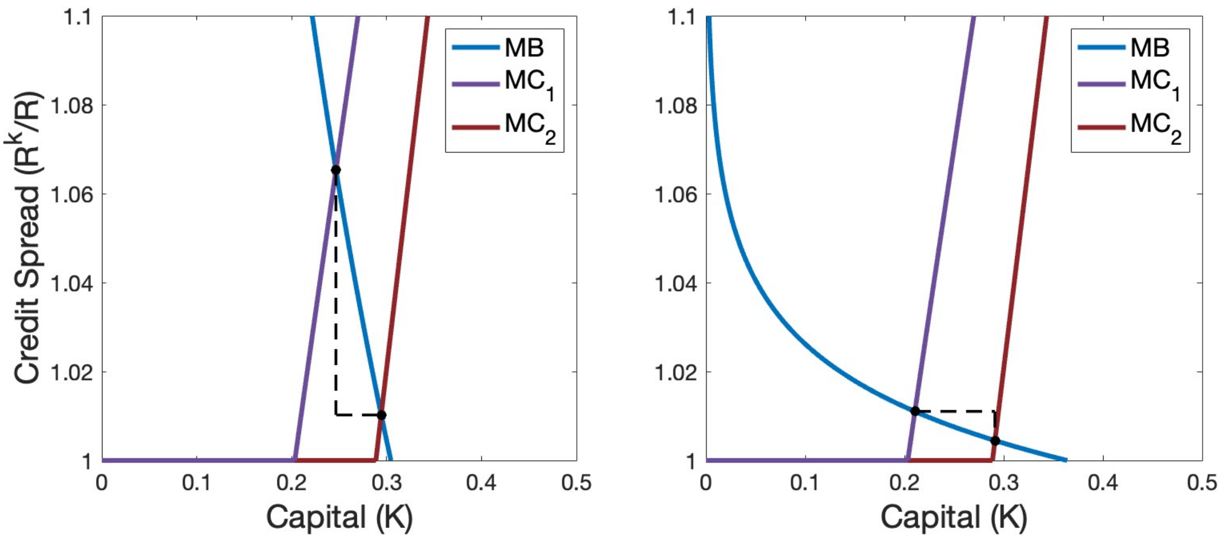
## 5.2 Rationalizing Our Empirical Results

In this section, we use our framework to study how monetary policy's effect on credit spreads and investment depends on a firm's EBP. Motivated by the large literature documenting monetary policy's effects on credit supply (e.g., Bernanke and Gertler, 1995, and Kashyap and Stein, 2000), we model a monetary policy easing as an increase in the net worth of

[16]Figure 7 displays an equilibrium in which lower-EBP firms have lower capital. While there is some empirical evidence for this (see Appendix C.3), if we assumed low-EBP firms also received positive sentiment from their intermediaries (López-Salido et al., 2017), modelled as a looser compatibility constraint, we could achieve an equilibrium in which low-EBP firms had the same or even higher capital than high-EBP ones.

FIGURE 8
Monetary Policy's Effect on Credit Spreads and Investment by Firm EBP

(A) High-EBP Firm (B) Low-EBP Firm




*Note.* Figure 8 presents the comparative statics to a monetary policy easing for two different firms, which differ by the slope of their marginal benefit curves, and hence their equilibrium EBPs. We describe the calibration of the parameters in Appendix C.1.

financial intermediaries: $N = N(R)$ and $N' < 0$.[17] This increase in intermediary net worth leads to a rightward shift in intermediaries' supply of capital curve, which is also firms' marginal cost curve, as seen in both panels of Figure 8.

Importantly, the response of firms' investment and credit spreads to this shift in the marginal cost curve depends on the slope of their marginal benefit curves. Specifically, low-EBP firms with flatter marginal benefit curves invest considerably following a monetary easing, despite a relatively mild fall in their credit spreads (Panel 8b). This is due to the relative resilience of these firms' marginal product of capital, which decreases at a relatively slow rate as they invest. Conversely, high-EBP firms with steeper marginal benefit curves are afforded a larger fall in their credit spreads, but invest relatively little due to the rapid depletion of their sufficiently-productive investment opportunities (Panel 8a). In sum, this comparative statics exercise rationalizes our empirical results for the sensitivity of firms' investment and credit spreads to monetary policy, conditional on their EBPs, by appealing

[17]For a literature review on the different channels of monetary policy, especially the intermediary lending channel, see Adrian and Liang (2018).

to the slope of their marginal benefit curves for capital.

# 6 Micro- and Macro-economic Implications

In this section, we test two implications of our model—one at the firm-level and one in the aggregate—to provide further support our model's mechanism. Specifically, we show that a firm's EBP regulates the sensitivity of its investment to movements in its credit spreads (Section 6.1) and that the cross-sectional EBP distribution governs the aggregate effectiveness of monetary policy (Section 6.2).

## 6.1 Firm-level Credit Spreads and Investment

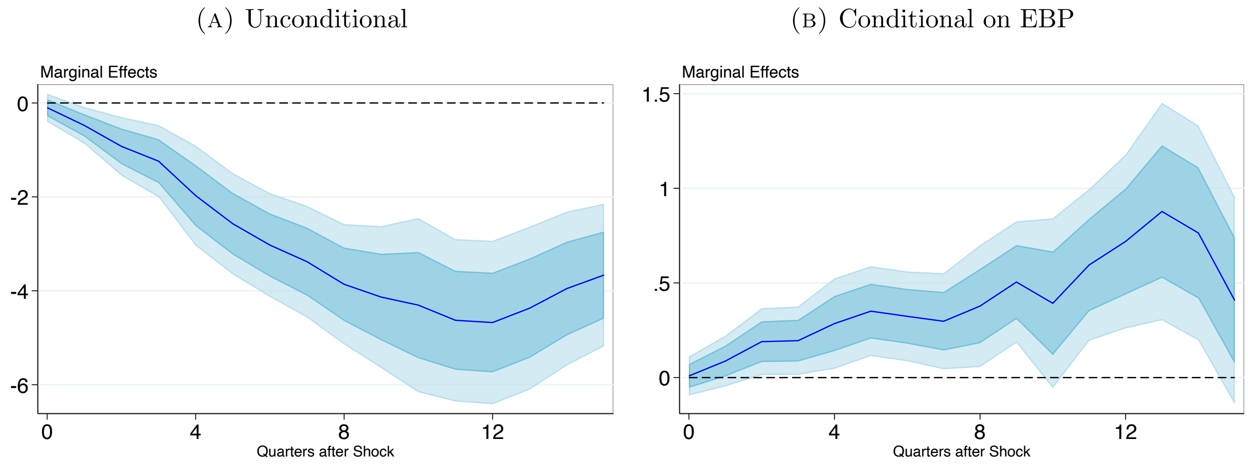
The theoretical framework outlined in Section 5.1 illustrates that the slope of a firm's marginal benefit curve matters not just for its sensitivity to monetary policy, but applies more generally for its responsiveness to any shift in the marginal cost curve. In this section, we build on the well-documented negative correlation between firms' credit spreads and their future investment (e.g. Gilchrist and Zakrajšek, 2007), which is consistent with credit supply shocks being dominant in capital markets. Specifically, we investigate how this spreads-investiment relationship depends on our proxy for the slope of firms' marginal benefit curves—their EBPs. As expected, we show that increases in credit spreads are associated with smaller declines in investment for high-EBP firms.

We estimate firm-level regressions of investment on changes in credit spreads, using a firm's ex-ante EBP as a state varible. Specifically, we use the following local projections:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \Delta S_{i,t} + \beta_2^h \Delta S_{i,t} \times EBP_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{10}$$

where $\mathbf{Z}_{it-1}$ includes the controls discussed in Section 2.4, plus $EBP_{it-1}^{ma}$. Our results are robust, as before, to including time-sector fixed effects (Appendix B.1), to conditioning on the EBP using dummy variables (Appendix B.2), and to conditioning on an EBP purged of its potential higher-order dependence on distance to default (Appendix B.6).

FIGURE 9
Firm-Level Credit Spreads and Investment

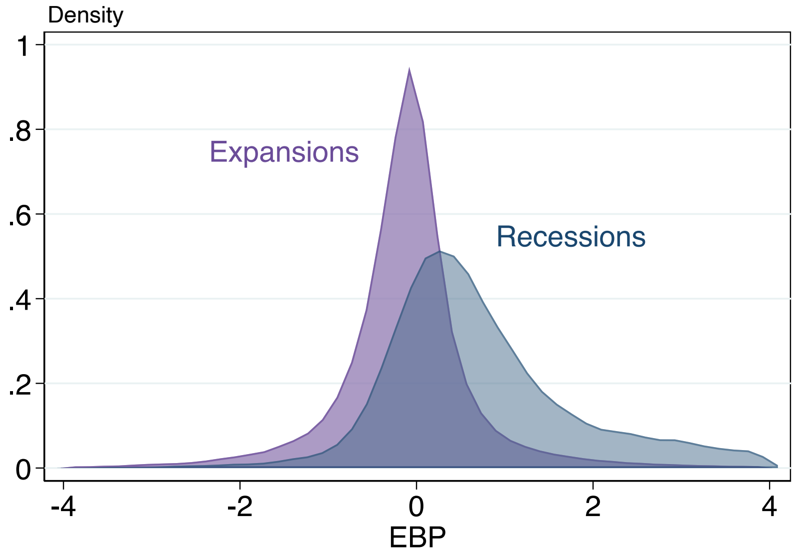



*Note.* Figure 9 reports the dynamic response of the h-quarter cumulative investment of firm i, $\log(K_{it+h}/\log K_{it-1})$, to a change in firm i's credit spread $\Delta S_{i,t}$, which we estimate using regression (10). Figure 9a shows unconditional effects, $\beta_1^h$. Figure 9b shows effects conditional on $EBP^{ma}_{it-1}$, $\beta_2^h$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and quarter.

Consistent with credit supply being the preeminent source of variation in capital markets, Panel 9a highlights that increases in firms' credit spreads are associated with significant and persistent declines in their investment. Furthermore, Panel 9b highlights that increases in credit spreads predict less-pronounced declines in investment for firms with higher EBPs, that is, for those with steeper marginal benefit curves. While many papers have explored the firm-level relationship between credit spreads and investment (e.g., Gilchrist et al., 2014 and Lin et al., 2018), we document *which* firms' investment is most responsive to movements in their marginal borrowing costs by conditioning on firms' EBPs.

Our results from this section highlight that the slope of a firm's marginal benefit curve is a key determinant of its responsiveness to changes in credit supply. To further support this claim, Appendix B.8 uses the intermediary capital risk factor from He et al. (2017) as a source of exogenous variation in credit supply. Consistent with our model, we find that the responses of credit spreads and investment, conditional on firms' EBPs, from this shock to intermediary net worth are qualitatively similar to those from a monetary policy shock.

FIGURE 10
Bond-level EBP Distribution in Recessions and Expansions




*Note.* Figure 10 presents kernel-density estimated bond-level EBP distributions during NBER-classified recessions and expansions over the period 1973:M1 to 2021:M12.

## 6.2 EBP Distribution and Monetary Policy's Aggregate Effects

In this section, we provide evidence that the cross-sectional distribution of firm EBPs, which we view as conveying the slopes of firms' marginal benefit curves, influences the effectiveness of monetary policy's transmission to the macroeconomy.

Our argument extends the representative firm framework from Section 5.1 to one with a continuum of firms that differ in their EBPs. In this heterogeneous firm setup, the response of aggregate investment to monetary policy would depend on the cross-sectional distribution of firm EBPs. Specifically, monetary policy should be less effective at stimulating aggregate investment when a larger mass of firms have steeper marginal benefit curves (higher EBPs) and more effective when a larger mass of firms have flatter marginal benefit curves (lower EBPs). Moreover, applying this argument to Figure 10, the considerable shift in mass from the left tail to the right tail of the EBP distribution in recessions portends a new rationale for the weaker transmission of monetary policy to the real economy during downturns.

To evaluate these predictions, we use local projections similar to those from previous sections, but with two important modifications: (i) we use aggregate investment $I_t$ to construct the dependent variable and (ii) we use the first three cross-sectional moments of the EBP distribution as state variables.[18] Greater skewness, all else equal, implies a shift in mass from the left tail to the right tail of the EBP distribution, which should render the transmission of monetary policy less potent. Similarly, all else equal, a higher median EBP implies a rightward shift of the EBP distribution, which should also make monetary policy less effective. Conversely, while the effect of a more dispersed EBP distribution is ex-ante ambiguous, it provides an indication of whether firm EBPs in the left or right tail exert a greater influence over the aggregate effectiveness of monetary policy.

Specifically, we estimate the following local projections at a quarterly frequency:

$$\frac{400}{h+1}\log\left(\frac{I_{t+h}}{I_{t-1}}\right) = \beta_0^h + \beta_1^h \varepsilon_t^m + \boldsymbol{\beta}_2^h \boldsymbol{M}_{t-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\delta}_l^h \mathbf{Y}_{t-1} + e_{th}, \tag{11}$$

where $\boldsymbol{M}_{t-1}^{ma}$ is a vector that contain the median, dispersion and Kelly-skewness of the bond-level cross-sectional EBP distribution, $\mathbf{Y}_{t-1}$ includes the aggregate controls discussed in Section 2.4, plus the vector $\boldsymbol{M}_{t-1}^{ma}$, and the factor $400/(h+1)$ annualizes aggregate investment growth ($\log I_{t+h}/I_{t-1}$).[19] In our baseline, we measure dispersion and skewness using the 10th and 90th percentiles of the EBP distribution, although our results are robust to measuring the cross-sectional moments using different percentiles (see Appendix B.9).[20] For inference, we use Newey-West standard errors with 12 lags.

The results are displayed in Figure 11 and are consistent with the predictions of our model.[21] First, Panel 11a traces the unconditional response of aggregate investment growth to a monetary easing shock. As expected, investment growth increases in a hump-shaped fashion, with a peak response 6 quarters after the shock. Panels 11b, 11c and 11d chart the effects of the monetary easing shock conditional on the skewness, median and dispersion of the EBP distribution, respectively. Focusing first on skewness, the negative marginal effects highlight that a more right-skewed EBP distribution dampens the effects of monetary policy

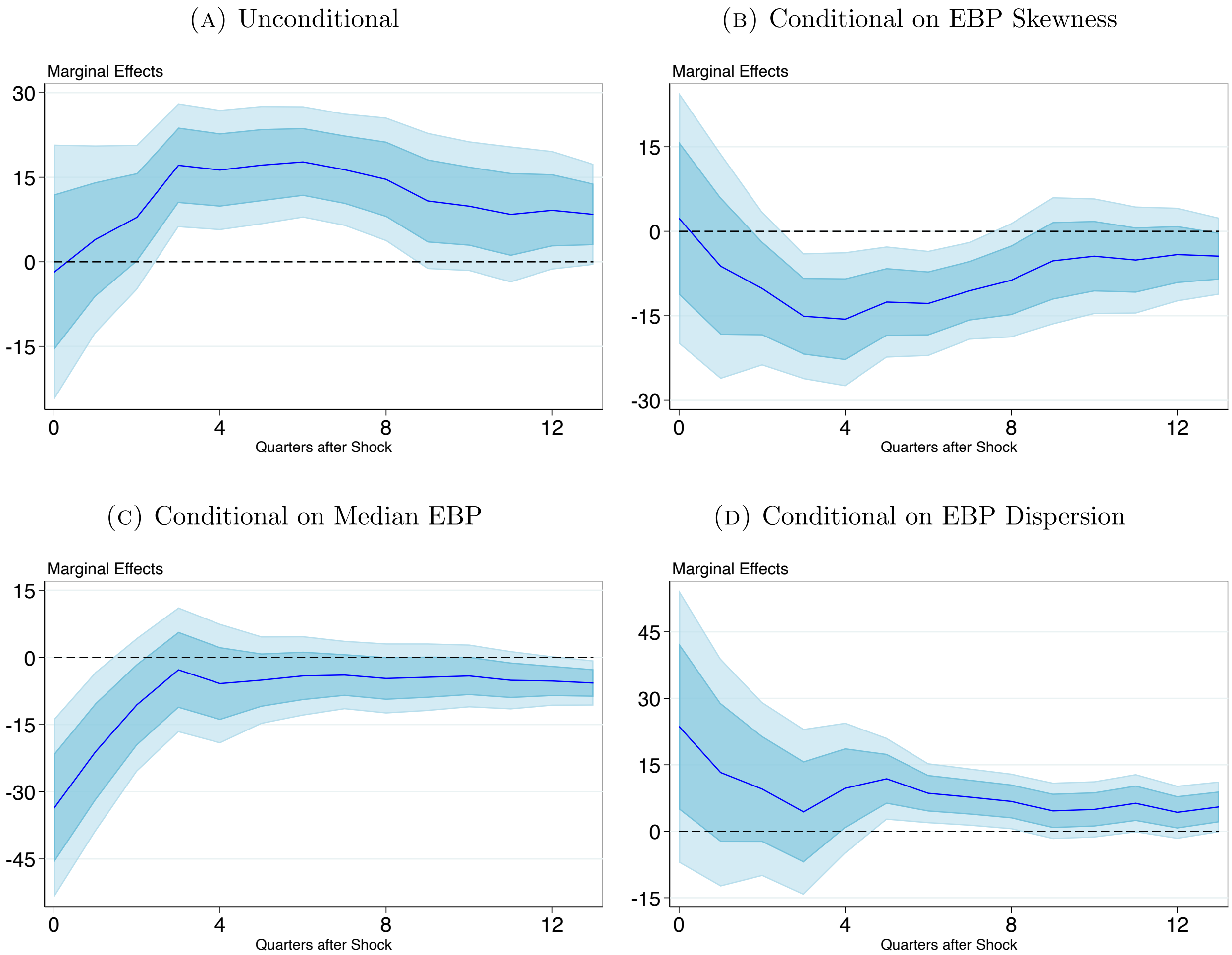
[18] We use annualized investment growth as our dependent variable to align ourselves with much of the existing empirical literature (e.g., Gilchrist and Zakrajšek, 2012). A similar pattern emerges if we use the level of aggregate investment.

[19] For this regression, we substitute GDP growth for investment growth in the aggregate controls $\mathbf{Y}_{t-1}$.

[20] Specifically, we first take the 4-quarter moving average of these percentiles of the EBP distribution, then combine them to construct our moments.

[21] In Appendix B.9, we show these results are robust to using alternative monetary policy shocks.

Figure 11
Monetary Policy's Effect on Aggregate Investment Growth




*Note.* Figure 11 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on h-quarter annualized aggregate investment growth, $400/(h+1)\log(I_{t+h}/I_{t-1})$, which we estimate using regression (11). Panel 11a shows unconditional effects, $\beta_1^h$. Panels 11b, 11c and 11d show the effects conditional on the skewness, median and dispersion of the EBP distribution, the three elements in $\boldsymbol{\beta}_2^h$, respectively. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using Newey-West standard errors with 12 lags.

on aggregate investment growth. Similarly, a higher median EBP also lessens the potency of monetary policy. Finally, a more dispersed EBP distribution amplifies the transmission of monetary policy, suggesting that the added stimulus from a lower left tail of the EBP distribution overcomes the drag from a higher right tail. That is, it is the investment prospects of left-tail EBP firms, those with the flattest marginal benefit curves, that is more responsible for the strength of the transmission of monetary policy to the macroeconomy.[22]

[22]We provide further support for this by interacting our monetary policy shock with the percentiles of the EBP distribution in Appendix B.9.

Finally, in Appendix B.9, we examine the extent to which the EBP distributions's impact on the aggregate effectiveness of monetary policy is related to the well-documented weaker effects of monetary policy in recessions. Importantly, we show the link between the potency of monetary policy and the slope of firms' marginal benefit curves for capital is general. Specifically, we find that monetary policy's effects conditional on the EBP distributions's skewness are unchanged, or even amplified, when controlling for monetary policy's effects conditional on recession indicators similar to those in Tenreyro and Thwaites (2016). The strength of the skewness result is consistent with our model's intuition since a right-skewing of the EBP distribution, all else equal, implies substituting firms with the flattest marginal benefit curves for firms with the steepest ones. Relative to the other moments, this should have the greatest impact on the aggregate potency of monetary policy.[23]

# 7 Conclusion

This paper examines how and why the responsiveness of firms' credit spreads and investment to monetary policy depends on their financial conditions, as measured by their EBPs. Our paper has three main parts. First, using a comprehensive bond- and firm-level database, we find that while expansionary monetary policy shocks compress credit spreads more for firms with ex-ante higher EBPs, it is firms with lower EBPs that increase investment more. Second, we rationalize these results using a model in which firms with flatter marginal benefit curves for capital, reflecting their access to investment projects whose marginal productivity is more resilient to capital accumulation, have lower EBPs in equilibrium. Third, we provide additional empirical support for the salience of the slope of firms' marginal benefit curves as an economic mechanism. Most importantly, we show that the effect of monetary policy on aggregate investment depends on the moments, in particular the skewness, of the cross-sectional EBP distribution.

Policy-makers and researchers often debate three key aspects of monetary policy's

[23]On the other hand, the effects conditional on the median of the EBP distribution are crowded out by the recession indicators. This accords with the findings of Gilchrist and Zakrajšek (2012) who show that an increase in aggregate EBP is a reliable recession indicator.

transmission: its distributional implications, its aggregate effectiveness, and the economic channels through which it operates. Our paper contributes to this policy-motivated debate. On the distributional front, we show that monetary policy is less-effective at stimulating firms with high EBPs, due to their steeper marginal benefit curves for capital. On the aggregate front, our paper not only provides a theoretical argument for the existence of time-varying effects of monetary policy, but also offers a specific observable—the cross-sectional EBP distribution—to measure and monitor these time-varying effects. On the modelling front, our paper provides new empirical evidence on the salience of firms' marginal benefit curves to feed the construction of richer models of the macroeconomy.

# References

**Abel, Andrew B**, *Investment and the Value of Capital* number 65, Dissertations-G, 1979.

**Adrian, Tobias and Nellie Liang**, "Monetary Policy, Financial Conditions, and Financial Stability," *International Journal of Central Banking*, 2018, *14* (1), 73–131.

**Anderson, Gareth and Ambrogio Cesa-Bianchi**, "Crossing the Credit Channel: Credit Spreads and Firm Heterogeneity," *working paper, Bank of England*, 2021.

**Baker, Scott R, Nicholas Bloom, and Steven J Davis**, "Measuring economic policy uncertainty," *The Quarterly Journal of Economics*, 2016, *131* (4), 1593–1636.

**Bauer, Michael D and Eric T Swanson**, "The Fed's response to economic news explains the" Fed information effect"," Technical Report, National Bureau of Economic Research 2020.

**Bernanke, Ben S and Mark Gertler**, "Agency Costs, Net Worth, and Business Fluctuations," *The American Economic Review*, 1989, *79* (1), 14–31.

**_ and _** , "Inside the black box: the credit channel of monetary policy transmission," *Journal of Economic Perspectives*, 1995, *9* (4), 27–48.

**_ , _ , and Simon Gilchrist**, "The financial accelerator in a quantitative business cycle framework," *Handbook of Macroeconomics*, 1999, *1*, 1341–1393.

**Bharath, Sreedhar T and Tyler Shumway**, "Forecasting default with the Merton distance to default model," *The Review of Financial Studies*, 2008, *21* (3), 1339–1369.

**Black, Fischer and Myron Scholes**, "The pricing of options and corporate liabilities," *Journal of Political Economy*, 1973, *81* (3), 637–654.

**Bu, Chunya, John Rogers, and Wenbin Wu**, "A unified measure of Fed monetary policy shocks," *Journal of Monetary Economics*, 2021, *118*, 331–349.

**Caglio, Cecilia R, R Matthew Darst, and Sebnem Kalemli-Ozcan**, "Risk-taking and monetary policy transmission: Evidence from loans to smes and large firms," Technical Report, National Bureau of Economic Research 2021.

**Chauvet, Marcelle**, "An Econometric Characterization of Business Cycle Dynamics with Factor Structure and Regime Switching," *International Economic Review*, 1998, *39* (4), 969–96.

**Chava, Sudheer and Alex Hsu**, "Financial constraints, monetary policy shocks, and the cross-section of equity returns," *The Review of Financial Studies*, 2020, *33* (9), 4367–4402.

**Clark, John Bates**, *The Distribution of Wealth: A Theory of Wages, Interest and Profits*, Macmillan, 1899.

**Cloyne, James, Clodomiro Ferreira, Maren Froemel, and Paolo Surico**, "Monetary Policy, Corporate Finance and Investment," Technical Report, Banco de Espana Working Paper No. 1911 2019.

**Crouzet, Nicolas and Neil R Mehrotra**, "Small and large firms over the business cycle," *American Economic Review*, 2020, *110* (11), 3549–3601.

**Favara, G, S Gilchrist, KF Lewis, and E Zakrajšek**, "Updating the recession risk and the excess bond premium (No. 2016-10-06)," *Board of Governors of the Federal Reserve System (US)*, 2016.

**Fisher, Irving**, *Theory of interest: as determined by impatience to spend income and opportunity to invest it*, Augustusm Kelly Publishers, Clifton, 1930.

**Gabaix, Xavier and Matteo Maggiori**, "International liquidity and exchange rate dynamics," *The Quarterly Journal of Economics*, 2015, *130* (3), 1369–1420.

**Gertler, Mark and Nobuhiro Kiyotaki**, "Financial intermediation and credit policy in business cycle analysis," in "Handbook of Monetary Economics," Vol. 3, Elsevier, 2010, pp. 547–599.

_ **and Peter Karadi**, "A model of unconventional monetary policy," *Journal of Monetary Economics*, 2011, *58* (1), 17–34.

_ **and Simon Gilchrist**, "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics*, 1994, *109* (2), 309–340.

**Gilchrist, Simon and Egon Zakrajšek**, "Investment and the cost of capital: New evidence from the corporate bond market," 2007.

_ **and** _ , "Credit spreads and business cycle fluctuations," *American Economic Review*, 2012, *102* (4), 1692–1720.

_ **, Jae W Sim, and Egon Zakrajšek**, "Uncertainty, financial frictions, and investment dynamics," Technical Report, National Bureau of Economic Research 2014.

**González, B., G. Nuño, D. Thaler, and S. Albrizio**, "Firm Heterogeneity, Capital Misallocation and Optimal Monetary Policy," Technical Report, CESifo, Munich 2021.

**Gürkaynak, Refet, Hatice Gökçe Karasoy-Can, and Sang Seok Lee**, "Stock market's assessment of monetary policy transmission: The cash flow effect," *The Journal of Finance*, 2022, *77* (4), 2375–2421.

**Gürkaynak, Refet S, Brian Sack, and Jonathan H Wright**, "The US Treasury yield curve: 1961 to the present," *Journal of Monetary Economics*, 2007, *54* (8), 2291–2304.

**Hayashi, Fumio**, "Tobin's marginal q and average q: A neoclassical interpretation," *Econometrica*, 1982, pp. 213–224.

**Hayek, Friedrich August**, *The pure theory of capital*, Routledge, 1941.

**He, Zhiguo, Bryan Kelly, and Asaf Manela**, "Intermediary asset pricing: New evidence from many asset classes," *Journal of Financial Economics*, 2017, *126* (1), 1–35.

**Ippolito, Filippo, Ali K Ozdagli, and Ander Perez-Orive**, "The transmission of monetary policy through bank lending: The floating rate channel," *Journal of Monetary Economics*, 2018, *95*, 49–71.

**Jeenas, Priit**, "Firm Balance Sheet Liquidity, Monetary Policy Shocks, and Investment Dynamics," *working paper, Pompeu Fabra*, 2019.

_ **and Ricardo Lagos**, "Q-Monetary Transmission," Technical Report, National Bureau of Economic Research 2022.

**Jordà, Òscar**, "Estimation and inference of impulse responses by local projections," *American Economic Review*, 2005, *95* (1), 161–182.

_ , **Moritz Schularick, and Alan M Taylor**, "The effects of quasi-random monetary experiments," *Journal of Monetary Economics*, 2020, *112*, 22–40.

**Jorgenson, Dale Weldeau**, "Investment: Capital theory and investment behavior," *American Economic Review*, 1963, *53.*

**Kashyap, Anil K and Jeremy C Stein**, "What do a million observations on banks say about the transmission of monetary policy?," *American Economic Review*, 2000, *90* (3), 407–428.

_ , **Owen A Lamont, and Jeremy C Stein**, "Credit conditions and the cyclical behavior of inventories," *The Quarterly Journal of Economics*, 1994, *109* (3), 565–592.

**Keynes, J. M.**, *The General Theory of Employment, Interest and Money*, Macmillan, 1936. 14th edition, 1973.

**Kiyotaki, Nobuhiro and John Moore**, "Credit cycles," *Journal of Political Economy*, 1997, *105* (2), 211–248.

**Lakdawala, Aeimit and Timothy Moreland**, "Monetary policy and firm heterogeneity: The role of leverage since the financial crisis," *Available at SSRN 3405420*, 2021.

**Lerner, Abba P**, "On the marginal product of capital and the marginal efficiency of investment," *Journal of Political Economy*, 1953, *61* (1), 1–14.

**Lian, Chen and Yueran Ma**, "Anatomy of corporate borrowing constraints," *The Quarterly Journal of Economics*, 2021, *136* (1), 229–291.

**Lin, Xiaoji, Chong Wang, Neng Wang, and Jinqiang Yang**, "Investment, Tobin'sq, and interest rates," *Journal of Financial Economics*, 2018, *130* (3), 620–640.

**López-Salido, David, Jeremy C Stein, and Egon Zakrajšek**, "Credit-market sentiment and the business cycle," *The Quarterly Journal of Economics*, 2017, *132* (3), 1373–1426.

**Lucas, Robert E and Edward C Prescott**, "Investment under uncertainty," *Econometrica*, 1971, pp. 659–681.

**McKay, Alisdair and Johannes F Wieland**, "Lumpy durable consumption demand and the limited ammunition of monetary policy," *Econometrica*, 2021, *89* (6), 2717–2749.

**Merton, Robert C**, "On the pricing of corporate debt: The risk structure of interest rates," *The Journal of finance*, 1974, *29* (2), 449–470.

**Miranda-Agrippino, Silvia**, "Unsurprising shocks: information, premia, and the monetary transmission," 2016.

**Ottonello, Pablo and Thomas Winberry**, "Financial Heterogeneity and the Investment Channel of Monetary Policy," *Econometrica*, 2020, *88* (6), 2473–2502.

**Ozdagli, Ali K**, "Financial frictions and the stock price reaction to monetary policy," *The Review of Financial Studies*, 2018, *31* (10), 3895–3936.

**Palazzo, Berardino and Ram Yamarthy**, "Credit risk and the transmission of interest rate shocks," *Journal of Monetary Economics*, 2022, *130*, 120–136.

**Philippon, Thomas**, "The bond market's q," *The Quarterly Journal of Economics*, 2009, *124* (3), 1011–1056.

**Ramey, Valerie A**, "Macroeconomic shocks and their propagation," *Handbook of Macroeconomics*, 2016, *2*, 71–162.

**Swanson, Eric T**, "Measuring the effects of federal reserve forward guidance and asset purchases on financial markets," *Journal of Monetary Economics*, 2021, *118*, 32–53.

**Tenreyro, Silvana and Gregory Thwaites**, "Pushing on a string: US monetary policy is less powerful in recessions," *American Economic Journal: Macroeconomics*, 2016, *8* (4), 43–74.

**Tobin, James**, "A general equilibrium approach to monetary theory," *Journal of Money, Credit and Banking*, 1969, *1* (1), 15–29.

**Vassalou, Maria and Yuhang Xing**, "Default risk in equity returns," *The Journal of Finance*, 2004, *59* (2), 831–868.

**Vavra, Joseph**, "Inflation dynamics and time-varying volatility: New evidence and an ss interpretation," *The Quarterly Journal of Economics*, 2014, *129* (1), 215–258.

**Wu, Wenbin**, "The credit channel at the zero lower bound through the lens of equity prices," *Journal of Money, Credit and Banking*, 2018, *50* (2-3), 435–448.

Internet Appendix

(Intended for online publication only)

# Firm Financial Conditions and the Transmission of Monetary Policy

by T. Ferreira, D. Ostry, J. Rogers

February 10, 2023

B.9 Aggregate Implications of EBP Heterogeneity

# C Model Appendix

C.1 Model Parameterization

C.2 Firm EBPs and Marginal Benefit Curves for Capital

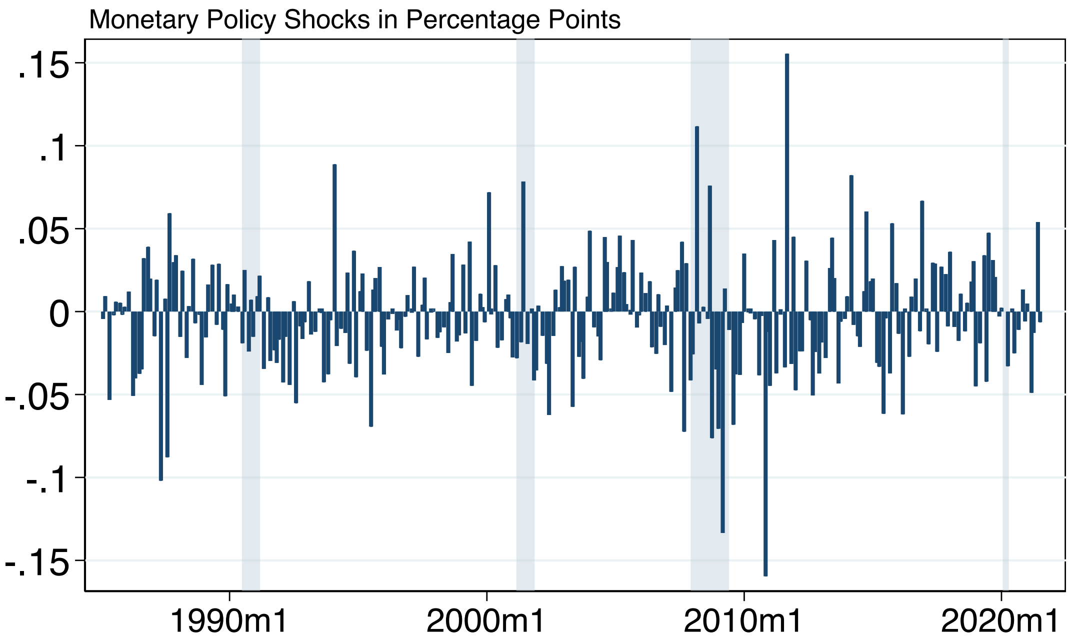
C.3 Firm EBPs and Capital Stock: Model and Data

# A Data Description and EBP Calculation

## A.1 Monetary Policy Shocks

This section provides more details about the Bu, Rogers and Wu (2021) monetary policy shocks, which we use in our baseline specifications throughout the paper. The start-date of our sample is January 1985, while the end-date is December 2021. Figure A.1 shows the times series of shocks. This "extended" series is longer than the original series of the paper, which runs from January 1994 to September 2019.

FIGURE A.1
Monetary Policy Shocks




*Note.* Figure A.1 plots the time series of Bu et al. (2021) monetary policy shocks from January 1985 to July 2021. Shaded columns represent periods classified as recessions by the National Bureau of Economic Research.

As discussed in the original paper, the Bu et al. (2021) monetary policy shocks are constructed using a two-step Fama-Macbeth procedure with identification achieved via a heteroskedasticity-based instrumental variable approach. The resulting shocks display a moderately-high correlation with other shock series in the literature, but have a number of notable properties: (i) they stably bridges periods of conventional and unconventional policy, providing us with a significantly larger sample than other empirical work in this area; (ii) they are devoid of the central bank information effects; and (iii) they are unpredictable from the information set available at the time of the shock. For more details on the calculation of the Bu et al. (2021) shock series, see the original paper. That said, as shown in Appendix B.5, our results are robust to using the Swanson (2021) shocks.

## A.2 Variable Definitions and Sample Selection

In this subsection, we first define the variables used in our paper and then discuss our sample. All variable definitions are standard in the literature; we draw particularly on those used in Ottonello and Winberry (2020) and Gilchrist and Zakrajšek (2012). The variables are:

1. *Real Investment*: defined as $log(\frac{K_{it+h}}{K_{it-1}})$ for $h = 0, 1, 2...$, where $K_{it-1}$ denotes the book value of the nominal capital stock of firm $i$ at the end of period $t-1$ deflated by the BLS implicit price deflator (IPDNBS in FRED database). This is the same timing convention as Ottonello and Winberry (2020), although they label the real capital stock of firm $i$ at the end of period $t-1$ as $K_{it}$. As in Ottonello and Winberry (2020), for each firm, we set the first value of their nominal capital stock to be the level of gross plant, property, and equipment (ppegtq in Compustat) in the first period in which this variable is reported in Compustat. From this period onwards, we compute the evolution of the capital stock using the changes of net plant, property, and equipment (ppentq in Compustat), which is a measure of net of depreciation investment with significantly more observations than ppegtq. If a firm has a missing observation of ppentq located between two periods with non-missing observations we estimate its value by linear interpolation. We consider only investment spells of 20 quarters or more.

2. *Credit spread*: defined as $S_{ikt} = y_{ikt} - y_t^T$ where $y_{ikt}$ is the yield quoted in the secondary market of corporate bond $k$ issued by firm $i$ in month $t$ from the Lehman-Warga and Merrill-Lynch databases and $y_t^T$ is the yield on a U.S. Treasury with the exact same maturity as the corporate bond $k$, using estimates from Gürkaynak et al. (2007).

3. *Distance to default*: firm's expected default risk defined by Merton (1974) model. Calculated as in Gilchrist and Zakrajšek (2012); see Appendix A.3 for further details.

4. *EBP*: defined as $EBP_{ikt} = S_{ikt} - \hat{S}_{ikt}$ where $\hat{S}_{ikt}$ is the predicted value of firm $i$'s bond $k$ credit spread at time t, which as in Gilchrist and Zakrajšek (2012), is calculated from a regression of $log(S_{ikt})$ on firm $i$'s distance to default and bond $k$'s characteristics. See Appendix A.3 for further details.

5. *Leverage*: defined as the ratio of total debt (sum of dlcq and dlttq in Compustat) to total assets (atq in Compustat).

6. *Liquid Assets*: defined as the ratio of cash and short-term investments (cheq in Compustat) to total assets (atq in Compustat), as in Jeenas (2019).

7. *Size*: measured as total assets (atq in Compustat) deflated using the BLS implicit price deflator (IPDNBS in FRED database).

8. *Sales growth*: measured as the log-difference of sales (saleq in Compustat) deflated using the BLS implicit price deflator (IPDNBS in FRED database).

9. *Age*: defined as age since initial public offering (begdat in Compustat).

10. *Tobin's (average) q*: defined as the ratio market value of assets to book value of assets. Market value of assets is equal to (i) book value of assets (atq in Compustat) plus (ii) market capitalization (share price times oustanding shares) minus common equity plus deferred taxes ((prccq * cshoq) - ceqq + txditcq, in Compustat), as in Cloyne et al. (2019). Since txditcq is sparsely available and is also a relatively small component of Tobin's q, we impute the value to be zero if an observation is missing.

11. *Short-Term Assets*: defined as the ratio of current assets (actq in Compustat) to total assets (atq in Compustat).

12. *Sectors*: we use 4-digit SIC codes.

13. *GDP and Aggregate Investment*: measured as real chained gross domestic product (GDPC1 in FRED) and real chained investment (RINV in FRED). Growth rates calculated as log-differences.

**Sample selection**: we focus on the non-financial firms whose balance sheets, equity prices and bond yields data are available in the Compustat, CRSP, and Lehman-Warga/Merrill-Lynch databases, respectively. To clean the data, similar to Gilchrist and Zakrajšek (2012), we first drop bond-time observations that display any of the following characteristics: they are puttable; they have spreads larger than 35% or below 0%; they have a residual maturity of less than 6 months or more than 30 years. After this, we drop bonds that have no spells of at least one year of consecutive observations. We then merge this bond-level dataset with the firm-level Compustat and CRSP databases for non-financial firms. To determine whether a firm is non-financial, we make use of both their NAICS/SIC code as well as the classification scheme internal to the Lehman-Warga/Merrill-Lynch databases. Specifically, if the NAICS/SIC code is available, we exclude those firms classified as financial according to their NAICS/SIC code; otherwise, we exclude firms classified as financial according to the Lehman-Warga/Merrill-Lynch databases.

## A.3 Calculating Distance to Default and the EBP

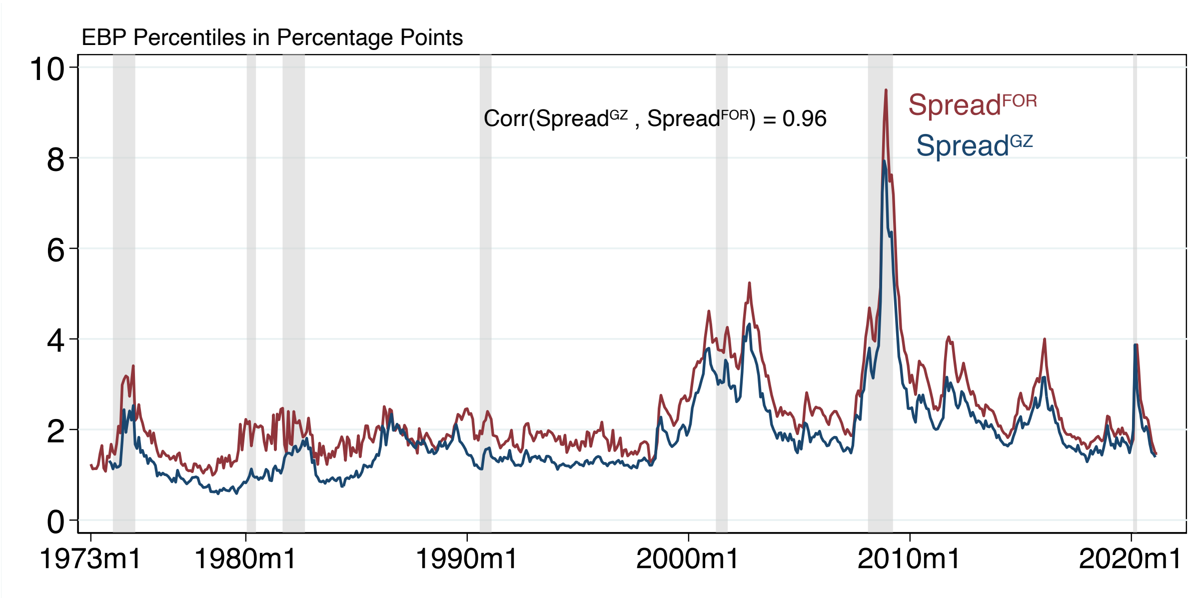
Our starting point is the credit spread $S_{ikt}$ for bond $k$ issued by firm $i$ at time $t$, which we calculate in a similar fashion to Gilchrist and Zakrajšek (2012). Figure A.2 plots the time series of our mean credit spread and that of Gilchrist and Zakrajšek (2012) and highlights that the correlation is 96%.

To derive each bond's $EBP_{ikt}$, as discussed in the main text, following Gilchrist and Zakrajšek (2012), we estimate:

$$\log S_{ikt} = \beta DD_{it} + \gamma^{'} \mathbf{Z}_{ikt} + \upsilon_{ikt}, \tag{A.1}$$

where $DD_{it}$ is firm $i$'s distance to default (Merton, 1974), and $\mathbf{Z}_{ikt}$ includes: (i) the bond's duration, age, par value, coupon rate (all in logs); (ii) a dummy for if the bond is callable; (iii) interactions between the characteristics listed in (i) and the call dummy in (ii); (iv) interactions between the call dummy in (ii) and $DD_{it}$, the first three principal components of the U.S. Treasury yield curve, and the volatility of the 10-year Treasury yield; and (v)

Figure A.2
Credit Spreads: Comparison with Gilchrist and Zakrajšek (2012)




*Note.* Figure A.2 compares the mean credit spread calculated in this paper, in red, with the mean credit spread calculated by Gilchrist and Zakrajšek (2012), in blue. Shaded columns represent periods classified as recessions by the National Bureau of Economic Research.

firm and credit rating fixed effects. Table A.1 provides the results from estimating regression (A.1). We discuss how we calculate $DD_{it}$ later in this section.

Assuming the error term is normally distributed, the predicted spread $\hat{S}_{ikt}$ is given by:

$$\hat{S}_{ikt} = exp\left[\hat{\beta}DD_{it} + \hat{\gamma}'\mathbf{Z}_{ikt} + \frac{\hat{\sigma}^2}{2}\right] \tag{A.2}$$

where $\hat{\beta}$ and $\hat{\gamma}$ denote the OLS estimated parameters and $\hat{\sigma}^2$ denotes the estimated variance of the error term. Finally, we define the excess bond premium as

$$EBP_{ikt} = S_{ikt} - \hat{S}_{ikt} \tag{A.3}$$

Implementing this procedure for the bonds in Merrill-Lynch and Lehman-Warga whose firm's balance sheet data and equity prices are available from Compustat and CRSP, respectively, yields, after data cleaning as described in Appendix A.2, a sample of monthly EBPs for 11,319 bonds from 1,913 firms. Figure A.3 plots the time series of our mean EBP and that of Gilchrist and Zakrajšek (2012) and highlights that the correlation is 86%.

TABLE A.1
Bond-Level Credit Spreads and Firm Default Risk

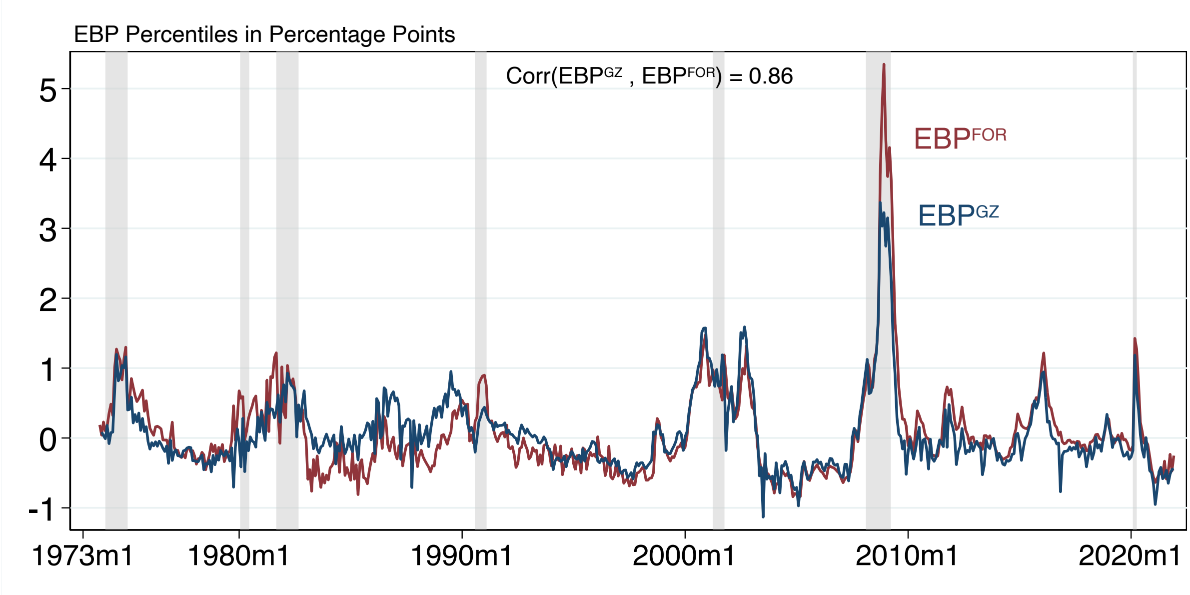
| $\log(S_{ikt})$ | Est. | S.E. | T-stat |
|---|---|---|---|
| $DD_{it}$ | -0.022 | 0.002 | -13.37 |
| $\log(Dur_{ikt})$ | 0.170 | 0.018 | 9.47 |
| $\log(Age_{ikt})$ | 0.094 | 0.010 | 9.51 |
| $\log(Par_{ikt})$ | 0.085 | 0.014 | 6.25 |
| $\log(Coupon_{ikt})$ | 0.040 | 0.043 | 0.94 |
| $\mathbf{1}_{Call_{ikt}}$ | 0.057 | 0.149 | 0.39 |
| $DD_{it} \times \mathbf{1}_{Call_{ikt}}$ | 0.010 | 0.001 | 7.27 |
| $\log(Dur_{ikt}) \times \mathbf{1}_{Call_{ikt}}$ | 0.030 | 0.018 | 1.65 |
| $\log(Age_{ikt}) \times \mathbf{1}_{Call_{ikt}}$ | -0.110 | 0.011 | -9.89 |
| $\log(Par_{ikt}) \times \mathbf{1}_{Call_{ikt}}$ | -0.094 | 0.015 | -6.05 |
| $\log(Coupon_{ikt}) \times \mathbf{1}_{Call_{ikt}}$ | 0.503 | 0.045 | 11.28 |
| $LEV_t \times \mathbf{1}_{Call_{ikt}}$ | -0.042 | 0.007 | -6.07 |
| $SLP_t \times \mathbf{1}_{Call_{ikt}}$ | -0.009 | 0.029 | -0.29 |
| $CRV_t \times \mathbf{1}_{Call_{ikt}}$ | 0.191 | 0.087 | 2.17 |
| $VOL_t \times \mathbf{1}_{Call_{ikt}}$ | 0.002 | 0.000 | 8.37 |
| Adj. $R^2$ | | 0.679 | |
| Firm Fixed Effects | | Yes | |
| Credit-Rating Fixed Effects | | Yes | |

*Note.* Table A.1 present the estimated coefficients, standard errors and T-statistics from estimating regression (A.1) by OLS. The sample period is October 1973 to December 2021 and includes 682,316 observations. $LEV_t$, $SLP_t$, $CRV_t$ refer to the level, slope and curvature (first three principal components) of the U.S. Treasury Yield Curve (Gürkaynak et al., 2007); $VOL_t$ refers to the realized volatility of daily 10-year Treasury yield. Standard errors are two-way clustered by firm and month.

The key predictor in the Gilchrist and Zakrajšek (2012) credit spread model is the firm's Merton (1974) Distance to Default (DD), an indicator of the firm's expected default risk. The DD framework assumes that the total value of the firm, denoted by $V$, is governed by following the stochastic differential equation:

$$dV = \mu_V V dt + \sigma_V V dZ_t \tag{A.4}$$

FIGURE A.3
Excess Bond Premium: Comparison with Gilchrist and Zakrajšek (2012)




*Note.* Figure A.3 compares the mean EBP calculated in this paper, in red, with the mean EBP calculated by Gilchrist and Zakrajšek (2012), in blue. Shaded columns represent periods classified as recessions by the National Bureau of Economic Research.

where $\mu_V$ is the expected growth rate of $V$, $\sigma_V$ is the volatility of $V$, and $Z_t$ denotes the standard Brownian motion. Assuming that the firm issues a single bond with face-value $D$ that matures in $T$ periods, Merton (1974) shows that the value of the firm's equity $E$ can be viewed as a call option on the underlying value of the firm $V$, with a strike price equal to the face-value of the firm's debt $D$ maturing at $T$.

Using the Black and Scholes (1973) pricing formula for a call option, the value of the firm's equity is then

$$E = V\Phi(\delta_1) - e^{-rT}D\Phi(\delta_2) \tag{A.5}$$

where $r$ denotes the risk-free interest rate, $\Phi(.)$ denotes the cdf of standard normal distribution, and

$$\delta_1 = \frac{log(V/D) + (r + 0.5\sigma_V^2)T}{\sigma_V^2\sqrt{T}} \quad \text{and} \quad \delta_2 = \delta_1 - \sigma_V\sqrt{T}.$$

Using equation (A.5), by Ito's lemma, one can relate the volatility of the firm's value to the volatility of the firm's equity

$$\sigma_E = \frac{V}{E}\Phi(\delta_1)\sigma_V \tag{A.6}$$

Assuming a time to maturity of one year ($T = 1$) and daily data on one-year Treasury yields $r$, the face value of firm debt $D$, the market value of firm equity $E$, and its one-year historical volatility $\sigma_E$, equations (A.5) and (A.6) provide a two equation system that can be used to solve for the two unknowns $V$ and $\sigma_V$.[24] Due to the issues raised in Vassalou and Xing (2004), we follow Gilchrist and Zakrajšek (2012) by implementing the two-step iterative procedure of Bharath and Shumway (2008). First, we set $\sigma_V = \sigma_E$ for each day in a one-year rolling window and then substitute $\sigma_V$ into equation (A.5) to solve for the market value $V$ for each of these days. Second, from our new estimated $V$ series, we calculate a year-long series of daily log-returns to the firm's value, $\Delta \log V$, which we then use to compute a new estimate for $\sigma_V$ as well as for $\mu_V$.[25]. We then iterate on $\sigma_V$ until convergence.

Given solutions $(V, \sigma_V, \mu_V)$ to the Merton DD model, we are able to calculate the firm's Distance to Default over a one-year horizon as

$$DD = \frac{\log(V/D) + (\mu_V - 0.5\sigma_V^2)}{\sigma_V} \tag{A.7}$$

Since default at T occurs when a firm's value falls below the value of its debt ($\log(V/D) < 0$), the DD captures the distance a firm is above default, given an expected asset growth rate $\mu_V$ and volatility $\sigma_V$ until T, in units of standard deviations.

[24] Daily data for $E$ is from CRSP ($prc * shrout$) and is used to calculate a daily 252-day historical rolling-window equity volatility $\sigma_E$. Quarterly data on firm debt $D =$ Current Liabilities$+\frac{1}{2}$Long-Term Liabilities is from Compustat ($dlcq + 0.5 * dlttq$) and is linearly interpolated to form a daily series.

[25] Using the formulas $\sigma_V = \sqrt{252} * \sigma(\Delta \log V)$ and $\mu_V = 252 * \mu(\Delta \log V)$

# B Additional Empirical Results and Robustness

In this section, we offer additional empirical results and robustness to complement our findings from the main text. In Section B.1, we show that our results are robust to including time-sector fixed effects. In Section B.2, we show our results are robust to conditioning on bond/firm EBPs using dummy variables. In Section B.3, we show that, when not conditioning on the EBP, default risk indeed regulates firms' responses to monetary policy. In Section B.4, we highlight that heterogeneous responses by EBP are robust to controlling for monetary policy's effects conditional on other firm characteristics. In Section B.5, we re-estimate our main specifications with alternative monetary policy shocks. In Section B.6, we re-estimate our results using an EBP purged of its higher-order dependence on default risk. In Section B.7, we document monetary policy's effects on firm debt issuance by EBP. In Section B.8, we study the conditioning effects of EBP for intermediary net worth shocks. Finally, in Section B.9, we showcase the robustness of our results linking the EBP distribution to the aggregate effectiveness of monetary policy.

## B.1 EBP Heterogeneity with Sector-Time Fixed Effects

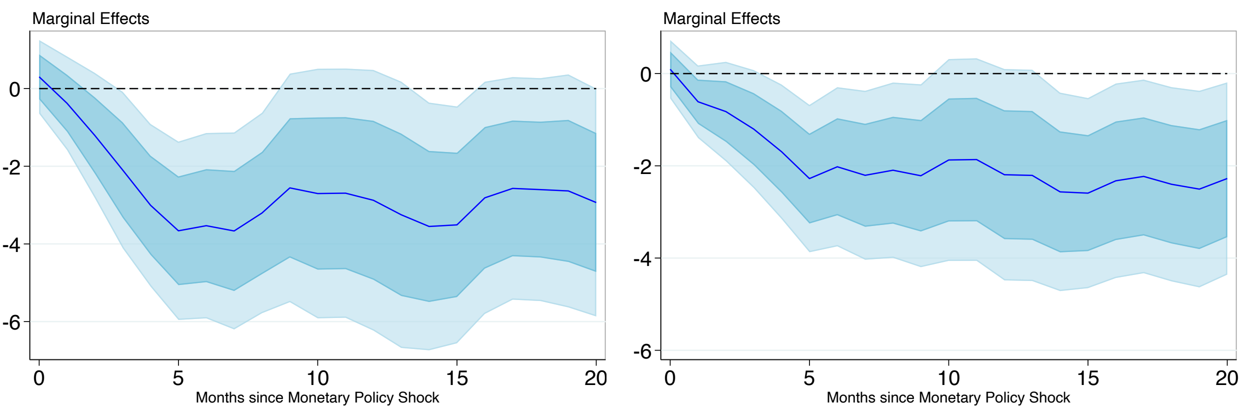
We begin by showing that our results for the heterogeneous responses conditional on EBP are robust to controlling for time-sector fixed effects. Indeed, we show that the spreads of high-EBP bonds and investment of low-EBP firms remain more sensitive to monetary policy shocks. In addition, we show the investment of low-EBP firms is more responsive to movements in their credit spreads. To show this, we define $\mathbf{W}_{it-1}$ as the vector of firm-level controls contained in $\mathbf{Z}_{it-1}$ (see Section 2.4), but excluding the macro-level controls.

**Monetary Policy on Credit Spreads:**

Beginning with monetary policy's effect on credit spreads, we include sector-time fixed

FIGURE B.1
Monetary Policy's Effect on Bond-Level Credit Spreads Depending on EBP

(A) Macro-Financial Controls (B) Sector-Time Fixed Effects




*Note.* Figure B.1 compares the effects of the dynamic interaction ($\beta_2^h$) between $EBP_{ikt-1}$ and the Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$) on the h-period change in credit spreads, $S_{ikt+h} - S_{ikt-1}$, for two different specifications: one that controls for macro-financial controls as in the main text (4) in Panel B.1a and one that includes time-sector fixed effects (B.1) in Panel B.1b. The frequency of the data is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

effects $\alpha_{s,t}^h$ in the following specification (B.1):[26]

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \alpha_{s,t}^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\gamma}^h \mathbf{W}_{it-1} + e_{ikth}, \qquad \text{(B.1)}$$

The interaction effect ($\beta_2^h$s) are displayed in Panel B.1b of Figure B.1, alongside the results from the original specification in Panel B.1a, which have been recopied from Panel 3b of Figure 3 for comparison. Figure B.1 highlights that our results from section 3 are robust to controlling for sector-time fixed effects: credit spreads of high-EBP bonds are more responsive to monetary policy.

**Monetary Policy on Firm Investment:**

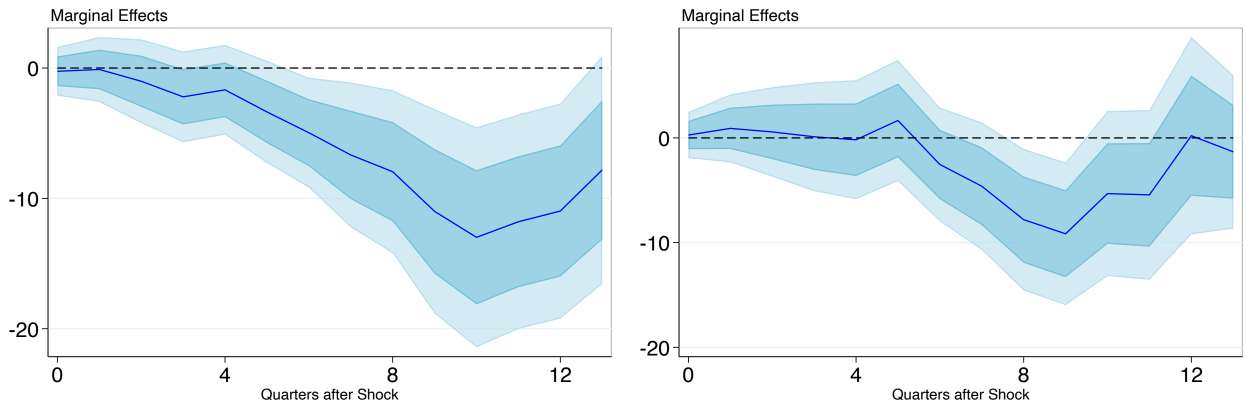
Next, turning to monetary policy's effects on investment, we include sector-time fixed

[26]Note that macro-financial controls, in addition to the unconditional monetary policy shock $\varepsilon_t^m$, would be absorbed by $\alpha_{s,t}^h$.

FIGURE B.2

Monetary Policy's Effect on Firm-Level Investment Depending on EBP

(A) Macro-Financial Controls (B) Sector-Time Fixed Effects




*Note.* Figure B.2 compares the effects of the dynamic interaction ($\beta_2^h$) between $EBP_{it-1}$ and the Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$) on h-period Investment of firm i, $\log K_{it+h} - \log K_{it-1}$, for two different specifications: one that controls for macro-financial controls as in the main text (6) in Panel B.2a and one that includes time-sector fixed effects (B.2) in Panel B.2b. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

effects $\alpha_{s,t}^h$ in the following specification (B.2):

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \alpha_{s,t}^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{it-1}^{ma} \times \varepsilon_t^m + \boldsymbol{\gamma}^h \mathbf{W}_{it-1} + e_{ith}, \tag{B.2}$$

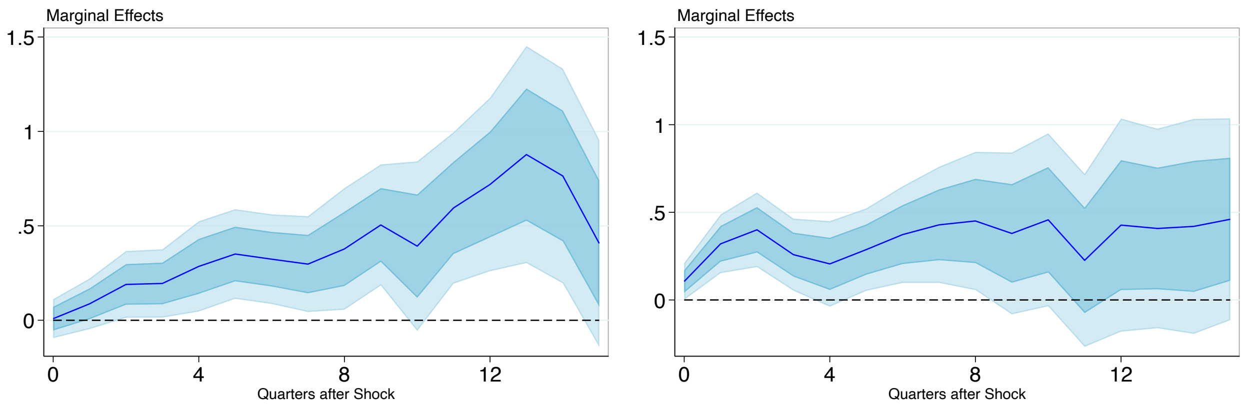
The interaction effect ($\beta_2^h$s) are displayed in Panel B.2b of Figure B.2, alongside the results from the original specification in Panel B.2a, which have been recopied from Panel 5b of Figure 5 for comparison. Figure B.2 highlights that our results from section 4 are robust to controlling for sector-time fixed effects: investment by low-EBP firms is more sensitive to monetary policy shocks.

**Firm Credit Spreads on Firm Investment:**

We assess the robustness of our results relating firms' investment responses to changes in their credit to the inclusion of sector-time fixed effects $\alpha_{s,t}^h$ using the following specifica-

Figure B.3
Credit Spreads' Effects on Firm Investment Depending on EBP

(a) Macro-Financial Controls (b) Sector-Time Fixed Effects




*Note.* Figure B.3 compares the effects of the dynamic effect ($\beta_1^h$) of a movement in credit spreads $\Delta S_{it}$ on h-period Investment of firm i, $\log K_{it+h} - \log K_{it-1}$, for two different specifications: one that controls for macro-financial controls as in the main text (10) in Panel B.3a and one that includes time-sector fixed effects (B.3) in Panel B.3b. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

tion (B.3):

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \alpha_{s,t}^h + \beta_1^h \Delta S_{i,t} + \beta_2^h \Delta S_{i,t} \times EBP_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{W}_{it-1} + e_{ith}, \tag{B.3}$$

The interaction effect ($\beta_2^h$s) are displayed in Panel B.3b of Figure B.3, alongside the results from the original specification in Panel B.3a, which have been recopied from Panel 9b of Figure 9 for comparison. As before, Figure B.3 highlights that our results from section 6 are robust to controlling for sector-time fixed effects: investment by low-EBP firms is more sensitive to movements in their credit spreads.

## B.2 EBP Heterogeneity with Dummy Variables

In this subsection, we demonstrate that our findings from the main text are not tied to the functional form of our EBP state variable, the moving yearly mean used by Jeenas (2019). In particular, we perform the same analysis as in the main text using the dummy variable approach used by Cloyne et al. (2019) and Anderson and Cesa-Bianchi (2021), and show that our conclusions are unchanged.

Denote by $\text{EBP}_{ikt}$ the EBP on firm i's bond k in period t. Then, define $\mathbf{1}\text{EBP}^{low}_{ikt}$ as a dummy variable taking the value of 1 if $\text{EBP}_{ikt}$ lies below the median of the EBP distribution in period t and 0 otherwise. Similarly, define $\mathbf{1}\text{EBP}^{high}_{ikt}$ as a dummy variable taking the value of 1 if $\text{EBP}_{ikt}$ lies above the median of the EBP distribution in period t and 0 otherwise. Now, we reconsider the results from sections 3, 4, and 6. When re-assessing each section, we evaluate two specifications. The first allows us to trace the distinct dynamic responses of spreads or investment to either monetary policy shocks or changes in spreads for $\mathbf{1}\text{EBP}^{low}_{ikt}$ and $\mathbf{1}\text{EBP}^{high}_{ikt}$ firms. The second specification allows us to assess the relative response of these two types of firms.

**Monetary Policy on Credit Spreads:**

To assess the distinct responses of credit spreads from monetary policy shocks for low- and high-EBP bonds, we estimate:

$$S_{ikt+h} - S_{ikt-1} = \beta^h_k + \beta^h_1 \varepsilon^m_t \times \mathbf{1}\text{EBP}^{low}_{ikt-1} + \beta^h_2 \varepsilon^m_t \times \mathbf{1}\text{EBP}^{high}_{ikt-1} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \quad \text{(B.4)}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}^{low}_{ikt-1}$ and $\mathbf{1}\text{EBP}^{high}_{ikt-1}$.

The impulse responses are displayed in Figure B.4, where we see that the credit spreads of high-EBP bonds are significantly more responsive to monetary policy than are the spreads of low-EBP bonds. This is consistent with our findings from the main text.

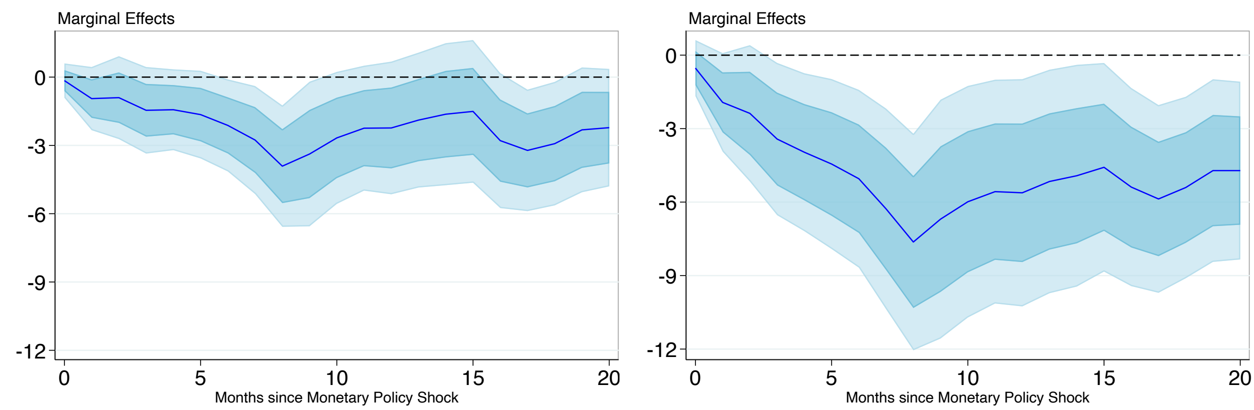
To see whether these two responses are distinct from one another, we estimate the adapted specification:

$$S_{ikt+h} - S_{ikt-1} = \beta^h_k + \beta^h_1 \varepsilon^m_t + \beta^h_2 \varepsilon^m_t \times \mathbf{1}\text{EBP}^{high}_{ikt-1} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \quad \text{(B.5)}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}^{high}_{ikt-1}$. Since we have included the monetary policy shock $\varepsilon^m_t$ on its own, the interaction coefficient $\beta^h_2$'s interpretation is now the response of the high-EBP bond's spread relative to low-EBP bond's spread

Figure B.4
Monetary Policy's Effect on Credit Spreads for Low- vs High-EBP Bonds

(A) Low-EBP (B) High-EBP




*Note.* Figure B.4 traces the response of spreads for low-EBP ($\mathbf{1}\text{EBP}^{low}$) bonds in Panel B.4a and high-EBP ($\mathbf{1}\text{EBP}^{high}$) bonds in Panel B.4b to a Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$), from regression (B.4), where the frequency is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

following a shock monetary policy easing. The interaction effect is displayed in Figure B.5 and highlights, as in the main text, that high-EBP bonds' spreads fall by more following a monetary easing than low-EBP bonds' spreads. This showcases that, under an alternative functional form for our state variable, the conclusions from Section 3 are unchanged.

**Monetary Policy on Investment:**

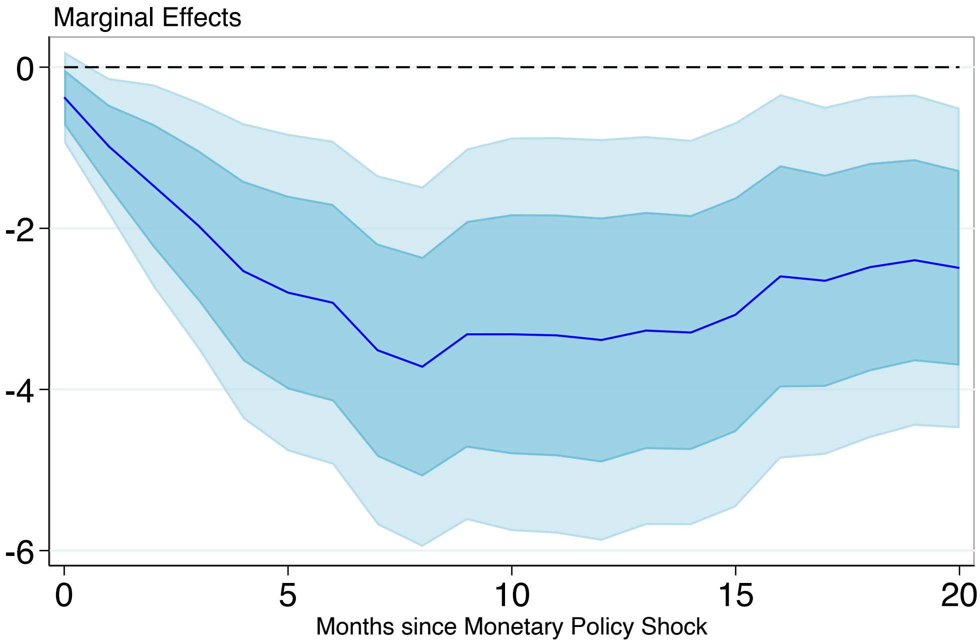
Proceeding as before, to assess the distinct investment responses to monetary policy shocks for low- and high-EBP firms, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \qquad \text{(B.6)}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$ and $\mathbf{1}\text{EBP}_{it-1}^{high}$.

The impulse responses are displayed in Figure B.6, where we see that the investment of low-EBP firms is significantly more responsive to monetary policy than are the investment of high-EBP bonds. This is consistent with our findings from the main text.

Figure B.5
Monetary Policy's Effect on Bond-Level Credit Spreads Depends on EBP




*Note.* Figure B.5 traces the relative response ($\beta_2^h$) of high-EBP $\mathbf{1}\text{EBP}_{ikt-1}^{high}$ bond's spreads relative to low-EBP $\mathbf{1}\text{EBP}_{ikt-1}^{low}$ bond's spreads from a Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$), from regression (B.5), where the frequency is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

Again, to see whether these two responses are distinct from one another, we estimate:

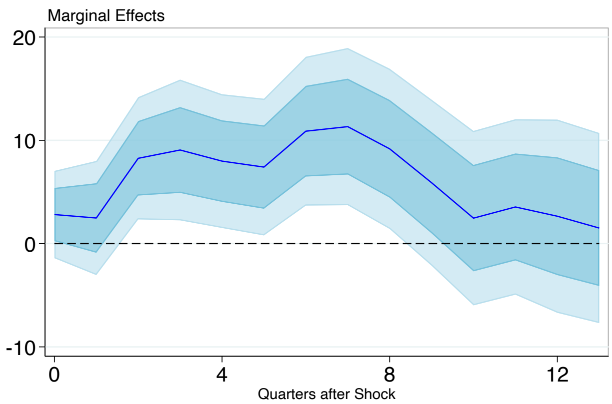
$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.7}$$

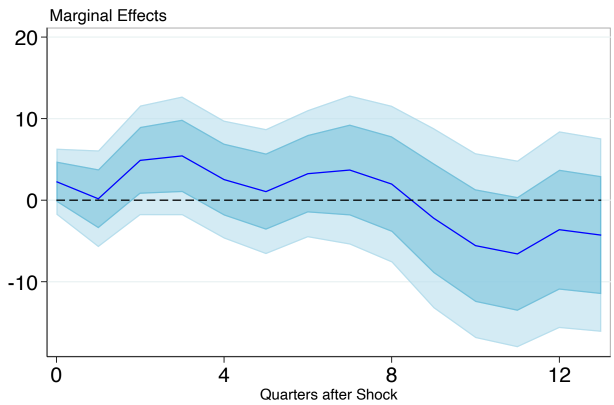
where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$. Since we have included the monetary policy shock $\varepsilon_t^m$ on its own, the interaction coefficient's ($\beta_2^h$) interpretation is now the response of low-EBP firms' investment relative to high-EBP firms' investment to a shock monetary policy easing.

The interaction effect is displayed in Figure B.7 and highlights that a shock monetary policy easing increases investment more for low-EBP firms than for high-EBP firms. This signifies, as before, that our conclusions from Section 4 are unchanged when using an alternative functional form for our state variable.

FIGURE B.6

Monetary Policy's Effect on Firm Investment for Low- vs High-EBP Firms




*Note.* Figure B.6 traces the response of investment for low-EBP ($\mathbf{1}\text{EBP}^{low}$) bonds in Panel B.6a and high-EBP ($\mathbf{1}\text{EBP}^{high}$) bonds in Panel B.6b to a Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$), from regression (B.6), where the frequency is quarterly. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

### Credit Spreads on Investment:

Finally, we assess the distinct investment responses to movements in credit spreads for low- and high-EBP firms by estimating:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \Delta S_{it} \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_2^h \Delta S_{it} \times \mathbf{1}\text{EBP}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \quad \text{(B.8)}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$ and $\mathbf{1}\text{EBP}_{it-1}^{high}$.

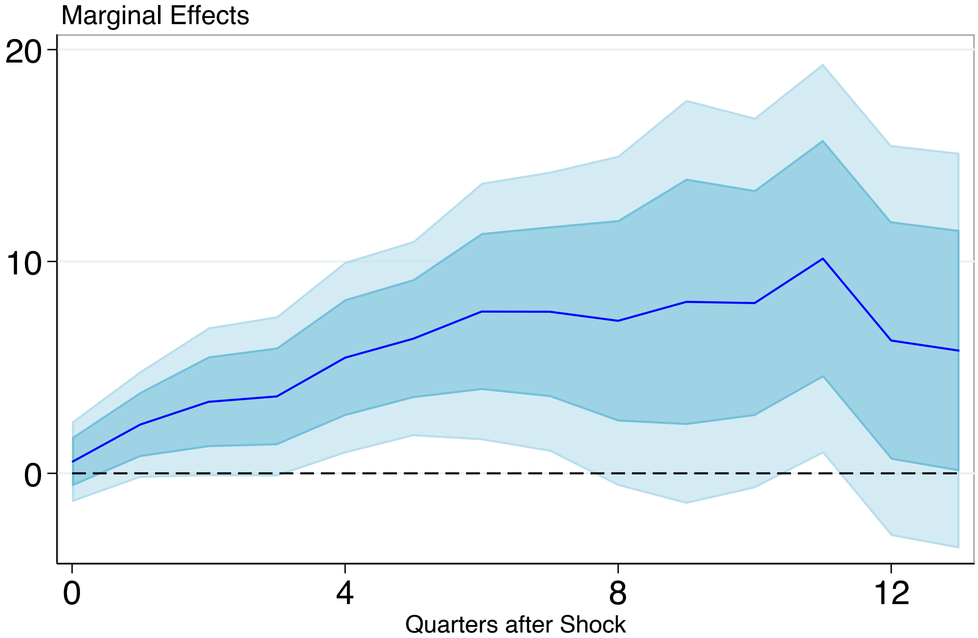
The impulse responses are displayed in Figure B.8, where we see that the investment of low-EBP firms is significantly more responsive to movements in their credit spreads compared to the investment of high-EBP firms. This is consistent with our findings from the main text.

To see whether these two responses are distinct from one another, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \Delta S_{it} + \beta_2^h \Delta S_{it} \times \mathbf{1}\text{EBP}_{it-1}^{low} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \quad \text{(B.9)}$$

FIGURE B.7

Monetary Policy's Effect on Firm-Level Investment Depends on EBP



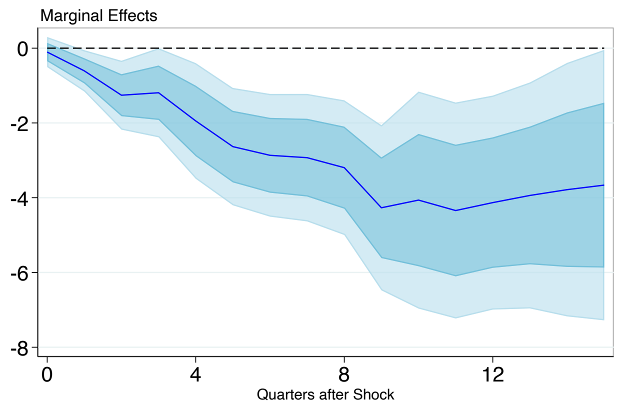

*Note.* Figure B.7 traces the relative response ($\beta_2^h$) of low-EBP $\mathbf{1}\mathrm{EBP}_{it-1}^{low}$ firms' investment relative to high-EBP $\mathbf{1}\mathrm{EBP}_{it-1}^{high}$ firms' investment from a Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$), from regression (B.7), where the frequency is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{EBP}_{it-1}^{low}$. Again, because we have included the credit spread shock $\Delta S_{it}$ on its own, the interaction coefficient's ($\beta_2^h$) interpretation is now the response of low-EBP firms' investment relative to high-EBP firms' investment to movements in credit spreads $\Delta S_{it}$.

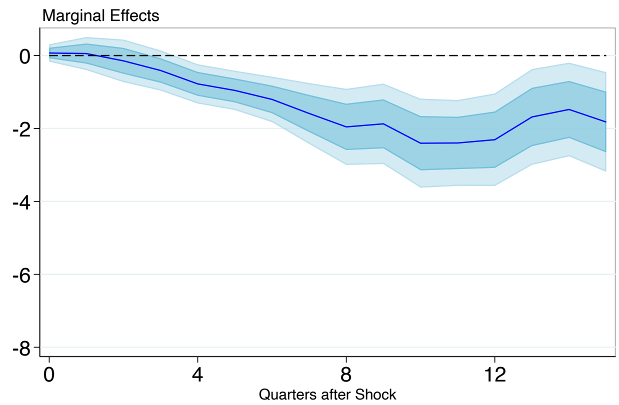
The interaction effect is displayed in Figure B.9 and highlights, as in the main text, that low-EBP firms' investment falls by more following an increase in their credit spreads relatve to high-EBP firms' investment, just as in Section 6.

Figure B.8
Credit Spread Shocks and Firm Investment for Low- vs High-EBP Firms

(a) Low-EBP Firms

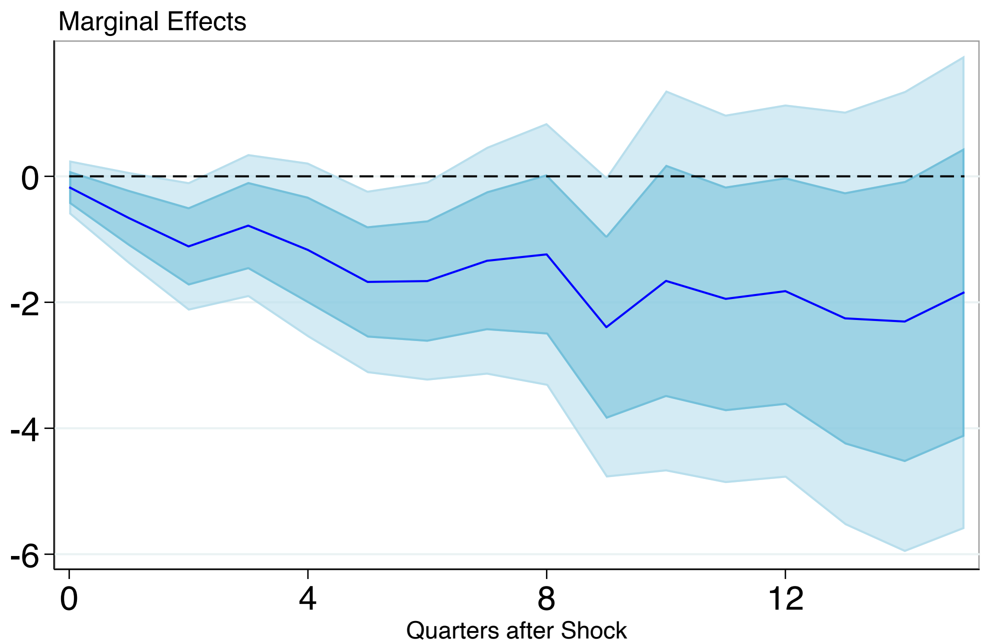



(b) High-EBP Firms




*Note.* Figure B.8 traces the response of investment for low-EBP ($\mathbf{1}\text{EBP}^{low}$) firms in Panel B.8a and high-EBP ($\mathbf{1}\text{EBP}^{high}$) firms in Panel B.8b to a change in credit spreads $\Delta S_{it}$, from regression (B.8), where the frequency is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

Figure B.9
Credit Spread's Effect on Firm-Level Investment Depends on EBP




*Note.* Figure B.9 traces the relative response ($\beta_2^h$) of low-EBP $\mathbf{1}\text{EBP}_{it-1}^{low}$ firms' investment relative to high-EBP $\mathbf{1}\text{EBP}_{it-1}^{high}$ firms' investment from a change in credit spreads $\Delta S_{it}$, from regression (B.9), where the frequency is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

## B.3 Default Risk as a State Variable

In this section, we document that, when not controlling for heterogeneity by EBP, default-risk does indeed regulate the response of firms' credit spreads and investment to monetary policy shocks in a manner consistent with the findings of Anderson and Cesa-Bianchi (2021) and Ottonello and Winberry (2020), respectively.

To demonstrate this, we use the dummy variable approach outlined in the previous section, since this is the functional form used by Anderson and Cesa-Bianchi (2021). Ottonello and Winberry (2020) use a linear functional form that purges firms' default risk of their in-sample firm-specific mean, which is motivated by firms being ex-ante identical in their model. To make our results comparable across as many studies as possible, we use the dummy variable approach.

**Monetary Policy on Credit Spreads:**

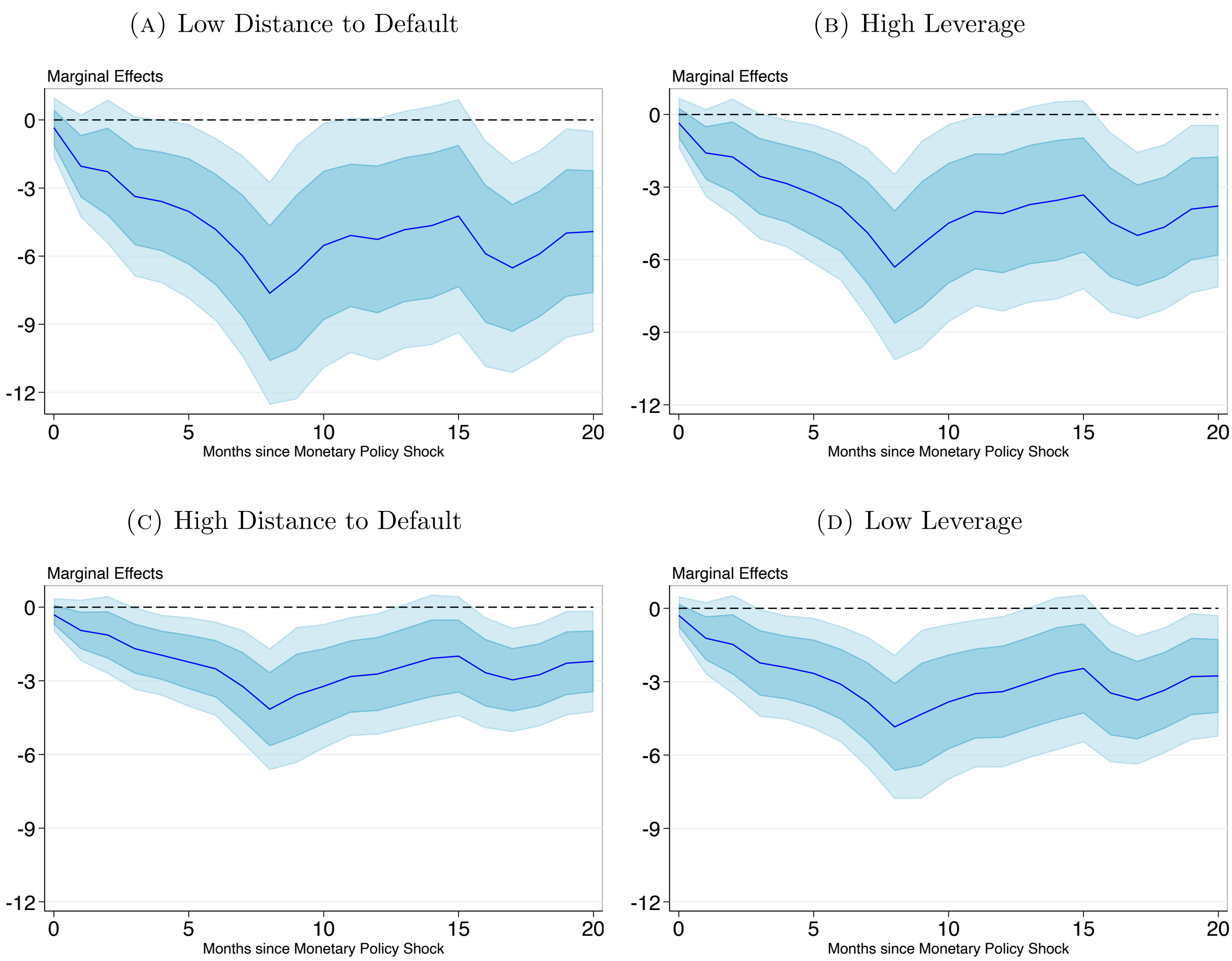
We begin by assessing the responses of bond-level credit spreads to monetary policy shocks for low- vs. high-default-risk firms. Recall that low distance to default and high leverage firms are viewed as having high default-risk. We begin by estimating the following specification at a monthly frequency:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{low} + \beta_2^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.10}$$

where $x$ denotes either distance to default or leverage. In the notation of the previous section, $\mathbf{1}\mathrm{x}_{it}^{low}$ is a dummy variable taking the value of 1 if $\mathrm{x}_{it}$ lies below the median of the firm-level distance to default or leverage distribution in period t and 0 otherwise. Similarly, define $\mathbf{1}\mathrm{x}_{it}^{high}$ as a dummy variable taking the value of 1 if $\mathrm{x}_{it}$ lies above the median of the firm-level distance to default or leverage distribution in period t and 0 otherwise. Note also that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{x}_{it-1}^{low}$ and $\mathbf{1}\mathrm{x}_{it-1}^{high}$.

The impulse responses are displayed in Figure B.10, where the Panels B.10a and B.10c trace $\beta_1^h$ and $\beta_2^h$, respectively, when $x$ is distance to default while Panels B.10b and B.10d trace $\beta_2^h$ and $\beta_1^h$, respectively, when $x$ is leverage. Clearly, we see that the marginal effects

FIGURE B.10
Monetary Policy's Effect on Spreads for Low vs. High Default-Risk Firms




(A) Low Distance to Default

(B) High Leverage

(C) High Distance to Default

(D) Low Leverage

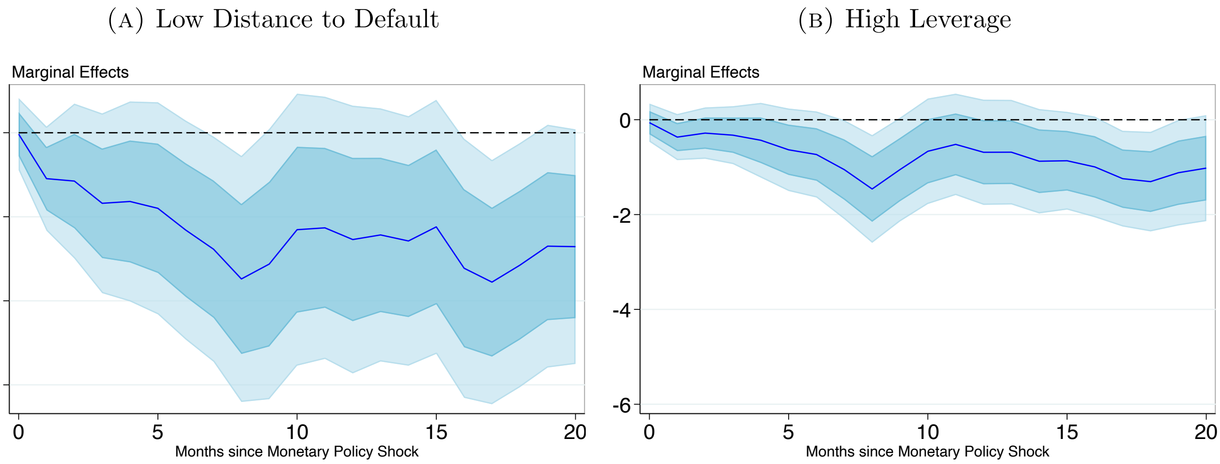
*Note.* Figure B.10 traces the distinct responses of low- and high- distance to default firms' spreads to a monetary policy shock in Panels B.10a and B.10c from estimating regression (B.10) with $x$ as distance to default, while Panels B.10b and B.10d trace the distinct responses of high- and low-leverage firms' spreads to a monetary policy shock from estimating regression (B.10) with $x$ as leverage. The frequency of the data is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

in the top row (Panels B.10a and B.10b), for low distance to default and high leverage firms, are larger than those in the bottom row. That is, consistent with the findings of Anderson and Cesa-Bianchi (2021), the credit spreads of firms with high default risk are more responsive to monetary policy shocks than are the firms with low default risk.

Following a similar path to the one from the previous section, we next assess whether the response of spreads for high- vs. low-default risk firms are statistically different from

Figure B.11

Monetary Policy's Relative Effect on Bond-Level Credit Spreads by Default Risk




*Note.* Figure B.11 traces the response of credit spreads for high-default risk, low distance to default in Panel B.11a and high-leverage in Panel B.11b, to a monetary policy shock from estimating regression (B.11), where the frequency is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

one another using:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{high(low)} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.11}$$

where, we include $\mathbf{1}\mathrm{x}_{it-1}^{low}$ when $x$ is distance to default and $\mathbf{1}\mathrm{x}_{it-1}^{high}$ when $x$ is leverage, to keep the responses comparable. As before, because we have included the monetary policy shock $\varepsilon_t^m$ on its own, the interaction coefficient's ($\beta_2^h$) interpretation is the response of high-default risk firms' (low distance to default or high leverage) spreads relative to low-default risk firms' spreads to a monetary policy shock. Note also that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{x}_{it-1}^{high(low)}$.

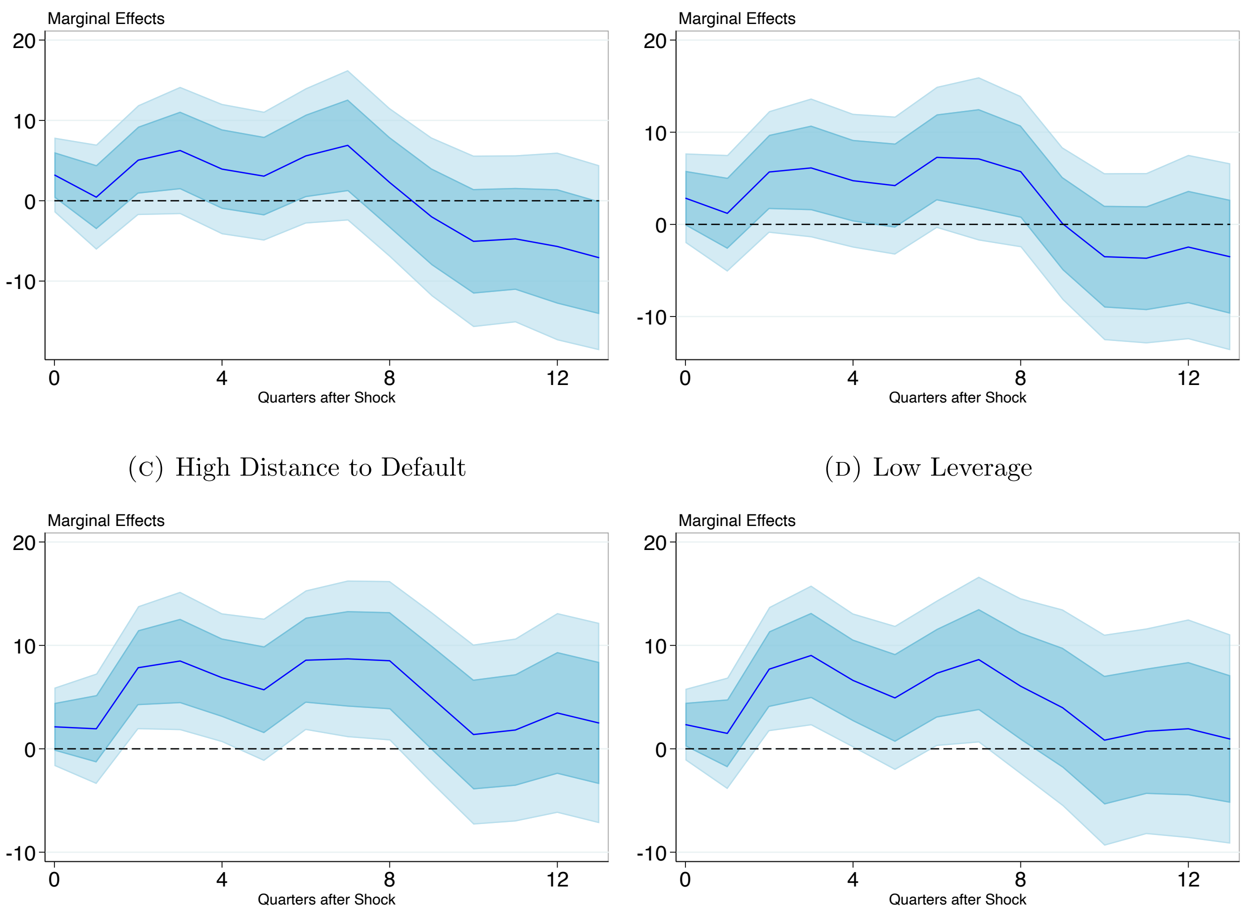
The interaction effect is displayed in Figure B.11 and highlights that high default-risk firms' spreads fall by more following a shock monetary policy easing compared to low default-risk firms', as is found by Anderson and Cesa-Bianchi (2021).

**Monetary Policy on Investment:**

To assess the distinct investment responses to monetary policy shocks for firms with

Figure B.12

Monetary Policy's Effect on Investment for Low v. High Default-Risk Firms




(A) Low Distance to Default

(B) High Leverage

(C) High Distance to Default

(D) Low Leverage

*Note.* Figure B.12 traces the distinct responses of low- and high- distance to default firms' investment to a monetary policy shock in Panels B.12a and B.12c from estimating regression (B.12) with $x$ as distance to default, while Panels B.12b and B.12d trace the distinct responses of high- and low-leverage firms' investment to a monetary policy shock from estimating regression (B.12) with $x$ as leverage. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

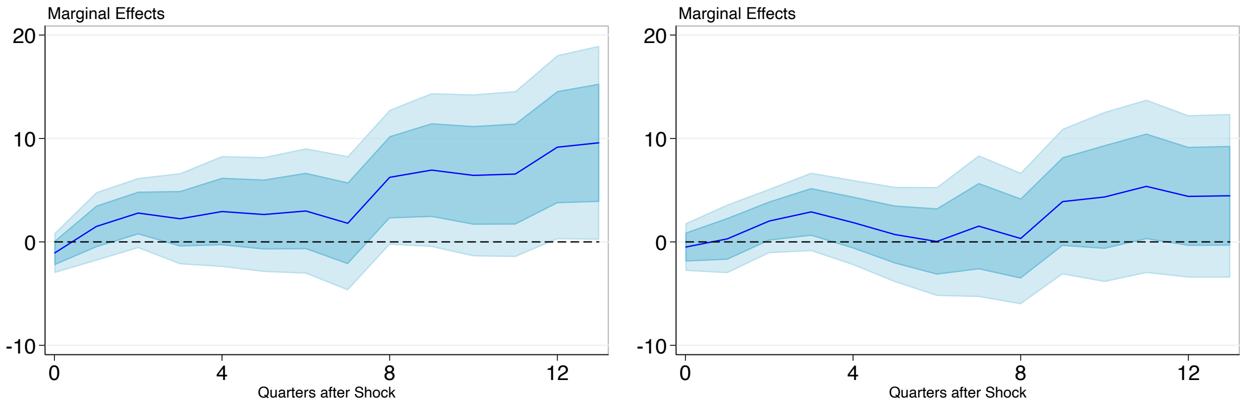
low- vs. high-default risk, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{low} + \beta_2^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.12}$$

where again $x$ refers either to firms' distance to default or leverage and $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{x}_{it-1}^{low}$ and $\mathbf{1}\mathrm{x}_{it-1}^{high}$.

Figure B.13
Monetary Policy's Relative Effect on Firm-Level Investment by Default Risk

(A) High Distance to Default (B) Low Leverage




*Note.* Figure B.13 traces the response of investment for low-default risk, high distance to default in Panel B.13a and low-leverage in Panel B.13b, to a monetary policy shock from estimating regression (B.13), where the frequency is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

The impulse responses are displayed in Figure B.12, where we see that only the investment responses of low default-risk—high distance to default (Panel B.12c) and low leverage (Panel B.12d)—firms are statistically different from zero. This is consistent with the findings of Ottonello and Winberry (2020).

Finally, to see whether the responses of low vs. high default-risk firms are distinct from one another, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{low(high)} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.13}$$

where, we include $\mathbf{1}\mathrm{x}_{it-1}^{low}$ when $x$ is leverage and $\mathbf{1}\mathrm{x}_{it-1}^{high}$ when $x$ is distance to default, to keep the responses comparable. As before, because we have included the monetary policy shock $\varepsilon_t^m$ on its own, the interaction coefficient's ($\beta_2^h$) interpretation is the response of low-default risk firms' (high distance to default or low leverage) investment relative to low-default risk firms' investment to a monetary policy shock. Note also that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{x}_{it-1}^{low(high)}$.

The impulse responses are traced in Figure B.13 and highlight that point estimates for both leverage and distance to default imply that low-default risk firms' investment increases by more than high-default risk firms'. However, only when using distance to default (Panel B.13a) is the effect statistically different from zero, albeit at longer horizons. This is consistent with Ottonello and Winberry (2020) who show that distance to default outperforms leverage in regulating firms' investment response to monetary policy. It is worth pointing out that Jeenas (2019) and Anderson and Cesa-Bianchi (2021) find that it is high-default-risk firms whose investment is more sensitive to monetary policy, while Lakdawala and Moreland (2021) highlight that the sign of heterogeneity by default risk may have changed following the global financial crisis. The differences in results across studies are part of an ongoing debate in the literature, which our results in this section for heterogeneity by default risk contribute to.

## B.4 Monetary Policy's Effect by EBP vs. other Characteristics

In this section, we show that the importance of firms' EBPs for determining their responsiveness to monetary policy is robust to conditioning on other competing firm characteristics. We first document that, as for the baseline linear interactions used in the main text, EBP heterogeneity tends to supersede heterogeneity by distance to default and leverage when using the dummy variable approach. Next, we consider heterogeneity by credit rating, age, size (assets) , sales growth, liquid assets, and Tobin's average Q and show that the EBP remains a significant state variable for the transmission of monetary policy when conditioning on these firm characteristics as well. To provide comparability with the existing studies, we use the dummy variable approach when assessing the conditioning effects of firms' EBPs relative to their credit rating (Ottonello and Winberry, 2020), age (Cloyne et al., 2019), and size and sales growth (Gertler and Gilchrist, 1994), but use our baseline linear interaction for liquid assets (Jeenas, 2019) and Tobin's average q.

### B.4.1 Distance to Default and Leverage with dummy variables:

In the main text, we ran horse-races between *linear* EBP interactions and *linear* default risk interactions to highlight that firms' responsiveness to monetary policy was largely a function of their EBPs.[27] In this section, we show that running similar horse-races using the dummy variable approach does not alter our conclusion that a firm's EBP supersedes its default risk as state variable for the transmission of monetary policy to both credit spreads and investment.

**Monetary Policy on Credit Spreads:**

We begin by running a horserace between the EBP and a measure of default risk $x$ (distance to default or leverage) as a conditioning variable for the impact of monetary policy on credit spreads:

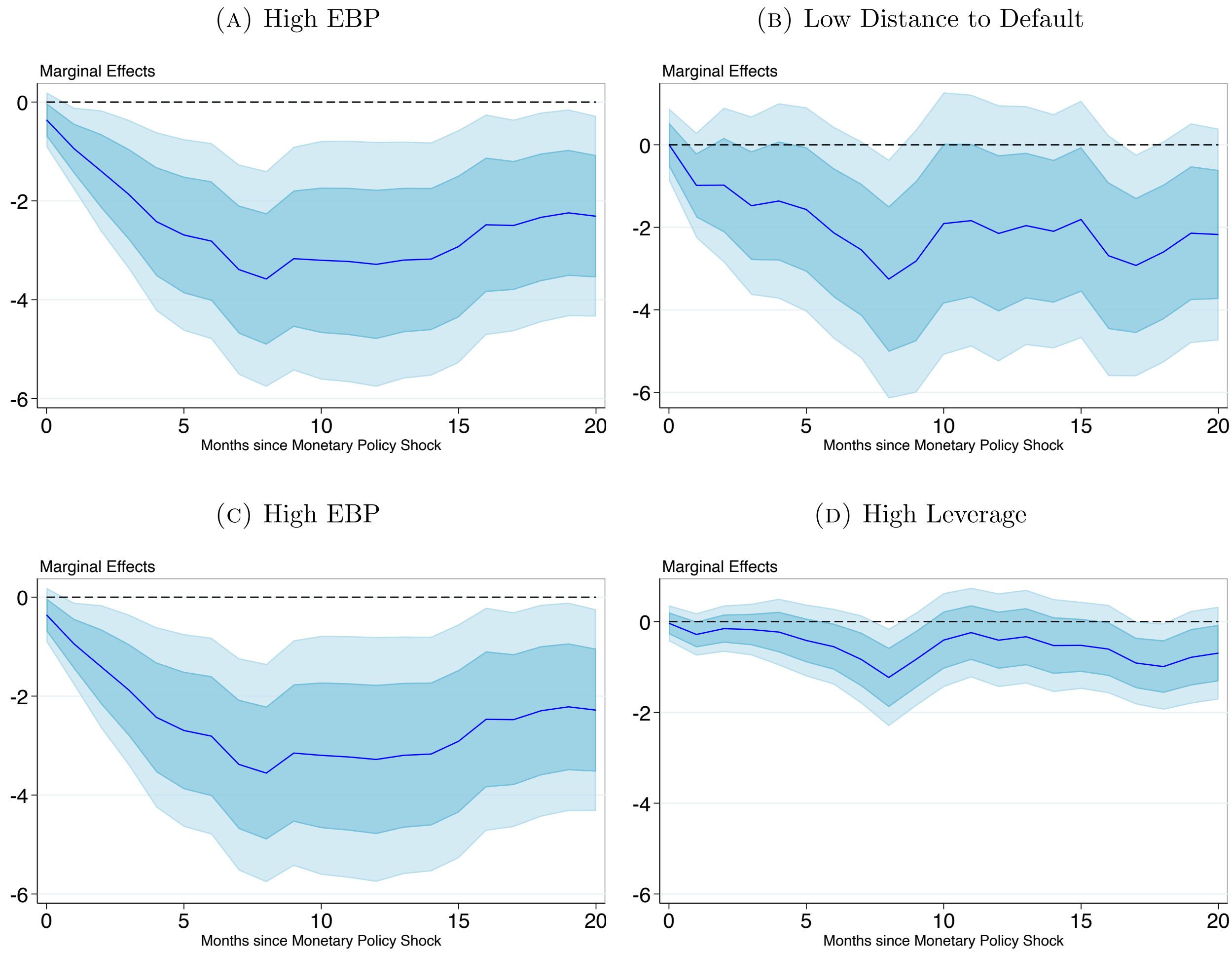
$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\mathrm{EBP}_{ikt-1}^{high} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\mathrm{x}_{it-1}^{low(high)} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.14}$$

where, as before, because we have included the monetary policy shock $\varepsilon_t^m$ on its own, the interaction coefficient associated with $\mathbf{1}\mathrm{EBP}_{ikt-1}^{high}$ ($\beta_2^h$) is interpreted as the credit spread response of high-EBP bonds relative to low-EBP bonds due to a monetary policy shock, controlling for heterogeneity by default risk. An analogous interpretation is associated with $\beta_3^h$. As before, we use $\mathbf{1}\mathrm{x}_{it-1}^{low}$ when $x$ is distance to default and $\mathbf{1}\mathrm{x}_{it-1}^{high}$ when $x$ is leverage, so as to capture the relative effect of high default risk firms relative to low default risk firms. Note also that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{EBP}_{ikt-1}^{high}$ and $\mathbf{1}\mathrm{x}_{it-1}^{low(high)}$.

The results are displayed in Figure B.14 and highlight, as in the main text, that firms' EBPs tends to supersede their default risk in regulating the sensitivity of firms' spreads to monetary policy shocks, and that it is firms whose bonds carry high-EBPs whose spreads are most responsive.

[27] Specifically, we used linear interactions between the one-year moving average of a firm's characteristic (EBP or default risk) and the monetary policy shock, as in Jeenas (2019).

Figure B.14
Monetary Policy's Relative Effect on Spreads by EBP vs. Default Risk




*Note.* Figure B.14 displays dynamic interaction coefficients from a horserace between (A) the relative response of high-EBP bonds' spreads compared to low-EBP bonds' (Panels B.14a and B.14c) and (B) the relative response of high-default-risk firms' spreads compared to low-default-risk firms' (low distance to default in Panel B.14b and high leverage in Panel B.14d) from a monetary policy shock $\varepsilon_t^m$ from estimating regression (B.14). Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

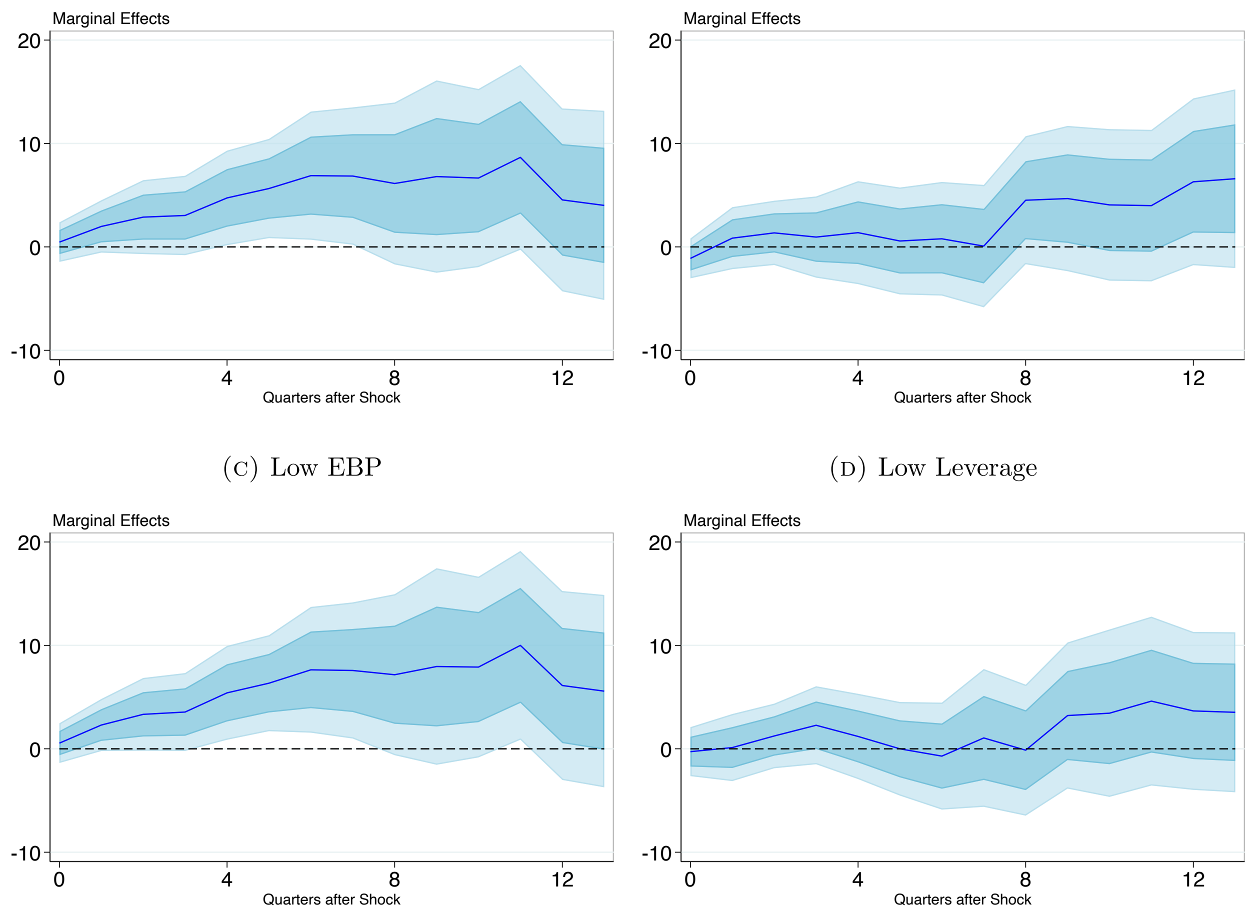
### Monetary Policy on Investment:

Next, we show the same for monetary policy's effect on investment, using the following local projection:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{x}_{it-1}^{high(low)} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.15}$$

FIGURE B.15

Monetary Policy's Relative Effect on Investment by EBP vs. Default Risk




(A) Low EBP

(B) High Distance to Default

(C) Low EBP

(D) Low Leverage

*Note.* Figure B.15 displays dynamic interaction coefficients from a horserace between (A) the relative response of low-EBP firms' investment compared to high-EBP firms' (Panels B.15a and B.15c) and (B) the relative response of low-default-risk firms' investment compared to high-default-risk firms' (high distance to default in Panel B.15b and low leverage in Panel B.15d) from a monetary policy shock $\varepsilon_t^m$ from estimating regression (B.15). Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

where, we include $\mathbf{1}\mathrm{x}_{it-1}^{high}$ when $x$ is distance to default and $\mathbf{1}\mathrm{x}_{it-1}^{low}$ when $x$ is leverage, so as to capture the relative effect of low default risk firms' investment response vs. to high default risk firms, and compare them to the relative response of low-EBP firms' investment, as compared to high-EBP firms'. Again, $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\mathrm{EBP}_{it-1}^{low}$ and $\mathbf{1}\mathrm{x}_{it-1}^{high(low)}$.

The results are displayed in Figure B.15. As in the main text, we see that firms'

EBPs tend to supersede their default risk in regulating the sensitivity of firms' investment to monetary policy shocks, and that it is firms with low-EBPs whose investment is most responsive.

### B.4.2 Credit Rating:

In their appendix, Ottonello and Winberry (2020) assess the conditioning power of firms' default risk as measured by their credit ratings, using the dummy variable approach. Here, we use the dummy variable approach to highlight that heterogeneity by EBP is robust to controlling for heterogeneity by credit rating.

**Monetary Policy on Credit Spreads:**

We begin by running the following local projection:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{ikt-1}^{high} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{Rate}_{it-1}^{low} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.16}$$

where $\mathbf{1}\text{Rate}^{low}$ denotes a dummy variable taking the value of one if the firms' credit rating lies below the median of the cross-sectional credit rating distribution in the period prior to the monetary surprise, that is, the firm is viewed as relatively risky. Note again that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{ikt-1}^{high}$ and $\mathbf{1}\text{Rate}_{it-1}^{low}$.

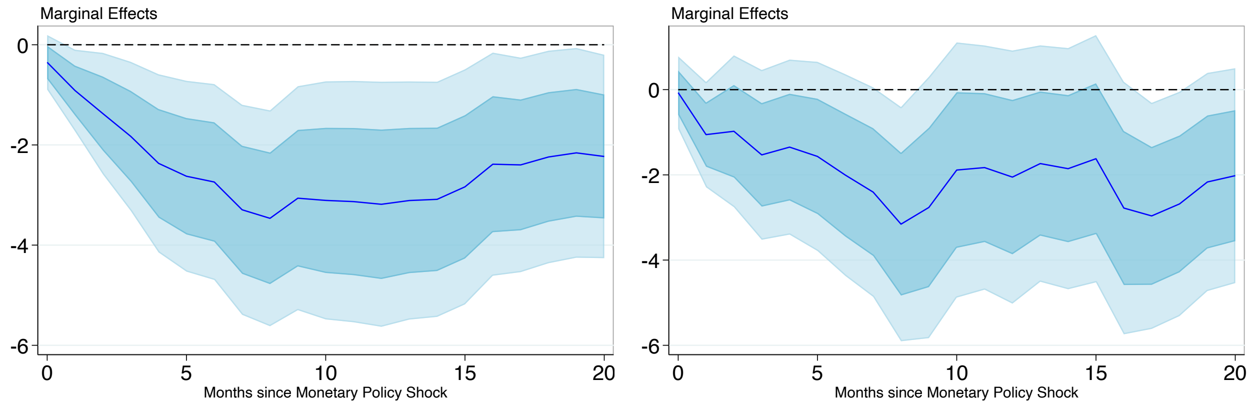
In Figure B.16, we see that while high-risk firms' spreads are more responsive to monetary shocks (Panel B.16b), the EBP continues to be an important determinant of the sensitivity of firms' spreads to monetary policy.[28]

**Monetary Policy on Investment:**

[28] Interestingly, since rating agencies rely on the Merton (1974) model as a primary determinant of the credit rating, the impulse responses for credit rating look similar to those for distance to default in this case.

Figure B.16
Monetary Policy's Relative Effect on Spreads by EBP vs. Credit Rating

(A) High EBP (B) Low Credit Rating




*Note.* Figure B.16 displays dynamic interaction coefficients from a horserace between (A) the relative response of high-EBP bonds' spreads compared to low-EBP bonds' (Panel B.16a) and (B) the relative response of low-credit-rating (risky) firms' spreads compared to high-rating (safe) firms' (Panel B.16b) from a monetary policy shock $\varepsilon_t^m$ from estimating regression (B.16). Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

Next, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h\varepsilon_t^m + \beta_2^h\varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_3^h\varepsilon_t^m \times \mathbf{1}\text{Rate}_{it-1}^{high} + \boldsymbol{\gamma}^h\mathbf{Z}_{it-1} + e_{ith}, \tag{B.17}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$ and $\mathbf{1}\text{Rate}_{it-1}^{high}$.

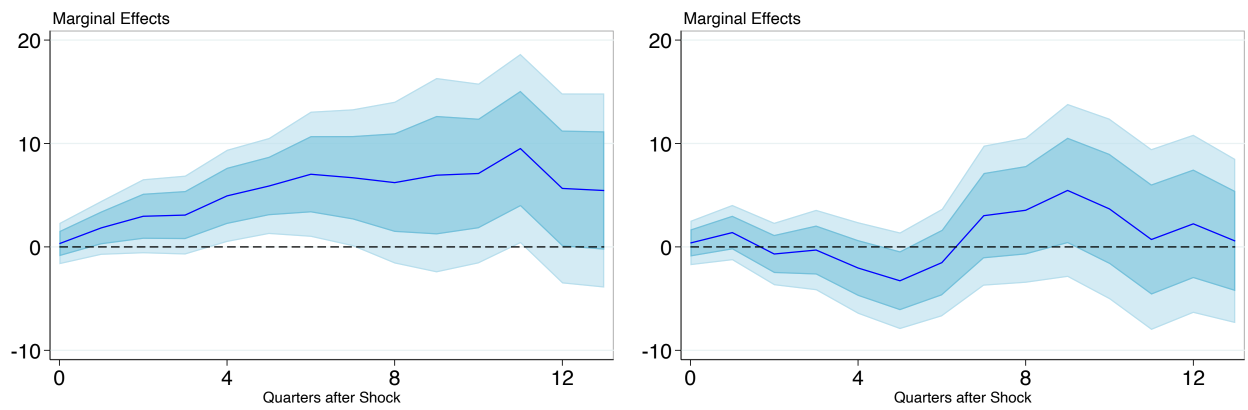
The impulse responses are presented in Figure B.17. We see again that the EBP regulates firms' investment response to monetary policy (Panel B.17a), as in the main text, superseding heterogeneity by credit rating (Panel B.17b).

### B.4.3 Age:

Next, we turn to demonstrate the robustness of our EBP state to firms' age, which Cloyne et al. (2019) show regulates the sensitivity of firms' investment to monetary policy shocks. Like Anderson and Cesa-Bianchi (2021), we use age since IPO, since this variable is available in the Compustat database. Admittedly, this is different from the age since incorporation

FIGURE B.17
Monetary Policy's Relative Effect on Investment by EBP vs. Credit Rating

(A) Low EBP (B) High Credit Rating




*Note.* Figure B.17 displays dynamic interaction coefficients from a horserace between (A) the relative response of low-EBP firms' investment compared to high-EBP firms' (Panel B.17a) and (B) the relative response of high-credit-rating firms' investment compared to low-rating firms' (Panel B.17b) from a monetary policy shock $\varepsilon_t^m$ from estimating regression (B.17). Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

variable used by Cloyne et al. (2019).

**Monetary Policy on Credit Spreads:**

Cloyne et al. (2019) use the dummy variable approach in establishing their empirical findings, and we follow them in our robustness check and run the following horserace regression:

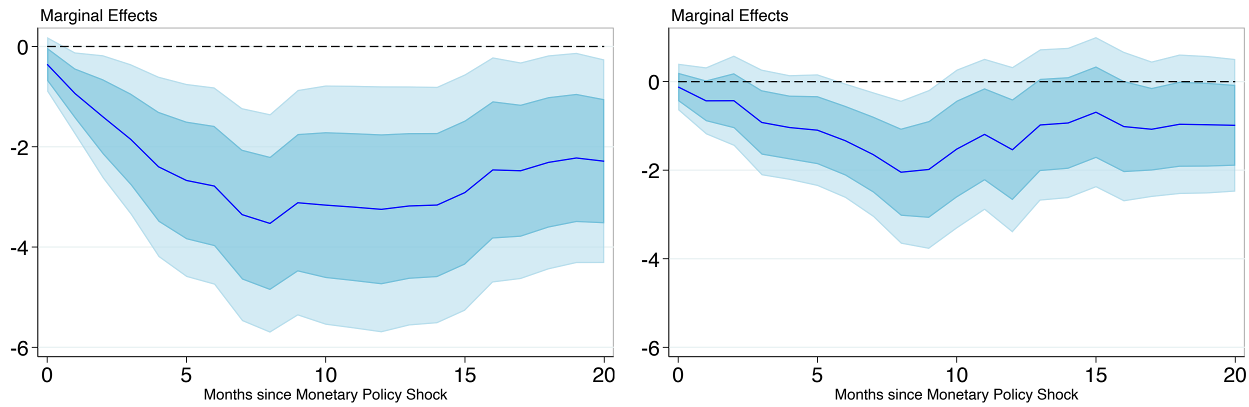
$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{ikt-1}^{high} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{Age}_{it-1}^{low} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.18}$$

where $\mathbf{1}\text{Age}_{it-1}^{low}$ is a dummy variable taking the value of 1 if a firms' age is below the median of firms' age distribution in the period before the monetary surprise, and zero otherwise. Note again that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{ikt-1}^{high}$ and $\mathbf{1}\text{Age}_{it-1}^{low}$.

Consistent with the direction of the heterogeneity in Cloyne et al. (2019), Panel B.18b of Figure B.18 highlights that the spreads of young firms are relatively more responsive to

Figure B.18
Monetary Policy's Relative Effect on Spreads by EBP vs. Age

(A) High EBP (B) Low Age (Young)




*Note.* Figure B.18 displays dynamic interaction coefficients from a horserace between (A) the relative response of high-EBP bonds' spreads compared to low-EBP bonds' (Panel B.18a) and (B) the relative response of low-age (young) firms' spreads compared to high-age (old) firms' (Panel B.18b) from a monetary policy shock $\varepsilon_t^m$ from estimating (B.18). Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

monetary policy shocks. Still, we see that our findings for heterogeneity by EBP from the main text are robust to conditioning on age (Panel B.18a).

**Monetary Policy on Investment:**

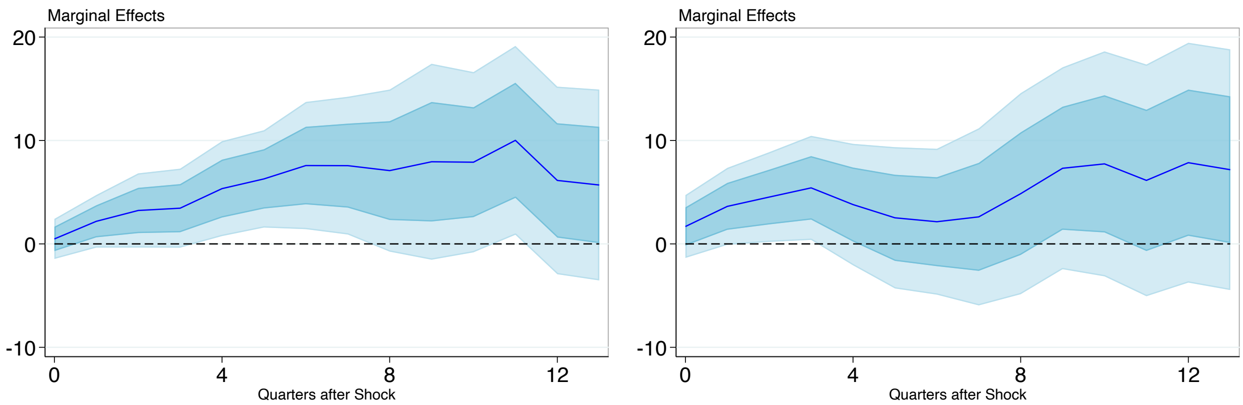
Next, we turn to confirm that the heterogeneous effects of monetary policy on investment by firms' EBPs are robust to controlling for heterogeneity by age. We do so using:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{Age}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.19}$$

where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$ and $\mathbf{1}\text{Age}_{it-1}^{high}$. The results displayed in Figure B.19 highlight that the EBP indeed continues to regulate the responsiveness of firms' investment to monetary policy. Surprisingly, we see in Panel B.19b that it is old firms whose investment response is larger compared to young firms following a monetary shock, in contrast to Cloyne et al. (2019), albeit only marginally. There are a few potential explanations. First, Cloyne et al. (2019) use a different measure of investment

Figure B.19
Monetary Policy's Relative Effect on Investment by EBP vs. Age

(A) Low EBP (B) High Age (Old)




*Note.* Figure B.19 displays dynamic interaction coefficients from a horserace between (A) the relative response of low-EBP firms' investment compared to high-EBP firms' (Panel B.19a) and (B) the relative response of high-age (old) firms' investment compared to low-age (young) firms' (Panel B.19b) from a monetary policy shock $\varepsilon_t^m$ from estimating (B.19). Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

to what is used by Ottonello and Winberry (2020) and in our paper and, in addition, study investment growth rather than the level of investment. Since our model speaks to investment, we prefer our measure. Second, we focus on firms who use bond finance, which tend to be larger and older firms, such that our samples are not identical. Third, Cloyne et al. (2019)'s monetary policy shocks are constructed from a proxy-VAR. Nonetheless, we show that heterogeneity by EBP is robust to controlling for heterogeneity by age.

### B.4.4 Size:

As in Cloyne et al. (2019), Gertler and Gilchrist (1994) employ a dummy variable approach to assess how a firm's size determines its sensitivity to monetary policy shocks. In this section, we measure size in assets and, as a measure of growth in size, we use sales growth, and compare each of their abilities to regulate firms' responses to monetary policy to firms' EBPs.

**Monetary Policy on Credit Spreads:**

We begin with monetary policy's effect on credit spreads:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{ikt-1}^{high} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{Size}_{it-1}^{low} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.20}$$

where $\mathbf{1}\text{Size}^{low}$ is a dummy taking the value of 1 if a firms' assets (sales growth) are below the median in the period before the monetary shock, and 0 otherwise. Note again that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{ikt-1}^{high}$ and $\mathbf{1}\text{Size}_{it-1}^{low}$.

The results are displayed in Figure B.20. We see that while firms' with low assets, that is small firms, have spreads who are more responsive to monetary policy, consistent with the findings in Gertler and Gilchrist (1994), sales growth does not seem to be a key determinant of the sensitivity of spreads. In both cases, heterogeneity by EBP is robust to controlling for the conditioning effects of these measures of (growth in) size.

**Monetary Policy on Investment:**

Next, turning to investment, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_3^h \varepsilon_t^m \times \mathbf{1}\text{Size}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.21}$$

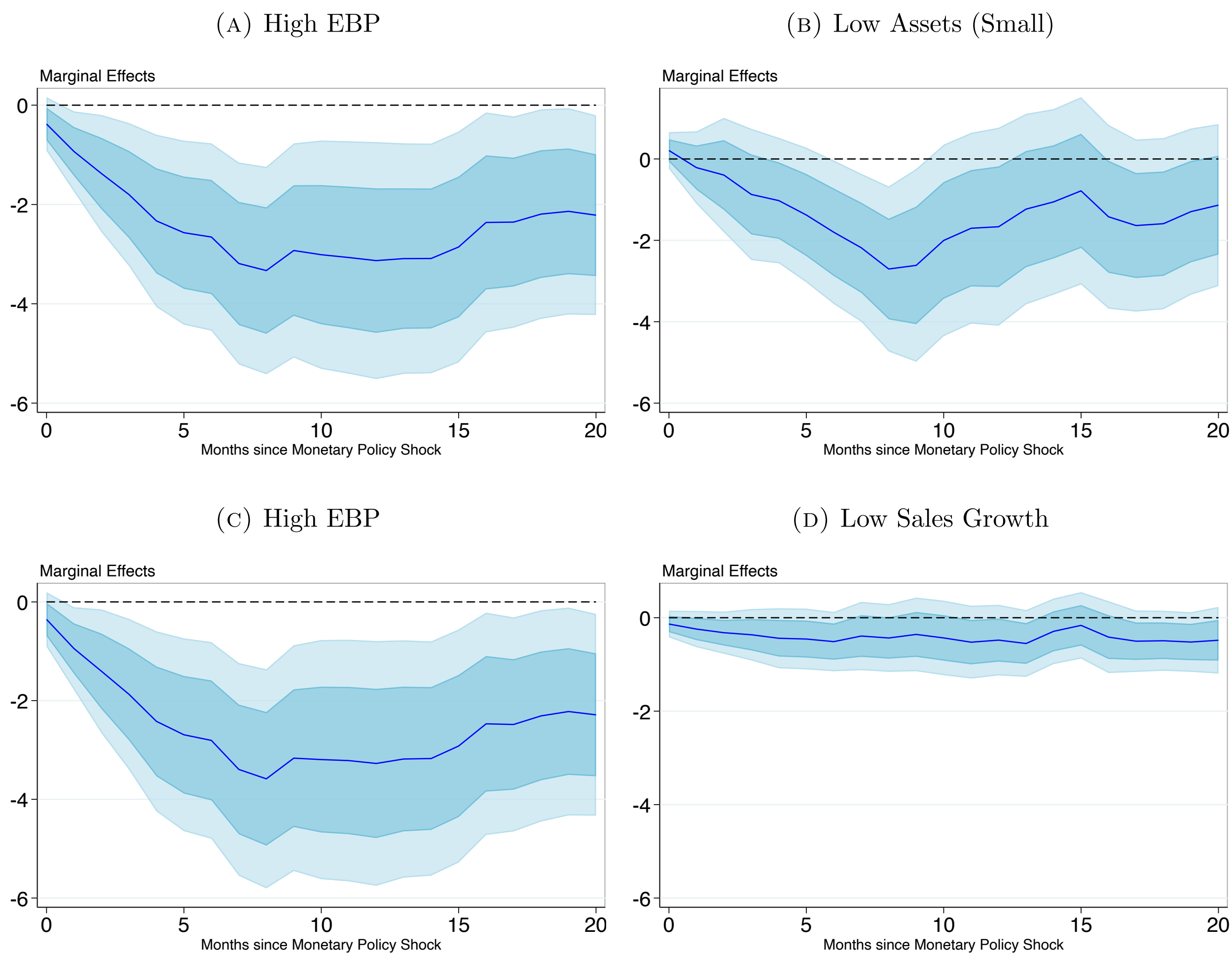
where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\mathbf{1}\text{EBP}_{it-1}^{low}$ and $\mathbf{1}\text{Size}_{it-1}^{high}$.

We display the results in Figure B.21. The point-estimates in Panel B.21b indicate that, consistent with Gertler and Gilchrist (1994), small firms adjust investment more than large firms in response to monetary policy shocks. In addition, firms with high sales growth also adjust investment more following monetary shocks, as seen in Panel B.21d. In both cases, however, the EBP remains significant as a determinant of firms' investment response to monetary policy.

### B.4.5 Liquidity:

Jeenas (2019) documents that the investment response to monetary policy of less liquid

Figure B.20
Monetary Policy's Relative Effect on Spreads by EBP vs. Size



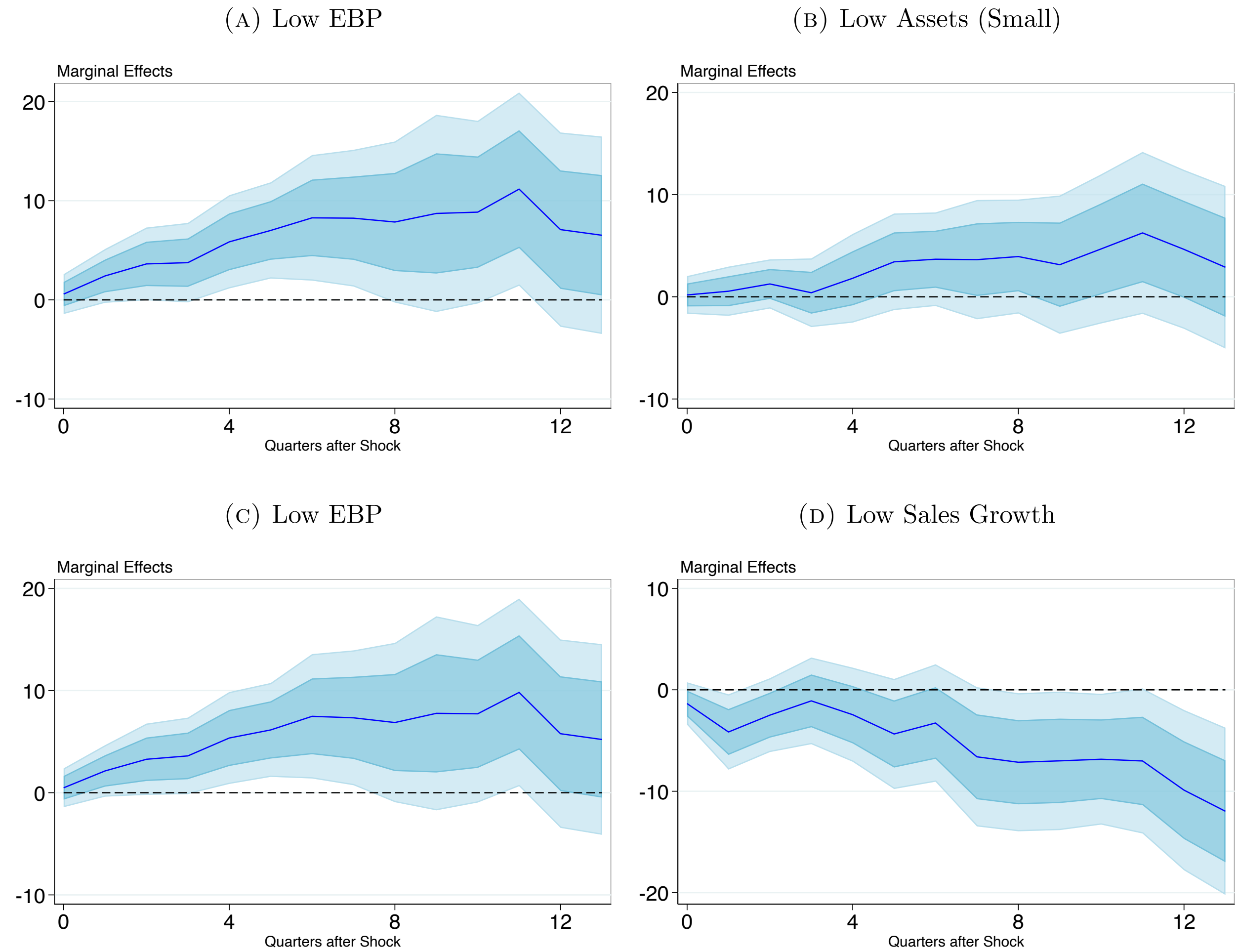

*Note.* Figure B.20 displays dynamic interaction coefficients from a horserace between (A) the relative response of high-EBP bonds' spreads compared to low-EBP bonds' (Panel B.20a) and (B) the relative response of low-asset-size (small) firms' spreads compared to large firms' (Panel B.20b) from a monetary policy shock $\varepsilon_t^m$ from estimating (B.20). Panels B.20c and B.20d do the same but replace small (in assets) firms with low sales growth firms. Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

firms is relatively large, where liquidity is measured as the ratio of cash and short-term investments to total assets. He does so using our functional form from the main text, so we revert back to the conditioning on the average value of a firms' characteristic over the previous year.

**Monetary Policy on Credit Spreads:**

Figure B.21

Monetary Policy's Relative Effect on Investment by EBP vs. Size




*Note.* Figure B.21 displays dynamic interaction coefficients from a horserace between (A) the relative response of low-EBP firms' investment compared to high-EBP firms' (Panel B.21a) and (B) the relative response of low-assets (small) firms' investment compared to large firms' (Panel B.21b) from a monetary policy shock $\varepsilon_t^m$ from estimating (B.21). Panels B.21c and B.21d do the same but replace small (in assets) firms with low sales growth firms. Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

We start by estimating:

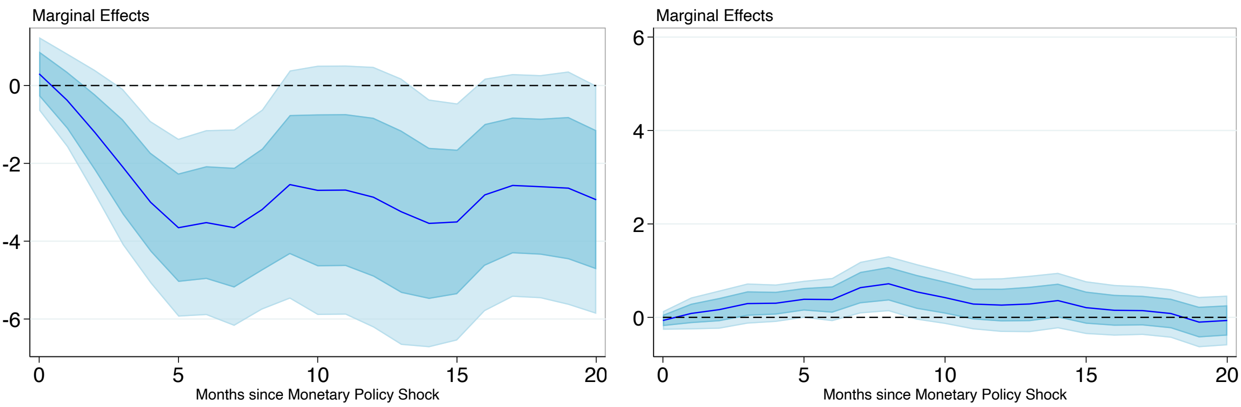
$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^m + \beta_3^h \varepsilon_t^m \times Liq_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.22}$$

where $Liq_{it-1}^{ma}$ refers to the average liquid-asset ratio of firm i over the previous year. Note again that $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\text{EBP}_{ikt-1}^{ma}$ and $\text{Liq}_{it-1}^{ma}$.

Figure B.22

Monetary Policy's Effect on Spreads by EBP vs. Liquidity

(A) EBP (B) Liquidity




*Note.* Figure B.22 displays dynamic interaction coefficients from a horserace between the interaction between a monetary policy shock and (A) the EBP (Panel B.22a) and (B) firms' liquidity (Panel B.22b) on the h-period change in credit spreads, $S_{ikt+h} - S_{ikt-1}$ from estimating (B.22). Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

The results are displayed in Figure B.22. We see that, consistent with the results in Jeenas (2019), less-liquid firms experience a larger reduction in their credit spreads following a monetary easing (Panel B.23b), although the effects are relatively small. By contrast, the heterogeneous effects conditional on firms' EBPs are larger and more significant.

**Monetary Policy on Investment:**

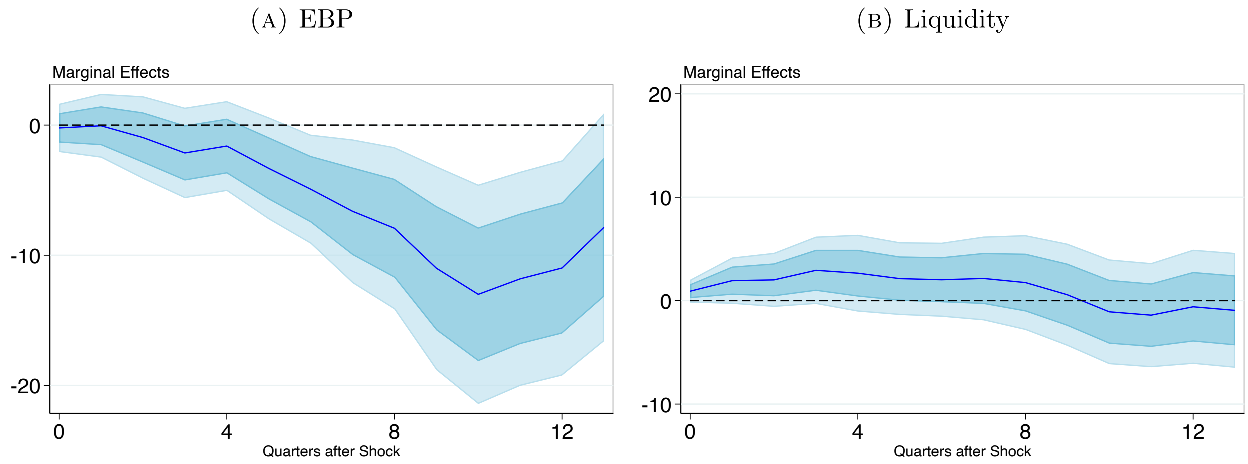
Turning now to investment, we estimate:

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{it-1}^{ma} \times \varepsilon_t^m + \beta_3^h \varepsilon_t^m \times Liq_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \quad \text{(B.23)}$$

The results are displayed in Figure B.23. We see that controlling for liquidity has little impact on on the EBP's ability to regulate firms' investment response to monetary policy. On the other hand, the heterogeneiety by firms' liquid asset share is not statistically significant.

Figure B.23

Monetary Policy's Effect on Investment by EBP vs. Liquidity




*Note.* Figure B.23 displays dynamic interaction coefficients from a horserace between the interaction between a monetary policy shock and (A) the EBP (Panel B.23a) and (B) firms' liquidity (Panel B.23b) on h-period cumulative investment $logK_{it+h} - logK_{it-1}$ from estimating (B.23). Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

### B.4.6 Tobin's average Q:

Tobin's average Q has received comparatively less attention in the recent literature relative to other state variables we have examined in this section. Still, we show that heterogeneity by EBP is robust to controlling for the conditioning effects by Tobin's average Q.

**Monetary Policy on Credit Spreads:**

We begin by augmenting our main specification from the main text with the interaction between the monetary policy shock and Tobin's average Q:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^m + \beta_3^h \varepsilon_t^m \times Q_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.24}$$

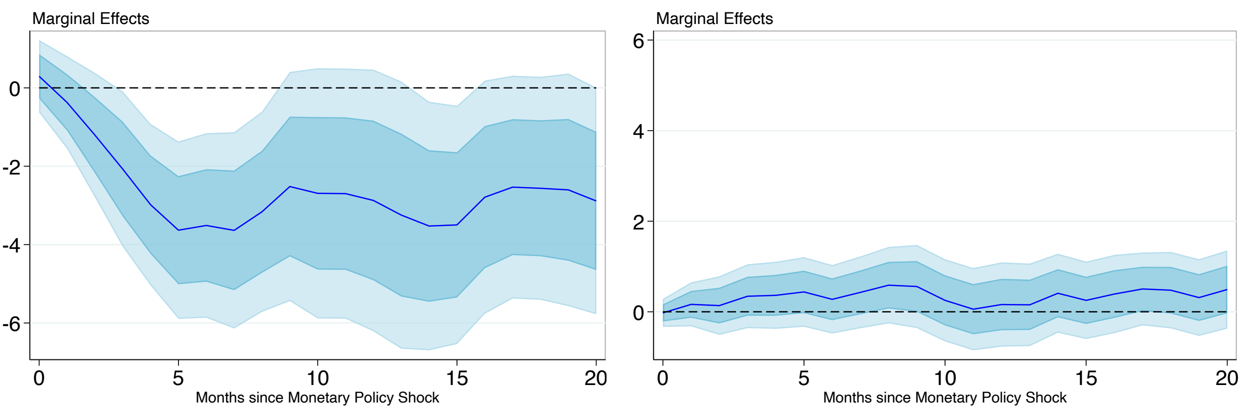
where $Q_{it-1}^{ma}$ refers to the average Q of the firm over the preceding year, as in Jeenas (2019).

The results are displayed in Figure B.24, and highlight that Tobin's Q's impact on the sensitivity of firms' spreads to monetary policy shocks is not statistically significant. Moreover, this variable does not affect the role of the EBP as a state variable for the

Figure B.24

Monetary Policy's Effect on Spreads by EBP vs. Tobin's Average Q

(A) EBP (B) Tobin's Average Q




*Note.* Figure B.24 displays dynamic interaction coefficients from a horserace between the interaction between a monetary policy shock and (A) the EBP (Panel B.24a) and (B) firms' average Tobin's Q (Panel B.24b) on the h-period change in credit spreads, $S_{ikt+h} - S_{ikt-1}$ from estimating (B.24). Frequency is monthly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t.

transmission of monetary policy to firm credit spreads.

**Monetary Policy on Investment:**

Turning now to investment, we estimate:

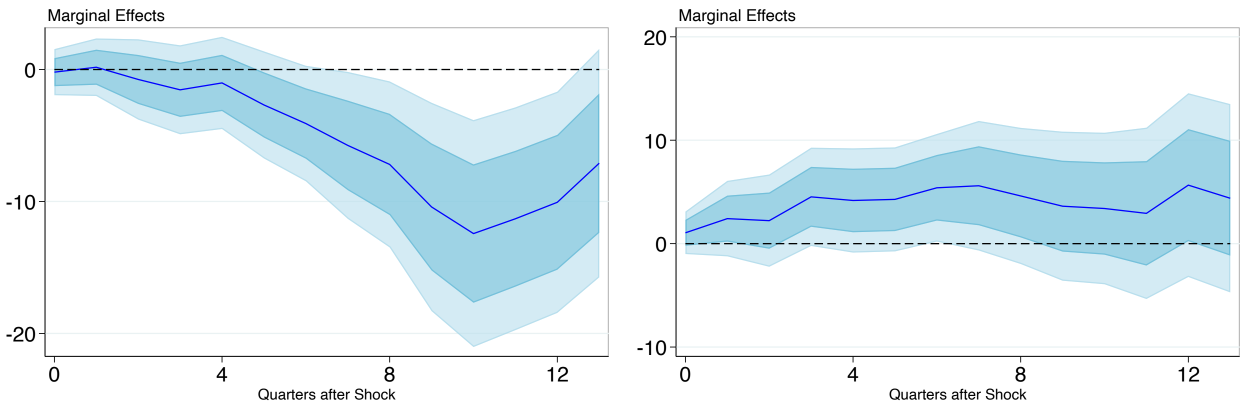
$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m + \beta_2^h EBP_{it-1}^{ma} \times \varepsilon_t^m + \beta_3^h \varepsilon_t^m \times Q_{it-1}^{ma} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \quad \text{(B.25)}$$

The results are displayed in Figure B.25. In Panel B.25b, the positive point-estimates, which are more statistically significant than for the credit spread regression, indicate that the investment of firms with higher Tobin's Qs are more sensitive to monetary policy shocks. Still, heterogeneity by EBP is larger and more significant (Panel B.25a).

FIGURE B.25

Monetary Policy's Effect on Investment by EBP vs. Tobin's Average Q

(A) EBP (B) Tobin's Average Q




*Note.* Figure B.25 displays dynamic interaction coefficients from a horserace between the interaction between a monetary policy shock and (A) the EBP (Panel B.25a) and (B) firms' average Tobin's Q (Panel B.25b) on h-period cumulative investment $logK_{it+h} - logK_{it-1}$ from estimating (B.25). Frequency is quarterly. Inner and outer shaded areas correspond to 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t.

## B.5 Alternative Monetary Policy Shocks

In this subsection, we demonstrate the robustness of our results to the use of alternative monetary policy shocks, namely those of Swanson (2021). Swanson (2021) constructs a series of three distinct types of monetary policy shocks: (i) conventional interest rate shocks; (ii) forward guidance shocks; and (iii) asset purchase shocks. To provide comparability with our baseline Bu et al. (2021) monetary policy shock, which provides a unified measure of both conventional and unconventional U.S. monetary shocks, we sum across the three types of Swanson (2021) shocks. In what follows, we show that, as in the main text, the spreads of high-EBP bonds and investment of low-EBP firms are more responsive to this unified Swanson (2021) monetary policy shock series. Furthermore, the shape of the impulse responses are very similar to those in our baseline specification.

**Monetary Policy on Credit Spreads:**

We begin by assessing the effects of a monetary policy easing on bond-level credit spreads, both unconditionally and conditional on a bond's EBP, by estimating the local projections in equation (4) from the main text using the unified Swanson (2021) monetary policy shock series.

The results are displayed in Figure B.26. They highlight that, as in the main text, a monetary policy easing induces a significant decline in credit spreads for the average firm (Panel B.26a). Moreover, consistent with our baseline results, the decline in credit spreads is larger for firms whose bonds carry a higher ex-ante EBP (Panel B.26b).

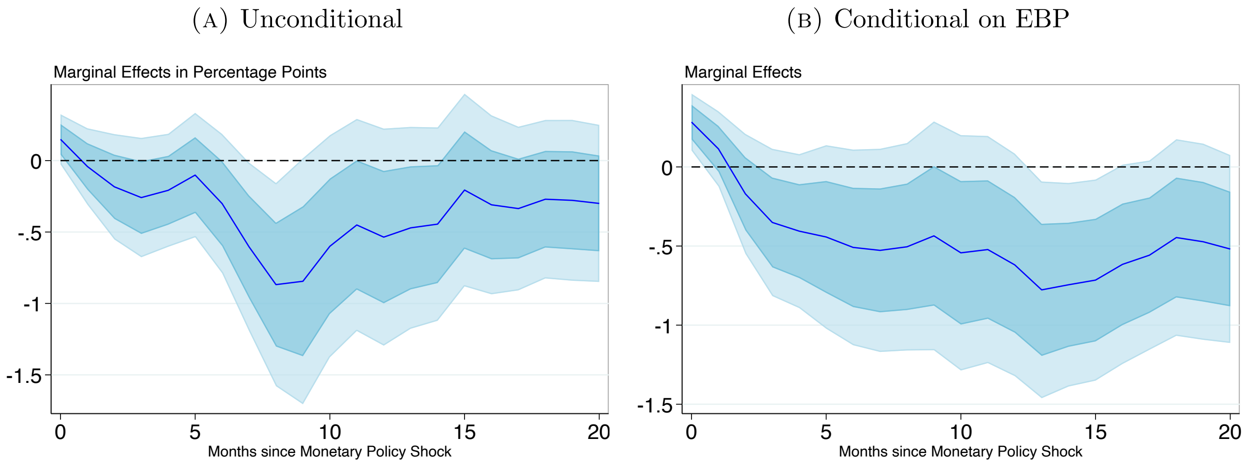
**Monetary Policy on Firm Investment:**

Next, we turn to evaluate the effects of a monetary policy easing on firm-level investment, both unconditionally and conditional on a bond's EBP, by estimating the local projections in equation (6) from the main text using the unified Swanson (2021) monetary policy shock series.

The results are displayed in Figure B.27. As in the main text, we see that a monetary easing induces an increase in investment for the average firm (Panel B.27a ). Furthermore,

FIGURE B.26

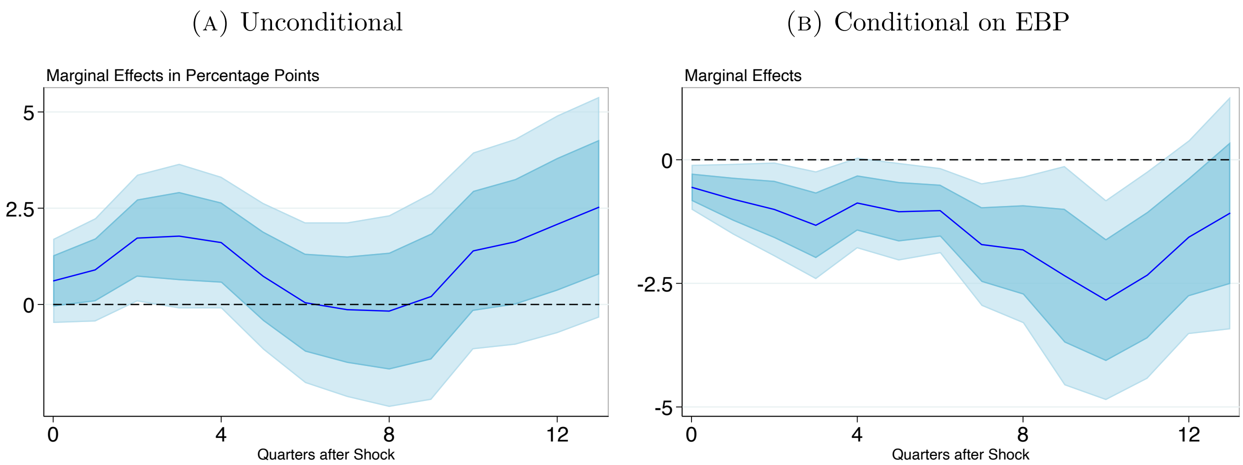
Monetary Policy's Effect on Bond-Level Credit Spreads Depends on EBP




*Note.* Figure B.26 presents the dynamic interaction effects ($\beta_2^h$) between $EBP_{ikt-1}$ and a Swanson (2021) monetary policy shock on the h-period change in credit spreads, $S_{ikt+h} - S_{ikt-1}$ from estimating regression (4) from the main text. The frequency of the data is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

FIGURE B.27

Monetary Policy's Effect on Firm-Level Investment Depends on EBP




*Note.* Figure B.27 presents the dynamic interaction effects ($\beta_2^h$) between $EBP_{it-1}$ and a Swanson (2021) monetary policy shock ($\varepsilon_t^m$) series on h-period cumulative investment , $logK_{it+h} - logK_{it-1}$ from estimating regression (6) from the main text. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

Panel B.27b highlights that this increase is larger for firms with ex-ante lower EBPs, which is consistent with our findings from the main text.

In all, the results from this section showcase that our findings are not tied to the Bu et al. (2021) monetary policy shock series, but hold also for the shocks constructed by Swanson (2021).

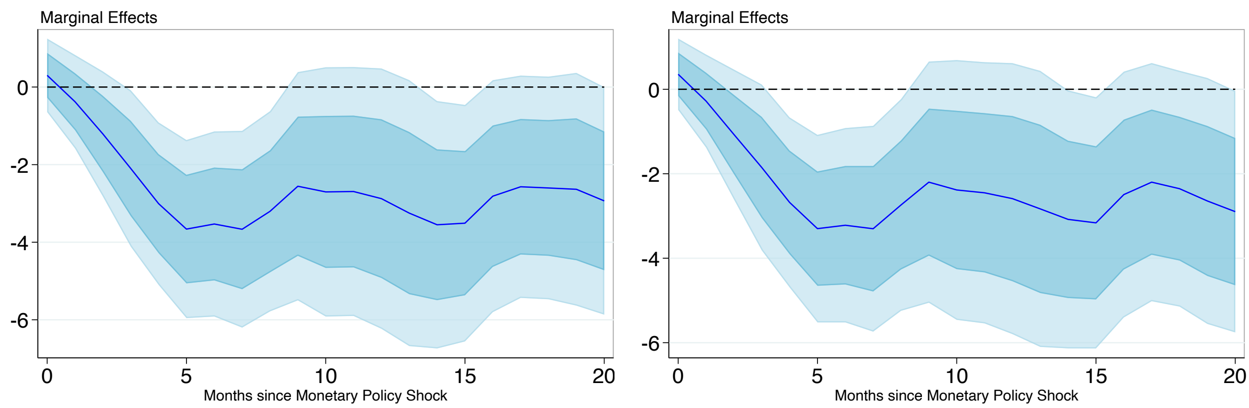
## B.6 EBP purged of Higher-Order Default-Risk

In this section, we demonstrate that our results from the main text are robust to conditioning on firm EBPs that have been purged of potential higher-order dependence on default risk. Specifically, we re-estimate our credit spread regression (1) with the square of firms' distance to default ($DD^2_{it}$) as an additional regressor. Then, following the same steps as in the baseline, we output a new EBP that is purged of its dependence the square of its distance to default. We then re-assess our conclusion from sections 3, 4, and 6 that the EBPs regulate firms' responsiveness to monetary policy using this new EBP measure.

The results are displayed in Figures B.28, B.29 and B.30 for, respectively, the effects of monetary policy on credit spreads, monetary policy on investment, and credit spreads on investment. In all cases, our results are robust to using this new measure of firms' EBP that is purged of the square of firms' distance to default.

FIGURE B.28
Monetary Policy's Effect on Bond-Level Credit Spreads by EBP ex. $DD^2$

(A) Baseline Conditional on EBP    (B) Conditional on EBP ex. $DD^2$

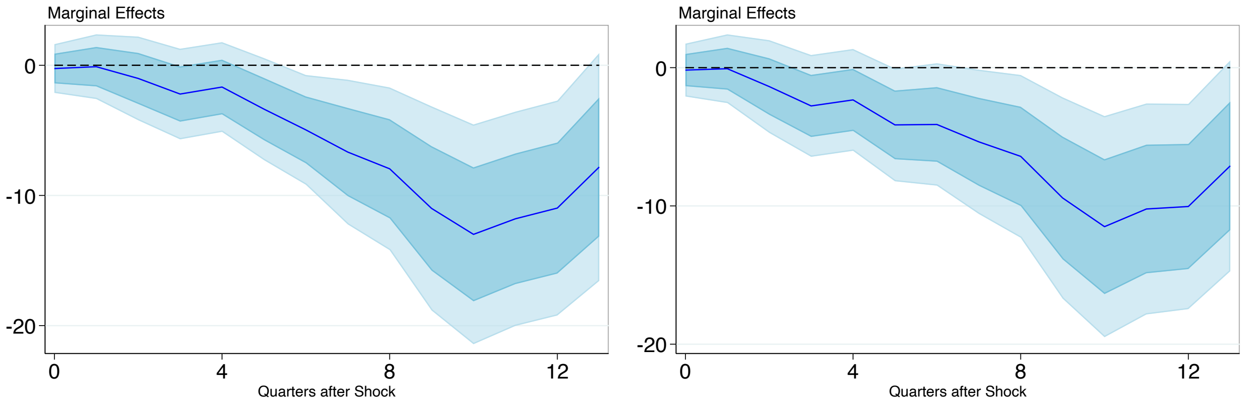



*Note.* Figure B.28 compares the effects of the dynamic interaction ($\beta_2^h$) between $EBP_{ikt-1}$ and the Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$) on the h-period change in credit spreads, $S_{ikt+h} - S_{ikt-1}$, from estimating regression (4) for 2 different EBPs. The first is our baseline EBP (Panel B.28a) and the second is the EBP purged of $DD^2$ (Panel B.28b). The frequency of the data is monthly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and month t, respectively.

FIGURE B.29

Monetary Policy's Effect on Firm-Level Investment by EBP ex. $DD^2$

(A) Baseline Conditional on EBP (B) Conditional on EBP ex. $DD^2$

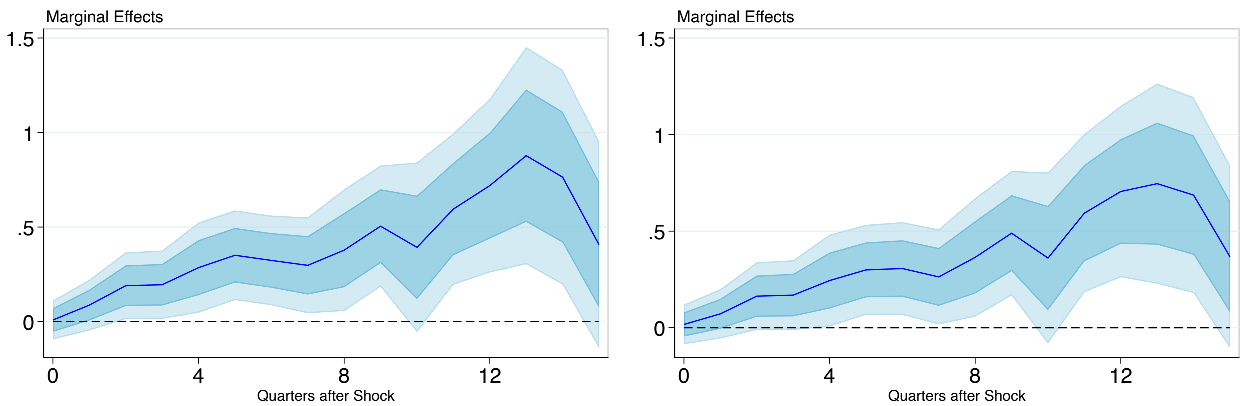



*Note.* Figure B.29 compares the effects of the dynamic interaction ($\beta_2^h$) between $EBP_{ikt-1}$ and the Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$) on the h-quarter cumulative investment of firm i, $\log K_{it+h} - \log K_{it-1}$, from estimating regression (6) for 2 different EBPs. The first is our baseline EBP (Panel B.29a) and the second is the EBP purged of $DD^2$ (Panel B.29b). The frequency of the data is quarterly. Inner and outer shaded areas correspond, respectively, to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and quarter.

FIGURE B.30

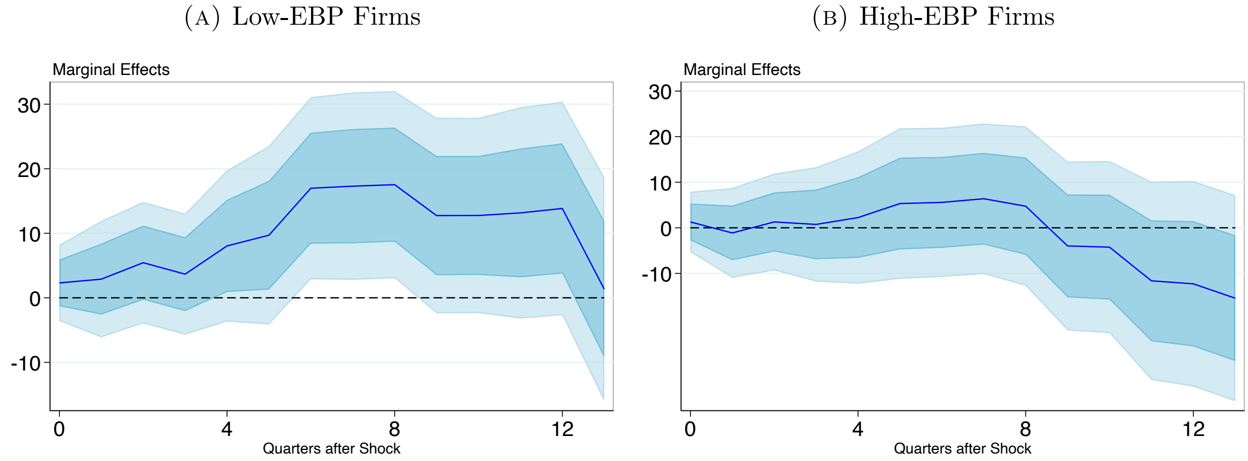
Credit Spread's Effects on Firm Investment by EBP ex. $DD^2$

(A) Baseline Conditional on EBP (B) Conditional on EBP ex. $DD^2$




*Note.* Figure B.30 compares the effects of the dynamic effect ($\beta_2^h$) between $EBP_{ikt-1}$ and a change in credit spreads $\Delta S_{it}$ on h-period Investment of firm i, $\log K_{it+h} - \log K_{it-1}$, from estimating regression (10) for 2 different EBPs. The first is our baseline EBP (Panel B.30a) and the second is the EBP purged of $DD^2$ (Panel B.30b). The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

FIGURE B.31
Monetary Policy's Effect on Firm Debt Issuance for Low- vs High-EBP Firms




*Note.* Figure B.31 traces the response of debt issuance growth for low-EBP ($\mathbf{1}\text{EBP}^{low}$) firms in Panel B.31a and high-EBP ($\mathbf{1}\text{EBP}^{high}$) firms in Panel B.31b to a Bu et al. (2021) monetary policy shock ($\varepsilon_t^m$), from estimating regression (B.26), where the frequency is quarterly. The frequency of the data is quarterly. The inner and outer shaded areas correspond to the 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm i and quarter t, respectively.

## B.7 Monetary Policy's Effect on Firm-Level Debt Issuance

In this section, we highlight that just as how investment increases by more for low-EBP firms following a shock monetary policy easing than for high-EBP firms, low-EBP firms increase debt-issuance compared to high-EBP ones following a monetary easing. We demonstrate this using the dummy-variable conditioning method outlined in Section B.2. Results are similar with our baseline linear functional form for the EBP interaction, but are more noisy.

As in our investment specification, to assess the distinct responses of low- and high-EBP firms' growth in debt issuance following a monetary shock, we estimate:

$$\log\left(\frac{D_{it+h}}{D_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{low} + \beta_2^h \varepsilon_t^m \times \mathbf{1}\text{EBP}_{it-1}^{high} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.26}$$

where $D_{i,t}$ is firm $i$'s real outstanding debt (short- plus long-term) in period $t$ and where $\mathbf{Z}_{it-1}$ includes the controls from the main text, plus $\text{EBP}_{it-1}^{low}$ and $\text{EBP}_{it-1}^{high}$. The results are displayed in Figure B.31 and highlight that only low-EBP firms increase debt following a monetary easing, which is consistent with our investment results.

## B.8 Intermediary Net Worth Shocks and EBP Heterogeneity

In this section, we study how shocks to the net worth of financial intermediaries influence firms' credit spreads and investment conditional on their EBPs. We measure these shocks using the intermediary capital risk factor of He et al. (2017).

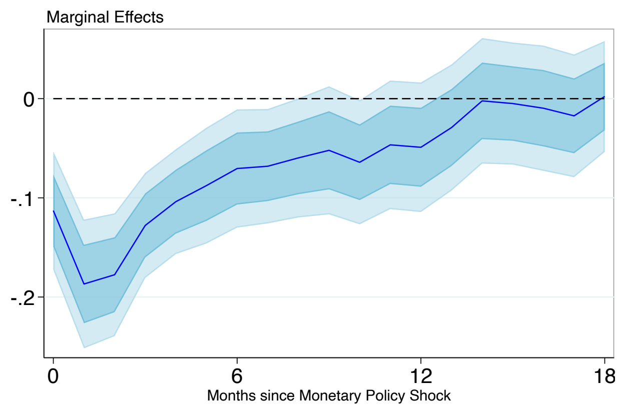
We first assess the effect on credit spreads by replacing the monetary policy shock $\varepsilon_t^m$ in our baseline monetary policy specification (4) with the net-worth shock $\varepsilon_t^{NW}$:

$$S_{ikt+h} - S_{ikt-1} = \beta_k^h + \beta_1^h \varepsilon_t^{NW} + \beta_2^h EBP_{ikt-1}^{ma} \times \varepsilon_t^{NW} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ikth}, \tag{B.27}$$

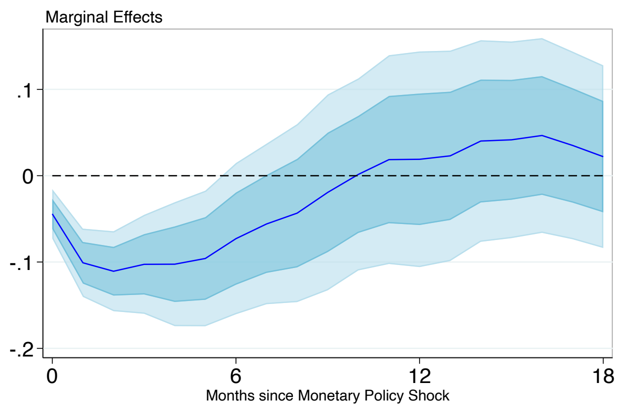
The unconditional (Panel B.32a) and conditional (Panel B.33b) results are displayed in Figure B.32. They highlight that a shock increase in intermediary net worth lowers firms' credit spreads, and that this decrease is larger for firms with higher EBPs. Thus, the effects of intermediary net-worth shocks are qualitatively similar to the effects of monetary policy shocks.

FIGURE B.32
Intermediary Net Worth Shocks on Credit Spreads by EBP

(A) Unconditional




(B) Conditional on EBP

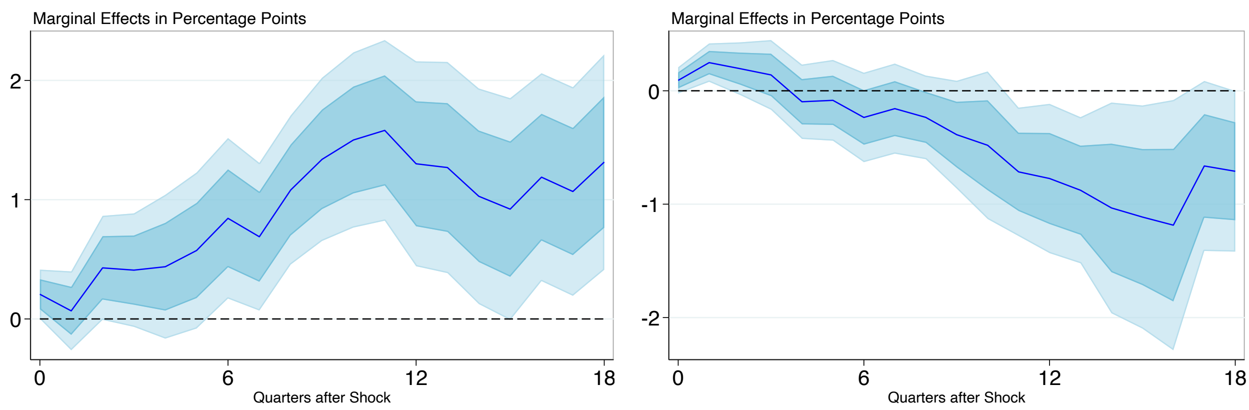



*Note.* Figure B.32 reports the dynamic effects of an intermediary net worth shock $\varepsilon_t^{NW}$ on the h-month change in bond credit spreads, $S_{ikt+h} - S_{ikt-1}$, which we estimate using regression (B.27). Panel B.32a shows the unconditional effects, $\beta_1^h$. Panel B.33b shows the effects conditional on $EBP_{ik,t-1}^{ma}$, $\beta_2^h$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and month.

Next, we perform a similar exercise by using the intermediary net worth shock in our

FIGURE B.33
Intermediary Net Worth Shocks on Investment by EBP

(A) Unconditional (B) Conditional on EBP




*Note.* Figure B.33 reports the dynamic effects of an intermediary net worth shock $\varepsilon_t^{NW}$ on the h-quarter cumulative investment of firm i, $\log(K_{it+h}/K_{it-1})$, which we estimate using regression (B.28). Panel B.33a shows the unconditional effects, $\beta_1^h$. Panel B.33b shows the effects conditional on $EBP_{ik,t-1}^{ma}$, $\beta_2^h$. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using two-way clustered standard errors by firm and quarter.

baseline investment specification (6):

$$\log\left(\frac{K_{it+h}}{K_{it-1}}\right) = \beta_i^h + \beta_1^h \varepsilon_t^{NW} + \beta_2^h EBP_{it-1}^{ma} \times \varepsilon_t^{NW} + \boldsymbol{\gamma}^h \mathbf{Z}_{it-1} + e_{ith}, \tag{B.28}$$

The results are displayed in Figure B.33 and highlight that a shock increase in intermediary net worth leads to an increase in firms' investment (Panel B.33a) which is larger for firms with lower EBPs (Panel B.33b). Again, this consistent with our baseline monetary policy results. Overall, this exercise reinforces the notion that firm EBPs reflect the slope of firms' marginal benefit curves for capital and are an important state variable for understanding firms' responsiveness to shifts in their marginal cost curves.

## B.9 Aggregate Implications of EBP Heterogeneity

In this section, we highlight the robustness of our conclusions from Section 6.2, where we showed that variation in the cross-sectional distribution of firm EBPs has important implications for the aggregate effectiveness of monetary policy. Specifically, we document that our results are robust to: (i) measuring moments of the EBP distribution using different percentiles; (ii) conditioning directly on the percentiles of the EBP distribution; (iii) using the unified Swanson (2021) monetary policy shocks; (iv) a horserace between monetary policy's interaction with the moments of the EBP distribution and its interaction with various recession indicators.

First, we show that our results from Section 6.2 are not tied to the particular percentiles we use to construct the moments of the EBP distribution, the $10^{th}$ and $90^{th}$ percentiles. To demonstrate this, we re-estimate regression (11) by constructing our moments using, respectively, the $5^{th}$ and $95^{th}$ percentiles, the $15^{th}$ and $85^{th}$ percentiles, the $20^{th}$ and $80^{th}$ percentiles, and the $25^{th}$ and $75^{th}$ percentiles of the EBP distribution. Figure B.34 presents the results, focusing on the skewness of the EBP distribution. In all cases, we see that an increase in skewness dampens the impact of a monetary easing on aggregate investment, consistent with our conclusions from the main text.

Second, rather than conditioning on the moments of the EBP distribution, we condition on the percentiles used to construct these moments, in particular, the $10^{\text{th}}$, $50^{\text{th}}$ (median), and $90^{\text{th}}$ percentiles. . The results are displayed in Figure B.35 and highlight that on-impact a rise in median EBP and a fall in the $90^{th}$ percentile of the EBP distribution dampens the effect of monetary policy on aggregate investment. Further, only the left-tail of the EBP distribution matters at medium horizons, where an increase meaningfully dampens the effects of expansionary monetary policy shocks on aggregate investment. This suggests that the $10^{th}$ percentile of the EBP distribution is responsible for the conditioning effects of the EBP distribution's skewness and dispersion from our baseline specification.

Third, we re-estimate our baseline specification using the unified Swanson (2021) monetary policy shocks discussed in Appendix B.5. The impulse responses displayed in Figure B.36 are qualitatively similar to those from the main text.

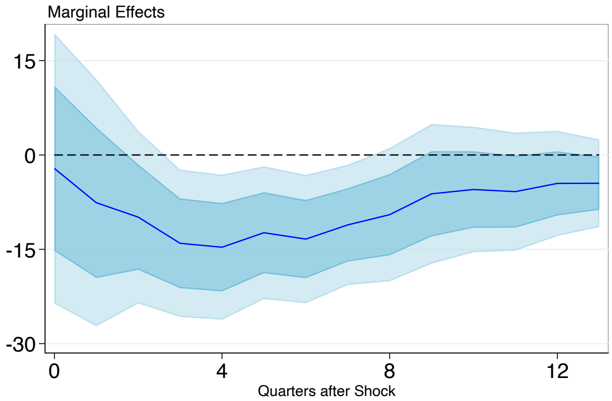
Finally, we examine the extent to which the EBP distributions's impact on the aggregate effectiveness of monetary policy is related to the well-documented weaker effects of monetary policy in recessions. We do so by running horseraces between our moment interactions and interactions between the monetary policy shocks and two types of (lagged) recession indicators: (i) the smoothed U.S. recession probability measure from Chauvet (1998); (ii) a dummy variable for NBER-classified U.S. recessions. In particular, the Chauvet (1998) measure very closely tracks the recession measure used in Tenreyro and Thwaites (2016). The results are displayed in Figures B.37 and B.38.

There are three key takeaways. First, an increase in the probability of a U.S. recession or the incidence of a recession severely dampens the expansionary power of an easing U.S. monetary policy shock, consistent with the existing evidence. Second, the inclusion of these interactions does not distort the conditioning power of the skewness of the EBP distribution, nor the dispersion, highlighting the generality of the relationship between the slope of firms' marginal benefit curves and the aggregate effectiveness of monetary policy. Third, the conditioning effects of the median of the EBP distribution are crowded out by the recession indicators. This is consistent with Gilchrist and Zakrajšek (2012)'s result that aggregate EBP rises in recessions and suggests a potential new transmission channel for monetary policy's weaker effects in recessions: the steeper slopes of firms' marginal benefit curves around equilibrium.

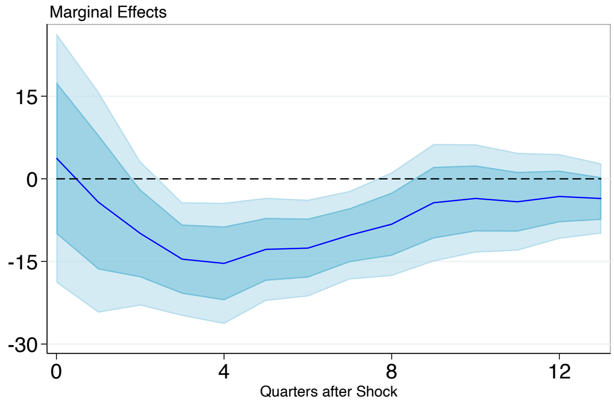
FIGURE B.34

EBP Skewness and Monetary Policy's Effect on Aggregate Investment

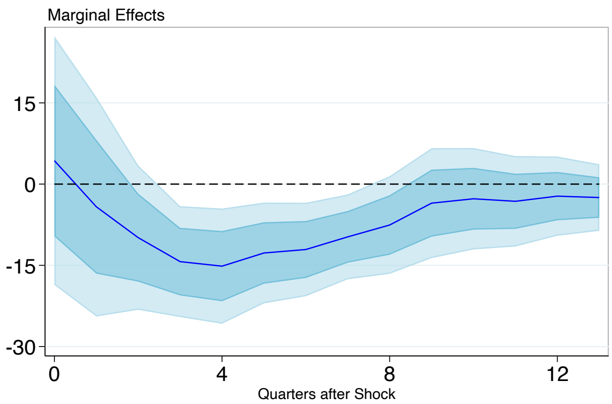
(A) Conditional on 95-05 EBP Skewness



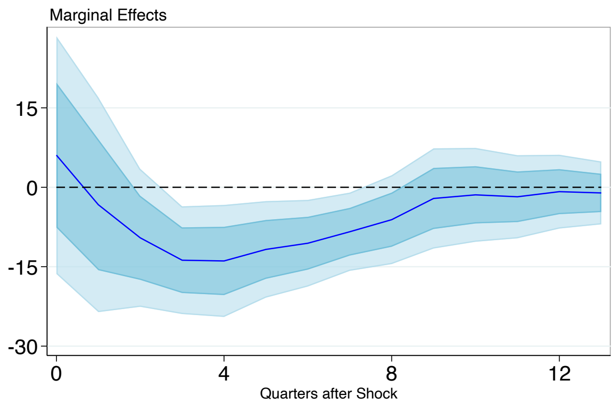

(B) Conditional on 85-15 EBP Skewness




(C) Conditional on 80-20 EBP Skewness




(D) Conditional on 75-25 EBP Skewness

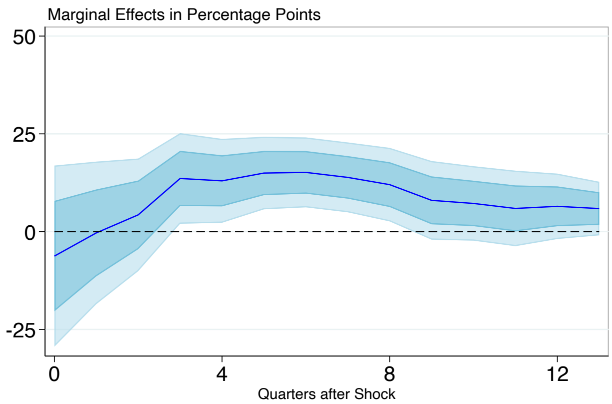



*Note.* Figure B.34 reports the dynamic effects from monetary policy shocks, conditional on the skewness of the EBP distribution ($\beta_2^h$),on the h-quarter cumulative aggregate investment, $400/(h+1)\log(I_{t+h}/I_{t-1})$, estimated using regressions (11). Panel B.34a, B.34b, B.34c, and B.34d measure skewness using the 95-05, 85-15, 80-20 and 75-25 percentiles of the EBP distribution, respectively. Inner and outer shaded areas correspond, respectively, to the 68% and 90% confidence intervals constructed using Newey-West standard errors with 12 lags.

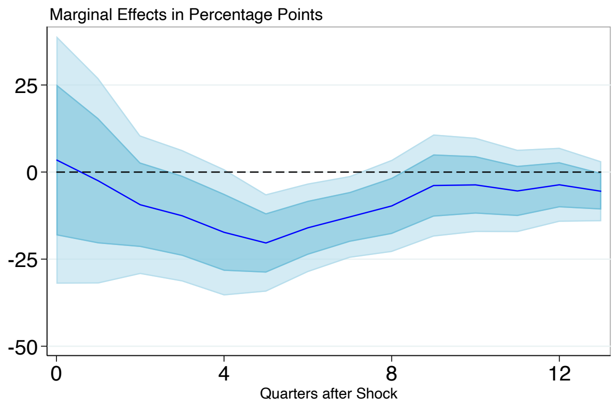
Figure B.35

EBP Percentiles and Monetary Policy's Effect on Aggregate Investment

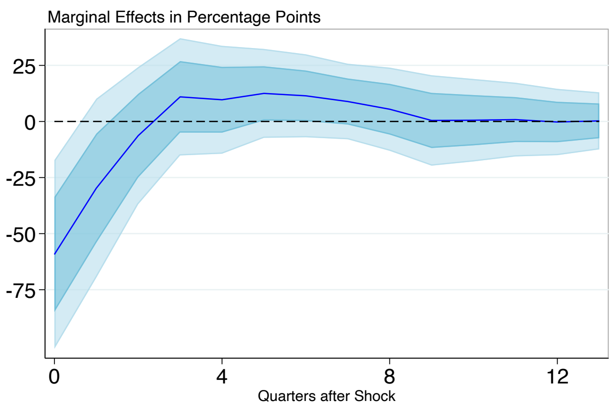
(a) Unconditional



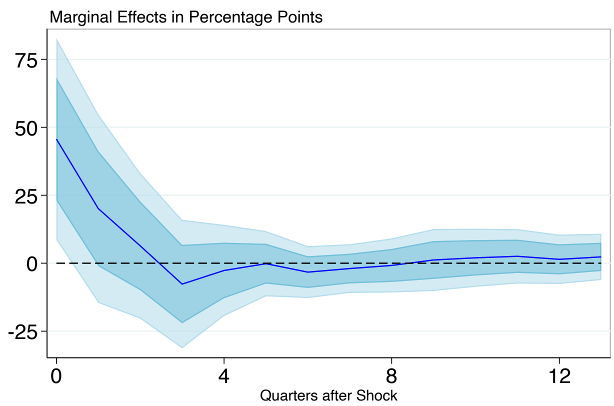

(b) Conditional on $10^{th}$ Percentile EBP




(c) Conditional on Median EBP

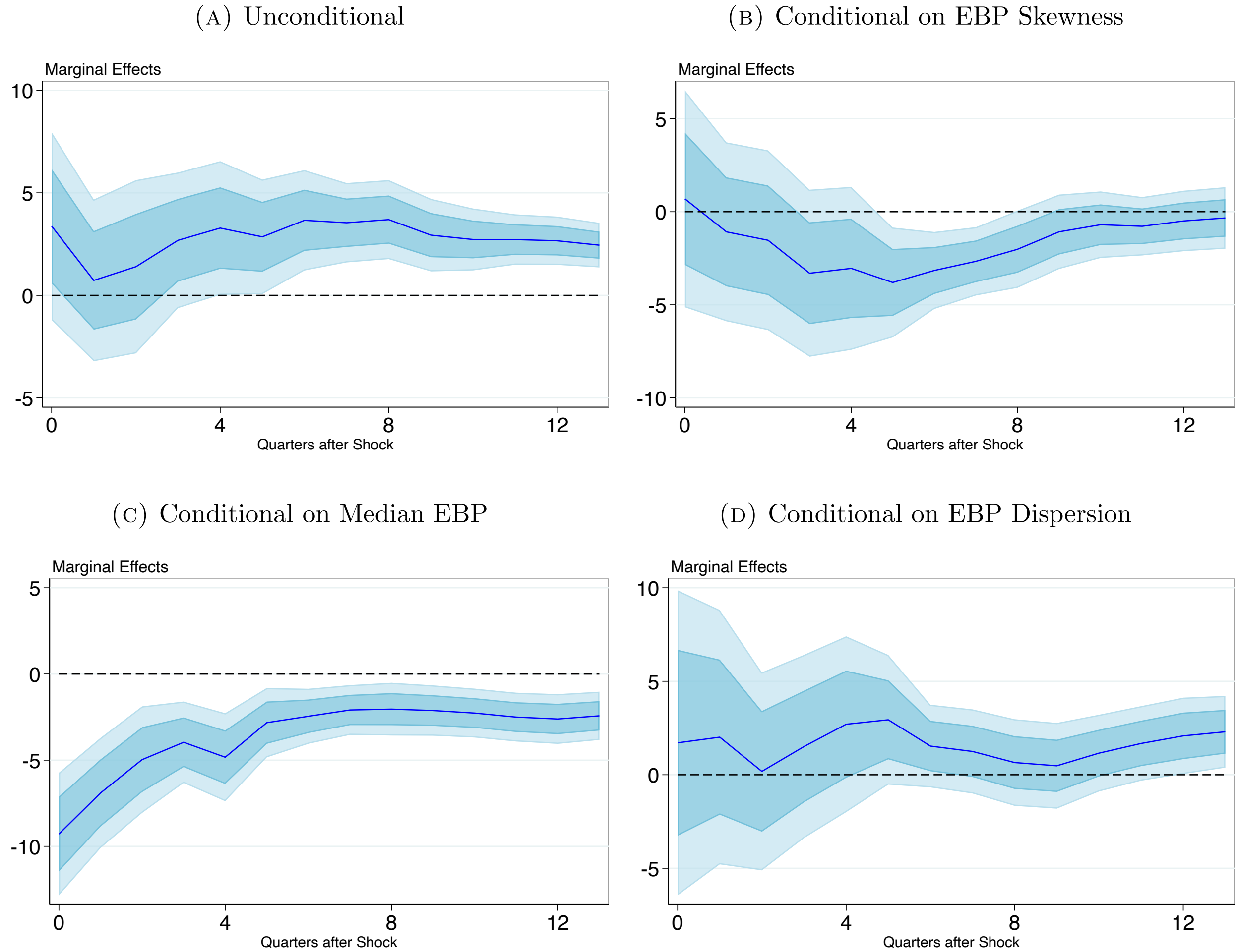



(d) Conditional on $90^{th}$ Percentile EBP




*Note.* Figure B.35 reports the dynamic effects from monetary policy shocks on h-quarter cumulative aggregate investment, $400/(h+1)\log(I_{t+h}/I_{t-1})$, estimated using a variant of regression (11). Panel B.35a shows unconditional effects ($\beta_1^h$). Panels B.35b, B.35c and B.35d shows effects conditional on the 10, 50 and 90th percentiles of the EBP distribution, respectively. Inner and outer shaded areas correspond, respectively, to the 68% and 90% confidence intervals constructed using Newey-West standard errors.

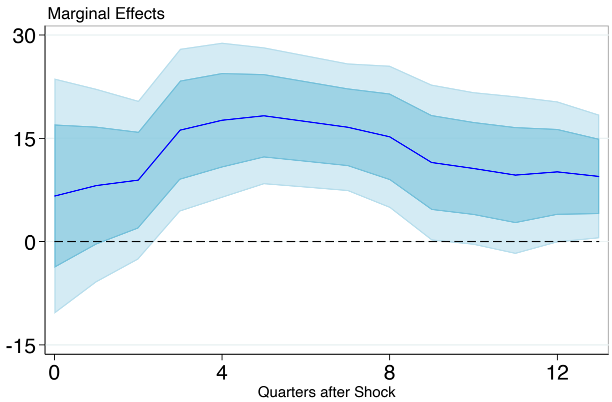
Figure B.36
Monetary Policy's Effect on Aggregate Investment Growth



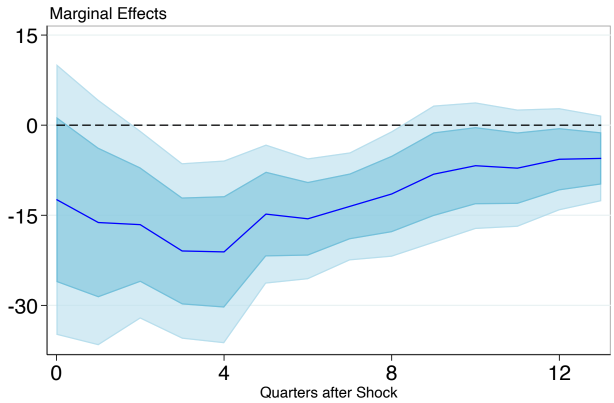

*Note.* Figure B.36 reports the dynamic effects of a Swanson (2021) monetary policy shock $\varepsilon_t^m$ on h-quarter annualized aggregate investment growth, $400/(h+1)\log(I_{t+h}/I_{t-1})$, which we estimate using regression (11). Panel B.36a shows unconditional effects, $\beta_1^h$. Panels B.36b, B.36c and B.36d show the effects conditional on the skewness, median and dispersion of the EBP distribution, the three elements in $\boldsymbol{\beta}_2^h$, respectively. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using Newey-West standard errors with 12 lags.

Figure B.37
Monetary Policy's Effect on Aggregate Investment Growth

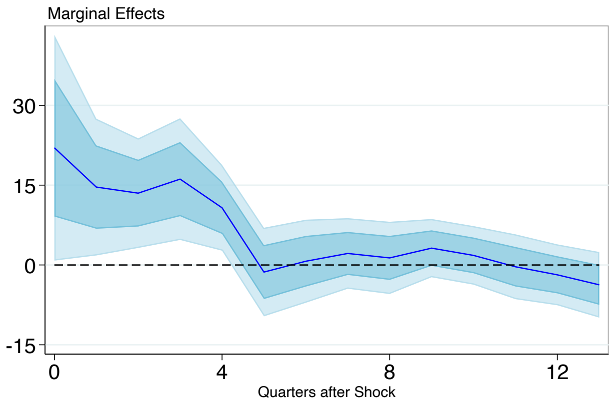
(a) Unconditional



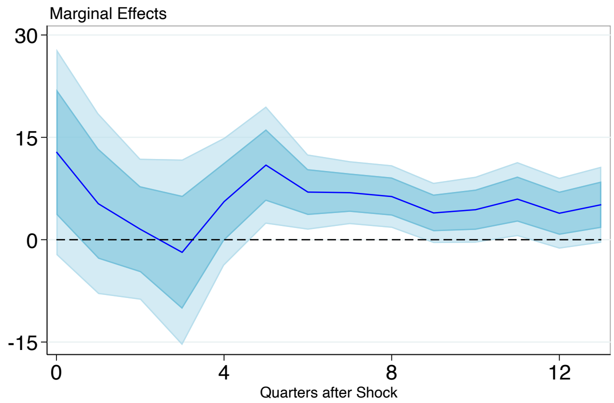

(b) Conditional on EBP Skewness



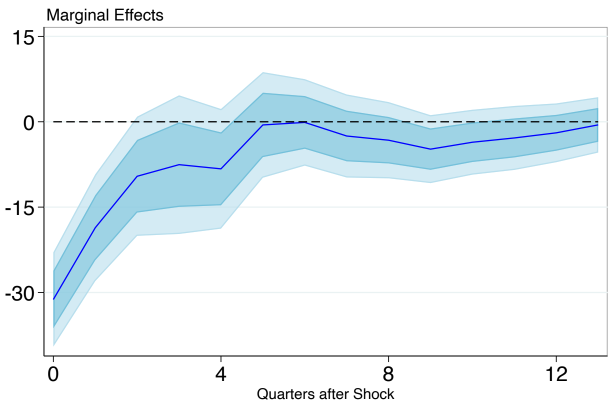

(c) Conditional on Median EBP




(d) Conditional on EBP Dispersion



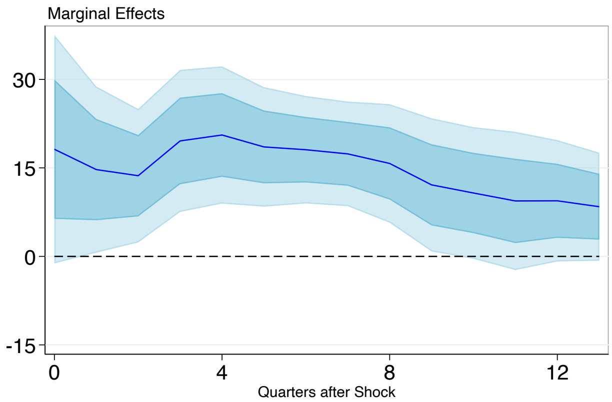

(e) Conditional on Recession Probability



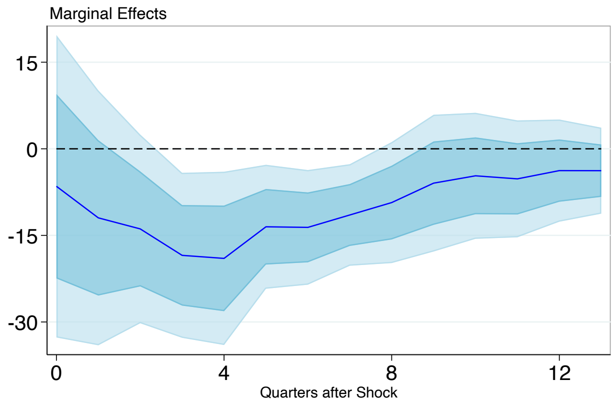

*Note.* Figure B.37 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on h-quarter annualized aggregate investment growth, $400/(h+1)\log(I_{t+h}/I_{t-1})$, which we estimate using regression (11). Panel B.37a shows unconditional effects, $\beta_1^h$. Panels B.37b, B.37c and B.37d show the effects conditional on the skewness, median and dispersion of the EBP distribution, the three elements in $\boldsymbol{\beta}_2^h$, respectively. Panel B.37e shows the effects conditional on the probability of a recession. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using Newey-West standard errors with 12 lags.

FIGURE B.38
Monetary Policy's Effect on Aggregate Investment Growth

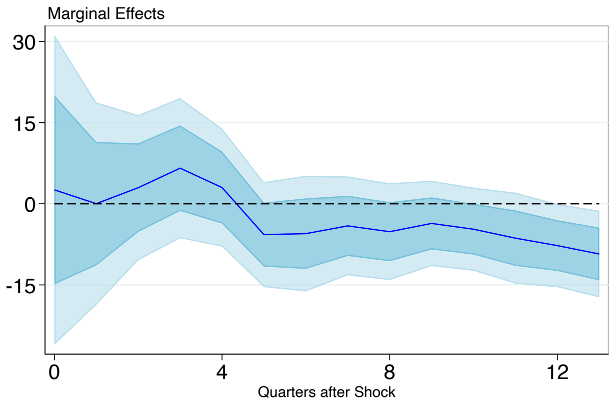
(A) Unconditional



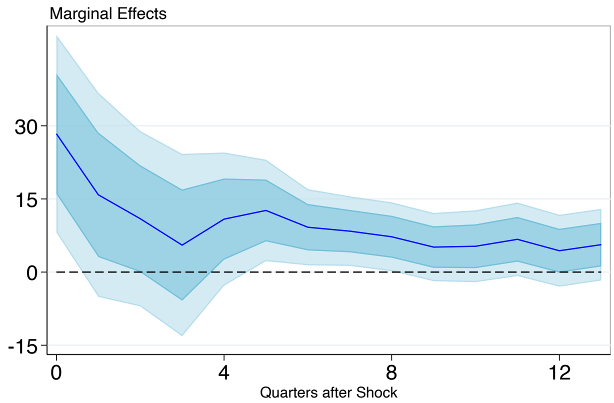

(B) Conditional on EBP Skewness



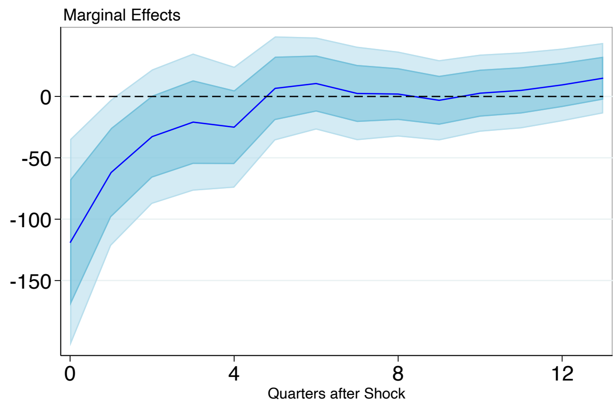

(C) Conditional on Median EBP




(D) Conditional on EBP Dispersion




(E) Conditional on NBER Recession




*Note.* Figure B.38 reports the dynamic effects of a monetary policy shock $\varepsilon_t^m$ on h-quarter annualized aggregate investment growth, $400/(h+1)\log(I_{t+h}/I_{t-1})$, which we estimate using regression (11). Panel B.38a shows unconditional effects, $\beta_1^h$. Panels B.38b, B.38c and B.38d show the effects conditional on the skewness, median and dispersion of the EBP distribution, the three elements in $\boldsymbol{\beta}_2^h$, respectively. Panel B.38e shows the effects conditional on an NBER-classified recession. Inner and outer shaded areas are, respectively, 68% and 90% confidence intervals constructed using Newey-West standard errors with 12 lags.

# C Model Appendix

In this section, we discuss several topics related to our model. In particular, we present the model's parameterization (Section C.1); provide details on the relationship between a firm's EBP and the slope of its marginal benefit curve (Section C.2); and discuss the relationship between firm EBPs and their capital stock in the data (Section C.3).

## C.1 Model Parameterization

TABLE C.1
Benchmark Model Parameterization

| Parameter | Value | Description |
|---|---|---|
| $N_1$ | 0.025 | Intermediary Net-Worth Pre-Shock |
| $N_2$ | 0.055 | Intermediary Net-Worth Post-Shock |
| $R$ | 1 | Safe Interest Rate |
| $\alpha_L$ | 0.7 | Cobb-Douglas capital elasticity |
| $\alpha_H$ | 0.98 | Cobb-Douglas capital elasticity |
| $\theta(K_t)$ | $0.9\mathrm{K}_t^{1.25}$ | Agency Friction |

Table C.1 presents our model's parameterization. Among the parameters are the net-worth of intermediaries before and after the shock, which we select such that intermediaries' constraints bind for both firms. The safe interest rate, $R$, is set to 1 in the model for simplicity. As mentioned in the main text, we vary the slope of firms' marginal benefit curves for capital by adjusting $\alpha$, the elasticity of firms' Cobb-Douglas production functions with respect to capital. While we have selected the particular values for $\alpha$ listed in the table for ease of exposition, we obtain qualitatively similar results so long as firms differ in the slope of their marginal benefit curves.

In addition, we follow Gabaix and Maggiori (2015) by assuming that the fraction of their revenues intermediaries can divert is increasing in the size of their balance-sheet: $\theta(K_t)$. The functional form $0.9K_t^{1.25}$ is selected to generate an (approximately) linear marginal cost of capital curve, which ensures our results are not tied to the slope of this curve.

## C.2 Firm EBPs and Marginal Benefit Curves for Capital

Figure 7 in the main text documents the relationship between a firm's EBP and the slope of its marginal benefit curve for capital in our model. Specifically, under our baseline parameterization in Table C.1, firms with flatter marginal benefit curves near the equilibrium had lower equilibrium EBPs. In what follows, we showcase the generality of this result by discussing the conditions under which it holds.

In the equilibria shown in Figure 7, the $\alpha_H$-firm has both the low EBP and a flatter marginal benefit curve (Panel 7b). From inspection, there are two potential ways this result could be violated: (i) intermediaries have sufficiently high net worth; and (ii) intermediaries have sufficiently low net worth. We discuss these two cases in turn.

Case (i): intermediaries have sufficiently high net worth. As the marginal benefit curve of the firm with $\alpha_L$ (Panel 7a) intersects the horizontal axis ($R^K = R$) before the firm with $\alpha_H$ (Panel 7b), we know that for sufficiently high intermediary net-worth, the $\alpha_L$-firm will have a lower equilibrium EBP. Thus, there exists an equilibrium in which (a) intermediaries' net worth is $\varepsilon > 0$ below this level, and (b) the $\alpha_L$-firm has both the lower-EBP and the steeper marginal benefit curve. We now bound this level of intermediary net worth and show that it is almost identical to the intermediary net worth for which the $\alpha_L$-firm is risk free under our baseline parameterization.

When intermediary net worth $N$, and hence equilibrium capital, is sufficiently high, the $\alpha_H$-firm always has a flatter marginal benefit curve but only has a lower EBP if $\alpha_H K_H^{\alpha_H - 1} < \alpha_L K_L^{\alpha_L - 1}$. The cutoff level of capital stock $K^*$ for which this ceases to hold occurs at the intersection of the two firms' marginal benefit curves:

$$K^* = \left[\frac{\alpha_L}{\alpha_H}\right]^{\frac{1}{\alpha_H - \alpha_L}} \tag{C.1}$$

The $N$ for which the $\alpha_H$-firm has $K_H < K^*$ can be found from $\alpha_H K_H^{\alpha_H - 1} = \frac{K_H - N}{K_H(1-\theta)}$, or:

$$\begin{aligned} N =& K_H - \alpha_H K_H^{\alpha_H}(1-\theta) \\ N <& \left[\frac{\alpha_L}{\alpha_H}\right]^{\frac{1}{\alpha_H - \alpha_L}} - \alpha_H \left[\frac{\alpha_L}{\alpha_H}\right]^{\frac{\alpha_H}{\alpha_H - \alpha_L}} (1 - \theta(\left[\frac{\alpha_L}{\alpha_H}\right]^{\frac{1}{\alpha_H - \alpha_L}})) \end{aligned} \tag{C.2}$$

If $N$ is below the value in (C.2), then the $\alpha_H$-firm has both a flatter marginal benefit curve and a lower EBP in equilibrium. In our baseline parameterization, this is $N \lessapprox 0.6$, which is nearly identical to the $N$ that makes the $\alpha_L$-firm have a credit spread of 1, which is incredibly rare in practice.

Case (ii): intermediaries have sufficiently low net worth. This condition, as it turns out, does not have any "bite" under our baseline parameterization. When $N \lessapprox 0.6$, and especially for small $N$, the $\alpha_H$-firm has the lower EBP but may not have the flatter marginal benefit curve. We show, in fact, that it always has the flatter marginal benefit curve by setting $N = 0$ and showing:

$$|\alpha_H(\alpha_H - 1)K_H^{\alpha_H - 2}| < |\alpha_L(\alpha_L - 1)K_L^{\alpha_L - 2}|, \tag{C.3}$$

under our baseline paramaterization. Solving for the equilibrium capital stock when $N = 0$ gives $K_H = 0.07$ and $K_L = 0.1991$, which implies inequality (C.3) holds.

## C.3 Firm EBPs and Capital Stock: Model and Data

Finally, a corollary of our baseline model is that when the low-EBP firm has a flatter marginal benefit curve, it also has a lower capital stock. Table C.2 highlights that, without controls, this positive relationship between firm EBPs and their capital stock is present in the data. On the other hand, when adding controls, we see that the EBP and firms' capital stock appear unrelated. As discussed briefly in Section 6.1, one can make firm EBPs unrelated from their capital stock, or even achieve a negative relationship between the two, if firms with flatter capital demand curves garner positive "sentiment" from intermediaries, modelled as a looser compatability constraint.

Table C.2
Firm EBPs and Capital Stock

| Vars | $\log K_{i,t}$ | $\log K_{i,t}$ | $\log K_{i,t}$ | $\log K_{i,t}$ |
|---|---|---|---|---|
| $\text{EBP}^{ma}_{i,t}$ | 0.028*** | 0.01 | -.003 | .002 |
| | (.008) | (.006) | (.009) | (.008) |
| Firm FE | Yes | Yes | Yes | Yes |
| Time FE | No | No | Yes | Yes |
| Firm Controls | No | Yes | No | Yes |