FALLING RATES AND RISING SUPERSTARS

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ABSTRACT

Using high frequency interest rate shocks, we find that falling rates in a low interest rate environment favor industry leaders. A fall in interest rate near the zero lower bound leads to a stronger decline in the borrowing rate for industry leaders, who also borrow more, invest more aggressively, and acquire assets at a faster pace. This advantage from falling rates enjoyed by industry leaders diminishes in a higher rate environment. We estimate a "competition-neutral" nominal federal funds rate of about four percentage points, a level at which industry leaders and followers are impacted equally from an interest rate change.

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1   Introduction

Interest rates have fallen steadily in the United States to record lows in recent decades. This paper investigates whether falling rates have impacted industry leaders versus industry followers in unequal ways. Our empirical design uses unanticipated high frequency changes in interest rates around FOMC announcements between 1994 and 2019 to trace out the differential firm-level response for industry leaders versus followers in the United States.

Our key finding is that falling rates in the very low interest rate environment of recent times have consistently favored industry leaders. In other words, falling rates tend to promote rising superstars. This result is robust and consistent across a wide range of firm outcomes. This finding offers one possible explanation for the time-series association between falling rates and rising market concentration: as interest rates continued to decline over the decades, measures of market concentration rose substantially, especially since 2000.

The empirical facts documented in this paper open a new set of questions on the possible supply-side consequences of a very persistent low rate environment. The existing literature on declining interest rates has largely focused on the possible causes of the decline, such as demographics, inequality, and technological change. However, there is surprisingly little work on the *consequences* of falling interest rates for the supply side of the economy. The results in this paper suggest that very low rates may have important implications for the supply side through their effect on market competition.

How can a falling interest rate, r, influence market competition? Section 2 outlines two theoretical mechanisms. First, as in Liu et al. (2022), industry leaders gain a progressively more powerful *strategic advantage* when r falls. Intuitively, a decline in r make the industry leader "fight off" the industry follower more aggressively, which then dissuades the follower from trying as hard. This strategic effect becomes more powerful as r falls toward zero. Second, the presence of financial frictions brings an additional *financial advantage* that favors industry leaders as r falls. A natural implication of progressively strengthening strategic and financial advantages for industry leaders is that as r falls toward zero, markets ultimately become more concentrated.

We empirically analyze the impact of falling rates on firms using high frequency interest rate shocks at FOMC announcements as exogenous shifters to the interest rate. Our identification strategy follows the important work of Gürkaynak et al. (2005), Nakamura and Steinsson (2018), and Bauer and Swanson (2021). We aggregate these high frequency shocks to the quarterly level, as in Ottonello and Winberry (2020) and Gertler and Karadi (2015), and merge them to firm-level Compustat data on publicly listed U.S. firms.

We then estimate the impulse response function of industry leaders relative to industry followers in a local-projections difference-in-differences framework. Industry leaders are firms that are in the top 5% of their industry by market capitalization. All other firms are classified as followers. We estimate impulse responses for firm outcomes including the cost of borrowing,

investment, acquisitions, and stock market returns. The key empirical test is to compare the differential response of industry leaders versus followers to interest rate shocks, and see how this differential response varies by the initial level of the interest rate.

We find that industry leaders benefit significantly more from lower rates in a low interest rate environment, and this leader-advantage dissipates in a higher rate environment. Let us define a nominal federal funds rate of 1% as representing a low interest rate environment. The results show that a 10 basis point reduction in the interest rate in a low interest environment results in a relative 10 basis point decline in the cost of borrowing for leaders versus followers. The pass-through of lower rates is much stronger for industry leaders in a low rate environment.

Other financial outcomes show a similar pattern, with industry leaders benefiting more from a fall in the interest rate in a low interest rate environment. In particular, industry leaders raise additional debt financing and increase their leverage ratio relative to industry followers. In terms of magnitudes, a 10 basis point reduction in the interest rate in a low rate environment leads to an 2.6% larger increase in issuance of debt and a 0.38 percentage point increase in the book leverage ratio. As with borrowing costs, the industry leader advantage in response to a negative interest rate shock is reduced at a higher level of the interest rate.

The leader advantage of falling rates translates into real outcomes as well, with industry leaders investing and growing at a faster rate. A negative 10 basis point interest rate shock in a low rate environment leads to a 1.74% stronger increase in Property, Plants, and Equipment of leaders relative to followers. Relative to followers, leaders' capital expenditures and acquisitions scaled by lagged assets also rise by 0.28 and 0.53 percentage points, respectively. Stock returns exhibit a similar result, with industry leaders experiencing a boost in valuation relative to followers in response to a negative interest rate shock in a low rate environment.

All of these effects that favor industry leaders in response to a decline in the interest rate are mitigated if the economy is in a higher rate environment. In fact, we can estimate a "competition-neutral" nominal federal funds rate at which the effect of a change in the interest rate is equal for both industry leaders and followers. The competition-neutral nominal federal funds rate is estimated to be between 3.8 and 4.4%.

Overall, the results imply that interest rate shocks are not market neutral in terms of competition in a low rate environment. In particular, a decline in the interest rate from an already low level boosts industry leaders relative to followers across all the outcomes we consider. This relative advantage becomes larger and larger as the interest rate approaches the lower bound. While the focus of this study is on the micro-level evidence, the results have implications for the macroeconomic patterns in the data. The results suggest that the rise in market concentration and the decline in interest rates are indeed linked, although more evidence is needed to test the link at the macroeconomic level.

The nominal Federal Funds rate has been below 3.8% for almost the entire period from July 2001 to 2019, (with an exception from 2005 and 2007). It has been well below this range since the Great Recession. In this persistently low interest rate environment, the results of this

study suggest that negative shocks to the interest rate have boosted industry leaders relative to industry followers. Interestingly, this is consistent with time-series evidence on the particular rise in concentration since 2000.

The high-frequency difference-in-differences identification strategy used in this paper offers important advantages, but we also conduct a number of robustness tests. The difference-in-differences methodology naturally differences out any macro-level news effects that may be spuriously correlated with high frequency FOMC shocks. For example, Bauer and Swanson (2021) and Bauer and Swanson (2022) highlight that the Federal Reserve may itself be responding to macroeconomic news, as measured by Blue Chip GDP forecast revisions, when making FOMC announcements. Hence the subsequent macroeconomic path potentially reflects the news rather than FOMC actions. However, to the extent such news effects are common across industry leaders and followers, our methodology differences them out.

There may still be a concern that macroeconomic news differentially affects industry leaders versus followers. We test for this by allowing the Blue Chip GDP forecast revisions and other such news shocks to impact industry leaders and followers differentially. Doing so does not materially change the findings.

The results are also robust to changes in definitions and the inclusion of firm-level control variables. For example, classifying leaders by sales instead of market capitalization or using the top 5 firms in each industry instead of the top 5% leads to similar results.

To our knowledge, other than the theory outlined in this paper, there are no prominent alternative hypotheses that also predict a differential effect of interest rate changes on industry leaders versus followers. Moreover, for an alternative hypothesis to explain our findings, it would also have to explain why the differential effect on industry leaders gets more powerful as r approaches zero. For all these reasons, we believe that the empirical tests conducted in this paper are high-powered.

Nonetheless, we still consider the possibility that there may be a spurious "time-trend"—for reasons as yet unknown—that has the following characteristics: industry leaders were not more responsive to interest rate shocks than industry followers early on, but over time have become more responsive for unknown reasons. This is a difficult possibility to rule out since the broader decline in r is naturally correlated with time. However, it is not perfectly correlated, and we show that even when we saturate a linear time trend and all its relevant interactions with the industry leader dummy and r, our core finding survives. The results pass this demanding test as well.

This paper presents a stark empirical asymmetry in the response of industry leaders versus followers to interest rate changes that requires explanation. Where does this asymmetry come from? Why is the asymmetry amplified as r gets closer to zero? Given the persistence of very low rates in recent past, and the continued forecast of very low forward rates by markets, these are likely important questions.

If very low rates are more favorable toward industry leaders, as the data suggest, this can

have deep implications for the macro-economy in the long-run and for ideas such as secular stagnation. The typical explanations of low r^* and secular stagnation attribute these phenomena to changes on the demand-side that reduce the equilibrium rate of interest, potentially leading the economy into a liquidity trap. But what if there is *also* a feedback mechanism, where the reduction in the interest rate in turn makes the economy more monopolistic? Such slow-moving but persistent dynamics can be dangerous. For example, such a feedback mechanism does not rely on nominal rigidities and as such may lead to more durable problems. Our hope is that the empirical facts documented in this paper lead to further investigation of these important questions.

Finally, the results of this paper should not be seen as reflecting in any way on the stance of monetary policy chosen by the Federal Reserve. We use FOMC announcement surprises to generate exogenous movement in interest rates, which by itself does not tell us if the particular direction chosen by the Federal Reserve was good or bad for the overall economy. For example, if broader demand-side forces are pushing down r^*, the Federal Reserve has to respond by accommodating those forces. Our results suggest that even if demand-side forces necessitate a fall in interest rates, that fall may have important supply-side consequences near the zero lower bound.

The findings of this study are related to the large body of research exploring the rise in market concentration in the United States since the 1980s (e.g., Grullon et al. (2019), Philippon (2019), Syverson (2019), De Loecker et al. (2020)). Scholars have proposed that the rise in concentration may be a reason behind weak investment and low productivity growth (e.g., Gutiérrez and Philippon (2017a), Gutiérrez and Philippon (2017b), Crouzet and Eberly (2019), Liu et al. (2022)). A closely related area focuses on the rise of superstar firms, and the implications of superstar firms for the labor share and productivity patterns (e.g., Andrews et al. (2016), Berlingieri et al. (2017), Olmstead-Rumsey (2019), Autor et al. (2020)). This paper suggests that falling interest rates may be one of the factors behind the important patterns documented in this extensive literature. The findings are also related to the empirical literature in asset pricing exploring the effects of interest rates on asset returns (e.g., Koijen et al. (2017), Van Binsbergen (2020)).

There is also a related literature exploring the role of financial constraints in the transmission of monetary policy to firm investment (e.g., Gertler and Gilchrist (1994), Ippolito et al. (2018), Ottonello and Winberry (2020), Vats (2020)). Another related study is Morlacco and Zeke (2021), who show that in response to a decline in the interest rate, large firms increase their spending on customer capital significantly more than small firms. To the best of our knowledge, the empirical demonstration that leaders benefit disproportionately from negative interest rate shocks as the level of the interest rate approaches the lower bound is new to the literature.

2 Developing Hypotheses

2.1 Motivating Aggregate Facts

Over the last 40 years, corporate market power has risen, evidenced by higher corporate profits (measured as a fraction of GDP) in panel (a) of Figure 1 and rising Tobin's Q in panel (b) of Figure 1. We measure corporate profits as a share of GDP from National Accounts and Q using the Flow of Funds. Gutiérrez and Philippon (2017b) show that this increase occurs both in aggregate accounts and in firm-level data, addressing concerns about measurement error in Tobin's Q. Gutiérrez and Philippon (2017b) document both facts and investigate the connection to low investment and rising common ownership (Gutiérrez and Philippon, 2018). Crouzet and Eberly (2019) focus instead on the role of intangible capital. Barkai (2019) links rising pure corporate profits to a declining labor and capital share. Measures of market concentration (Autor et al. (2020), Grullon et al. (2019), Kwon et al. (2021)) and of markups (De Loecker and Eeckhout (2018), De Loecker et al. (2020), Syverson (2019)) have also increased.

While market power has steadily risen, interest rates have been steadily declining. Figure 2 plots the average borrowing cost in Compustat data for industry leaders, defined as the top 5% of firms by market value within a Fama-French industry in a year, over time. Since 1980, the average corporate borrowing cost of industry leaders among U.S. public firms has fallen from from 11% to 3%.

The decline in interest rates is widespread (Caballero et al., 2008). Recent work has studied the connection between rising market power, low interest rates, and other macroeconomic trends over the past decades using structural models (e.g., Farhi and Gourio (2019), Eggertsson et al. (2021)) to jointly analyze the driving forces behind multiple macro trends from past decades.

The contribution of this study is to exploit micro data to directly test for the link between declining borrowing costs and measures of market power. In particular, we are interested in whether the largest firms within an industry, the "leaders," benefit disproportionately from falling interest rates as compared to the "followers" who directly compete with them. Furthermore, this study tests whether the relative advantage of leaders when interest rates fall depends on the initial level of the interest rate. The following two sub-sections provide a theoretical discussion of this relative advantage.

2.2 An Illustrative Model

Time is discrete. Two firms compete on a technological ladder, such that the firm that is further ahead on the ladder has a strategic advantage and earns higher profits. The distance between two firms on the technological ladder represents the state variable. To keep the analysis as simple as possible, we assume that an industry has only three states: firms can compete neck-and-neck (state = 0) with flow profit $\pi_0 = \frac{1}{2}$ each, they can be one step apart earning flow profits $\pi_1 = 1$ for the leader and $\pi_{-1} = 0$ for the follower, or they can be two steps apart. If

firms are two steps apart, that state becomes permanent, with the leader and follower earning $\pi_2 = 1$ and $\pi_{-2} = 0$ perpetually (respectively).

Firms compete by investing to move forward on the technological ladder in order to out-run the competitor. Starting with a technological gap of one step, if the current follower succeeds before the leader, their technological gap closes to zero. The two firms then compete neck-and-neck, both earning flow profit 1/2, and they continue to invest in order to move ahead on the technological ladder. Ultimately, each firm is trying to get two steps ahead of the other firm in order to enjoy permanent profit of $\pi_2 = 1$.

We interpret the firm in state $s = 1$ (-1) as the temporary leader (follower), and the firm in state $s = 2$ (-2) as the permanent leader (follower). At an interest rate r, the value of a permanent leader is $v_2 = 1/r$ and the value of a permanent follower is $v_{-2} = 0$. Firms that are zero or one-step apart choose investment levels to maximize their firm values, taking the other firm's investment level as given. The equilibrium firm value functions must satisfy the following Bellman equation for $s \in \{-1, 0, 1\}$:

$$v_1 = \max_{\eta \geq 0} \pi_1 - \eta + \frac{1}{1+r} \left[\frac{\eta}{\eta + \eta_{-1} + \kappa + x} v_2 + \frac{\eta_{-1} + \kappa}{\eta + \eta_{-1} + \kappa + x} v_0 + \frac{x}{\eta + \eta_{-1} + \kappa + x} v_1 \right] \quad (1)$$

$$v_0 = \max_{\eta \geq 0} \pi_0 - \eta + \frac{1}{1+r} \left[\frac{\eta}{\eta + \eta_0 + x} v_1 + \frac{\eta_0}{\eta + \eta_0 + x} v_{-1} + \frac{x}{\eta + \eta_0 + x} v_0 \right] \quad (2)$$

$$v_{-1} = \max_{\eta \geq 0} \pi_{-1} - \eta + \frac{1}{1+r} \left[\frac{\eta + \kappa}{\eta + \kappa + \eta_1 + x} v_0 + \frac{\eta_1}{\eta + \kappa + \eta_1 + x} v_{-2} + \frac{x}{\eta + \kappa + \eta_1 + x} v_{-1} \right] \quad (3)$$

where η_s is the investment choice in state s. An equilibrium is the set of investment decisions and value functions $\{\eta_s, v_s\}_{s \in \{-1,0,1\}}$ that satisfy (1)-(3).

The Bellman equation can be interpreted as follows. In a given period, a firm in state s has valuation v_s, which consists of flow profit π_s, investment cost $-\eta_s$, and an expected continuation value corresponding to the terms in brackets; these terms account for the possibility of moving up the ladder to $s+1$, moving down to $s-1$, or staying in state s. Take state $s = 1$ as an example (noting that in equilibrium, $\eta = \eta_1$ in equation 1): first, with probability $\frac{\eta_1}{\eta_1 + \eta_{-1} + \kappa + x}$ the firm advances on the technological ladder, in which case the continuation value is v_2. Second, with probability $\frac{\eta_{-1} + \kappa}{\eta_1 + \eta_{-1} + \kappa + x}$ the firm's competitor advances, thus the firm falls down a step on the ladder with continuation value v_0. Finally, with probability $\frac{x}{\eta_1 + \eta_{-1} + \kappa + x}$ neither firm advances on the ladder, and both firms' continuation values are the same as at the start of the period. $\kappa \in (0, 1/2)$ is an exogenous tailwind that helps the follower to catch up in state $s = -1$; it is added for technical simplicity and can be treated as close to zero for our analysis. $x \geq 0$ is an exogenous constant that parameterizes the probability of staying in the current state. Ceteris paribus, the more a firm invests, the more likely it advances and its competitor retreats. Note that equations (1)-(3) do not impose constraints on investment levels based on the firm's state or profits; they represent a friction-less environment in which the Modigliani-Miller (MM) theorem holds. We introduce financial frictions in the next sub-section.

A firm in state s invests not only for higher profits in state $s + 1$ but also for gaining a

strategic advantage and the prospect of becoming the permanent monopolist (i.e., reaching state 2) in the future. To see this, consider Bellman equation (3), from which it is evident that the marginal cost of a higher investment η_{-1} is always equal to one, whereas the marginal benefit is

$$MB_{-1} = \frac{\eta_1 \left(v_0 - v_{-2}\right) + x \left(v_0 - v_{-1}\right)}{(1+r)\left(\eta_s + \eta_{-s} + \kappa + x\right)^2}. \tag{4}$$

The forward-looking incentives are encoded in the value functions in (4). When r is high, firms discount future benefits more heavily, and short-term changes in profits $(\pi_{s+1} - \pi_s)$ account for the bulk of the investment incentive. This is most clearly illustrated by taking the limit as $r \to \infty$: $\eta_s \to 0$ for all s, and the marginal investment benefit in state $s = -1$ becomes $MB_{-1} \to \frac{v_0 - v_1}{(1+r)(\kappa+x)} = \frac{\pi_0 - \pi_{-1}}{r(1+r)(\kappa+x)}$. Notably, the investment incentive in state s depends only on the change in flow profits from s to $s + 1$; flow profits outside of these two states disappear from the expression.

By contrast, when r is low, firms are effectively more forward-looking, and the bulk of the investment incentive arises from the prospect of reaching $s = 2$ and not from short-term changes in profits. As $r \to 0$, a firm's investment decision no longer depends on flow profits in temporary states 0, 1, and -1 and is instead solely determined by its strategic position, meaning the number of steps from becoming the permanent monopolist.

We now establish that investments and valuations of the leader and the follower respond asymmetrically to a decline in r, and the degree of asymmetry depends on the initial level of r. Starting from a low-rate environment, the leader responds more to a decline in r than the follower; the asymmetry widens as r falls toward zero and dissipates as r rises.

Proposition 1. *For a sufficiently low initial interest rate, the leader's investment responds more than the follower's to a decline in r ($\frac{\mathrm{d}(\eta_1 - \eta_{-1})}{-\mathrm{d}r} > 0$). The asymmetry dissipates as r rises ($\frac{\mathrm{d}^2(\eta_1 - \eta_{-1})}{-\mathrm{d}r^2} < 0$) and widens to infinity as r declines to zero ($\lim_{r \to 0}(\eta_{-1} - \eta_{-1}) = \infty$).*

The same asymmetry holds for firms' valuation: for sufficiently low r, $\frac{\mathrm{d}(v_1 - v_{-1})}{-\mathrm{d}r} > 0$, $\frac{\mathrm{d}^2(v_1 - v_{-1})}{-\mathrm{d}r^2} < 0$, and $\lim_{r \to 0}(v_{-1} - v_{-1}) = \infty$.

The proposition corroborates Liu et al. (2022) in our discrete-time setting. To understand the result, note that in a low-r environment, investments are not driven by short-term flow profits but by the ultimate goal of becoming a permanent monopolist in $s = 2$. The leader in $s = 1$ responds aggressively to a decline in r because doing so directly raises the prospect of reaching $s = 2$. For the follower in $s = -1$, however, the response is less aggressive because of the endogenous response of its competitor in state $s = 0$ were the follower to successfully catch up. In particular, a fall in r also makes firms compete more fiercely in the neck-and-neck state, thereby increasing the expectation of a tougher fight were the follower to successfully catch up to $s = 0$. While the expectation of a more fierce competition in the future state-zero disincentivizes the follower from catching up, the possibility of "escaping" the fierce competition through investment raises the incentive for the leader. This strategic asymmetry continues to

amplify indefinitely as $r \to 0$, giving us the result that $\lim_{r \to 0} (\eta_1 - \eta_{-1}) = \infty$. The proposition further shows that the investment asymmetry translates into a valuation asymmetry as well.

To summarize, standard intuition suggests that both firms raise investments in response to a decline in r. The proposition demonstrates an asymmetry between the investment and valuation response of the leader and that of the follower, and the asymmetry depends on the initial level of r. Starting from a low-rate environment, the leader's investment and valuation respond more to a decline in r than the follower's; the asymmetry dissipates as r rises and widens as r falls; as r declines toward zero, the asymmetry actually snowballs towards infinity.

2.3 Financing Investment with Short-term Debt

We now introduce financial frictions and demonstrate that the leader's strategic advantage may translate into a financial advantage, thereby reinforcing the strategic advantage and further handicapping the follower relative to the MM setting. Specifically, we assume firms can finance investments by issuing non-contingent, one-period risky debt to a risk-neutral lender. For a firm in state s with outstanding debt d facing a competitor with outstanding debt d_{comp}, its value function is

$$v_s \left(d, d_{comp}\right) = \max_{\eta, d^{next}} \left[\max \left\{0, \pi_s - d\right\} - \eta + \frac{1}{1+r} \mathbb{E}_{s^{next}} \left[v_{s^{next}} \left(d^{next}, d_{comp}^{next}\right) \right] \right] \quad (5)$$

$$\text{s.t. } 0 \leq \eta \leq \max \left\{0, \pi_s - d\right\} + \frac{1}{1+r} \mathbb{E}_{s^{next}} \left[\min \left\{ \pi_{s^{next}}, d^{next} \right\} \right], \quad (6)$$

$$0 \leq d^{next} \leq \pi_{s+1}, \quad (7)$$

where s^{next} is the state variable in the next period, with transition probabilities as described in equations (1)-(3):

$$s^{next} = \begin{cases} s+1 & \text{with probability } \frac{\eta + \kappa \cdot \mathbf{1}_{s=-1}}{\eta + \eta_{-s} + \kappa \cdot \mathbf{1}_{s \in \{-1,1\}} + x}, \\ s & \text{with probability } \frac{x}{\eta + \eta_{-s} + \kappa \cdot \mathbf{1}_{s \in \{-1,1\}} + x}, \\ s-1 & \text{with probability } \frac{\eta_{-s} + \kappa \cdot \mathbf{1}_{s=1}}{\eta + \eta_{-s} + \kappa \cdot \mathbf{1}_{s \in \{-1,1\}} + x}. \end{cases}$$

The constraint (6) implies that the firm can either use retained earnings (net of repayment of outstanding debt) or issue new one-period debt to finance current-period investment. For newly issued one-period debt d^{next}, its present value $\frac{1}{1+r} \mathbb{E}_{s^{next}} \left[\min \left\{ \pi_{s^{next}}, d^{next} \right\} \right]$ is endogenously determined by the investment levels of both firms (through the expectation operator): when the competitor's investment η_{-s} is high, it is less likely for the firm in state s to advance to state $s+1$, and the constraint (6) becomes endogenously tighter. The gross interest rate is

$$R_s \equiv (1+r) \frac{d^{next}}{\mathbb{E}_{s^{next}} \left[\min \left\{ \pi_{s^{next}}, d^{next} \right\} \right]},$$

which reflects a firm's borrowing cost.

In general, (5) is a difficult problem to solve because of the additional state variables. However, for a sufficiently low interest rate, constraints (6) and (7) always bind, and both firms always invest up to the maximum feasible levels of investment. Hence, after repaying debt, each firm's retained earning is always zero,[1] and investment is always equal to the present value of the next-period profits:

$$\eta_s = \frac{1}{1+r} \mathbb{E}_{s^{next}} \left[\pi_{s^{next}} \right].$$

Because the follower in state $s = -1$ only earns positive profits if it were to advance to state $s = 0$, its investment is

$$\eta_{-1} = \frac{1}{1+r} \frac{\eta_{-1} + \kappa}{\eta_1 + \eta_{-1} + \kappa + x} \pi_0, \tag{8}$$

whereas the leader's investment is

$$\eta_1 = \frac{1}{1+r} \left[\frac{\eta_1}{\eta_1 + \eta_{-1} + \kappa + x} \pi_2 + \frac{\eta_{-1} + \kappa}{\eta_1 + \eta_{-1} + \kappa + x} \pi_0 + \frac{x}{\eta_1 + \eta_{-1} + \kappa + x} \pi_1 \right].$$

We have the following Proposition.

Proposition 2. *Suppose firms must finance investment using short-term debt (as in 5). As $r \to 0$, the follower's investment converges to $\eta_{-1} \to \frac{\kappa}{1+2\kappa+2x}$, and the leader's investment converges to $\eta_1 \to \frac{1+\kappa+2x}{1+2\kappa+2x}$. This implies that, as the follower's exogenous tailwind κ goes to zero, in a low-r environment (as $r \to 0$), the follower's investment goes to zero, the follower's borrowing cost go to infinity, and the probability that the temporary leader eventually becomes the permanent leader goes to 1.*

Proposition 2 can be understood as follows. As $r \to 0$, both firms would like to invest as aggressively as debt capacity allows. A firm's borrowing cost—and thus the firm's investment—is endogenous to its competitor's investment levels. Because the leader has a strategic advantage—more pledgeable profits in the next period—it also has a financial advantage and is able to invest more than the follower. The financial advantage in turn reduces the follower's probability of repayment and further constrains the follower's investment (a higher investment by the leader, η_1, lowers the right-hand side of equation 8), thereby reinforcing the leader's strategic advantage by raising the probability that the temporary leadership becomes permanent. As $r \to 0$, the two-way reinforcement is so strong that the value of the follower's debt capacity becomes fully tied to the exogenous tailwind; as $\kappa \to 0$, the follower's borrowing cost goes to infinity and investment capacity goes to zero, and the follower endogenously loses the possibility of advancing to a higher state.

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[1]This is except for the initial period in which outstanding debt is exogenous. For expositional simplicity, we assume the initial debt is sufficiently large such that the second period retained earning is zero after repaying debt.

3 Data and Empirical Methodology

3.1 Data

The main data set used in this paper comes from quarterly merged CRSP-Compustat data covering 1994 to 2019. We focus on this time period because that is the time period for which we can construct interest rate shocks in the next subsection. Starting from the full quarterly data set of US-incorporated public firms, we apply the following filters that are standard in the literature (e.g. Gutiérrez and Philippon (2017b) and Ottonello and Winberry (2020)).

First, we drop the financial sector (SIC between 6000 and 6999) and public administration (SIC between 9000 and 9999). We also drop firms with 10 or fewer observations. We drop firms with leverage, defined as current debt (dlcq) plus long-term debt (dlttq) divided by assets (atq), exceeding 10. Further, we drop firms with net current asset ratio, defined as current assets (actq) minus current liabilities (lctq) over total assets (atq), exceeding 10 or below -10 and firms with real sales growth, defined as growth in nominal sales (saleq) adjusted by the CPI, exceeding 100% or below -100%.

Finally, we winsorize the distribution of leverage at the .5 and 99.5 percentile and we linearly interpolate missing values of assets. One of our main dependent variable, borrowing costs, is defined as quarterly interest expenses (xintq) over interest-bearing debt (dlcq + dlttq). We exclude the top 5% of borrowing costs to remove implausibly large values and set negative borrowing costs to missing.

Table 1 provides an overview of the final firm-level panel data. We report summary statistics for borrowing cost, stock return, leverage, acquisitions, capital expenditures, debt, assets, and property, plant and equipment. Variable construction for each of these variables in Compustat sample is described in Table 1's footnote. In the analysis, a critical distinction will be between industry "leaders" and "followers". The baseline definition of industry leaders is according to size as measured by market value. A firm is classified as an industry leader if it is in the top 5 percent of firms in its respective Fama-French industry based on market value at the beginning of the period when outcomes are computed. Robustness results in the appendix show similar results for alternative leader definitions based on sales, the top 5 firms within each industry and for SIC instead of Fama-French industries.

3.2 Empirical Specification

The discussion in Section 2 motivates the following specification:

$$\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,j,t-1}) + \beta_\Delta^h(\omega_t * L_{i,j,t-1} * FFR_{t-1})$$
$$+\delta_h' z_{i,j,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,j,t-\ell} + \epsilon_{i,j,t+h-1} \tag{9}$$

where $\Delta y_{i,j,t+h-1} = y_{i,j,t+h-1} - y_{i,j,t-1}$ is the cumulative change in the outcome variable of interest for firm i in industry j from quarter $t-1$ to $t+h-1$, $L_{i,j,t-1}$ is an indicator variable equal to 1 if firm i is an industry leader in the top 5% of market capitalization in its industry j at date $t-1$, FFR_{t-1} is the lagged level of the nominal Federal Funds rate, ω_t is our measure of interest rate shocks between $t-1$ and t (discussed in the next sub-section), $z_{i,j,t} = \{L_{i,j,t-1}, L_{i,j,t-1} * FFR_{t-1}\}$ is a vector of market leadership controls while $\theta_{i,j,t-l}$ is a vector containing lagged values of all variables in the system (including the outcome variable). We also control for industry-time fixed effects $\alpha_{j,t}$. Thus, our estimates remove cross-industry variation. Olea and Plagborg-Møller (2020) show that augmenting the local projection with lags of each variable removes the need to correct standard errors for autocorrelation, meaning heteroskedasticity robust standard errors are appropriate when estimating equation (9). The specification also has the advantage of appropriately handling the issue of dynamic heterogeneous treatment effects as highlighted by Dube et al. (2022).

Finally, h indicates the time horizon in quarters of the local projection. For our main results, we will estimate equation (9) for $h = 1, 2, 3, ..., 11$. The variable ω_t is the sum of all interest rate shocks that occur between quarters $t-1$ and t, as discussed in the next sub-section. The coefficients at $h = 1$ therefore capture the contemporaneous response of the dependent variable, and the coefficient at $h = 0$ is zero by construction.

The two main coefficients of interest are β_{ZLB}^h and β_{Δ}^h. Partially differentiating equation 9 with respect to the leader indicator variable ($L_{i,j,t-1}$) helps elucidate the importance of these two coefficients:

$$\frac{\partial \Delta y_{i,j,t+h-1}}{\partial L_{i,j,t-1}} = \beta_{ZLB}^h * \omega_t + \beta_{\Delta}^h * \omega_t * FFR_{t-1} \tag{10}$$

If the lagged interest rate is equal to zero ($FFR_{t-1} = 0$), then the differential effect of a shock to the interest rate on the leader's outcome relative to the follower's is fully captured by β_{ZLB}^h. This is why we refer to the coefficient as the zero lower bound coefficient; it is the effect of a shock to the interest rate when interest rates are already at the zero lower bound. As the lagged interest rate moves above zero, the effect of an interest rate shock changes with the lagged level of the interest rate, which is captured by β_{Δ}^h.

To map these coefficients to the model developed in Section 2, let's fix the outcome variable to be investment. Suppose there is a negative shock to interest rates (ω_t) starting from a very low level of interest rates, approximated by $FFR_{t-1} = 0$. The model postulates that β_{ZLB}^h will be negative, and therefore a negative shock to interest rates close to the zero lower bound will lead to a positive relative increase in investment for leaders relative to followers.

However, suppose instead there is a negative shock to interest rates starting from a high level of the lagged interest rate FFR_{t-1}. In this case, the effect of the negative shock is captured by both β_{ZLB}^h and β_{Δ}^h. The model postulates that β_{Δ}^h will be positive: the relative increase in investment for a leader versus a follower after a negative interest rate shock will be mitigated

when the initial interest rate is high. At a high enough initial interest rate, the total effect of a negative shock to interest rates on leader versus follower investment may reverse, with the follower seeing a larger increase in investment after a negative interest rate shock.

In general, equation (10) implies that when the level of interest rate is r, the relative impact of interest rate change on lender versus follower is $(\beta_{ZLB} + r * \beta_{\Delta})$. We can hence define the level of interest rate that is "competition-neutral" by setting this expression equal to zero. The competition-neutral rate is the interest rate at which a change in interest rate has the same effect for both industry leaders and followers. We estimate this neutral level of interest rate in Section 5.

3.3 High Frequency Estimation of ω

In order to estimate equation (9), we need an ω that represents an exogenous movement in economy-wide interest rates. We follow the recent literature by using high-frequency changes in interest rates around FOMC announcements to construct ω. FOMC announcements started being communicated directly through a press release in 1994.[2] Hence prior to 1994, we do not have a sharp and clear timing of FOMC announcements for high-frequency analysis. While people have used open market operations to infer policy decisions prior to 1994, post-1994 FOMC announcements provide the cleanest opportunity for high-frequency analysis. Scheduled FOMC meetings occur roughly once every 6 weeks.

FOMC announcements provide a useful opportunity to generate plausibly exogenous shifts in expected interest rates. Gürkaynak et al. (2005) show that high-frequency movements around FOMC announcements represent two separate factors, a short-run "current Federal Funds rate target" and a longer-run "future path of policy". In other words, high-frequency shocks represent a shift in the entire yield curve, and not just the short end (see also Hanson and Stein (2015)). This is useful for our analysis because firm-level outcomes that we analyze depend on the full expected path of interest rates. Moreover, FOMC announcements continue to impact expected interest rates through the forward guidance channel even when the level of the Federal Funds rate is at or near zero, providing useful empirical variation even in recent years.

Nakamura and Steinsson (2018) and Bauer and Swanson (2022) calculate the first principal component of changes in the Federal Funds rate and Eurodollar futures contracts around FOMC announcements. The first principal component therefore reflects the unanticipated shift in the yield curve around the 30-minute FOMC announcement window starting at 10 minutes prior to the FOMC press release.

We take this first principal component from Nakamura and Steinsson (2018) and updated by Acosta and Saia (2020) to more recent data as our default measure of ω.[3] Specifically, it

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[2]The absence of a press release at 2:15pm following an FOMC meeting between 1994-1999 indicated no change in policy rate. Since May 1999, even no change is explicitly reported via press release.

[3]We have also used the first principal component measure from Bauer and Swanson (2022) which essentially gives

is the first principal component of the change in the following five interest rates over a 30-minute FOMC window: the Federal Funds rate, the expected Federal Funds rate following the next FOMC meeting, and the expected Eurodollar interest rates at two, three, and four quarter horizons. We shall refer to it throughout the paper as the "r-news shock."

The first principal component, ω, does not have any units. We therefore normalize it such that the average borrowing cost moves one-for-one for a one unit ω shock after four quarters. This impulse response function is estimated in the next subsection.

Nakamura and Steinsson (2018) interpret their FOMC announcement effect on interest rates as a "Fed information effect"; the Fed communicates its superior information about the economy to the market through the FOMC press release. However, Bauer and Swanson (2022) contest this as the sole interpretation of FOMC announcement effects. Instead, they partly attribute the surprises to markets underestimating the Fed's responsiveness to changes in economic fundamentals, as opposed to the market getting new information about economic fundamentals from the Fed's actions.

The difference in the interpretation of the FOMC announcement effect matters if one wants to use the announcement effect as a monetary policy shock for the overall economy. However, since we have a difference-in-differences methodology, common shocks driven by macroeconomic events prior to FOMC are naturally differenced out. The more specific concern for us would be if the GDP forecast revision shocks highlighted by Bauer and Swanson (2021) affected industry leaders and followers differentially. Our empirical section will therefore explicitly control for such possibility.

Our high frequency identification methodology should be seen as using the FOMC announcement as an unanticipated shifter in interest rates, regardless of whether it comes from a Fed information effect or an revision of the beliefs about the Fed's responsiveness to economic fundamentals. As Bauer and Swanson (2022) also note, such FOMC announcement effects "can be used without correction for estimating asset price responses."

We also split ω into news about the short versus long end of the yield curve. The variable ω^{ff} captures the response of Federal Funds rate Futures within a 30-minute time window (-10 minutes until +20 minutes) around FOMC meeting announcements. We obtain the data from Gorodnichenko and Weber (2016). These shocks capture the response of the short end of the yield curve. The long end of the yield curve is captured by $\tilde{\omega}$, which is obtained as the residual from the following regression.

$$\omega_t = \alpha + \beta \omega_t^{ff} + \tilde{\omega}_t \tag{11}$$

where $\tilde{\omega}$ is the residual after controlling for the short end of the yield curve and can therefore be interpreted as capturing the long end of the yield curve.

Figure 3 plots ω against ω^{ff}. $\tilde{\omega}$ is the distance between the individual dots in the scatter-plot

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very similar results.

and the dashed line of best fit. While the short end of the yield curve has strong predictive power for the r-news shock ω, a significant fraction of variation in ω is captured by the orthogonal component $\tilde{\omega}$ that represents the impact of ω on other components along the yield curve.

One concern with the construction of r-news shocks could be that the largest shocks are disproportionately associated with times of crisis, which might come with other confounding shocks. Some large shocks do correlate with times of crisis such as the second quarter of 2008; however, as shown in Figure 3, several non-crisis episodes also produce variation in interest rate shocks. We also check for robustness of the results by removing unscheduled FOMC announcements relating to crisis episodes.

The unanticipated shocks to interest rates are calculated over a 30-minute window on FOMC days which typically occur once every 6 weeks. We follow the literature such as Ottonello and Winberry (2020) and Gertler and Karadi (2015), and aggregate FOMC shocks over a quarter by summing them. This allows us to match interest rate shocks with quarterly firm-level data from Compustat. Table 2 summarizes the variation across the three measures of shocks at quarterly level in basis points.

All three measures of shocks display sizable variation. The Nakamura and Steinsson (2018) shocks range from -72.1 basis points to 37.3 basis points with a standard deviation of 16.3 basis points. The shock to the Federal Funds rate spans from -40.9 basis points to 26.1 basis points with a standard deviation of 9.0 basis points, while the orthogonalized shocks span a narrower range. Overall, the three measures suggest that news shocks to interest rates play an important role. Whereas the long-run trend in rates has been downward since the 1980s, the news shocks cover both surprise declines and surprise increases in rates.

A less appreciated fact of the high-frequency shocks is that while they are constructed using a 30-minute window around FOMC announcements, the interest rate movements during these high-frequency events represent a surprisingly high fraction of the persistent component of the change in the interest rate over the longer-run. For example, the -1.7 average quarterly basis point change around 30-minute FOMC window is roughly equivalent to the quarterly cumulative federal funds rate change over the sample period. This is also consistent with Hillenbrand (2020) who shows that the cumulative decline in long-term rates also tends to concentrate around FOMC meetings.

A concern with the use of the interest rate shocks is that they are correlated with other economy-wide shocks that could spuriously generate results consistent with the hypotheses developed in Section 2. However, it is important to emphasize that the hypotheses being tested are quite specific as they imply that β_{ZLB}^{h} and β_{Δ}^{h} are of the opposite sign. Spurious shocks would have to explain why leaders versus followers see stronger outcomes when interest rates fall from a low level, and they would also have to explain why the relative effect becomes weaker when interest rates fall from a high level.

3.4 Pass-through to Borrowing Costs

High-frequency shocks would be useful for testing our hypothesis if ω translates into changes in the cost of borrowing for firms. We measure borrowing costs at the firm level by dividing interest expense paid by firms by their interest-bearing debt. Table **??** reports results from a firm-level regression of borrowing costs on a range of covariates with a time fixed effect.

Across all columns of Table **??**, the measure of borrowing costs relates to covariates with an intuitive sign, and the relationships are highly statistically significant. Column (1) shows that leaders pay on average 164 basis points lower rates. Larger firms, as measured by higher market value, pay lower rates. A 1 percent increase in market value corresponds to a .4 basis points reduction in borrowing costs in column (2).

Several measures of firms' financial position also relate to borrowing costs. More levered firms pay higher rates in column 3 (an increase in leverage by 10% relative to assets corresponds to 10.7 basis points higher borrowing costs). Firms with higher price to earnings ratios, higher interest coverage and higher distance to default pay lower rates in columns (4) - (6). Higher profitability, measured as earnings over assets, correlates with lower borrowing costs. In column (7), an increase in earnings of 1% measured as a percentage of assets implies a 5 basis point lower borrowing cost. Finally, our measure of borrowing costs strongly correlates with ratings. We code ratings numerically from 1 (for AAA) to 9 (for C). Moving down one rung on the rating ladder, say from BBB to BB, is associated with a 98 basis points increase in the cost of borrowing.

Figure 4 plots the impulse response function for the average (debt-weighted) borrowing cost across firms to an ω shock. Over the four quarters following a shock, borrowing costs rise gradually until they rise by 1 basis points for a 1 basis point shock before leveling off.

As mentioned earlier, we normalized ω such that a one unity increase leads to a one unit rise in firm borrowing cost on average after four quarters. This gradual rise in the borrowing cost in response to the high frequency shock is consistent with firms slowly reacting to an FOMC announcement. Fixed-rate debt instruments do not reset rates immediately after an ω shock and the process of taking out new loans or issuing new corporate bonds at lower interest rates after a negative ω shock occurs progressively.

4 The Effect of Interest Rate Decline on Leaders versus Followers

This section reports results from estimating Equation (9) for a range of firm-level outcome variables. We estimate local projections at horizon of up to 11 quarters after a shock and plot the main coefficients of interest, β_{ZLB}^h and β_{Δ}^h with their 95 % confidence bands.

4.1 Cost of Borrowing

How does a decline in interest rates affect the cost of borrowing for industry leaders versus followers? Figure 5 reports β_{ZLB}^h in the left column and β_Δ^h in the right column across the three different interest rate news shocks, ω, ω^{ff}, and $\tilde{\omega}$. Across all specifications β_{ZLB} is positive. That is, a fall in the interest rate due to an FOMC announcement leads to a larger fall in borrowing costs for industry leaders versus followers in a low interest rate environment. We discuss magnitudes of the impulse responses two years after the shock at $h = 8$.

For a 10 basis point negative ω shock, borrowing costs for leaders fall 14.5 basis points more than for followers at the zero lower bound. This implies that an additional decline in the interest rate benefits leaders disproportionately at the zero lower bound. Magnitudes are comparable for the other measures of our interest rate news shock, ω^{ff} (Panel b) and $\tilde{\omega}$ in (Panel c). The effect emerges over the first four quarters after the shock, which indicates that pass-through from changing economy-wide rates into borrowing costs occurs over time.

How does this effect vary with the initial interest rate? The figures in the right column of Figure 5 show that the triple-interaction term β_Δ is negative: The differential financing advantage for leaders after a negative interest rate shock is weakened when the lagged level of the interest rate is high. Jointly, the estimates for β_{ZLB}^h and β_Δ^h imply that as the level of the interest rate is lower, a negative shock to the interest rate boosts the differential financing advantage of leaders. Quantitatively, the 14.5 basis point differential decline in leaders' financing advantage for a 10 basis points negative ω shock at the zero lower bound shrinks by about one half when the level of the interest rate is at 2%. The fact that the leaders' financing advantage shrinks for a higher level of the initial interest rate (i.e. $\beta_\Delta^h < 0$) implies that there is a level of the interest rate that would be neutral for the leader's financing advantage. We will return to this idea in Section 5.

In standard asset pricing models, the rise in the borrowing spread between industry leaders and industry followers would be compensation for additional risk. If industry followers become riskier relative to industry leaders when there is a decline in aggregate measures of interest rates, then this effect boosts the value of industry leaders relative to industry followers, and it therefore should be included as part of the advantage lower interest rates give to industry leaders. This is related to the model in Section 2.3, where debt capacity of the follower endogenously shrinks as the interest rate declines because the competitive position of the follower becomes weaker.

4.2 Firm Growth

Do industry leaders take advantage of the lower cost of debt financing by borrowing more aggressively and growing? Figure 6 displays results from estimating equation (9) with the natural logarithm of assets, the natural logarithm of debt, and leverage as dependent variables, and ω as the policy news shock.[4]

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[4]For expositional purposes, the results are only shown for ω; the results are largely similar for other news shocks. These results are reported in panels a) - c) of Figure A.1 in the appendix.

There are large and persistent effects of interest rate news shocks on assets and the capital structure of leaders relative to followers. Close to the zero lower bound (left column of Figure 6), an additional 10 basis points reduction in interest rates implies 1.9% differentially larger asset growth for leaders two years after the shock. Moreover, leaders use the differentially stronger decline in their borrowing costs relative to followers for a 3.3% differential increase in debt issued, which leads to a 0.48 percentage point increase in their book leverage. All three effects are mitigated as the level of the lagged interest rate rises (right column of Figure 6). As before, the effects are typically halved as interest rate rises from zero to 2%.

4.3 Investment

Does the cost of capital and financing advantages for leaders at low rates translate into real outcomes as well? Figure 7 estimates equation (9) with log Property Plant and Equipment (PPE), cumulative capital expenditures, and cumulative acquisitions as outcome variables. We normalize capital expenditures and acquisitions by assets in $t-1$.

For all three outcomes, estimates of β_{ZLB} are negative (left column of Figure 7), implying that a negative interest rate shock when the economy is near the zero lower bound leads to a relative increase in real activity by leaders versus followers. Quantitatively, a 10 basis points reduction in interest rates when the economy is near the zero lower bound leads to 2.1% higher PPE of leaders relative to followers after two years. Their capital expenditure rises differentially by 0.33 percentage points more and their acquisitions rise by 0.68 percentage points more relative to total assets.

Estimates of β_Δ are positive (right column of Figure 7). If the economy starts at a high initial interest rate, the relative increase in real economic activity by leaders versus followers after a negative interest rate shock is smaller. As before, the effects are roughly halved as the level of interest rate rise from zero to 2%.[5]

The overall pattern in Figure 7 suggests that a negative interest rate shock will have different effects depending on the initial interest rate. When the initial interest rate is very low, the advantage of the leaders relative to the followers in response to a further decline in the interest rate is particularly large. This result hints at the importance of declining interest rates in explaining product market competition: the big get bigger when interest rates decline from an already low level. These findings also support the model proposed by Chatterjee and Eyigungor (2020), who argue that a lower risk-free rate benefits bigger firms because they can increase leverage by more than smaller firms, and therefore acquire more of the new product varieties arriving into the economy.

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[5]Figure A.2 in the appendix confirms that these effects are largely robust to using the other interest rate shocks. Interestingly, the investment response seems particularly driven by the short end of the yield curve.

4.4 Stock Returns

Lower interest rates disproportionately benefit the top 5% of firms in an industry. Figure 8 shows that the differential financing advantage and investing activity of leaders is reflected in differentially higher stock returns after a negative interest rate news shock ω.

Results are statistically weaker than the ones for borrowing costs, capital structure, and investment. Yet, we observe that a reduction in interest rates when the economy is close to the zero lower bound leads to higher returns for leaders (left panel of Figure 8) relative to followers. This effect is reduced if the level of interest rate is higher (right panel of Figure 8).

4.5 Robustness Checks

We performed a number of robustness checks for the main results documented in this section. The details are all mentioned in online appendix, but we enumerate the robustness checks here. First, we show robustness to alternative definitions of shock ω, including using just the federal funds rate or the component orthogonal to federal funds. Second, we show that our results are robust to alternative definitions of leader variable, including using sales to rank firms. Third, the results are also robust to alternative industry definitions used in the literature.

Fourth, we estimate the local projections in levels. We also show robustness to alternative window length around FOMC, and dropping unscheduled FOMC meetings.

4.6 Summary

Table **??** presents the point estimates for equation (9) for all of the outcomes discussed above. For this specification, the local projection is for $h = 8$; that is, the outcomes are evaluated eight quarters after the interest rate shock ω. The only exception to this is column (8) with stock return as the dependent variable. Since stock return is by definition a forward looking variable, we report the coefficient for the first quarter after shock, i.e. $h = 1$.

When the economy is close to the zero lower bound, a negative shock to the interest rate leads to a relative decline in borrowing costs for leaders versus followers, and also a relative increase in debt, assets, investment, acquisitions, and stock returns. Furthermore, the stronger relative effects for leaders versus followers are mitigated if the negative interest rate shock happens in a high interest rate environment. In general, the stronger effect for leader close to zero lower bound drops by about one-half when interest rate is 2% instead of zero.

5 The Competition-Neutral Rate

The mitigation of the advantage that leaders receive from a decline in interest rates in a high rate environment across a range of firm outcomes suggests the notion of a "competition-neutral rate", or an economy-wide interest rate level at which the change in the interest rate is neutral

from a competition perspective. When the economy is operating at the competition-neutral rate, a change in the interest rate has the same effect for both industry leaders and followers.

The notion of competition-neutral rate is thus analogous to the traditional notion of neutral or natural rate in macroeconomics that refers to the economy-wide interest rate that balances aggregate demand and aggregate supply. The empirical results in this paper suggest the possibility of another neutral rate that balances the level of competition between industry leaders and followers. This opens up interesting questions for future work. For example, if the traditional natural rate of interest does not coincide with the competition-neutral rate of interest, there is a natural trade-off to explore when evaluating monetary, fiscal, and other macroeconomic policies.

Let η be the competition-neutral nominal rate of interest. We can estimate η in our empirical framework as:

$$\eta = -\frac{\beta_{ZLB}}{\beta_\Delta}. \tag{12}$$

When the economy-wide interest rate is η, the effect of a change in interest rate is equal for both industry leaders and followers. We next discuss how η can be estimated for each firm-level outcome, and how these different estimates of η can be combined together to give us the implied economy-wide estimate of the competition-neutral rate.

5.1 Individual Estimates of Competition-Neutral Rate

We use equation (12) and the two year out (i.e. at $h = 8$) estimates of β_{ZLB} and β_Δ in section 4 to estimate the competition-neutral rate $\hat{\eta}$ for each outcome variable. Asymptotically consistent standard errors for each of these neutral rates are calculated according to the delta method. Defining $\hat{\eta} = g(\hat{\beta}_{ZLB}, \hat{\beta}_\Delta)$, the variance of $\hat{\eta}$ is given by $\nabla g(\hat{\beta}_{ZLB}, \hat{\beta}_\Delta)' \Sigma \nabla g(\hat{\beta}_{ZLB}, \hat{\beta}_\Delta)$, where $\nabla g(\hat{\beta}_{ZLB}, \hat{\beta}_\Delta)$ denotes the gradient of g and Σ denotes the covariance matrix of $[\hat{\beta}_{ZLB}, \hat{\beta}_\Delta]$.

Panel A of Table ?? reports the eight individual estimates of the neutral rate. Given our variable definitions, the competition-neutral rate is measured in terms of nominal federal funds rate. The estimates for competition-neutral rate range from 3.7 percentage points in the case of borrowing costs as the dependent variable, to 6.6 percentage points with capital expenditure as the dependent variable.

While this is a large range, it is important to realize that specifications with smaller point estimates (columns 1, 3, 7 and 8) are much more precisely estimated than remaining specifications that have higher point estimates. We therefore need a formal procedure for appropriately averaging these estimates in order to come up with an efficient estimate of the economy-side competition-neutral rate. The procedure should naturally take into account the standard error of each of the eight estimates, as well as the correlation between each estimate. For example, if two firm-level outcomes are highly correlated, then their respective $\hat{\eta}$ estimates should not treated as independent.

5.2 Economy-wide Estimate of Competition-Neutral Rate

The efficient estimation of economy-wide competition-neutral rate optimally weighs each individual estimate such that the variance of the economy-wide estimate is minimized. Formally, let R be the $G \times 1$ vector of the individual neutral rate estimates and let Ω be the associated $G \times G$ covariance matrix. Taking these quantities as given for the moment, the variance of the weighted average is given by $w'\Omega w$, where w is the $G \times 1$ vector of weights. Thus, the optimal weights solve the following problem:

$$\min_{w} w'\Omega w \qquad \text{s.t.} \tag{13}$$

$$w'\mathbf{1}_k = 1 \tag{14}$$

where $\mathbf{1}_k$ is a $G \times 1$ vector of ones. This problem is identical to a minimum variance portfolio problem with variance-covariance matrix Ω.

The set of weights w^* that minimise the variance of the weighted average and jointly sum to one are given by the solution to the following system:

$$\begin{bmatrix} 2\Omega & 1 \\ \mathbf{1}_k' & 0 \end{bmatrix} \begin{bmatrix} w \\ \lambda \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \tag{15}$$

To carry out this procedure, we first obtain estimates of Ω, the covariance matrix for our estimates of the competition-neutral rate for various firm outcomes. The delta method outlined above gives us estimates of the variance of each estimator, that is, the diagonal entries of Ω. If the samples used to estimate each equation were distinct, we could assume independence and thus that Ω is diagonal. However our eight estimates come from highly correlated variables in the same sample. We must therefore account for this by estimating the covariance between our distinct estimates of the natural rate.

We obtain estimates of the covariance of coefficients across models using the seemingly unrelated regression (SUR) approach introduced by Zellner (1962). We use this method to calculate the covariance matrix of the entire set of regressors across all models and then apply a multivariate version of the delta method to obtain the covariance matrix Ω of the G neutral rate estimates. In turn, we obtain the optimal weights w^* from solving the system of equations in (15) and can construct the joint estimate $\bar{\hat{\eta}} = R'w^*$.

For the SUR model, we proceed as follows. In general terms, one can express the full model for a sample of N observations and G individual models, the seemingly unrelated regressions. Each individual model features K_g regressors and let $K = \sum_g K_g$. Letting $y_{i,g}$ denote the dependent variable and $x_{i,g}$ the vector of independent variables of equation $g \in \{1, ..., G\}$ we

can write the full model as the following system of equations:

$$
\begin{bmatrix} y_{i,1} \\ \vdots \\ y_{i,G} \end{bmatrix} = \begin{bmatrix} x_{i,1} & 0 & \ldots & 0 \\ 0 & x_{i,2} & & \vdots \\ \vdots & & & 0 \\ 0 & \ldots & 0 & x_{i,G} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_G \end{bmatrix} + \begin{bmatrix} u_{i,1} \\ \vdots \\ u_{i,G} \end{bmatrix} \tag{16}
$$

In our case, $G = 8$. $x_{i,g}$ contains the double and triple interaction terms as well as the lag augmented variables and the time-industry fixed effects. β_g contains $\beta_{ZLB,g}$ and $\beta_{\Delta,g}$ and the coefficients on the other regressors.

More compactly, we can write the system as $Y_i = \beta X_i + U_i$ and after stacking the observations in a matrix, we can in turn express the entire model as:

$$
\boldsymbol{Y} = \boldsymbol{X}\boldsymbol{\beta} + \boldsymbol{U}
$$

where $\boldsymbol{Y} = (Y_1, ..., Y_N)'$ is an $NG \times 1$ vector and $\boldsymbol{X} = (X_1, ..., X_N)'$ is an $NG \times K$ matrix. We can estimate this system by OLS, with the estimate being given by $\hat{\boldsymbol{\beta}} = (\boldsymbol{X'X})^{-1}(\boldsymbol{X'Y})$. These estimates are numerically equivalent to equation by equation OLS estimation of $\hat{\beta}_g$. The covariance matrix of these estimates, $\boldsymbol{\beta}$, can be estimated consistently as $V(\hat{\boldsymbol{\beta}}) = (\boldsymbol{X'X})^{-1}(\sum_i X_i'\hat{U}_iU_i'\hat{X}_i)^{-1}(\boldsymbol{X'X})^{-1}$. The final step consists of applying the multivariate delta-method to obtain the variance-covariance matrix of $\bar{\bar{\eta}}$, $V(\bar{\bar{\eta}})$. Combining everything, we obtain the optimal weights w^* and can use those to construct the single estimate of the neutral rate $\bar{\bar{\eta}}$, which we report in Panel B of Table **??**.

We perform three variations of this exercise. First, we use the baseline regressions reported in Table **??** to obtain a single estimate of the neutral rate. These regressions feature overlapping but distinct samples. When an observation is used in model g but is missing in model h, we can just set its weight to zero when calculating the covariance between coefficients in g and h. Hence, if all models were estimated on mutually exclusive samples, the covariance matrix Ω would be diagonal.

Second, we estimate $\bar{\bar{\eta}}$ only from the common sample of observations for which we observe all 8 outcome variables. This ensures that our estimate is not driven by those observations which only enter the estimation for some of the outcome variables. Third, we estimate a version of the SUR where we not only use a common sample but also modify the baseline equation (9) to include the same explanatory variables for all observations. So we include lags of all eight independent variables in each equation when lag-augmenting the regressions. One can interpret the common sample version of the SUR model as a version of the vector regression with zero sign restrictions on the lags of the dependent variable, other than dependent variable of equation g.

Panel B of Table **??** contains our economy-wide estimates of η. The baseline estimate

using all available observations in column (1) gives us an economy-wide competition-neutral rate of 4.4 percentage points. This is in the lower range of the individual estimates in Panel A, consistent with the earlier intuition that the lower point estimates in Panel A are more precisely estimated and are therefore more informative.

Columns (2) and (3) use only the common sample and the competition-neutral interest rate is estimated to be 3.8. Overall, these exercises suggest an economy-wide competition-neutral rate of around 4 percentage points over our sample period. Below that rate, a fall in the interest rate benefits leaders more than follower, and the differential benefit grows as the economy-wide nominal interest rate gets closer to zero.

6 Testing for Identification Concerns

This section tests for various identification concerns that one may have with the methodology used earlier. First, we test whether the differential impact of interest rate change ω is spuriously drive by macro news shocks that FOMC announcement may itself be responding to. Second, we test if our results are driven by some spurious time-trend such that industry leaders benefit more from interest rate cuts as time passes. Third, we test if our leader dummy at the firm level happens to be spuriously correlated with certain firm-level attributes that are the fundamental drivers of our results.

6.1 Controlling for Macro News

As we discussed in section 3.3, one recent criticism of high frequency identification is that the high frequency change in interest rate around FOMC announcement is itself a function of macro news. In particular, change in interest rate around FOMC window is positively correlated with change in monthly Blue Chip consensus GDP forecast. Nakamura and Steinsson (2018) interpret the positive correlation as forecasters reacting to Fed's superior inside information that generates the interest rate surprise. However, Bauer and Swanson (2022) argue that the positive association reflects market's surprise that the Fed responded more aggressively to macro news than anticipated at FOMC announcement. [6]

While this debate is clearly important for the interpretation of FOMC announcement effect for the macroeconomy, the criticism does not directly affect our identification since we have a difference-in-differences approach. As long as the prior macro news impact leaders and followers similarly, our methodology essentially differences out this component.

However, one may still have a concern that macro news shocks leading up to FOMC announcements have materially different implications for industry leaders versus followers. While it is hard to think of an obvious theory why that would be the case in general, it is even harder to come up with an alternative theory that can explain why differential impact amplifies

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[6]See also Jarociński and Karadi (2020)

in a low-rate environment. Therefore, a priori such identification concerns have low likelihood of being important.

Nevertheless, Figure 9 explicitly allows for the possibility that macro news shocks may differentially impact industry leaders versus followers. The figure plots β^h_{ZLB} and β^h_Δ for each of the eight dependent variables after controlling for the change in Blue Chip consensus GDP forecast and its interactions with the leader dummy as well as with the leader dummy times level of interest rate interaction.[7]

The solid black line in Figure 9 represents the baseline estimate as depicted in Figures 5 through 8 for comparison. The estimated β^h_{ZLB} and β^h_Δ coefficients after controlling for macro news shock are very similar to earlier estimates reported in section 4. In fact the coefficient magnitudes are even stronger in the case of leverage and stock returns as dependent variables.

We also repeat this exercise using expected output growth from the Philadelphia Fed's Survey of Professional Forecasters (SPF) as the macro news control variable in Figure 10. The SPF surveys a set of typically 30 - 40 forecasters about their economic expectations. The estimated coefficients are once again very similar to our baseline estimates represented by the solid black line.

6.2   Controlling for Time Trend

One of our core results is that the advantage gained by industry leaders in response to interest rate decline gets stronger in low-rate environment. This is captured by the coefficient β_Δ. Since there has been a general tendency for the interest rate to decline over recent decades, there may be a concern that the strengthening of the leader advantage in response to an interest rate decline is driven by some other spurious time trend.

As discussed in the introduction, it is difficult to come up with a specific alternative hypothesis that would generate such a spurious time trend. Nonetheless, we still consider the possibility that there may be a spurious "time-trend"—for reasons as yet unknown—that has the following characteristics: industry leaders were not more responsive to interest rate shocks than industry followers early on, but over time have become more responsive for unknown reasons.

This is a difficult possibility to rule out since the broader decline in r is naturally correlated with time. However, it is not perfectly correlated. Figure 11 plots β^h_Δ coefficients after controlling for a linear time trend, its interactions with the leader dummy as well as with the leader dummy times the level of interest rate interaction.[8] The specification with time trend controls is quite demanding as it identifies β_Δ from differences in the level of interest rates beyond the secular downward trend in rates. As an example, there are large tightening cycles in the mid 1990s and again in the mid 2000s.

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[7]See figure notes for the full formal specification. We use exactly the same change in Blue Chip consensus GDP forecast variable used in the original Nakamura and Steinsson (2018) for consistency with earlier work. However, we also constructed this variable from raw data ourselves and get very similar results.

[8]See figure notes for full formal specification

The results indicate that even after controlling for a linear time trend and its interactions, the core results broadly hold across the eight dependent variables. As before, the solid black line in Figure 11 represents the baseline estimate as depicted in Figures 5 through 8. With the exception of leverage, the new point estimate after including the time trend, represented by the solid blue line, tracks closely the point estimate when we do not include a time trend. The confidence intervals get wider with the inclusion of time trends, highlighting the reduction in statistical power. This is likely due to the fact that the time trend absorbs a lot of the baseline variation in interest rates due to the secular downward trend in nominal and real interest rates over the past thirty years.

6.3 Firm-level Controls

We have so far controlled for variables that might be spuriously correlated with the interest rate shock ω_t, or the level of interest rate FFR_{t-1} in equation (9). We now control for firm-level variables that might be spuriously correlated with the industry leader dummy $L_{i,j,t-1}$. The black dot in Figure 12 indicates the baseline estimate for the 8 quarter ahead local projection estimate for β_{ZLB} or β_Δ respectively, along with their 95% confidence interval.

Figure 12 then reports how the estimates of β_{ZLB} and β_Δ change when adding a specific firm-level controls $x_{i,t-1}$ by a) itself, (b) interacting it with the interest rate shock ω, (c) with the level interest rate FFR_{t-1}, and (d) with ω times the level of interest rate FFR_{t-1}. The firm-level controls we consider include a firm's market beta, interest coverage ratio, book-to-market value, price-to-earnings ratio, and leverage. The idea is to test whether factors correlated with being a leader are responsible for the differential effect of interest rate shocks on outcomes.

One concern is that leaders and followers differ by their sensitivity to the market. Industry-time fixed effects absorb differences in cross-industry differences in sensitivity to market beta but within-industry differences remain. The first robustness check controls for firms' market beta. The red squares show that the point estimates when controlling for market beta interacted with the interest rate shock lies close to the baseline estimates.

Next, a control for the book-to-market ratio is added (green crosses in Figure 12). High book-to-market is typically associated with value stocks as compared to growth stocks with low book-to-market ratios. If, within each industry, leaders are disproportionately growth stocks, this would be an alternative potential explanation for the results above. Moreover, the book-to-market ratio is a common proxy for Tobin's Q and controlling for Q therefore also attempts to control for differences in investment opportunities. Including market-to-book ratios leaves all point estimates nearly unchanged.

Given that changes in interest rates affect the present value of discounted cash flows, differences in the duration of leaders' and followers' cash flows could partly be driving our results. In particular, if leaders have longer duration cash flows, they would be more sensitive to the same interest change as compared to followers. We use a firm's price-to-earnings ratio as a

proxy for the duration of cash flows, with the idea that a higher price-to-earnings ratio implies a longer duration of cash flows. The yellow crosses in Figure 12 indicate that the point estimates when controlling for the price-to-earnings ratio interacted with the interest rate shock do not meaningfully change. Differences in the duration of cash flows are unlikely to be driving the baseline results.

The next set of results controls for firms' ex-ante financial position, again interacted with the interest rate shock. The different responses across leaders and followers could be driven by ex-ante differences in leverage or interest coverage. For instance, if leaders are less levered, they have more ex-ante remaining debt capacity when an interest rate shock occurs and this might be driving the differential financing responses.

The purple circles show the point estimates when including leverage interacted with the interest rate shock. All point estimates lie within the baseline 95% confidence band and, except for PPE and assets, there is little difference in the baseline point estimate.

Finally, a control for the interest coverage ratio interacted with the interest rate shock is added. Even if differences in leverage do not explain the results, there is a concern that if leaders are financially less vulnerable because they can more easily cover their interest expenses, these differences could explain the differential financing response across leaders and followers. The interest coverage ratio is computed as earnings over interest expenses at the firm-level. The blue triangles in Figure 12 show that most point estimates are very similar to the baseline estimates. Results are quantitatively slightly smaller for PPE, assets, and debt but statistically indistinguishable from the baseline point estimates.

Overall, the baseline results are robust to the inclusion of various firm-level controls that address specific alternative hypotheses. It should also be kept in mind when considering candidates for firm-level controls that we do not control for firm attributes that are potentially endogenous according to the theory highlighted in section 2. For example, interest rate decline in a low rate environment endogenously makes market followers weaker as they cannot compete as well with industry leaders as before. In this sense, one would not want to "over control" with firm level controls in the regression specification.

7 Conclusion

Using CRSP-Compustat merged data from 1994 to 2019 and high frequency interest rate shocks as a source of variation in economy-wide interest rates, we find that a decline in the interest rate disproportionately lowers the cost of borrowing of industry leaders relative to industry followers. Leaders take advantage of the lower cost of borrowing to raise additional debt financing, increase leverage, boost capital investment, and conduct acquisitions. All of these effects become stronger as the level of the interest rate declines; that is, a decline in interest rates has a stronger effect on all of these outcomes of leaders relative to followers when the initial level of the interest rate is already low.

These results suggest that there is a "competition-neutral" level of interest rate, at which the effect of interest rate change is the same for both industry leaders and followers. We formally estimate the competition-neutral nominal federal funds rate to be 4.4 percentage points over 1994 to 2019 period when average inflation was 2.2 percentage points. The findings provide empirical support to the idea that extremely low interest rates may be a contributing factor in explaining the rise of superstar firms in the U.S. economy.

The basic empirical facts documented in this paper open some interesting questions for further investigation. What are the deeper factors that make industry leaders benefit from a very low rate environment? We offered some suggestions in the theoretical section, but clearly there may be other useful avenues to explore.

Our results also open up a more fundamental question. What if the competition-neutral rate is significantly different from r^*, or the natural rate of interest? While it is only natural for monetary policy to move toward r^*, one may need to combine monetary policy with other policies such as anti-trust policy to mitigate the potentially negative effects on competition. As the world increasingly finds itself in a very low rate environment for long periods of time, these and related questions deserve greater attention.

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Table 1: Summary Statistics of Outcomes

	N	Mean	SD	p25	p50	p75
Borrowing Costs	286,863	7.43	3.79	5.02	7.00	9.19
Stock Returns	401,927	-1.32	25.63	-12.02	0.72	11.37
Leverage	417,482	23.49	23.69	2.16	19.10	36.40
Acquisitions Expenditure	333,292	3.66	16.82	0.00	0.00	1.09
Capital Acquisition Expenditure	346,870	6.73	15.65	1.81	3.90	7.76
Debt	418,252	656.19	5,095.14	0.77	16.23	196.60
Assets	433,064	2,746.59	15,422.87	45.05	201.92	1,039.01
Property, Plant, and Equipment	432,049	955.01	5,276.53	5.17	34.91	256.10

Notes: This table reports summary statistics for our main outcomes. Borrowing Costs is defined as the annualized quarterly interest expenses (xintq) over interest-bearing debt (dlcq + dlttq). Stock Returns is log(price at quarter t + dividends at price t) / log(price at quarter t-1). Leverage is current debt (dlcq) plus long-term debt (dlttq) divided by assets (atq). Acquisition Expenditure is the sum of funds destined to companies acquisitions (acqy) over 4 quarters divided by its lagged assets (atq). Capital Acquisition Expenditure is the sum of Capital Expenditure (capxy) over 4 quarters divided by its lagged assets (atq). Borrowing Costs, Stock Returns, Leverage, Acquisition Expenditure, and Capital Acquisition Expenditure are in percentage points. Debt is defined as current debt (dlcq) plus long-term debt (dlttq). Assets is the total value of assets (atq). Property, Plant, and Equipment is the total value of tangible fixed property net of depreciation (ppentq). Debt, Assets, and Property, Plant, and Equipment are in millions of dollars.

Table 2: Summary Statistics of Shocks

	ω	ω^{ff}	$\tilde{\omega}$
Mean	–0.88	–1.70	0.00
SD	16.32	8.98	10.32
Min	–72.12	–40.94	–32.66
Max	37.27	26.10	28.15
N	99	103	99

Notes: All units are in basis points. ω denotes r-news shocks around FOMC meeting announcements as calculated by Nakumura and Steinsson (2018) and extended by Acosta and Saia (2020). Federal Funds shock denotes the shock to fed funds futures around FOMC meeting announcements. We use data from Gorodnichenko and Weber (2015) to extend the series of Fed Funds shocks where possible. Orthogonalized Policy News Shock is the residual from regressing Policy News shocks on Federal Funds shocks.

Table 3: Borrowing Cost

	(1) Leader	(2) Market val	(3) Leverage	(4) P/E	(5) ICR	(6) Distance to default	(7) Earnings /Assets	(8) S&P Rating
X	-1.64***	-0.40***	1.07***	-0.0043***	-0.11***	-0.15***	-5.37***	0.98***
	(0.083)	(0.014)	(0.12)	(0.00056)	(0.0028)	(0.0092)	(0.46)	(0.031)
N	275,494	284,517	286,851	220,076	216,165	155,852	270,287	85,723
R-sq	0.108	0.144	0.097	0.128	0.199	0.109	0.109	0.316

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Differential response of leaders to monetary policy shocks

	Dependent Variable							
	borrowing cost	log debt	leverage	log assets	log PPE	capital exp	acquisitions	stock return
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\hat{\beta}_{ZLB}$	1.45***	-0.33***	-0.048***	-0.19***	-0.21***	-0.033***	-0.068***	-0.13***
	(0.38)	(0.096)	(0.012)	(0.047)	(0.050)	(0.0097)	(0.019)	(0.020)
$\hat{\beta}_{\Delta}$	-0.39***	0.073***	0.010***	0.041***	0.036***	0.0051**	0.015***	0.022***
	(0.089)	(0.027)	(0.0029)	(0.013)	(0.013)	(0.0024)	(0.0043)	(0.0047)
N	137,959	177,759	234,066	249,311	247,342	228,906	212,148	303,155
R-sq	0.35	0.16	0.18	0.22	0.26	0.55	0.12	0.44

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Regression results for the lag augmented local projection specification $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t^m * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t^m * L_{i,t-1} * i_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \omega_{i,t-\ell} + \epsilon_{i,t+h-1}$ for firm i in industry j at date t. $L_{i,t}$ is an indicator equal to 1 at date t when a firm i is a leader in its industry, defined as top 5% of firms by market capitalization in an industry on date $t-1$. i_{t-1} being the effective federal funds rate at the end of the previous quarter and ω_t being the sum of r-news shocks between time $t-1$ and t. Industry classifications are the Fama-French industry classifications (FF). $z_{i,t} = \{L_{i,j,t-1}, L_{i,j,t-1} * i_{t-1}\}$ is a vector of contemporary controls while $\omega_{i,t-1} = \{\Delta y_{i,t-1}, \epsilon_{t-1}^m * L_{i,t-2}, \epsilon_{t-1}^m * L_{i,t-2} * i_{t-1}, z_{i,t-1}\}$ is a vector containing lagged values of all variables in the system. Lag augmentation implies heteroskedasticity-robust standard errors are sufficient, according to Olea and Plagborg-Møller (2020).

**Table 5:** Neutral rate $\hat{\eta}$ estimate for each outcome variable

	Panel A: Estimates of the Neutral Rate							
	borrowing cost	log debt	leverage	log assets	log PPE	capital exp	acquisitions	stock return
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\hat{\eta}$	3.69***	4.55***	4.67***	4.49***	5.83***	6.58***	4.43***	5.91***
	(0.47)	(0.84)	(0.60)	(0.78)	(1.11)	(1.85)	(0.58)	(0.63)
N	137,959	177,759	234,066	249,311	247,342	228,906	212,148	303,155

	Panel B: Combining estimates of neutral rate		
	(1)	(2)	(3)
	Baseline	Common sample	Vector Regression
$\bar{\hat{\eta}}$	4.37***	3.84***	3.84***
	(0.47)	(0.41)	(0.39)
N	306,213	113,591	113,591

Standard errors in parentheses

$^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

This table reports estimates of the neutral interest rate implied from table **??**. The neutral rate η is an estimate of nominal federal funds rate, such that an r-news shock ω has the same impact for both industry leaders and followers. It is given by $\hat{\eta} = -\frac{\beta_{ZLB}}{\beta_{\Delta}}$. The combined estimates given in panel B are the weighted average of the estimates in panel A, with weights chosen to minimize the variance of the combined estimator $\bar{\hat{\eta}} = \sum w_k \hat{\eta}_k$. Standard errors of this estimate are calculated accoridng to the delta method.

Figure 1: Corporate Profits and Tobin's Q

**(a)** Corporate Profits/ GDP

(b) Tobin's Q
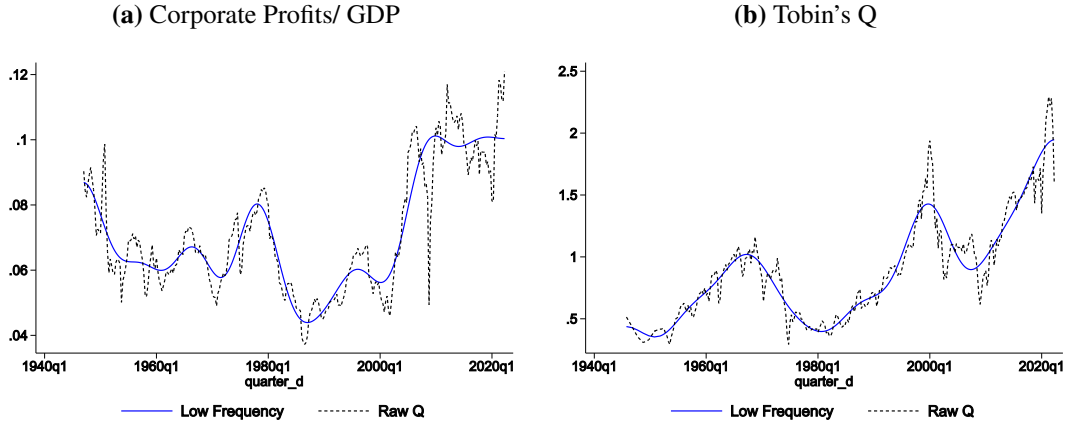
Data for panel a) is from National Accounts and sourced through FRED. Data for Panel b) is from Flow of Funds. Low Frequency series are estimated according to the methods outlined by Müller and Watson (2018), considering only frequencies greater than 10 years (40 quarters). Defining the function $\psi(s,j) = \sqrt{2}cos(\pi js)$, we let Ψ be the $T \times q$ matrix defined such that $\Psi_{t,q} = \psi((t-1/2)/T, j)$, where $q = 2T/40$. We then define the low frequency projection of x_t to be predicted values from regressing $\Psi^0 = [1_T, \Psi]$ on x_t, where 1_T is a $T \times 1$ vector of ones. This filter removes variation at frequencies below the threshold we choose.

**Figure 2:** Borrowing costs for leaders since 1980
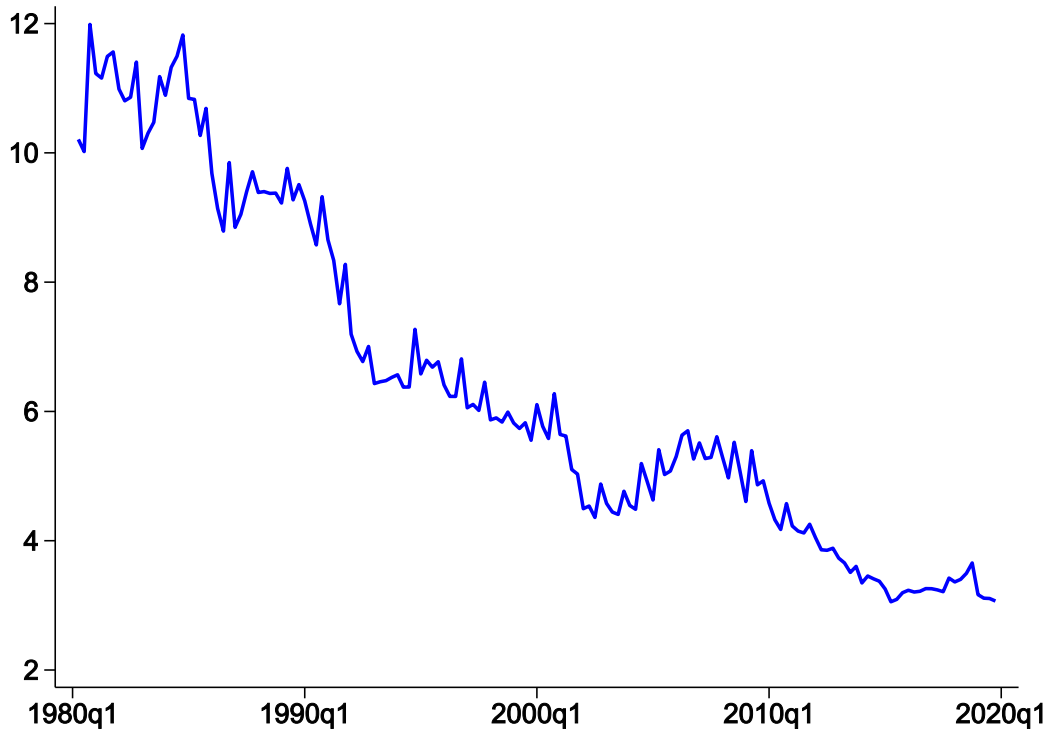
The figure plots the market value weighted average of firm borrowing costs. Borrowing cost is given by interest expense as a ratio of debt, measured in compustat.

Figure 3: r-news shocks and Federal Funds shocks
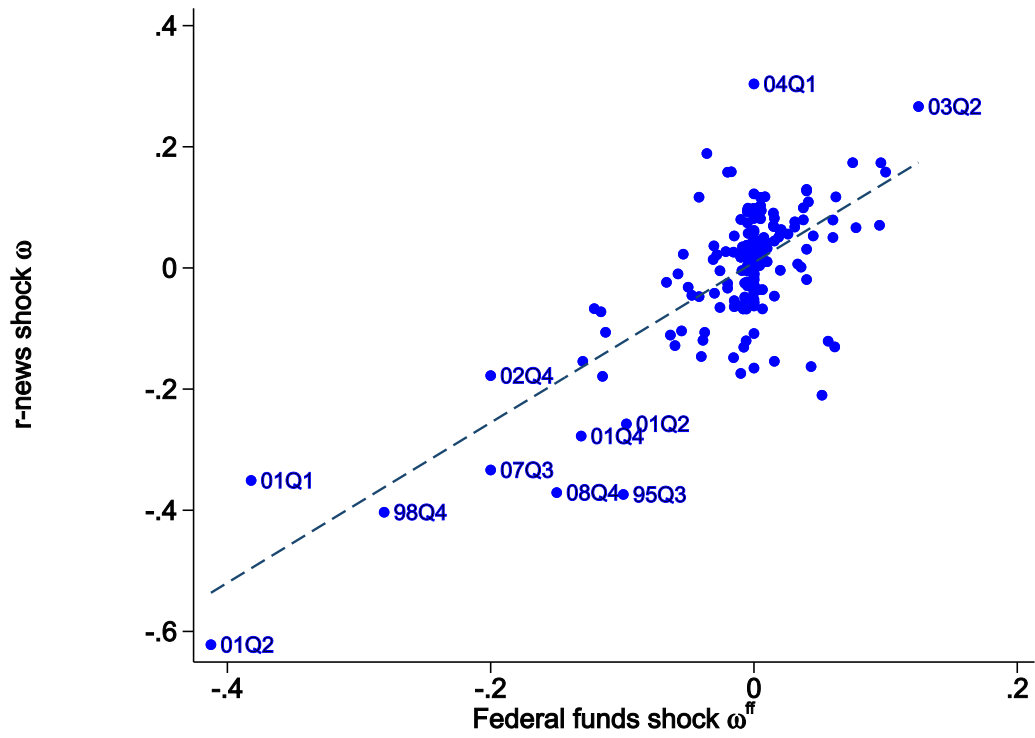
The figure plots the total r-news shock with its component of short term Federal Funds shock (obtained from Gorodnichenko and Weber (2016)). Note that various quarters with high interest rate shock variation are not related to crisis episodes.

**Figure 4:** Response of average borrowing cost to r-news shock (ω)
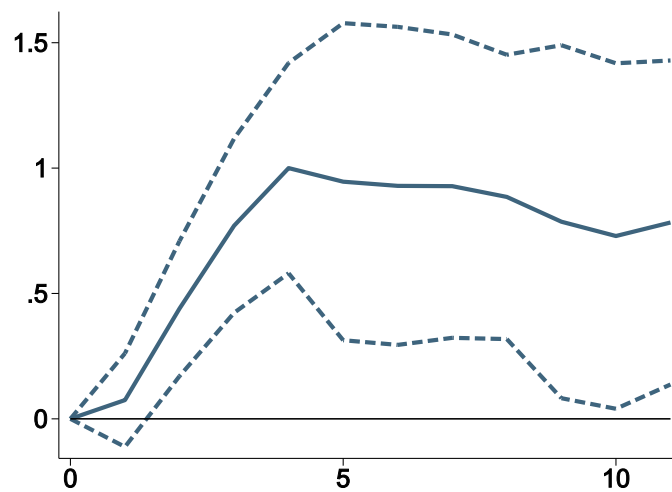
The figure shows the impulse response function of borrowing cost to r-news shock. The estimating equation is: $\Delta y_{t+h-1} = \alpha_h + \beta_h \omega_t + + \sum_{\ell=1}^{3} \Gamma'_h \omega_{t-\ell} + \sum_{\ell=1}^{3} \Theta'_h \Delta y_{(t-\ell)+h-1} + \epsilon_{t+h-1}$, where y denotes the average borrowing cost across firms and ω_t is the monetary policy shock. The plot shows β_h going from h = 1 to h = 11. ω is normalized such that the impact after four quarters is 1 basis point.
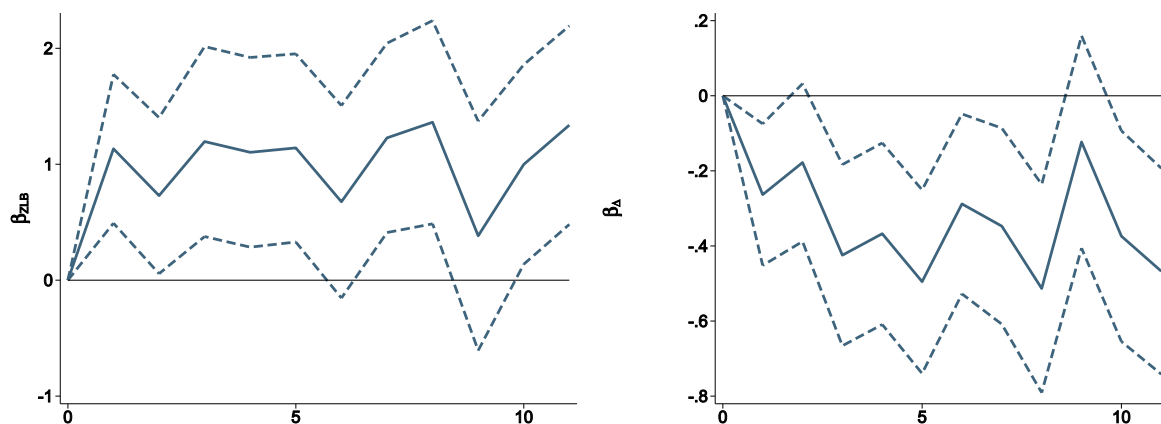
Figure 5: Response of borrowing cost to r-news shocks

(a) r-news shock (ω)
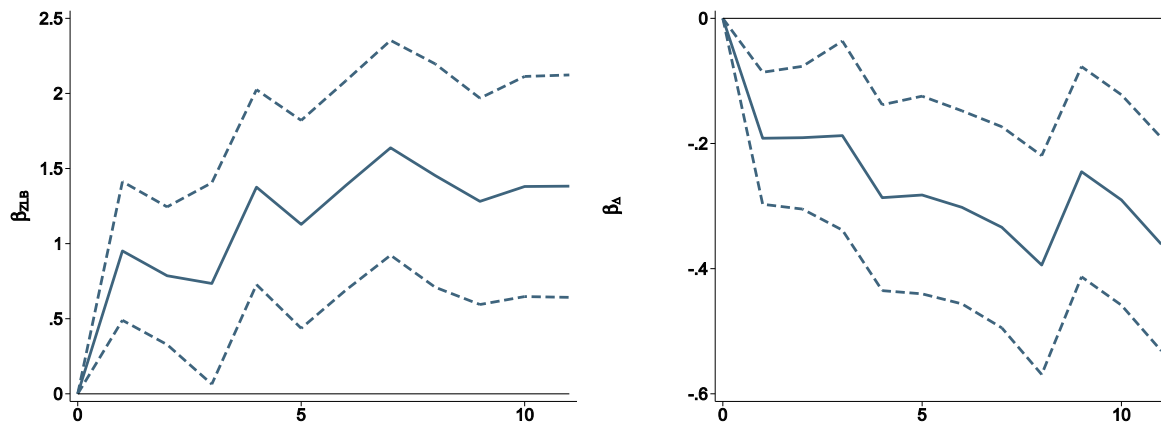
(b) Fed Funds shock (ω^{ff})
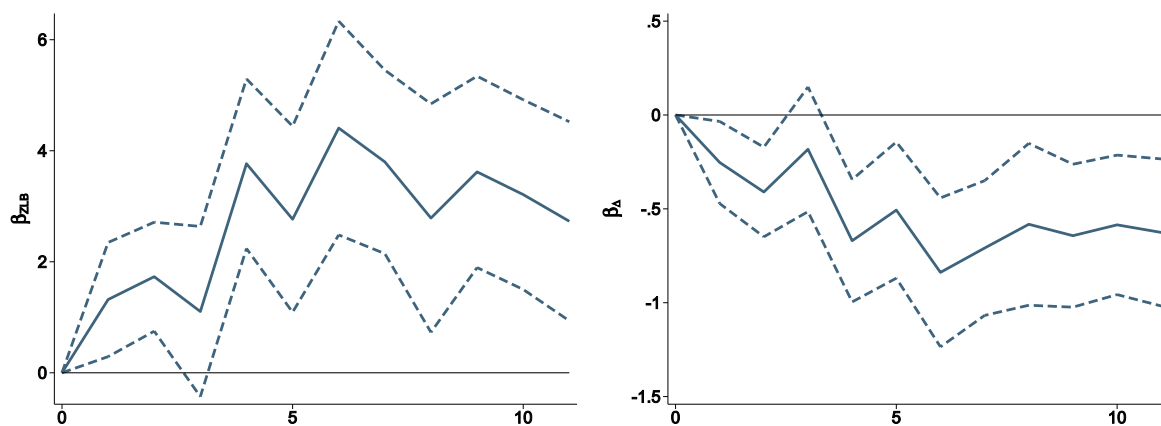
(c) Orthogonalized news shocks ($\tilde{\omega}$)

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^{3} \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes the average interest rate of firm i and ω is the monetary policy shock in question. The dotted lines indicate 95% confidence intervals.

Figure 6: Response of Financials to r-news shocks (ω)
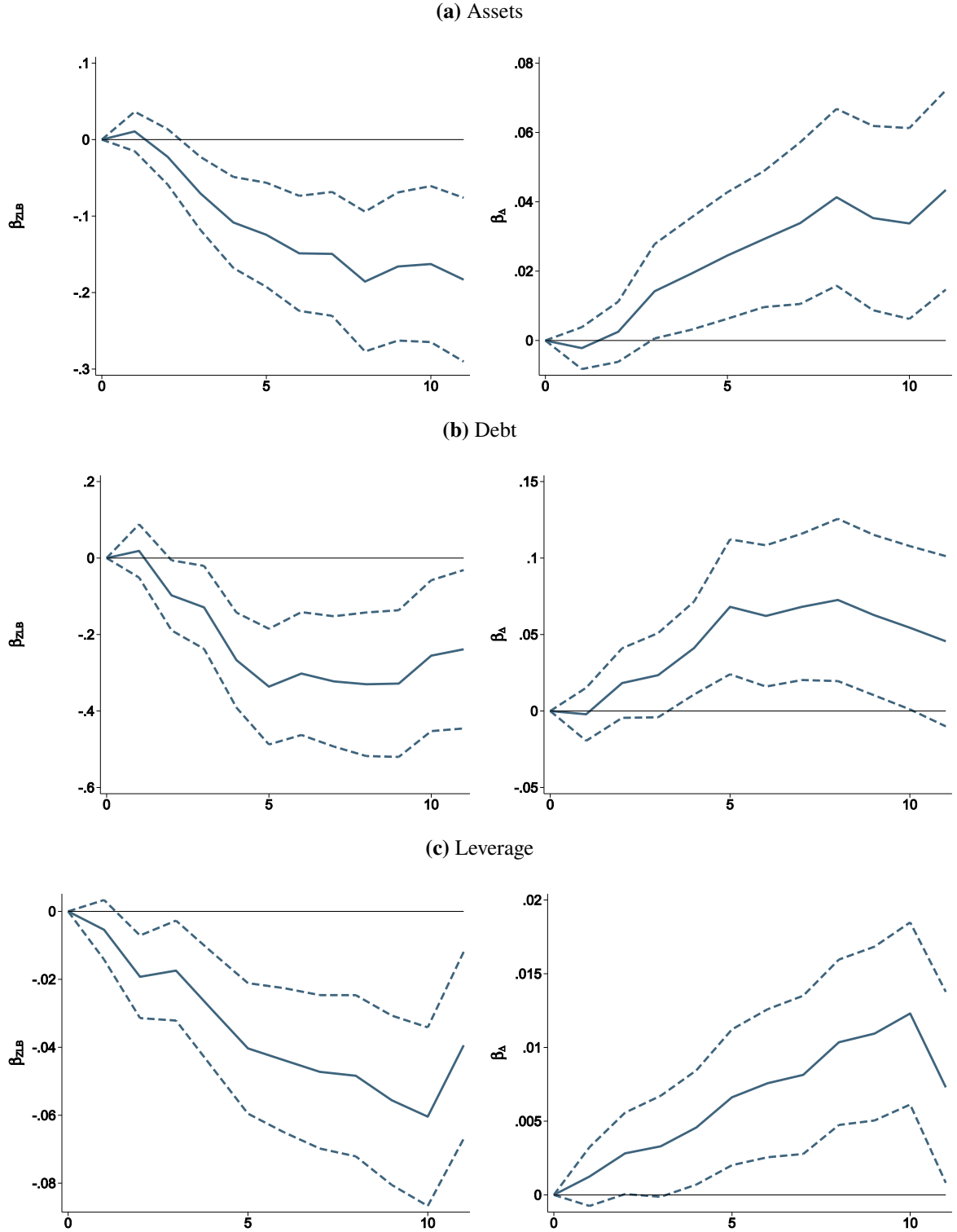
(a) Assets

(b) Debt

(c) Leverage

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes log of assets, log of debt and leverage of firm i. The dotted lines indicate 95% confidence intervals.

Figure 7: Response of firm investment to r-news shocks (ω)

(a) Property, Plant and Equipment
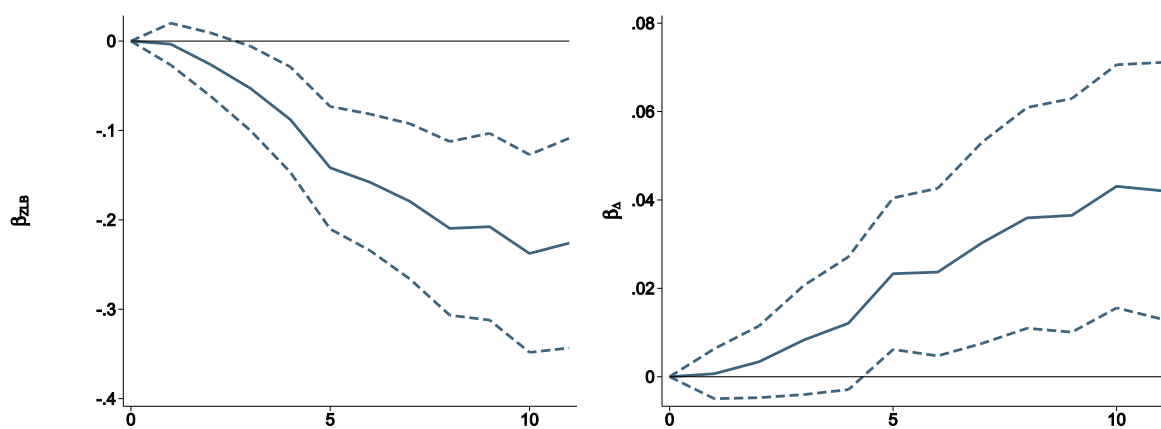
(b) Capital Expenditure

(c) Acquisitions
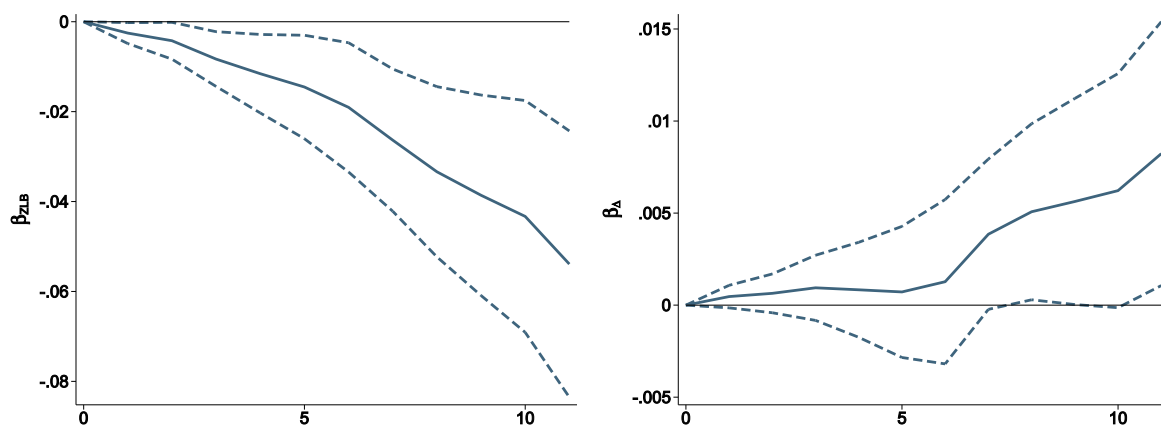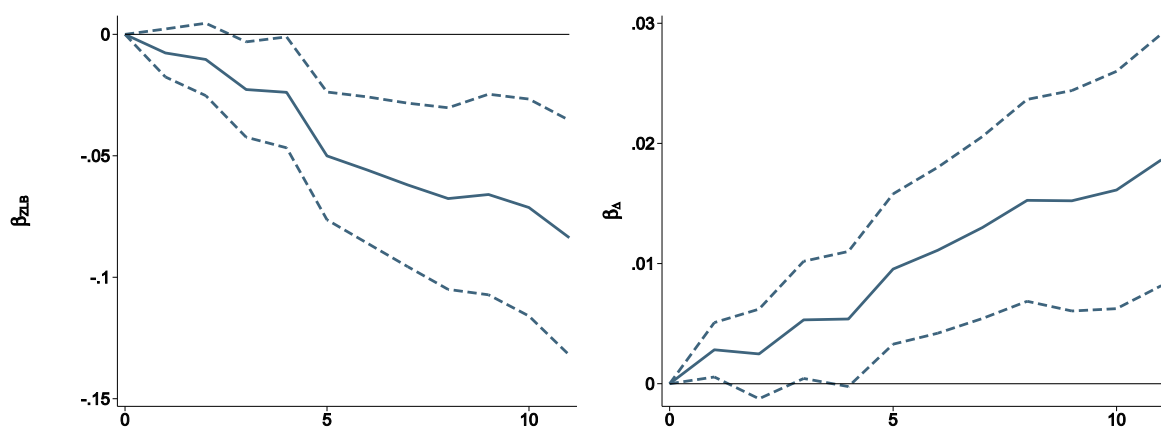

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_Δ^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_\Delta^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes log of PPE (property,plant and equipment), cumulative capital expenditure and cumulative acquisitions of firm i. We measure cumulative cash flows by cumulating and normalising by initial assets, such that $y_{i,t} = \sum_{t=-1}^t \frac{x_{i,t}}{a_{i,-1}}$ where $a_{i,t}$ denotes the firms assets and $x_{i,t}$ is capital expenditure of acquisitions. The dotted lines indicate 95% confidence intervals.

Figure 8: Response of stock returns to interest rate shocks (ω)
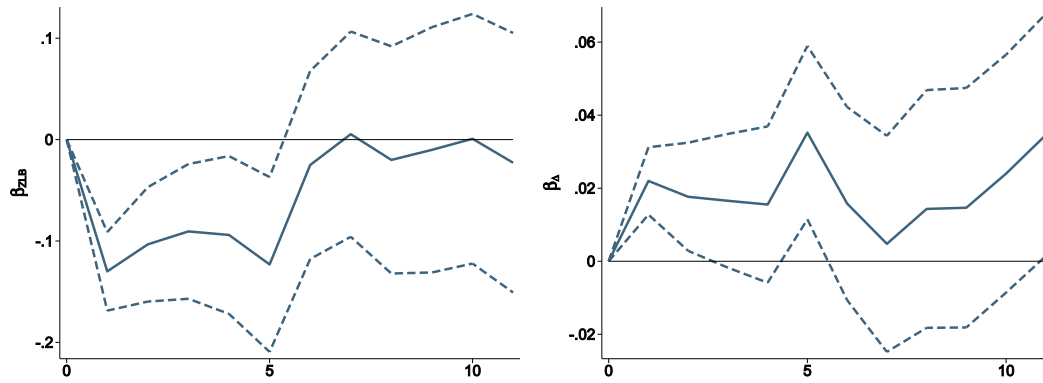
The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where $y_{i,t} = (p_{i,t} + d_{i,t})/p_{i,t-1}$ denotes log stock return of firm i, including dividends. Stock prices are calculated using the average daily stock price in the quarter. The dotted lines indicate 95% confidence intervals.

Figure 9: Robustness to output surprises - Blue Chip GDP forecast
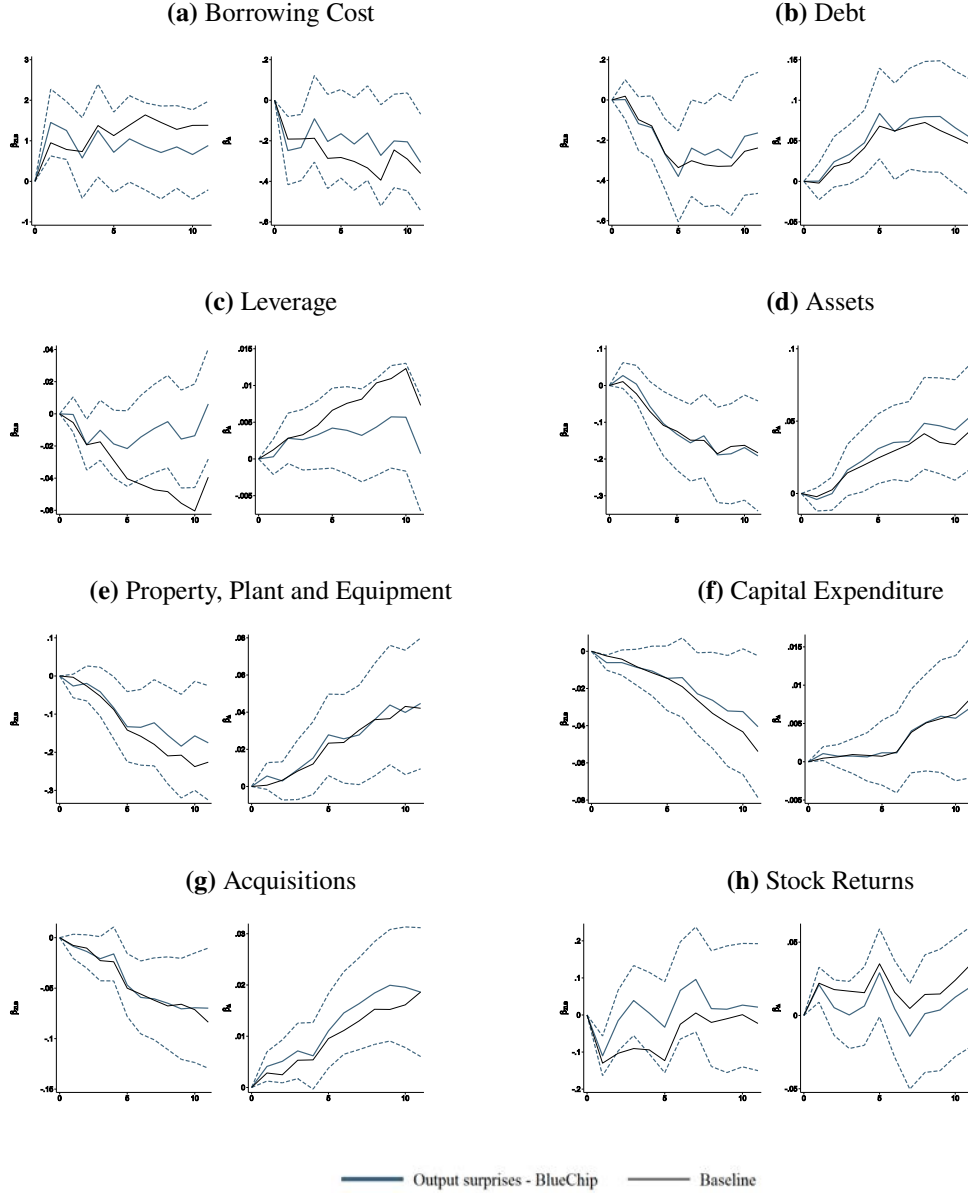
(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

Output surprises - BlueChip ——— Baseline

These figures plots estimates of β_{ZLB}^h and β_Δ^h , estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_\Delta^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \gamma_{ZLB}^h(\nu_t * L_{i,t-1}) + \gamma_\Delta^h(\nu_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes the dependent variable for firm i and ν_t denotes the quarterly change in expected output growth, as measured by the Blue chip consensus forecasts. The black lines plot baseline estimates of β_Δ^h given in Figures 5-8. The dotted lines indicate 95% confidence intervals.

Figure 10: Robustness to output surprises - Survey of Professional Forecasters

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

———— Output surprises - SPF   ———— Baseline

These figures plots estimates of β^h_{ZLB} and β^h_Δ , estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha^h_{j,t} + \beta^h_{ZLB}(\omega_t * L_{i,t-1}) + \beta^h_\Delta(\omega_t * L_{i,t-1} * FFR_{t-1}) + \gamma^h_{ZLB}(\nu_t * L_{i,t-1}) + \gamma^h_\Delta(\nu_t * L_{i,t-1} * FFR_{t-1}) + \delta'_h z_{i,t} + \sum_{\ell=1}^{3} \Gamma'_h \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes the respective dependent variable for firm i and ν_t denotes the quarterly change in expected output growth, as measured by the Philadelphia Federal Reserve Survey of Professional Forecasters. The black lines plot baseline estimates of β^h_Δ given in Figures 5-8. The dotted lines indicate 95% confidence intervals.

Figure 11: Robustness of β_Δ to time trend

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

——— Time trend ——— Baseline
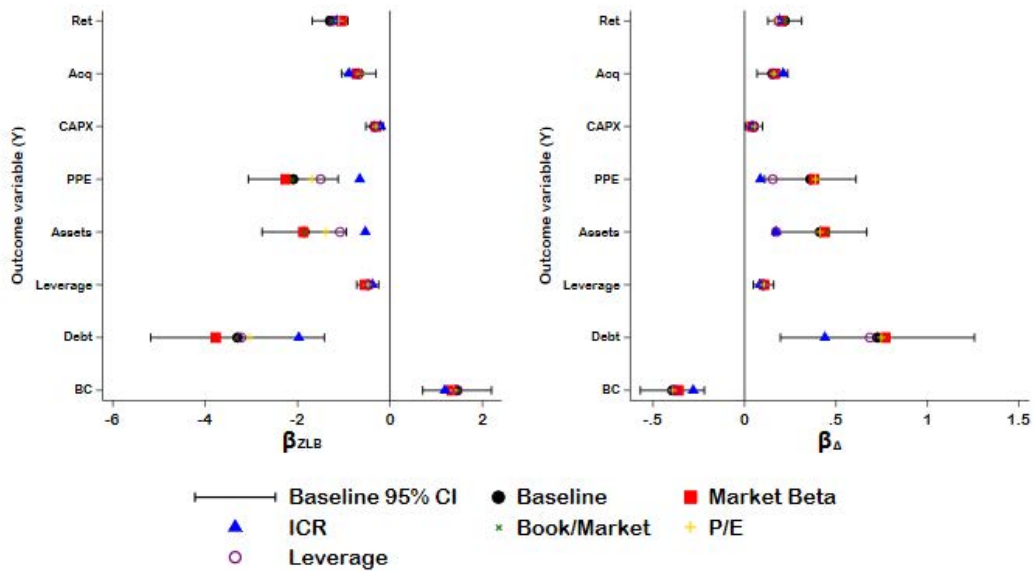
These figures plots estimates of β_Δ^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_\Delta^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \gamma_{ZLB}^h(L_{i,t-1} * t) + \gamma_\Delta^h(L_{i,t-1} * t * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where y denotes the respective outcome variable for firm i and t denotes a time trend. The black lines plot baseline estimates of β_Δ^h given in figures 5 - 8. The dotted lines indicate 95% confidence intervals.

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Figure 12: Robustness to various firm-level controls

The left panel of these figures plots estimates of β^8_{ZLB}, while the right panel plots estimates of β^8_Δ, estimated from the local projection $\Delta y_{i,j,t+8-1} = \alpha^8_{j,t} + \beta^8_{ZLB}(\omega_t * L_{i,t-1}) + \beta^8_\Delta(\omega_t * L_{i,t-1} * FFR_{t-1}) + \gamma^8(x_{i,t-1}) + \gamma^8_{ZLB}(\omega_t * x_{i,t-1}) + \gamma^8_{FFR}(x_{i,t-1} * FFR_{t-1}) + \gamma^8_\Delta(\omega_t * x_{i,t-1} * FFR_{t-1}) + \delta'_8 z_{i,t} + \sum_{\ell=1}^3 \Gamma'_8 \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$, where $x_{i,t}$ is a firm level control and y is the outcome. Standard errors for the baseline estimates are calculated as in Table **??**. Sample sizes vary depending on the control variable x included. The range of sample sizes are given by (136,720-302,831) for Market Beta, (106,451-148,619) for ICR, (136,970-301,517) for Book to market ratio, (106,776-194,032) for price to earnings ratio, and (137,107 -287,445) for leverage.

A Online Appendix

A.1 Proofs of Propositions 1 and 2

Proof of Proposition 1 Taking first-order conditions of the Bellman equation, we see that equilibrium investments in $s \in \{-1, 0, 1\}$, if interior (i.e., $\eta_s > 0$), must satisfy

$$1 = \frac{(\eta_{-1} + \kappa)(v_2 - v_0) + x(v_2 - v_1)}{(1 + r)(\eta_1 + \eta_{-1} + \kappa + x)^2}$$

$$1 = \frac{\eta_0(v_1 - v_{-1}) + x(v_1 - v_0)}{(1 + r)(2\eta_0 + x)^2}$$

$$1 = \frac{\eta_1(v_0 - v_{-2}) + x(v_0 - v_{-1})}{(1 + r)(\eta_1 + \eta_{-1} + \kappa + x)^2}$$

As $r \to 0$, $v_2 = \frac{1+\epsilon}{r} \to \infty$; it is thus easy to see that for sufficiently low interest rates, equilibrium investments must be interior in all states, and in fact $\eta_s \to \infty$, $v_s \to \infty$ for all $s \in \{-1, 0, 1\}$.

We use $x \sim y$ to represent $\lim_{r \to 0} x = \lim_{r \to 0} y$, and we guess-and-verify that despite investments and value functions diverge to infinity in all states, $\widetilde{\eta}_s \equiv \lim_{r \to 0} r\eta_s$ and $\widetilde{v}_s \equiv \lim_{r \to 0} rv_s$ are finite. To see this, note the first-order condition can be represented as

$$1 \sim \frac{\eta_{-s}(v_{s+1} - v_{s-1})}{(\eta_s + \eta_{-s})^2} \qquad \text{for all } s$$

$$\iff \widetilde{\eta}_s + \widetilde{\eta}_{-s} = \frac{\widetilde{\eta}_{-s}}{\widetilde{\eta}_s + \widetilde{\eta}_{-s}}(\widetilde{v}_{s+1} - \widetilde{v}_{s-1}) \tag{17}$$

Likewise, as $r \to 0$, the value functions solve

$$\begin{aligned}
\widetilde{v}_s &= -\widetilde{\eta}_s + \left[\frac{\widetilde{\eta}_s}{\widetilde{\eta}_s + \widetilde{\eta}_{-s}} \widetilde{v}_{s+1} + \frac{\widetilde{\eta}_{-s}}{\widetilde{\eta}_s + \widetilde{\eta}_{-s}} \widetilde{v}_{s-1} \right] \\
&= -\widetilde{\eta}_s + \left[\widetilde{v}_{s+1} - \frac{\widetilde{\eta}_{-s}}{\widetilde{\eta}_s + \widetilde{\eta}_{-s}}(\widetilde{v}_{s+1} - \widetilde{v}_{s-1}) \right] \\
&= -\widetilde{\eta}_s + \left[\widetilde{v}_{s+1} - (\widetilde{\eta}_s + \widetilde{\eta}_{-s}) \right]
\end{aligned}$$

thereby implying

$$2\widetilde{\eta}_s + \widetilde{\eta}_{-s} = \widetilde{v}_{s+1} - \widetilde{v}_s \tag{18}$$

Note that conditions (17) and (18) form six conditions with six endogenous variables $\{\widetilde{\eta}_s, \widetilde{v}_s\}$ for $s \in \{-1, 0, 1\}$ (note $\widetilde{v}_2 = 1$ and $\widetilde{v}_2 = 0$). We can solve for the endogenous variables and obtain $\widetilde{\eta}_1 = \frac{9 - \sqrt{33}}{4}$ and $\widetilde{\eta}_1 = \frac{\sqrt{33} - 5}{4}$, thereby verifying $\lim_{r \to 0} \eta_1 - \eta_{-1} = \infty$. Moreover, the analysis also implies

$$\lim_{r \to 0} \frac{\mathrm{d} \ln \eta_s}{\mathrm{d} \ln r} = -1$$

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The fact that $\lim_{r \to 0} \eta_1 - \eta_{-1} > 0$ thus further implies $\frac{d(\eta_1 - \eta_{-1})}{- dr} > 0$ and $\frac{d^2(\eta_1 - \eta_{-1})}{- dr^2} < 0$, as desired.

Proof of Proposition 2 We first assume that both firms invest as much as their debt capacity allows in all states and show

$$\lim_{r \to 0} \eta_{-1} = \frac{\kappa}{1 + 2\kappa + 2x}, \quad \lim_{r \to 0} \eta_1 = \frac{1 + \kappa + 2x}{1 + 2\kappa + 2x}.$$

We then verify that it is indeed an equilibrium for both firms to invest as much as their debt capacity allows.

The debt capacity of the follower implies

$$\eta_{-1} = \frac{1}{1 + r} \mathbb{E}_{s^{next}} \left[\pi_{s^{next}} \right] = \frac{1}{2} \frac{1}{1 + r} \frac{\eta_{-1} + \kappa}{\eta_{-1} + \eta_1 + \kappa + x}$$

and for the leader

$$\eta_1 = \frac{1}{1 + r} \left[\frac{\eta_1 + x}{\eta_{-1} + \eta_1 + \kappa + x} + \frac{1}{2} \frac{\eta_{-1} + \kappa}{\eta_{-1} + \eta_1 + \kappa + x} \right]$$

As $r \to 0$,

$$2\eta_{-1} \to \frac{\eta_{-1} + \kappa}{\eta_{-1} + \eta_1 + \kappa + x}, \quad 2\eta_1 \to \left[1 + \frac{\eta_1 + x}{\eta_{-1} + \eta_1 + \kappa + x} \right]$$

Hence $\eta_1 + \eta_{-1} \to 1$, and

$$2\eta_{-1} \to \frac{\eta_{-1} + \kappa}{1 + \kappa + x} \implies \eta_{-1} \to \frac{\kappa}{1 + 2\kappa + 2x}$$

$$2\eta_1 \to \left[1 + \frac{\eta_1 + x}{1 + \kappa + x} \right] \implies \eta_1 \to \frac{1 + \kappa + 2x}{1 + 2\kappa + 2x}$$

as desired.

We next note that as $r \to 0$, value functions (let $\widetilde{v}_s \equiv \lim_{r \to 0} r v_s$) solve

$$\widetilde{v}_1 = \left[\frac{\eta_1}{1 + \kappa + x} \widetilde{v}_2 + \frac{\eta_{-1} + \kappa}{1 + \kappa + x} \widetilde{v}_0 + \frac{x}{1 + \kappa + x} \widetilde{v}_1 \right]$$

$$\widetilde{v}_0 = \left[\frac{1}{1 + x} \frac{1}{2} \left(\widetilde{v}_1 + \widetilde{v}_{-1} \right) + \frac{x}{1 + x} \widetilde{v}_0 \right]$$

$$\widetilde{v}_{-1} = \left[\frac{\eta_{-1} + \kappa}{1 + \kappa + x} \widetilde{v}_0 + \frac{\eta_1}{1 + \kappa + x} \widetilde{v}_{-2} + \frac{x}{1 + \kappa + x} \widetilde{v}_{-1} \right]$$

where $\widetilde{v}_{-2} = 0$ and $\widetilde{v}_2 = 1$. We can solve this system of equations and obtain

$$\widetilde{v}_2 - \widetilde{v}_1 = \widetilde{v}_{-1} = \frac{1 + \kappa - \eta_1}{1 + \kappa} \frac{1}{2}$$

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$$\widetilde{v}_0 - \widetilde{v}_{-1} = \widetilde{v}_1 - \widetilde{v}_0 = \frac{\eta_1}{1+\kappa}\frac{1}{2}$$

$$\widetilde{v}_1 - \widetilde{v}_{-1} = 2\left(\widetilde{v}_1 - \widetilde{v}_0\right) = \frac{\eta_1}{1+\kappa}$$

To verify that firms indeed would invest as much as their debt capacity allows, we need to verify that the marginal investment benefit in each state is greater than one—so that the constraint (6) binds—and that the marginal investment benefit in each state is no less than the expected continuation investment benefit—so that the constraint (7) binds, implying that firms do not prefer to marginally reduce current investment and raise investments in the next period.

The marginal investment benefit in each state is

$$MB_1 = \frac{(\eta_{-1} + \kappa)(v_2 - v_0) + x(v_2 - v_1)}{(1+r)(\eta_1 + \eta_{-1} + \kappa + x)^2}$$

$$MB_0 = \frac{\eta_0(v_1 - v_{-1}) + x(v_1 - v_0)}{(1+r)(2\eta_0 + x)^2}$$

$$MB_{-1} = \frac{\eta_1(v_0 - v_{-2}) + x(v_0 - v_{-1})}{(1+r)(\eta_1 + \eta_{-1} + \kappa + x)^2}$$

As $r \to 0$, the numerators in these expressions all diverge to infinity, while the denominators stay bounded; hence $\lim_{r \to 0} MB_s > 1$ for all s, and the constraint (6) must bind. And as $r \to 0$, the expected continuation investment benefit in each state is

$$\mathbb{E}_{s^{next}}\left[MB_{s^{next}} | s = 1\right] = \frac{\eta_1}{1+\kappa+x}\underbrace{MB_2}_{\equiv 0} + \frac{\eta_{-1}+\kappa}{1+\kappa+x}MB_0 + \frac{x}{1+\kappa+x}MB_1$$

$$\mathbb{E}_{s^{next}}\left[MB_{s^{next}} | s = 0\right] = \frac{1}{1+x}\frac{1}{2}\left(MB_1 + MB_{-1}\right) + \frac{x}{1+x}MB_0$$

$$\mathbb{E}_{s^{next}}\left[MB_{s^{next}} | s = -1\right] = \frac{\eta_{-1}+\kappa}{1+\kappa+x}MB_0 + \frac{\eta_1}{1+\kappa+x}\underbrace{MB_{-2}}_{\equiv 0} + \frac{x}{1+\kappa+x}MB_{-1}$$

We need to show $MB_s \geq \mathbb{E}_{s^{next}}\left[MB_{s^{next}} | s\right]$ for all s, which can be verified using our earlier solutions for $\widetilde{v}_{s+1} - \widetilde{v}_{s-1}$ and $\widetilde{v}_{s+1} - \widetilde{v}_s$ and noting that $\kappa < 1/2$.

A.2 Further Robustness Checks

In this last subsection, we provide a battery of additional robustness checks. First, we show that our results are robust to alternative definitions of our leader variable. Second, we exclude unscheduled FOMC meetings from our policy news shocks time series. Third, we run a specification with the dependent variable in levels - instead of changes. And finally, we show that our results do not depend on the length of the monetary policy time window used in the high-frequency identification procedure.

A.2.1 Alternative Leader Definitions

One could be concerned that the previous results hinge on the specific definition of industry leaders. While the top 5% of firms by market value is a natural definition, it is not dictated by economic theory. We therefore do three alternative sortings and show that they do not materially affect results.

First, we retain the top 5 firms, instead of the top 5% of firms, as industry leaders. While the top 5% might be a growing (in the 1990s) or shrinking (in the 2000s and 2010s) number of firms within each industry, the top 5 keeps the number of leaders per Fama-French industry constant. Both measures have their pros and cons. Using the top 5 implies that firms do not just switch from being followers to being leaders because of their industry growing. On the other hand, the top 5 might be too small a set of firms in industries where several leaders compete neck-on-neck.

Figure A.3 reports results for the top 5 measure. Most point estimates (the solid blue line) are very similar to the baseline point estimates (solid black line). For several variables (Assets, PPE, capital expenditures, acquisitions, stock returns), the point estimates are close to identical. One notable exception are the responses of leverage, which turn statistically insignificant and where the point estimates also become economically smaller.

Second, we show robustness with respect to the definition of industries. Rather than using Fama-French industries as we do in our main specification, Figure A.4 reports results for leaders classified within 2-digit SIC industries. Point estimates in panels c) to h) of Figure A.4 are almost identical to the baseline estimates and retain high statistical significance. Results for borrowing costs and debt (Panels a) and b)) are significant but economically smaller in magnitude.

Third, we sort firms by sales - instead of assets - and then define leaders as the top 5% of firms within each industry by sales. Estimates for β_{ZLB} and for β_{Δ} as reported in Figure A.5 again display a high degree of robustness. One exception is β_{Δ} for PPE as the dependent variable, which becomes economically and statistically close to zero. Yet, for capital expenditures, another measure of investment, we still find a large and significant snowballing effect as the level of the interest rate is falling.

In sum, the snowballing effect of borrowing costs, financing and investment are largely unaffected by the precise definition of industry leaders.

A.2.2 Excluding Unscheduled Meetings

In our next robustness check, we exclude unscheduled FOMC meetings since those meetings may be in response to other confounding shocks. In our sample period, there are 8 unscheduled meetings.[9]

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[9]The unscheduled meetings are on 10/15/1998, 01/03/2001, 04/18/2001, 08/10/2007, 08/17/2007, 01/22/2008, 03/11/2008 and 10/08/2008. We follow the convention from Nakamura and Steinsson (2018) and always exclude

Figure A.6 reports the results for the policy news shock ω. The point estimates are almost identical in most cases. In particular, all results exhibit a statistically significant snowballing effect. Interestingly, the results for stock returns strengthen once we exclude the unscheduled meetings. Both the zero-lower bound and the the snowballing effect are stronger, highlighting that using only regularly scheduled meetings already contains substantial unanticipated information that affects leaders' returns relative to followers.

A.2.3 Levels Specification

A further robustness check in Figure A.7 consists of estimating the main specification (Equation 9) with the dependent variable in levels and adding firm-fixed effects instead of first differences. Since returns, capital expenditure and acquisitions are by definition already measuring changes, those are omitted from Figure A.7.

For borrowing costs, debt and leverage (Panels a-c), we obtain very similar results as in our baseline specification. The evidence for the snowballing effect β_Δ is slightly weaker for assets and PPE. However, panel data regressions in levels, especially in panels with relatively short time dimension, are subject to concerns about the Nickell (1981) bias. The lagged dependent variables that we include as regressors introduce correlation between the error term and the mean dependent variable that is captured by the fixed effect, hence producing inconsistent estimates.
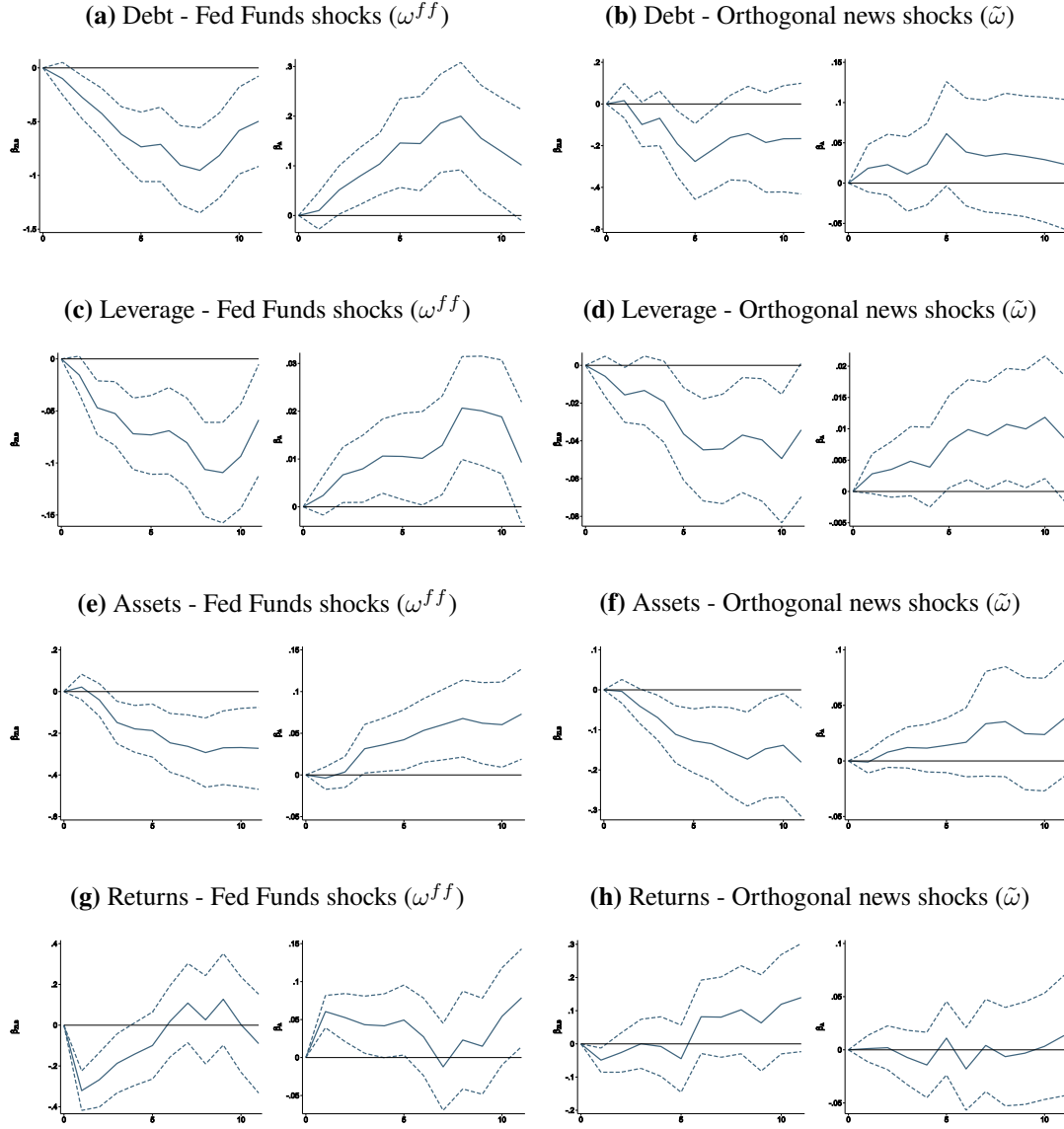
A.2.4 Time Window for Federal Funds Shock

In our last robustness check, we investigate how sensitive our results are with respect to the definition of the time window for shocks to the Federal Funds rate. The identifying assumption for monetary policy shocks identified directly from movements in Fed Funds Futures is that no other macroeconomic news occur in the time window around the FOMC meeting. Under that assumption, the change in Federal Funds Futures around the FOMC announcement is plausibly driven only by the change to monetary policy. In our main specifications, we use a 30-minute time window.

Figure A.8 re-estimates our main specification for short-term Federal Funds shocks but instead of using ω^{ff}, which was identified over a 30-minute time window, the shock in Figure A.8 is identified over a 60 minute time window (-15 minutes to +45 minutes around the FOMC announcement). We use Federal Rates shock in this robustness check instead of our usual shock definition because we only have data over 60-minute window for the Federal Rates shock. All our results are fully robust to this alternative definition.

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those meetings in the wake 09/11, i.e. 09/13/2001 and 09/17/2001.

Figure A.1: Robustness to alternative shocks: financials and returns

(a) Debt - Fed Funds shocks (ω^{ff})   **(b)** Debt - Orthogonal news shocks ($\tilde{\omega}$)

(c) Leverage - Fed Funds shocks (ω^{ff})   **(d)** Leverage - Orthogonal news shocks ($\tilde{\omega}$)

(e) Assets - Fed Funds shocks (ω^{ff})   **(f)** Assets - Orthogonal news shocks ($\tilde{\omega}$)

(g) Returns - Fed Funds shocks (ω^{ff})   **(h)** Returns - Orthogonal news shocks ($\tilde{\omega}$)

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t^{alt} * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t^{alt} * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^{3} \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where ω_t^{alt} is the monetary policy shock in question. The dotted lines indicate 95% confidence intervals.

Figure A.2: Robustness to alternative shocks: investment
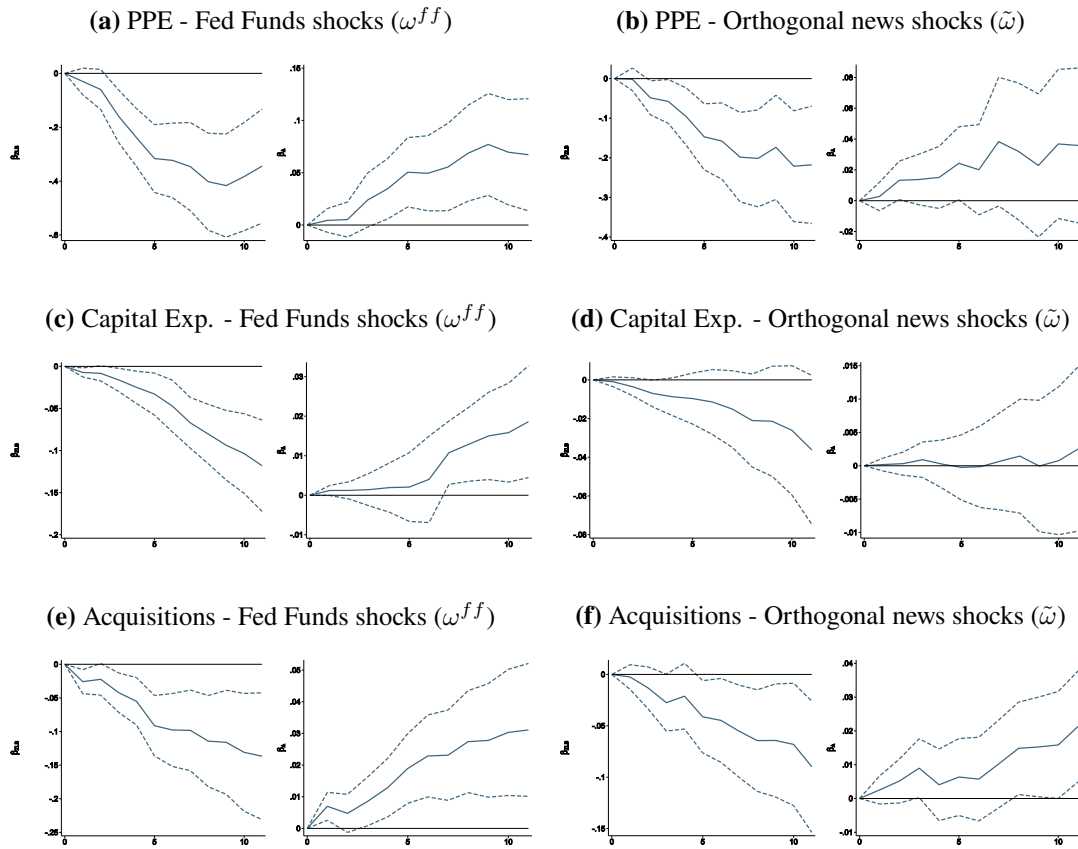
(a) PPE - Fed Funds shocks (ω^{ff})

(b) PPE - Orthogonal news shocks ($\tilde{\omega}$)

(c) Capital Exp. - Fed Funds shocks (ω^{ff})

(d) Capital Exp. - Orthogonal news shocks ($\tilde{\omega}$)

(e) Acquisitions - Fed Funds shocks (ω^{ff})

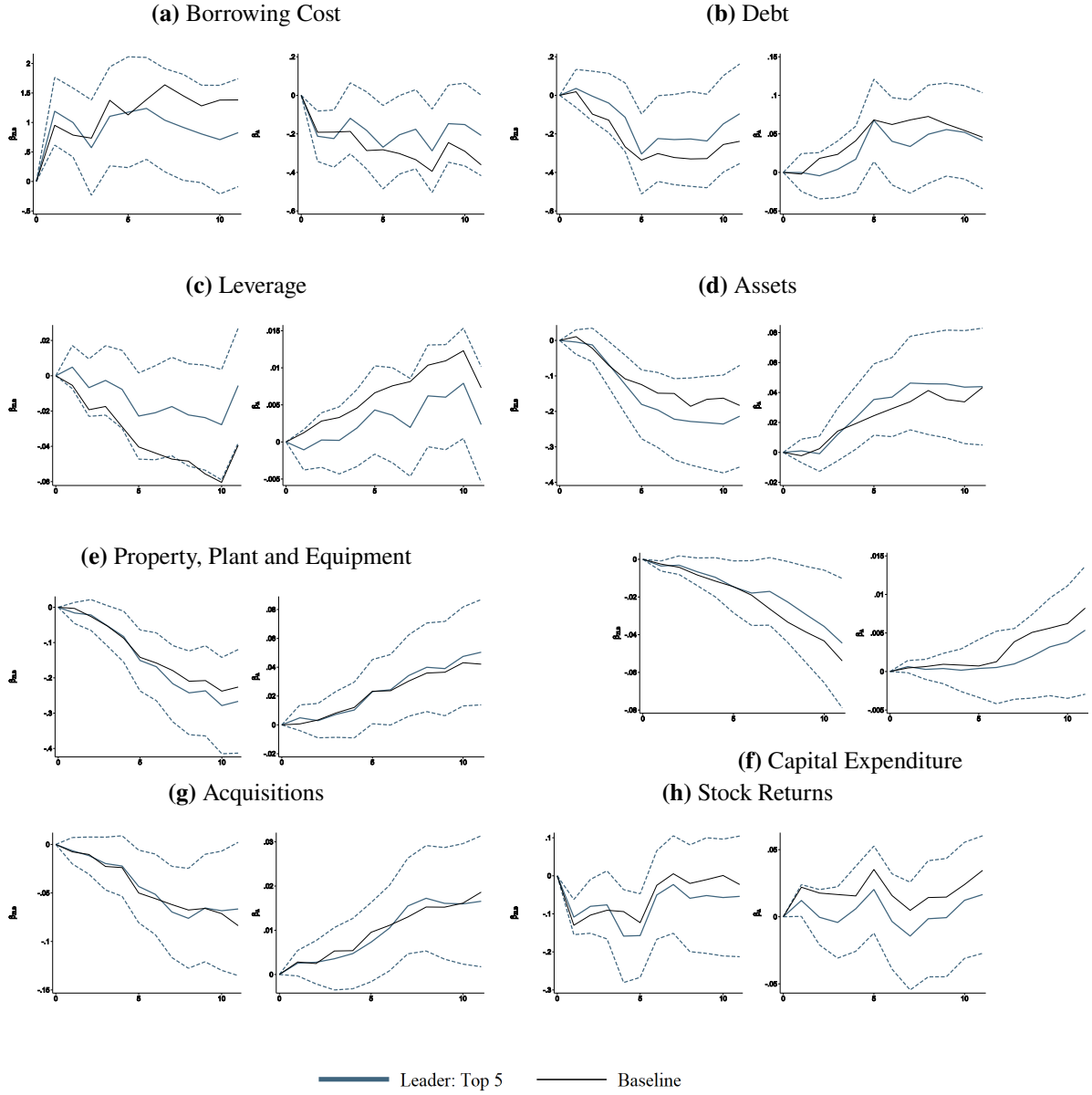**(f)** Acquisitions - Orthogonal news shocks ($\tilde{\omega}$)

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t^{alt} * L_{i,t-1}) + \beta_{\Delta}^h(\omega_t^{alt} * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where ω_t^{alt} is the monetary policy shock in question. The dotted lines indicate 95% confidence intervals.

Figure A.3: Impulse Responses using alternative leader/ follower definition - Top 5 firms

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions
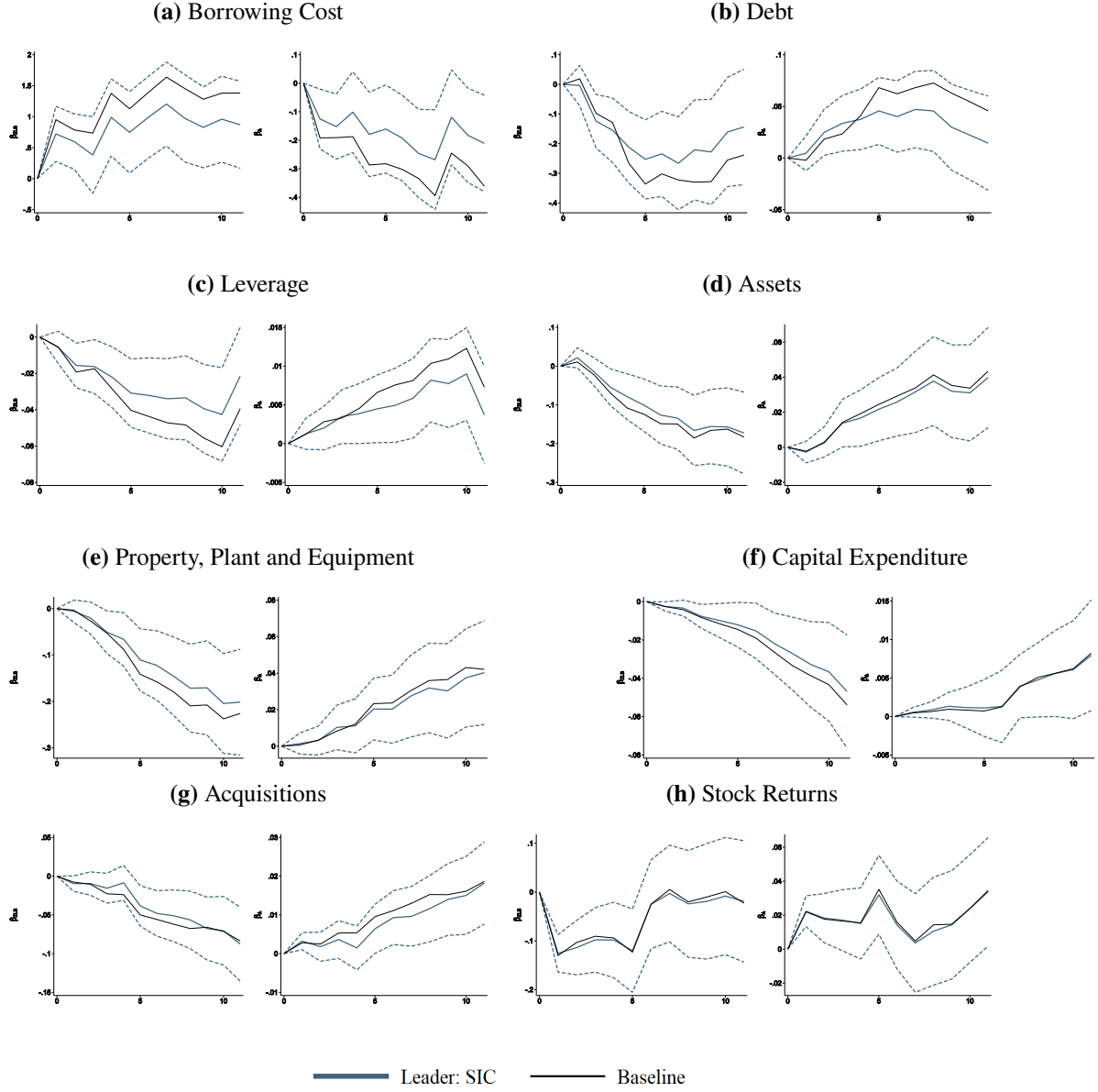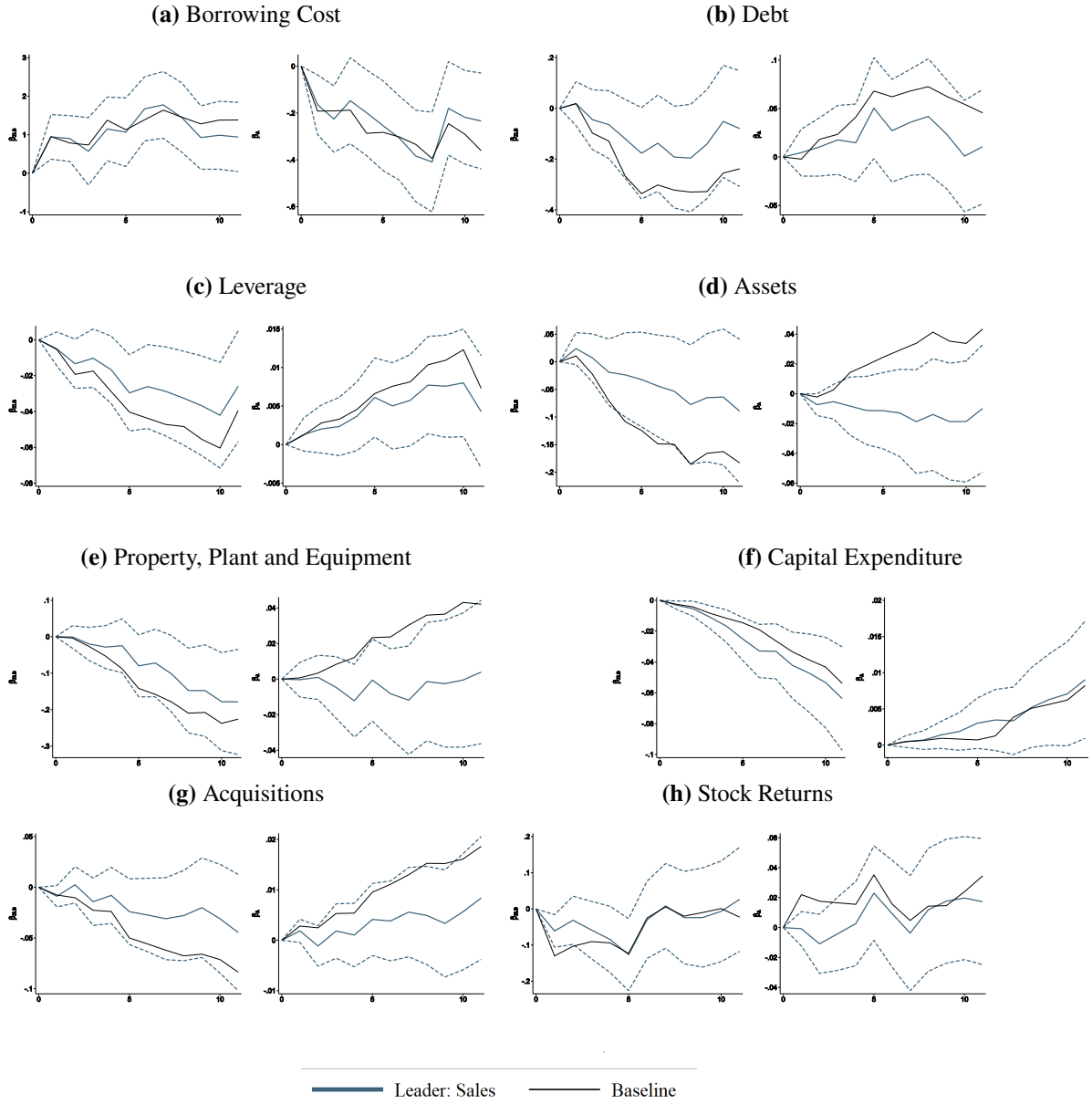
(h) Stock Returns

Leader: Top 5 —— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_Δ^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h (\omega_t * L_{i,t-1}) + \beta_\Delta^h (\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where $L_{i,j,t}$ is equal to one if a firm i is in the top 5 firms in Fama-French industry j by market value in period t. The black lines plot baseline estimates from Figures 5 - 8.

Figure A.4: Impulse Responses using alternative leader/ follower definition - SIC industries

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

——— Leader: SIC   ——— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h (\omega_t * L_{i,t-1}) + \beta_{\Delta}^h (\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where $L_{i,j,t}$ is equal to one if a firm i is in the top 5 firms in SIC industry j by market value in period t. The black lines plot baseline estimates from Figures 5 - 8.

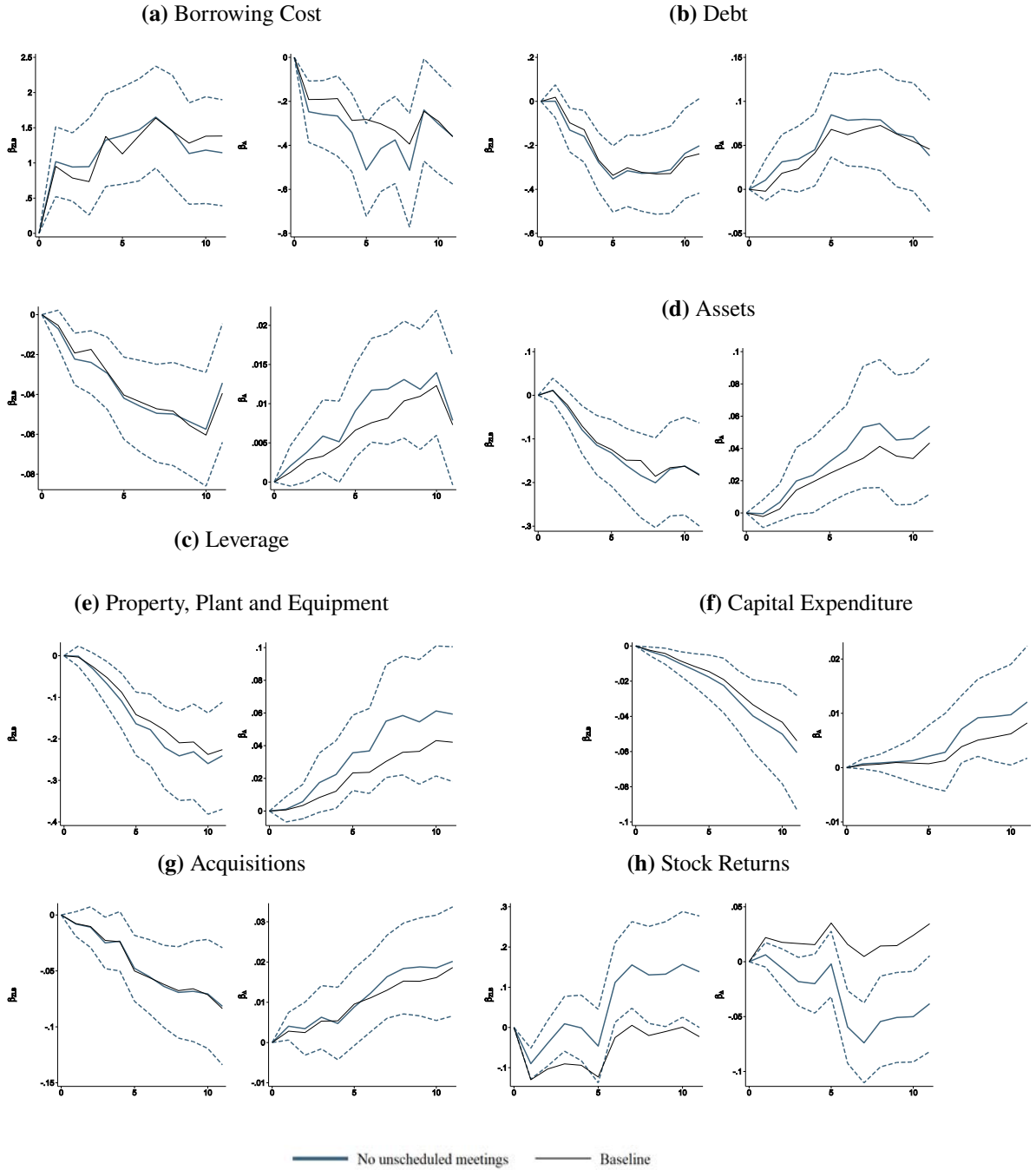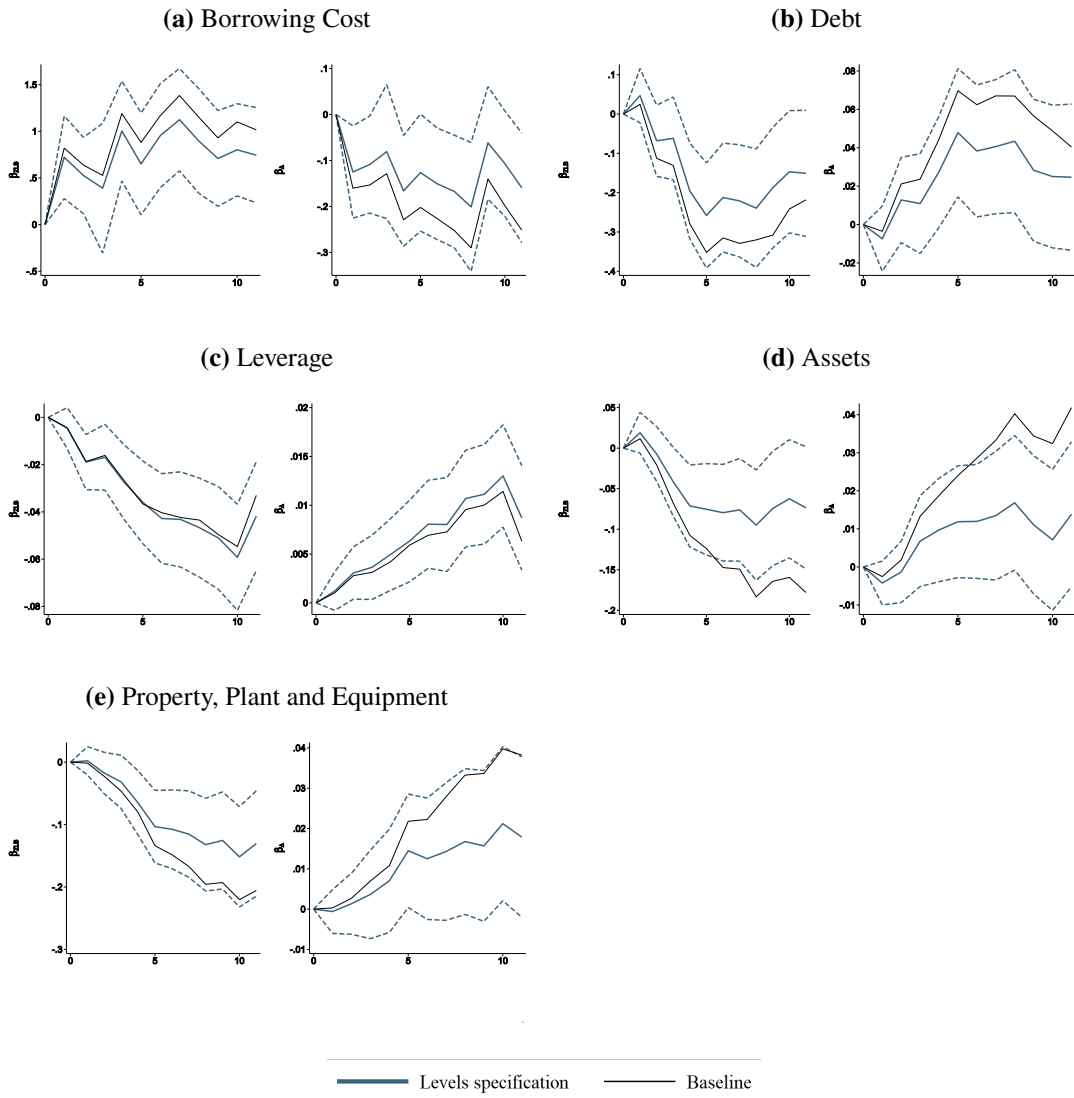**Figure A.5:** Impulse Responses using alternative leader/ follower definition - Sales

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

Leader: Sales ——— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_Δ^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_\Delta^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where $L_{i,j,t}$ is equal to one if a firm i is in the top 5% firms in Fama French industry j by sales in period t. The black lines plot baseline estimates from Figures 5 - 8.

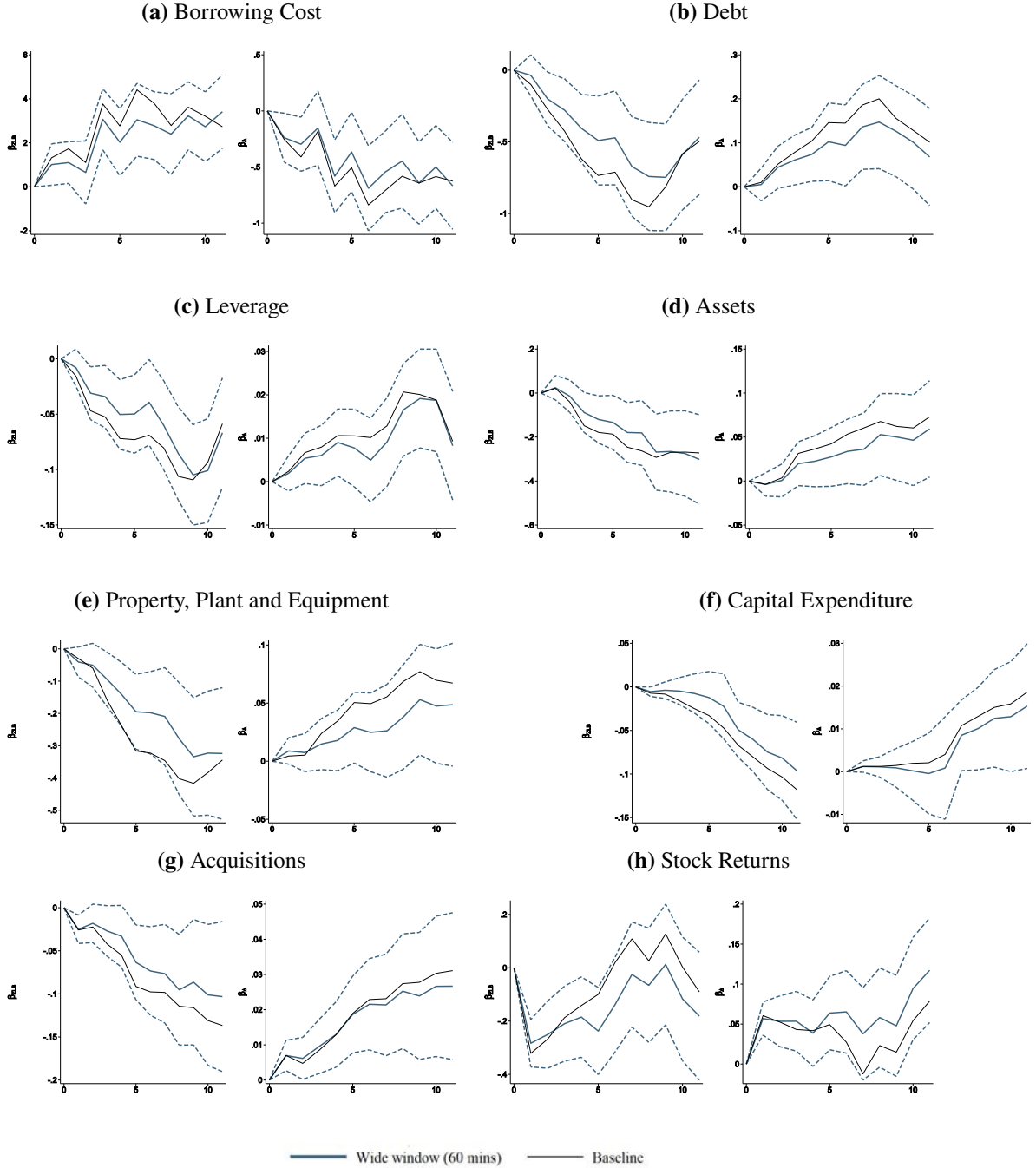**Figure A.6:** Robustness to alternative shocks - No unscheduled meetings

(a) Borrowing Cost

(b) Debt

(d) Assets

(c) Leverage

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

────── No unscheduled meetings   —— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_Δ^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_t * L_{i,t-1}) + \beta_\Delta^h(\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^3 \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where ω is the r-news shock, excluding unscheduled FOMC meetings. The black lines plot the baseline estimates from figures 5 - 8. The dotted lines indicate 95% confidence intervals.

Figure A.7: Robustness to levels specification

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

———— Levels specification   ———— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $y_{t+h} = \alpha_i^h + \alpha_{j,t}^h + \beta_{ZLB}^h (\omega_t * L_{i,t-1}) + \beta_{\Delta}^h (\omega_t * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^{3} \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where α_i^h are firm fixed effects. The black lines plot baseline estimates from Figures 5 - 8. The dotted lines indicate 95% confidence intervals.

Figure A.8: Wide vs. tight (baseline) window Federal Funds Shock

(a) Borrowing Cost

(b) Debt

(c) Leverage

(d) Assets

(e) Property, Plant and Equipment

(f) Capital Expenditure

(g) Acquisitions

(h) Stock Returns

———— Wide window (60 mins) ———— Baseline

The left panel of these figures plots estimates of β_{ZLB}^h, while the right panel plots estimates of β_{Δ}^h, estimated from the local projection $\Delta y_{i,j,t+h-1} = \alpha_{j,t}^h + \beta_{ZLB}^h(\omega_{wide}^{ff} * L_{i,t-1}) + \beta_{\Delta}^h(\omega_{wide}^{ff} * L_{i,t-1} * FFR_{t-1}) + \delta_h' z_{i,t} + \sum_{\ell=1}^{3} \Gamma_h' \theta_{i,t-\ell} + \epsilon_{i,t+h-1}$ where ω_{wide}^{ff} is the Fed Funds shock in a wider (60-minute) window around FOMC meeting announcements. The black lines plot estimates using the Fed Funds shocks in the tight window (ω^{ff}) The dotted lines indicate 95% confidence intervals.