

# THE MISALLOCATION CHANNEL OF MONETARY POLICY

MATTHIAS MEIER<sup>†</sup> AND TIMO REINELT<sup>‡</sup>

– *preliminary and incomplete: please do not cite* –

January 11, 2019

## Abstract

While the effects of monetary policy shocks on macroeconomic aggregates are well-documented, surprisingly little is known about the aggregate TFP response. This paper establishes that contractionary monetary policy shocks lower aggregate TFP. Using firm-level data, we further show that capital misallocation increases. Quantitatively, the increase in capital misallocation explains a large part of the TFP decline. Other transmission channels, including utilization and markups, explain little of the TFP decline. We argue that size-dependent financial frictions are key to understand the monetary transmission channel. Consistent with this view, we find that a large part of the misallocation response is driven by an increase in misallocation across small firms.

KEYWORDS: Monetary Policy, TFP, Misallocation.

---

<sup>†</sup> Universität Mannheim, Department of Economics, Block L7, 3-5, 68161 Mannheim, Germany; E-mail: [m.meier@uni-mannheim.de](mailto:m.meier@uni-mannheim.de).

<sup>‡</sup> Universität Mannheim, Center for Doctoral Studies in Economics (CDSE), Block B6, 30-32, 68159 Mannheim, Germany; E-mail: [timo.reinelt@gess.uni-mannheim.de](mailto:timo.reinelt@gess.uni-mannheim.de).

## 1. INTRODUCTION

The nature of the monetary transmission channel is a classical question in macroeconomics. Understanding it is of central importance for positive questions of business cycle research and for normative aspects of monetary policy. This paper establishes a *novel* transmission channel, the *misallocation channel* of monetary policy. Contractionary monetary policy shocks affect the allocation of capital across producers as a result of which aggregate TFP falls. Our evidence suggests that size-dependent financial frictions are part of the explanation.

The motivating empirical finding of this paper is that contractionary monetary policy shocks lower aggregate TFP. While a vast empirical literature estimates the effects of monetary policy shocks on macroeconomic aggregates,<sup>1</sup> little is known about the effects of monetary policy shocks on aggregate productivity.<sup>2</sup> This is surprising when contrasted with the prominent role of productivity fluctuations in DSGE models.<sup>3</sup> To identify US monetary policy shocks, we use high-frequency changes in federal funds futures around monetary policy announcements.<sup>4</sup> We find that a contractionary monetary policy shock, that raises the federal funds rate by 25 basis points, depresses aggregate TFP by up to 1.0%.

One possible explanation of the adverse TFP response is misallocation. In general, capital is misallocated if reallocating the aggregate capital stock across firms can increase aggregate output. Hence, misallocation depresses aggregate TFP. We use quarterly US firm-level data from Compustat and measure capital misallocation as the cross-sectional variance of the firm-level (revenue) marginal product of capital (MPK). We focus on variation of MPK within narrowly-defined sectors and within quarters. This measure is justified by theory and widely used in a related literature that studies misallocation as a source of cross-country TFP differences.<sup>5</sup> We establish that contractionary monetary policy shocks significantly raise MPK dispersion. Quantitatively, the response of MPK dispersion explains more than half of the TFP decline after contractionary monetary policy shocks.

---

<sup>1</sup>E.g., [Christiano et al. \(1999\)](#), [Romer and Romer \(2004\)](#), and [Gertler and Karadi \(2015\)](#).

<sup>2</sup>An exception is [Evans and Santos \(2002\)](#) who use the [Christiano et al. \(1999\)](#) methodology and find that TFP declines after contractionary monetary policy shocks. Relatedly, [Evans \(1992\)](#) shows that TFP fluctuations are predictable from lags of the money stock and treasury bill rates.

<sup>3</sup>Productivity fluctuations are not only a central driver of business cycles in Real Business Cycle models, [Kydland and Prescott \(1982\)](#), they remain important in many estimated New Keynesian models, [Smets and Wouters \(2007\)](#), and in business cycle accounting, [Brinca et al. \(2016\)](#).

<sup>4</sup>This identification strategy follows a recent literature, see, e.g., [Gertler and Karadi \(2015\)](#), [Gordnichenko and Weber \(2016\)](#), and [Nakamura and Steinsson \(2018\)](#).

<sup>5</sup>To name but a few, see [Hsieh and Klenow \(2009\)](#), [Asker et al. \(2014\)](#), [Midrigan and Xu \(2014\)](#).

One explanation of higher capital misallocation is that firms' external financing conditions are differentially affected by monetary policy shocks, related to the credit view of monetary policy.<sup>6</sup> Empirically, [Kashyap et al. \(1993\)](#) and [Kashyap and Stein \(2000\)](#) show that tighter monetary policy reduces bank loan supply, with stronger effects for small and low-liquidity banks. Firms are affected, because they engage in long-term lending relationships with banks, which makes it costly to switch banks in response to reduced loan supply, see [Chodorow-Reich \(2014\)](#). While large firms can respond by substituting bank loans for corporate bonds, small firms lack access to the corporate bond market, see [Becker and Ivashina \(2014\)](#). Consistent with this explanation, we find that most of the increase in capital misallocation after monetary policy shocks is driven by higher misallocation across small firms.<sup>7</sup>

Apart from the misallocation channel, there are a number of alternative explanations for the TFP response to monetary policy shocks. First, commonly used measures of TFP ([Fernald, 2014](#)) in the tradition of [Solow \(1957\)](#) use the labor income share as Solow weight. Such TFP is mis-measured in the presence of markups, see [Hall \(1986\)](#). We show that tighter monetary policy can lower (mis-measured) TFP when true productivity is unchanged. The effect is amplified if tighter monetary policy additionally raises markups. Empirically, however, using the correct markup-adjusted measure changes the TFP response to monetary policy shocks only marginally. We consider this important because the standard New Keynesian transmission mechanism operates through markups.<sup>8</sup> Together with the mixed evidence of whether markups increase after contractionary monetary policy shocks,<sup>9</sup> we think the markup channel is unlikely important to understand the TFP response.

A second alternative explanation of the TFP decline involves capacity utilization. If utilization falls after tighter monetary policy and the TFP measure does not take this into account, the decline in TFP might be an artefact. We find that utilization-adjusted TFP still falls significantly, but somewhat less strongly. A third alternative explanation of the TFP decline is that firms reduce efforts to raise productivity after tighter monetary policy. Aggregate TFP may drop because firm-level productivity falls. One way in which firms can become more productive is through R&D invest-

---

<sup>6</sup>The credit view focuses on the lending channel of monetary policy. Early work on the credit view includes [Tobin and Brainard \(1963\)](#) and [Bernanke and Blinder \(1988\)](#).

<sup>7</sup>Note that small Compustat firms are medium-sized in the universe of US firms.

<sup>8</sup>[Gali \(2015\)](#) and [Woodford \(2003\)](#) present a variety of New Keynesian models, in which the markup channel of monetary policy shocks is of central importance.

<sup>9</sup>[Nekarda and Ramey \(2013\)](#) argue that the evidence is mixed at best both for the counter-cyclicality of markups and for whether contractionary monetary policy shocks raise markups.

ment.<sup>10</sup> Empirically, however, R&D investment does not respond significantly to a contractionary monetary policy shock.

This paper relates to a growing empirical literature that studies the heterogeneous impact of monetary policy shocks on firms as a means to better understand the relevant monetary transmission channels. An early contribution is the seminal [Gertler and Gilchrist \(1994\)](#), which finds that small firms are more responsive to monetary policy shocks than large firms. More recently, [Ippolito et al. \(2018\)](#) show that firms with unhedged floating rate loans are more responsive. [Ottonello and Winberry \(2018\)](#) find that firms with low leverage are more responsive, while [Jeenas \(2018\)](#) shows that firms with little liquid assets are more responsive. In contrast, our paper studies responses in the cross-sectional distribution of firms, which map into misallocation. On misallocation, [Eisfeldt and Rampini \(2006\)](#) provide evidence of countercyclical fluctuations in capital misallocation. Instead, we study fluctuations in capital misallocation *conditional* on monetary policy shocks. A further related paper is [Gopinath et al. \(2017\)](#), which argues the productivity slowdown in South Europe is the result of increased capital misallocation, in turn a consequence of low interest rates and size-dependent financial frictions. Interestingly, our findings go in the opposite direction. We find that unexpectedly *higher* interest rates increase capital misallocation.

In addition, this paper relates to a number of papers that study capital misallocation as a transmission mechanism for a variety of business cycle shocks: for example, aggregate productivity shocks in [Khan and Thomas \(2008\)](#), financial shocks in [Khan and Thomas \(2013\)](#), uncertainty shocks in [Bloom \(2009\)](#), and supply chain disruptions in [Meier \(2018\)](#). More closely related, [Pasten et al. \(2018\)](#) and [Baqae and Farhi \(2018\)](#) (in the Appendix), study the macroeconomic effects of monetary policy in multi-sector models with markup heterogeneity giving rise to misallocation. In contrast, our paper provides direct empirical evidence of misallocation as transmission channel. To the best of our knowledge, this is the first paper to do so.

The remainder of this paper is organized as follows. Section 2 discusses theories of fluctuations in measured TFP. Section 3 provides new empirical evidence on the effects of monetary policy shocks. Section 4 concludes and an Appendix follows.

---

<sup>10</sup>E.g., [Comin and Gertler \(2006\)](#) develop a DSGE model in which firms choose R&D investment.

## 2. TFP FLUCTUATIONS

Aggregate TFP can fluctuate for several reasons. The traditional view is that productivity fluctuates for exogenous reasons. We show under which conditions the presence of markups generates movements of measured TFP even if actual productivity is constant. Lastly, we show how capital misallocation lowers aggregate TFP.

### 2.1. *The Solow residual*

Measuring aggregate TFP goes back to the seminal [Solow \(1957\)](#), which we briefly review here. Consider a constant-returns-to-scale aggregate production function

$$(2.1) \quad Y = A \cdot F(K, L),$$

where  $A$  is exogenous productivity,  $K$  and  $L$  denote aggregate capital and labor, respectively. Log-differentiating with respect to time yields

$$(2.2) \quad \Delta y = \Delta a + \frac{\partial y}{\partial k} \Delta k + \frac{\partial y}{\partial \ell} \Delta \ell,$$

where lowercase letters denote the natural logarithms of capitalized variables. We denote nominal wages and nominal rents by  $W$  and  $R$  and the labor and capital share by

$$(2.3) \quad w_\ell = \frac{WL}{PY} \quad \text{and} \quad w_k = \frac{RK}{PY}.$$

Under perfect competition on factor and output markets, factor prices equal their marginal products. Hence  $w_k = \frac{\partial y}{\partial k}$  and  $w_\ell = \frac{\partial y}{\partial \ell}$ . This yields the Solow residual,

$$(2.4) \quad \Delta \text{TFP} = (\Delta y - \Delta k) - w_\ell(\Delta \ell - \Delta k).$$

Under the above assumptions,  $\Delta \text{TFP}$  equals actual productivity growth  $\Delta a$ . For the remainder of this paper, we refer to  $\Delta \text{TFP}$  as measured aggregate TFP according to equation (2.4), which is consistent with the baseline TFP series in [Fernald \(2014\)](#).

The first potential reason why  $\Delta \text{TFP}$  may mismeasure true productivity is variable capacity utilization. If utilization is adjusted proportionally for capital and labor by  $\Delta u$ , we can compute utilization-adjusted TFP as

$$(2.5) \quad \Delta \text{TFP}_{\text{util}} = \Delta \text{TFP} - \Delta u,$$

which corresponds to the utilization-adjusted TFP series in [Fernald \(2014\)](#).

### 2.2. *Markups and TFP*

Consider now a positive aggregate price markup, denoted  $\mu$ , over aggregate marginal costs, denoted  $X$ , such that  $P = \mu X$ . Under the constant-returns-to-scale assumption, cost minimization implies  $w_\ell = \frac{1}{\mu} \frac{WL}{XY} = \frac{1}{\mu} \frac{\partial y}{\partial \ell}$ . Now suppose the economy is hit by a monetary policy shock (or any non-productivity shock) which lowers  $(\Delta y - \Delta k)$  and leaves exogenous productivity unchanged ( $\Delta a = 0$ ). If markups are strictly positive, then such a shock raises measured, aggregate TFP by

$$(2.6) \quad \Delta \text{TFP} = \frac{\mu - 1}{\mu} (\Delta y - \Delta k).$$

Thus, market power may explain why measured, aggregate TFP falls after contractionary monetary policy shocks. Importantly, the TFP decline is amplified if the price markup increases after the shock.

Fundamentally, in the presence of markups, the correct Solow weight is not the labor income share, but the labor expenditure share. The insight that markups distort the original Solow residual goes back to [Hall \(1986\)](#), who suggests a markup-adjusted TFP measure,

$$(2.7) \quad \Delta \text{TFP}_{\text{hall}} = (\Delta y - \Delta k) - \mu w_\ell (\Delta \ell - \Delta k),$$

which uses the labor expenditure share as effective Solow weight.

### 2.3. *Misallocation and TFP*

Even if TFP is correctly measured using (2.2), aggregate TFP can fluctuate absent aggregate productivity shocks. Misallocation of capital across firms lowers aggregate TFP. To evaluate the TFP losses from misallocation, we propose a stylized model.

Consider firms, indexed by  $i$ , that operate a decreasing-returns-to-scale CD technology,  $Y_i = A_i K_i^\alpha L_i^\nu$ , combining labor  $L_i$  and capital  $K_i$  and face profits

$$(2.8) \quad \pi_i = A_i K_i^\alpha L_i^\nu - W L_i - R K_i,$$

where  $A_i$  are firm-specific productivity shocks. Wages  $W$  and user costs  $R$  are common across firms. We abstract from labor adjustment frictions and distortions.

For capital, instead, a firm-specific wedge  $\Omega_i$  distorts the firm's first order condition

$$(2.9) \quad MPK_i = \alpha A_i K_i^{\alpha-1} L_i^\nu = R \Omega_i.$$

The wedge is a shortcut that may capture frictions that prevent a firm from operating its statically optimal capital stock, but it may also capture firm-specific borrowing costs. Firms differ in  $(A_i, \Omega_i)$ , which we assume to have a joint distribution in logs,

$$(2.10) \quad \log \begin{pmatrix} A_i \\ \Omega_i \end{pmatrix} \sim \left( \begin{bmatrix} \mu_a \\ \mu_\omega \end{bmatrix}, \begin{bmatrix} \sigma_a^2 & \\ \sigma_{a\omega} & \sigma_\omega^2 \end{bmatrix} \right).$$

A model-consistent measure of aggregate TFP can be computed as

$$(2.11) \quad \text{TFP}_{\text{model}} = \log \left( \int Y_i di \right) - \alpha \log \left( \int K_i di \right) - \nu \log \left( \int L_i di \right),$$

which requires aggregating the economy. If (2.10) is Gaussian, and if not up to second-order approximation, we obtain

$$(2.12) \quad \text{TFP}_{\text{model}} = \mu_a + \frac{1}{1-\alpha-\nu} \frac{\sigma_a^2}{2} - \frac{\alpha(1-\nu)}{1-\alpha-\nu} \frac{\mathbb{V}(mpk_i)}{2},$$

where  $\mathbb{V}(mpk_i) = \sigma_\omega^2$  summarizes the TFP loss of misallocation. Hence, we can study the misallocation channel of monetary policy by studying the response of log MPK dispersion. While  $\text{TFP}_{\text{model}}$  provides a straightforward mapping between misallocation and TFP, it is different from the baseline TFP measure in (2.4). Baseline TFP, however, provides a less sharp characterization of the misallocation-TFP nexus.<sup>11</sup> In the empirical analysis, we will consider both baseline and model-consistent TFP.

### 3. EMPIRICAL EVIDENCE

This section provides novel empirical evidence. We first show that contractionary monetary policy shocks lower aggregate productivity. Second, these shocks raise capital misallocation which implies a sizable TFP loss. Finally, we provide evidence that most of the response in MPK dispersion is driven by misallocation across small firms, which suggests size-dependent financial frictions.

---

<sup>11</sup>TFP in (2.4), computed in the model, is  $\text{TFP} = -(1-nu)\mu_\omega - \frac{1-\nu}{1-\alpha-\nu}\sigma_{a\omega} - \frac{(1-\nu)^2-\alpha^2}{(1-\alpha-\nu)^2} \frac{\mathbb{V}(mpk_i)}{2}$ , which makes it harder to map misallocation into TFP because this requires estimating the covariance between MPK and productivity.

### 3.1. *Identification of monetary policy (MP) shocks*

We identify monetary policy shocks using high-frequency futures data, which capture market expectations about the fed funds rate. The identifying restriction is that during a narrow time window around FOMC announcements, no shock other than the monetary policy shock affects the price of futures. We denote the price of a future by  $f_\tau$ , where  $\tau$  is the time of the monetary announcement. A monetary policy shock in FOMC meeting period  $\tau$  is defined as<sup>12</sup>

$$(3.1) \quad \varepsilon_\tau^{\text{MP}} = \omega(\tau)(f_{\tau+\Delta\tau^+} - f_{\tau-\Delta\tau^-}).$$

We set  $\Delta\tau^- = 10$  minutes and  $\Delta\tau^+ = 20$  minutes.

Because both the micro data and the macro data we use is available at quarterly frequency, we aggregate daily shocks. We assign daily shocks fully to the current quarter if they occur on the first day of the quarter. If they occur within the quarter, we partially assign the shock to the subsequent quarter. In this way, we weight shocks across quarters corresponding to the amount of time firms have had to respond.<sup>13</sup> Formally, let  $t$  denote quarters, then we compute quarterly shocks as

$$(3.2) \quad \varepsilon_t^{\text{MP}} = \sum_{\tau \in \mathcal{D}(t)} \phi(\tau) \varepsilon_\tau^{\text{MP}} + \sum_{\tau \in \mathcal{D}(t-1)} (1 - \phi(\tau)) \varepsilon_\tau^{\text{MP}},$$

where  $\mathcal{D}(t)$  is the set of days in quarter  $t$  and  $\phi(\tau) = (\text{remaining number of days in quarter } t \text{ after announcement in } \tau) / (\text{total number of days in quarter } t)$ .

Our baseline monetary shock is based on the three-month ahead federal funds future as in [Gertler and Karadi \(2015\)](#). For robustness, we also consider the current month federal funds futures, and the policy news shock as in [Nakamura and Steinsson \(2018\)](#), who extract the first principal component of the current and next month federal funds futures and the 2/3/4-quarters ahead Eurodollar futures. Panel (a) of Figure 4 in the Appendix plots the three shock series.

---

<sup>12</sup>Specifically the current-month federal funds futures settle on the month's *average* effective overnight federal funds rate. Shocks happen at different days of the month. To make them comparable, we use an adjustment  $\omega(\tau)$ . We have  $\omega(\tau) = (\text{total number of days in announcement month}) / (\text{remaining number of days in announcement month after meeting in } \tau)$ . If  $\tau$  is within the last seven days of the month, we use the unadjusted change in the next-month federal funds future. Any other federal funds future we consider, as well as the Eurodollar futures, have their respective reference periods in the future. Then the adjustment simplifies to  $\omega(\tau) = 1$ .

<sup>13</sup>The same approach is employed in [Ottonello and Winberry \(2018\)](#).



### 3.2. *Macro evidence: contractionary MP shocks lower aggregate TFP*

We first document that contractionary monetary policy shocks lower aggregate TFP. We estimate the dynamic responses of aggregate productivity using Jordà (2005)'s local projections. Our baseline specification is

$$(3.3) \quad x_{t+h} - x_{t-1} = \alpha^h + \beta_0^h \varepsilon_t^{\text{MP}} + \beta_1^h \varepsilon_{t-1}^{\text{MP}} + \gamma^h (x_{t-1} - x_{t-2}) + u_t^h,$$

where  $x_t$  denotes log aggregate productivity in quarter  $t$ , and  $h = 0, \dots, 16$  the horizon. The coefficient  $\beta_0^h$  is the cumulative response of productivity growth  $h$  periods after a monetary policy shock. We include lagged productivity growth to control for a potentially changing conduct of monetary policy along the path of productivity growth. We include one lag of the monetary policy shock to control for the serial correlation that arises from time aggregation in (3.2).

As measures of aggregate productivity, we consider TFP and utilization-adjusted TFP from Fernald (2014), which correspond to equations (2.4) and (2.5).<sup>14</sup> We further consider labor productivity, which obviates the need to specify an aggregate production function.<sup>15</sup> Panel (c) of Figure 4 in the Appendix plots the three productivity series. Our sample runs from 1994Q1 to 2018Q1. We exclude the apex of the financial crisis in 2008Q3 to 2009Q2.<sup>16</sup>

Panel (a) of Figure 1 shows the estimated responses of aggregate productivity to a contractionary monetary policy shock. The figure has three main takeaways. First, tighter monetary policy lowers aggregate productivity. This decline is both statistically and economically significant. A 25 basis point unexpected increase in the federal funds rate lowers aggregate productivity by up to 0.6% within the first three years. Second, the response of aggregate productivity builds up gradually and is highly persistent.<sup>17</sup> Third, the differences across productivity measures are relatively small. Utilization adjustment accounts for about one third of the baseline TFP response.

---

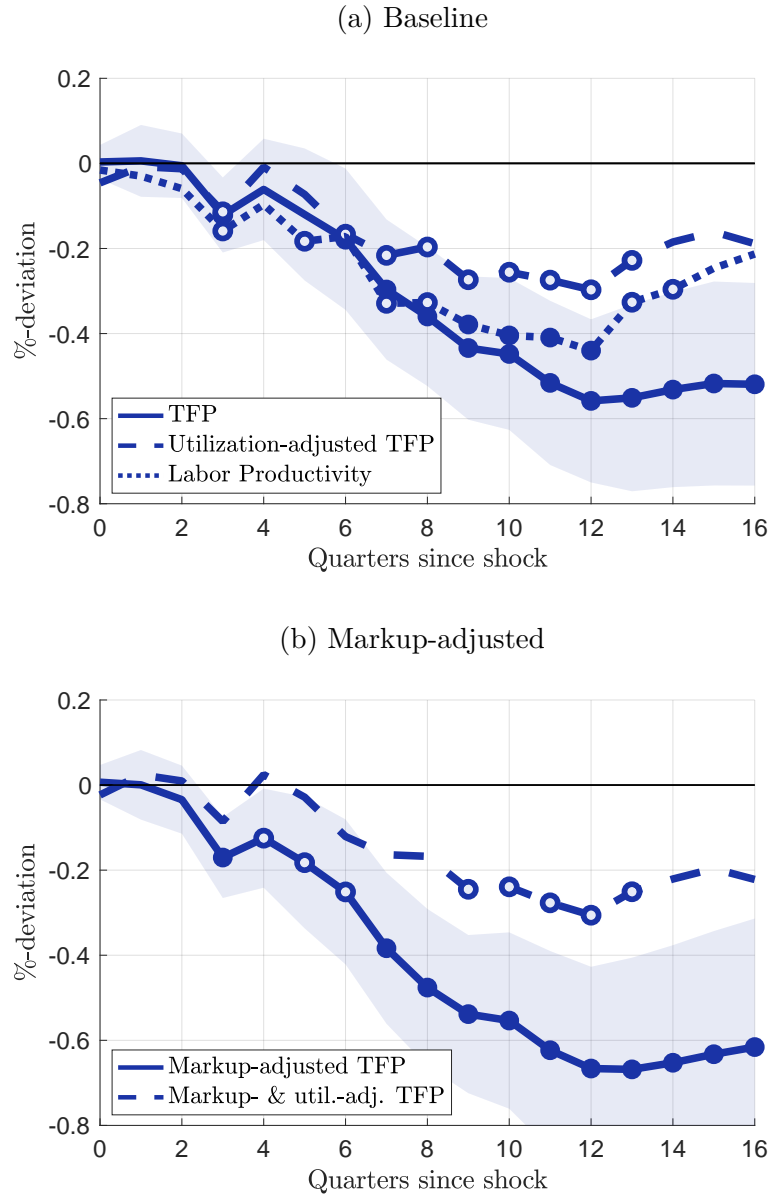
<sup>14</sup>Fernald (2014) computes  $\Delta y$  as real business output growth,  $\Delta k$  is the real capital growth (after applying the perpetual inventory method to 15 types of NIPA investment categories),  $\Delta \ell$  is the growth of hours worked plus growth in labor composition/quality, and growth in the utilization rate is computed as growth in hours per worker.

<sup>15</sup>Labor productivity is real output per hour in the nonfarm business sector, in FRED: OPHNFB.

<sup>16</sup>We want to avoid that our results are predominantly driven by extraordinarily large macroeconomic shocks around the Great Recession. Including this period strengthens our findings.

<sup>17</sup>At a six-year horizon, the responses of TFP and utilization-adjusted TFP regress toward zero and become less significant, see panel (a) of Figure 6 in the Appendix.

Figure 1: Responses of aggregate productivity (in %) to a 25 basis points contractionary monetary policy shock



Notes: This plot shows the responses of aggregate productivity to a contractionary monetary policy shock, i.e. coefficients  $\beta^h$  in equation (3.3). Markup-adjustment follows equation (2.7). Inference is based on Newey-West standard errors. The shaded area is the one standard error band for the response of TFP. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

Apart from utilization adjustment, aggregate TFP may be mismeasured if firms have market power, see Section 2. To address potential mis-measurement, we compute a markup-corrected measure of aggregate TFP, see equation (2.7). This requires price markups and we use the estimated markup series in [De Loecker and Eeckhout \(2018\)](#). Panel (b) of Figure 1 shows that both TFP responses are only marginally affected when using markup-adjusted TFP series instead of the baseline series. Given the prominent role of markups in the monetary transmission of New Keynesian models, we consider this an important result.

Finally, we investigate the robustness of our results in various directions. First, we use alternative monetary policy shocks, notably the high-frequency changes in the current month fed funds future and the one in [Nakamura and Steinsson \(2018\)](#). Figure 5 shows that the responses of baseline TFP, utilization-adjusted TFP, and labor productivity are broadly robust. Second, to investigate whether some outliers drive the empirical results, panel (a) of Figure 7 provides a scatterplot of the local projection. While some events play a larger role than others, the results are clearly not driven by a few outliers. Third, the aggregate TFP response is not exclusively the response of TFP in either the investment good or the consumption good sector, see panel (b) of Figure 6. Fourth, our results are robust against alternative model specifications, notably a model in levels instead of first differences and a model that drops the lagged first difference in the baseline.

Another concern may be that our results are specific to unconventional monetary policy during the sample period. To address this concern, we drop all monetary policy shocks during QE announcements. Panel (c) of Figure 6 shows that this leaves our results practically unchanged.

Yet another concern may be the informational content of monetary policy announcement. If the Fed has private information about the future state of the economy, policy announcements will be signals of such information, see, [Nakamura and Steinsson \(2018\)](#), and [Jarocinski and Karadi \(2018\)](#). In this case, monetary policy shocks are not fully exogenous. To address this concern, we adopt the ‘poor-man sign restriction’ in [Jarocinski and Karadi \(2018\)](#), which excludes any monetary policy shock that coincide with stock market price movements in the same direction. While this excludes half of the initial shocks, the quarterly shock series is similar to the original one, see panel (b) of Figure 4. Importantly, the productivity responses are only somewhat weaker compared to the baseline result, see panel (d) of Figure 6.

### 3.3. *Micro evidence: contractionary MP shocks increase misallocation*

Motivated by the empirical evidence that aggregate TFP strongly falls, we next ask whether factor misallocation across firms may account for some of the TFP decline. Using firm-level data, we show that capital misallocation indeed increases in response to contractionary monetary policy shocks, and the increase explains more than half of the decline in aggregate TFP. In addition we find that most of the increase in misallocation comes from misallocation across small firms, which is consistent with size-dependent financial frictions.

To study misallocation, we use balance-sheet data from Compustat. Compustat has two advantages. First, it provides data for a large number of US firms at *quarterly* frequency. With annual firm-level data (e.g., IRS data), we would need to aggregate monetary policy shocks over a full year. This likely dilutes the informativeness of the (iid) shocks. Second, while Compustat only contains listed firms, it does cover all sectors. In contrast, there is excellent establishment level data, that, however, only covers the manufacturing sector (e.g., AMS data).

Consistent with theory in Section 2, we measure capital misallocation by the cross-sectional dispersion in the marginal product of capital (MPK). In a stylized economy, the first-best capital allocation is achieved if the MPKs are equalized across firms. Against this benchmark, a higher cross-sectional dispersion in MPK indicates more capital misallocation.<sup>18</sup> In quarterly Compustat data, we consider all industries except finance, insurance, real estate, and public administration. We define MPK as the ratio of sales (*saleq*) over the capital stock (the net value of property, plant and equipment, *ppentq*).<sup>19</sup> Importantly, we demean (log) MPK for every industry-quarter pair. This controls for level shifts in the interest rate across time and industries, and for variation in depreciation rates or production technologies across industry and time. Out of concern that imprecisely estimated industry-quarter means distort our dispersion measures, we only consider industry-quarter observations for which we have at least five observations. Panel (d) of Figure 4 in the Appendix shows the time series evolution of the within industry-quarter MPK dispersion.

To estimate the effects of monetary policy shocks on capital misallocation, we reuse the regression model in equation (3.3), where  $x_t$  now becomes the cross-sectional variance of log MPK. The baseline monetary policy shock is, again, based on high-

---

<sup>18</sup>MPK dispersion has been widely used to measure capital misallocation, see [Hsieh and Klenow \(2009\)](#), [Asker et al. \(2014\)](#), [Midrigan and Xu \(2014\)](#).

<sup>19</sup>In Compustat data, [David et al. \(2018\)](#) construct the same measure of misallocation.

frequency changes in the three-month federal fund futures around FOMC announcements. Panel (a) of Figure 2 shows the response of the quarterly cross-sectional dispersion of log MPK to a contractionary monetary policy shock. The key finding is that dispersion in log MPK significantly increases, which suggests that capital becomes more misallocated following a monetary contraction. Further, the response of MPK dispersion is quite persistent, albeit less than aggregate productivity.

A regular concern with micro data is measurement error. We address this by examining alternative data treatments, in which exclude certain observations. We consider three alternative treatments: First, the information provided by small firms might be more erroneous so we drop all observations with real sales below 1 mln (in 2010 USD). Second, we trim the top and bottom one percent of log MPK for every quarter. Third, we drop observations with real sales growth above 200% or below -66%. Panel (b) of Figure 2 shows that the alternative, and, arguably, more aggressive, data treatments somewhat diminish the magnitudes of the response. However, the overall conclusion that MPK dispersion significantly increases remains robust against these data treatments.

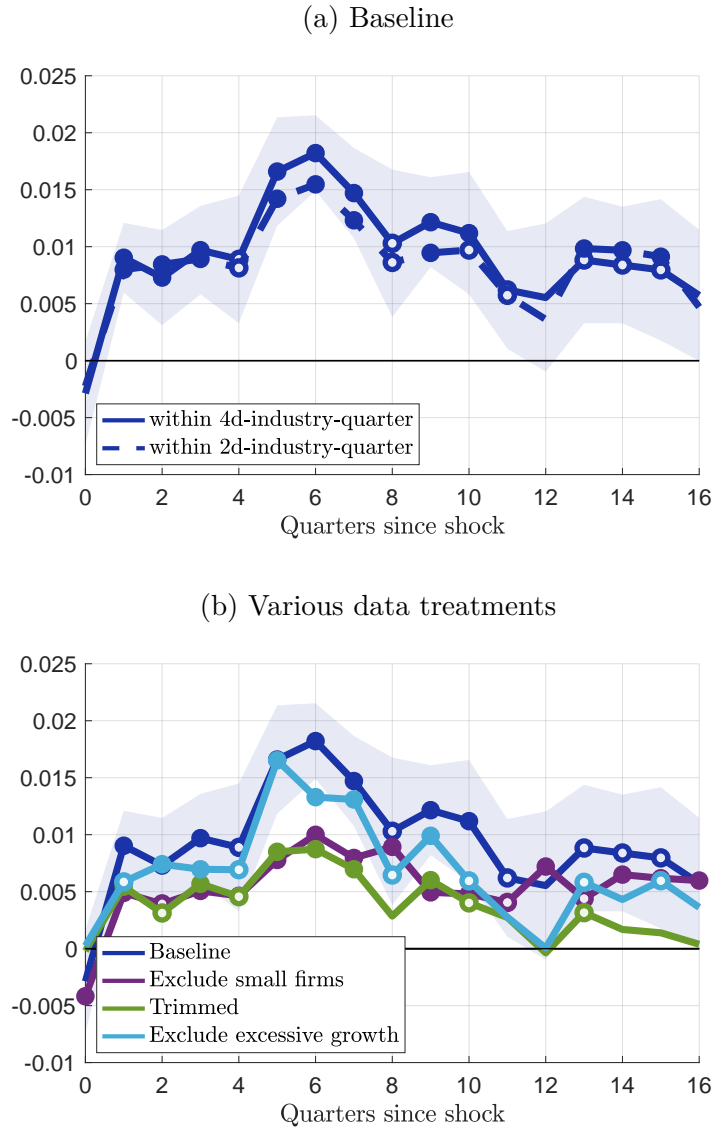
Furthermore, the response of MPK dispersion holds up to the same scrutiny we applied to the TFP response. In particular, we consider alternative monetary policy shock series: one based on the current-month fed funds future and one following [Nakamura and Steinsson \(2018\)](#). Panel (a) and (b) of Figure 9 shows that our results are broadly robust. Panel (c) and (d) of Figure 9 show that higher MPK dispersion in response to contractionary MP shocks is neither driven by QE-related shocks, nor by the information component of monetary announcement. To investigate whether peculiar outliers may drive the result, panel (b) of Figure 7 provides a scatterplot to introspect what drives our  $\beta_0^h$  coefficient (for  $h = 8$ ). While some events play a larger role than others, there does not seem to be a few outliers that drive all results.

Next, we ask whether the increase in MPK dispersion can quantitatively account for the estimated negative TFP response. To map MPK dispersion into TFP, we use the accounting model in Section 2. Denote by  $\varepsilon^{\text{MP}}$  the monetary policy shock, then

$$(3.4) \quad \frac{\partial \text{TFP}}{\partial \varepsilon^{\text{MP}}} = -\frac{\alpha(1-\nu)}{2(1-\alpha-\nu)} \frac{\partial \mathbb{V}(\text{mpk})}{\partial \varepsilon^{\text{MP}}}.$$

The parameters  $\alpha$  and  $\nu$  have been estimated on quarterly Compustat by [Gilchrist](#)

Figure 2: Responses of log MPK dispersion to a 25 basis points contractionary monetary policy shock



Notes: Panel (a) compares the response of within two-digit or four-digit industry-quarter dispersion of log MPK. Panel (b) compares data treatments (within 4d-quarter): *Exclude small firms* drops observations with real sales below 1 mln (in 2010 USD). *Trimmed* the top and bottom 1% of log MPK for every quarter. *Exclude excessive growth* drops observations with real sales growth above +200% or is below -66%. Inference is based on Newey-West s.e. The shaded area is the one-s.e. band for the baseline (within four-digit) response. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

et al. (2014) at 0.255 and 0.600, respectively.<sup>20</sup> Using these parameter values, the estimated increase in  $\mathbb{V}(mpk)$  of up to 0.015 lowers aggregate TFP by 0.5%. This is a large part of the estimated maximum decline of 0.6% in aggregate TFP, see Figure 1. To summarize, the presented evidence suggests that the misallocation channel of monetary policy shocks is quantitatively of central importance and explains more than half of the adverse TFP effects of monetary policy shocks.

Finally, we provide an attempt of an explanation why monetary policy shocks affect misallocation and some suggestive evidence in support of it. Our explanation is based on the bank lending channel of monetary policy. Kashyap et al. (1993) establish empirically that bank loan supply falls after contractionary monetary policy shocks. The fall in loan supply, however, is not uniform across bank, but substantially heterogeneous, as shown in Kashyap and Stein (2000). Further, firms are engaged in long-term lending relations with banks, and switching is costly, see Chodorow-Reich (2014). So the heterogeneous bank loan supply reduction may translate into heterogeneous borrowing (shadow) costs for firms, and eventually capital misallocation. However, large firms will find it relatively easier to raise equity or issue corporate bonds, as a means to substitute reduced bank loan supply, see Becker and Ivashina (2014).

We investigate the implication that misallocation should be more responsive for small firms by grouping Compustat firms in four quartile groups according to the real value of assets. For every quarter, we then compute the variance contribution of the four size groups. Finally, we estimate the response of the group-specific contribution to the variance to monetary policy shocks. Figure 3 shows that most of the increase in log MPK variance is driven by small firms. This is consistent with our hypothesis, that size-specific financial frictions are important for the monetary transmission mechanism.

### 3.4. *Alternative explanations of lower TFP*

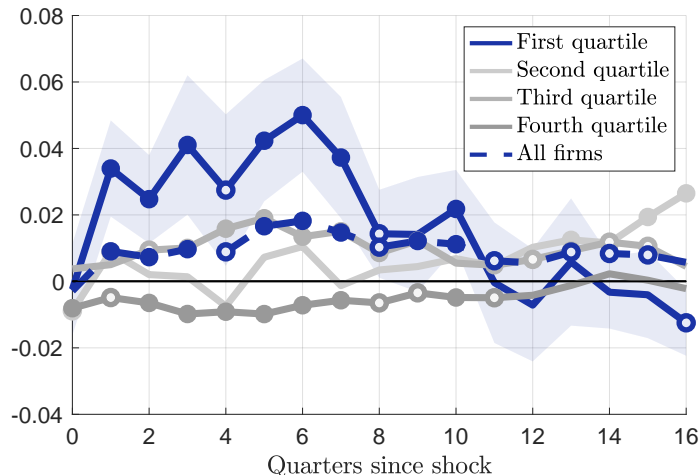
Finally, we want to address alternative explanations of lower TFP and higher misallocation in response to tighter monetary policy, notably R&D investment and uncertainty. However, the evidence on these channels is inconclusive.

An alternative reason for lower TFP is that firms reduce efforts to raise their productivity after tighter monetary policy. Aggregate TFP then falls because firm-

---

<sup>20</sup>Related studies using different data and methodology obtains comparable estimates, see Winberry (2016) using IRS data, and Cooper and Haltiwanger (2006) using LRD data.

Figure 3: Firm size and the responses of log MPK dispersion



Notes: Firms are grouped by quartiles of real value of assets. Inference is based on Newey-West s.e. The shaded area is the one-s.e. band for the baseline (within four-digit) response. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

level productivity falls. One way in which firms can raise their own productivity is R&D investment. For instance, [Comin and Gertler \(2006\)](#) develops a DSGE model in which firms choose R&D investment. However, panel (c) of Figure 8 in the Appendix shows that R&D investments does not consistently and significantly fall after contractionary monetary policy shocks.

Higher uncertainty is an alternative explanation of higher misallocation and thus lower TFP. If tighter monetary policy raises uncertainty, this may increase capital misallocation, e.g., through the real option channel, see [Bloom \(2009\)](#). We consider four measures of uncertainty: macro uncertainty in [Jurado et al. \(2015\)](#), financial uncertainty in [Ludvigson et al. \(2018\)](#), the VIX used in [Bloom \(2009\)](#), and policy uncertainty in [Baker et al. \(2016\)](#). Figure 10 in the Appendix shows that uncertainty does not consistently increase across uncertainty measures. While macro and financial uncertainty increase under our baseline monetary policy shock, the VIX and policy uncertainty rather decline.

#### 4. CONCLUSION

This paper presents new empirical evidence, which strongly supports capital misallocation as an important transmission channel of monetary policy shocks. In partic-



ular, we show that contractionary monetary policy shocks lower aggregate TFP and raise capital misallocation. Through the lense of our model, the increase in capital misallocation can explain a large part of the TFP decline. Finally, we argue that size-dependent financial frictions are important to understand the misallocation channel.

## REFERENCES

- ASKER, J., A. COLLARD-WEXLER, AND J. D. LOECKER (2014): “Dynamic Inputs and Resource (Mis)Allocation,” *Journal of Political Economy*, 122, 1013–1063.
- BAKER, S. R., N. BLOOM, AND S. J. DAVIS (2016): “Measuring Economic Policy Uncertainty,” *The Quarterly Journal of Economics*, 131, 1593.
- BAQAEE, D. R. AND E. FARHI (2018): “Productivity and Misallocation in General Equilibrium,” *NBER Working Paper Series*.
- BECKER, B. AND V. IVASHINA (2014): “Cyclicality of credit supply: Firm level evidence,” *Journal of Monetary Economics*, 62, 76–93.
- BERNANKE, B. S. AND A. S. BLINDER (1988): “Credit, Money, and Aggregate Demand,” *American Economic Review*, 78, 435–439.
- BLOOM, N. (2009): “The Impact of Uncertainty Shocks,” *Econometrica*, 77, 623–685.
- BRINCA, P., V. V. CHARI, P. J. KEHOE, AND E. MCGRATTAN (2016): *Accounting for Business Cycles*, vol. 2, Elsevier B.V., 1 ed.
- CHODOROW-REICH, G. (2014): “The Employment Effects of Credit Market Disruptions: Firm-level Evidence from the 2008-09 Financial Crisis,” *Quarterly Journal of Economics*, 129, 1–59, lead article.
- CHRISTIANO, L. J., M. EICHENBAUM, AND C. L. EVANS (1999): “Monetary policy shocks: What have we learned and to what end?” *Handbook of Macroeconomics*, 1, 65–148.
- COMIN, D. AND M. GERTLER (2006): “Medium-Term Business Cycles,” *American Economic Review*, 96, 523–551.
- COOPER, R. W. AND J. C. HALTIWANGER (2006): “On the Nature of Capital Adjustment Costs,” *Review of Economic Studies*, 73, 611–633.
- DAVID, J., L. SCHMID, AND D. ZEKE (2018): “Risk-Adjusted Capital Allocation and Misallocation,” mimeo, USC.
- DE LOECKER, J. AND J. ECKHOUT (2018): “Global Market Power,” *mimeo*, 122, 1013–1063.
- EISFELDT, A. L. AND A. A. RAMPINI (2006): “Capital reallocation and liquidity,” *Journal of*

- Monetary Economics*, 53, 369–399.
- EVANS, C. L. (1992): “Productivity shocks and real business cycles,” *Journal of Monetary Economics*, 29, 191–208.
- EVANS, C. L. AND F. T. SANTOS (2002): “Monetary policy shocks and productivity measures in the G-7 countries,” *Portugese Economic Journal*, 1, 47–70.
- FERNALD, J. (2014): “A quarterly, utilization-adjusted series on total factor productivity,” *Federal Reserve Bank of San Francisco Working Paper Series*.
- GALÍ, J. (2015): *Monetary Policy, Inflation, and the Business Cycle: an Introduction to the New Keynesian Framework and its Applications*.
- GERTLER, M. AND S. GILCHRIST (1994): “Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms,” *The Quarterly Journal of Economics*, 109, 309–340.
- GERTLER, M. AND P. KARADI (2015): “Monetary Policy Surprises, Credit Costs and Economic Activity,” *American Economic Journal: Macroeconomics*, 7, 44–76.
- GILCHRIST, S., J. W. SIM, AND E. ZAKRAJŠEK (2014): “Uncertainty, Financial Frictions, and Investment Dynamics,” Working Paper 20038, National Bureau of Economic Research.
- GOPINATH, G., . KALEMLI-ÖZCAN, L. KARABARBOUNIS, AND C. VILLEGAS-SANCHEZ (2017): “Capital Allocation and Productivity in South Europe,” *Quarterly Journal of Economics*, 132, 1915–1967.
- GORODNICHENKO, Y. AND M. WEBER (2016): “Are Sticky Prices Costly? Evidence from the Stock Market,” *American Economic Review*, 106, 165–99.
- HALL, R. (1986): “Market Structure and Macroeconomic Fluctuations,” *Brookings Papers on Economic Activity*, 17, 285–338.
- HSIEH, C.-T. AND P. J. KLENOW (2009): “Misallocation and Manufacturing TFP in China and India,” *The Quarterly Journal of Economics*, CXXIV, 1403–1448.
- IPPOLITO, F., A. K. OZDAGLI, AND A. PEREZ-ORIVE (2018): “The transmission of monetary policy through bank lending: The floating rate channel,” *Journal of Monetary Economics*, 95, 49 – 71.
- JAROCINSKI, M. AND P. KARADI (2018): “Deconstructing monetary policy surprises: the role of information shocks,” .
- JEENAS, P. (2018): “Firm Balance Sheet Liquidity, Monetary Policy Shocks, and Investment Dynamics,” *mimeo*.
- JORDÀ, Ò. (2005): “Estimation and Inference of Impulse Responses by Local Projections,” *American Economic Review*, 95, 161–182.

- JURADO, K., S. C. LUDVIGSON, AND S. NG (2015): “Measuring Uncertainty,” *American Economic Review*, 105, 1177–1216.
- KASHYAP, A., J. STEIN, AND D. WILCOX (1993): “Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance,” *American Economic Review*, 83, 78–98.
- KASHYAP, A. K. AND J. C. STEIN (2000): “What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?” *American Economic Review*, 90, 407–428.
- KHAN, A. AND J. K. THOMAS (2008): “Idiosyncratic Shocks and the Role of Nonconvexities in Plant and Aggregate Investment Dynamics,” *Econometrica*, 76, 395–436.
- (2013): “Credit Shocks and Aggregate Fluctuations in an Economy with Production Heterogeneity,” *Journal of Political Economy*, 121, 1055–1107.
- KYDLAND, F. E. AND E. C. PRESCOTT (1982): “Time to Build and Aggregate Fluctuations,” *Econometrica*, 50, 1345–70.
- LUDVIGSON, S. C., S. MA, AND S. NG (2018): “Uncertainty and Business Cycles: Exogenous Impulse or Endogenous Response?” Tech. rep., New York University.
- MEIER, M. (2018): “Time To Build and the Business Cycle,” *mimeo U Mannheim*.
- MIDRIGAN, V. AND D. Y. XU (2014): “Finance and Misallocation: Evidence from Plant-Level Data,” *The American Economic Review*, 104, 422–458.
- NAKAMURA, E. AND J. STEINSSON (2018): “High Frequency Identification of Monetary Non-Neutrality: The Information Effect,” *Quarterly Journal of Economics*, 133, 1283–1330.
- NEKARDA, C. J. AND V. A. RAMEY (2013): “The Cyclical Behavior of the Price-Cost Markup,” Working Paper 19099, National Bureau of Economic Research.
- OTTONELLO, P. AND T. WINBERRY (2018): “Financial Heterogeneity and the Investment Channel of Monetary Policy,” .
- PASTEN, E., R. SCHOENLE, AND M. WEBER (2018): “The Propagation of Monetary Policy Shocks in a Heterogeneous Production Economy,” *mimeo*.
- ROMER, C. D. AND D. H. ROMER (2004): “A New Measure of Monetary Shocks: Derivation and Implications,” *American Economic Review*, 94, 1055–1084.
- SMETS, F. AND R. WOUTERS (2007): “Shocks and Firctions In US Business Cycle: A Bayesian DSGE Approach,” *American Economic Review*, 97, 586–606.
- SOLOW, R. M. (1957): “Technical Change and the Aggregate Production Function,” *The Review of Economics and Statistics*, 39, 312–320.
- TOBIN, J. AND W. BRAINARD (1963): “Financial Intermediaries and the Effectiveness of Monetary

Policy,” *American Economic Review, Papers and Proceedings*, 53, 383–400.

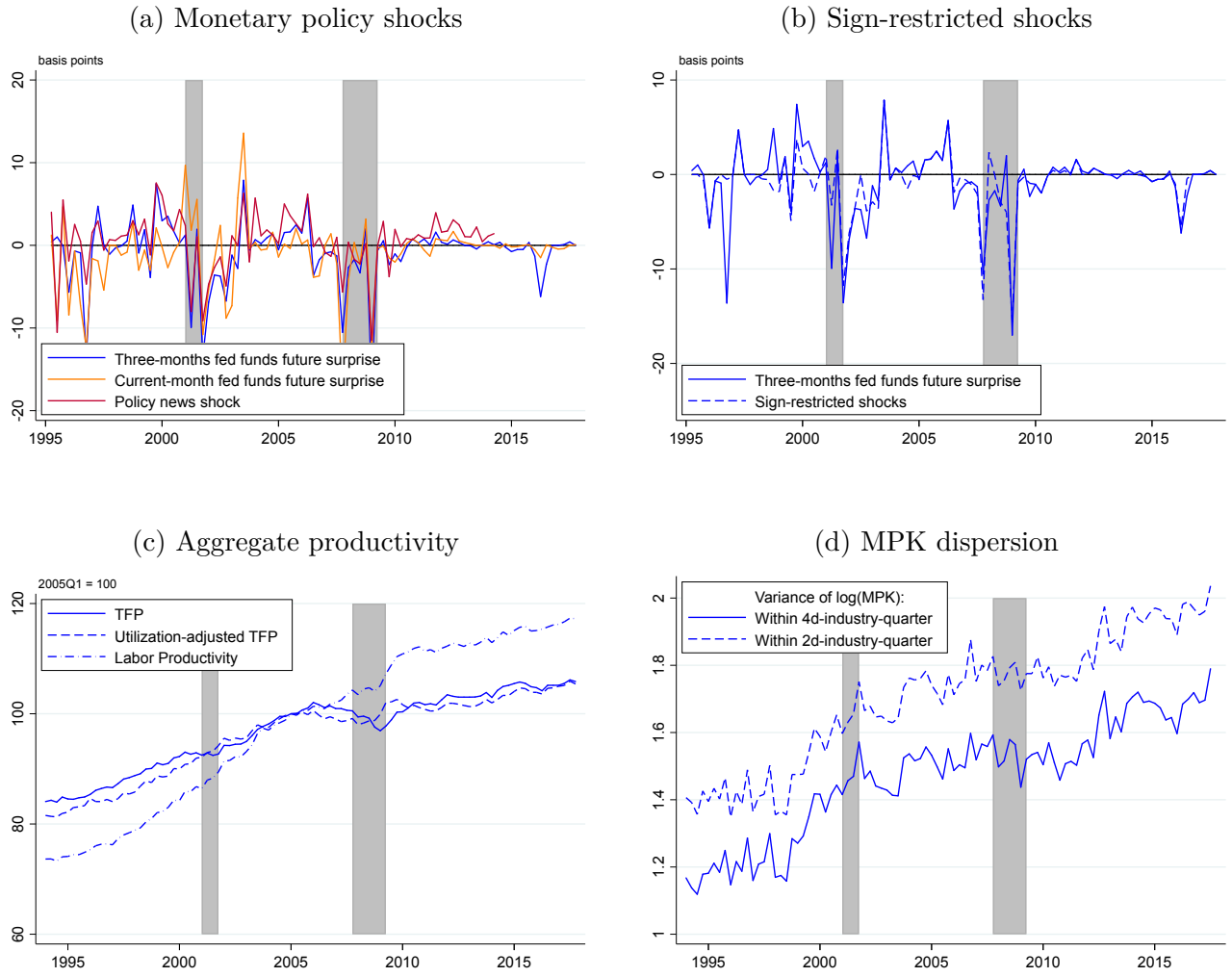
WINBERRY, T. (2016): “Lumpy Investment, Business Cycles, and Stimulus Policy,” mimeo, Chicago Booth.

WOODFORD, M. (2003): *Interest and Prices*, Princeton University Press.

APPENDIX

APPENDIX A: DESCRIPTIVE STATISTICS

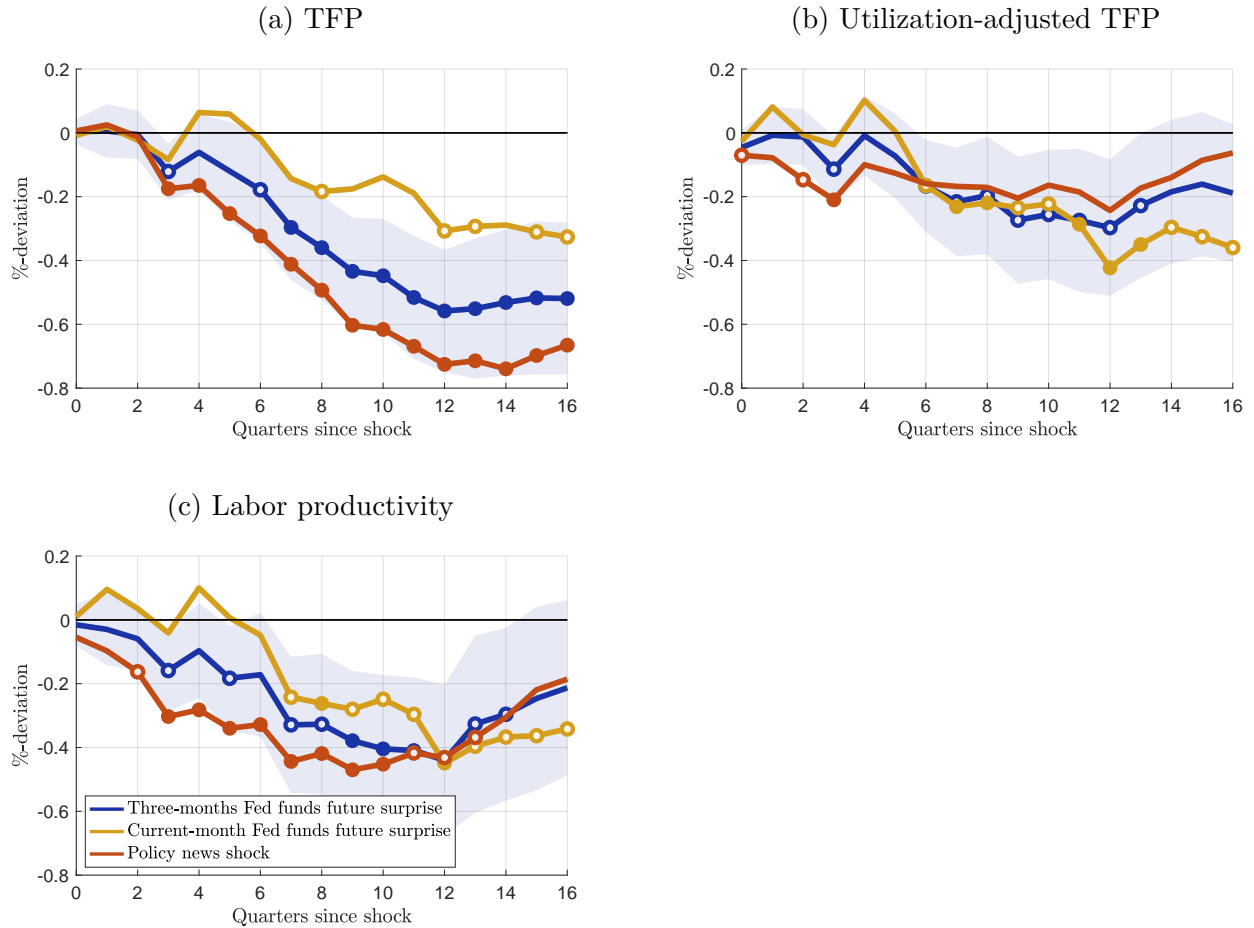
Figure 4: Time series plots



Notes: Aggregate productivity, MPK dispersion, and monetary policy shocks are at quarterly frequency. Shaded gray areas indicate NBER recession dates.

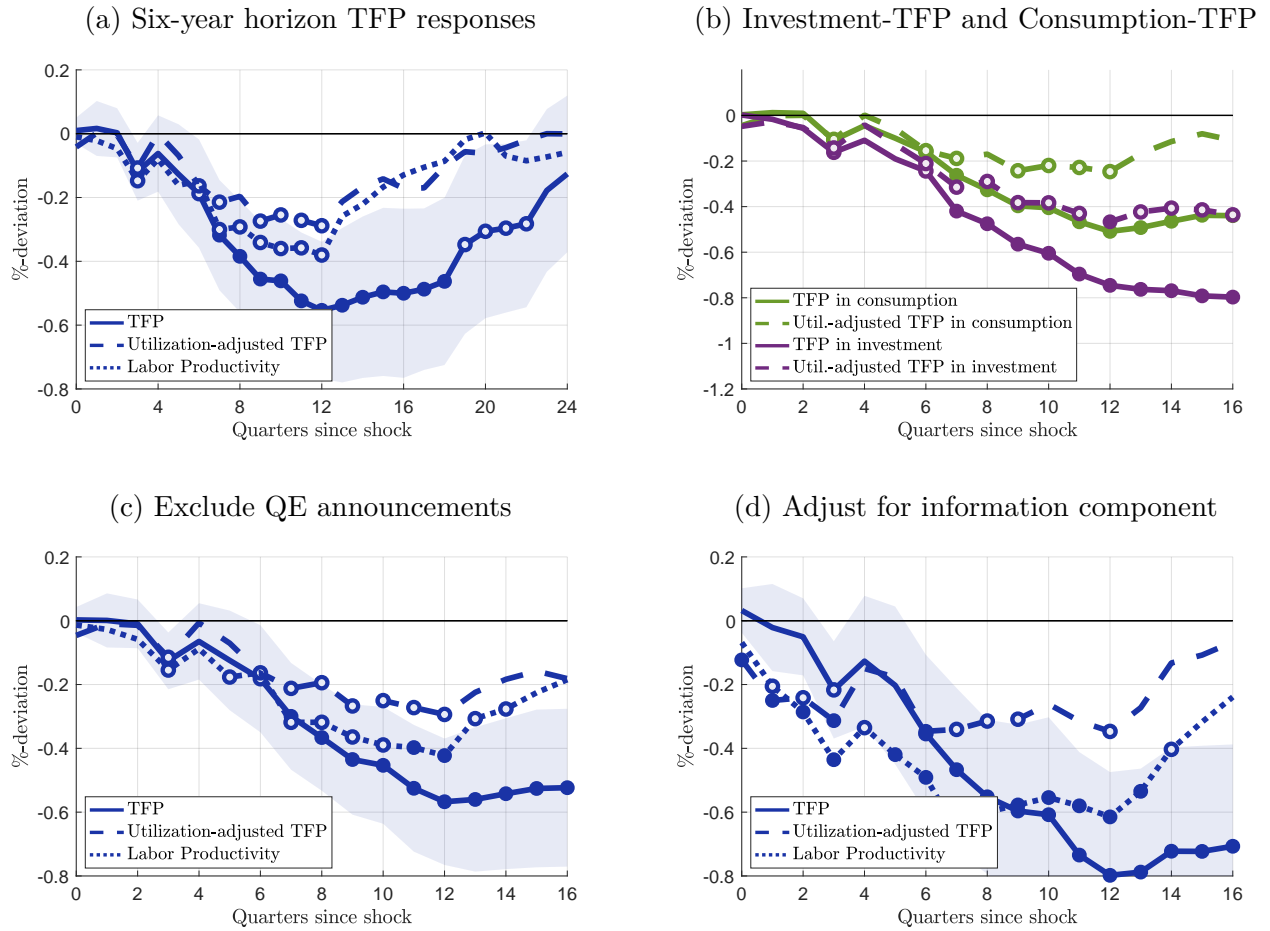
APPENDIX B: ROBUSTNESS OF EMPIRICAL FINDINGS

Figure 5: Productivity IRFs for alternative monetary policy shocks



Notes: Blue lines are the baseline responses to a surprise in the 3-month federal funds future. Yellow lines show the responses to a surprise in the current-month federal funds future. The red lines show the responses to the shock in Nakamura and Steinsson (2018). All responses are scaled to have a peak impact on the federal funds rate of 25 basis points. Inference is based on Newey-West standard errors. The shaded area shows a one standard error band for the response of TFP. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

Figure 6: Further productivity IRFs

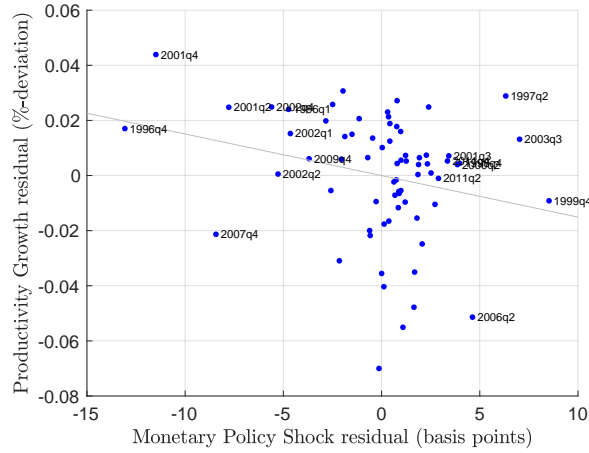


Notes: Exclude QE announcements excludes any monetary policy shock on announcement dates of Quantitative Easing (QE) 1, QE 2, QE 3, and Operation Twist. Adjust for information component excludes any monetary policy shock that coincides with stock market price movements in the same direction. Estimating the productivity responses at a six-year horizon effectively changes the sample that we consider. Investment-TFP and Consumption-TFP are from Fernald (2014). Inference is based on Newey-West standard errors. The shaded area shows a one standard error band for the response of TFP. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

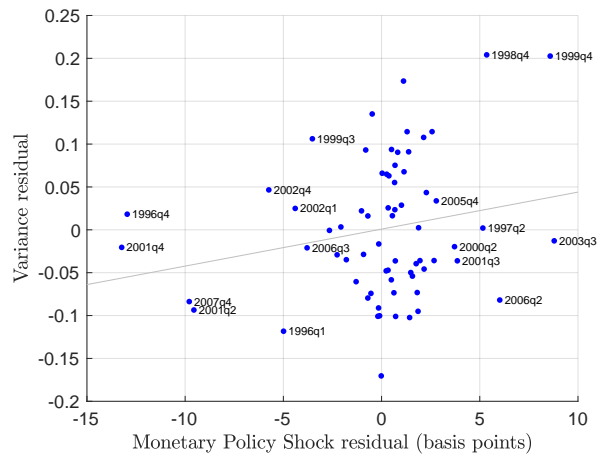


Figure 7: Scatter plots on the responses of TFP and MPK dispersion

(a) TFP

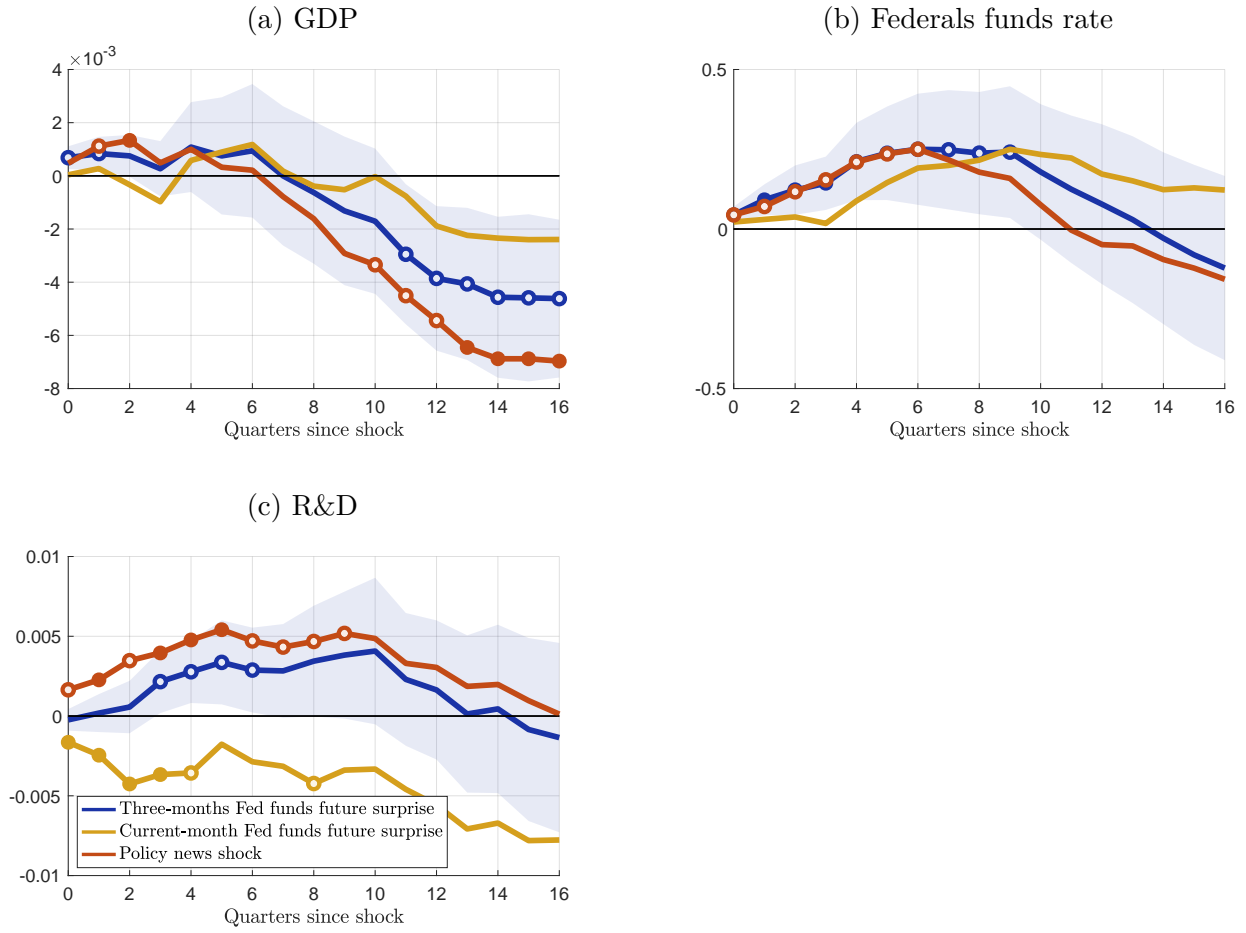


(b) MPK dispersion



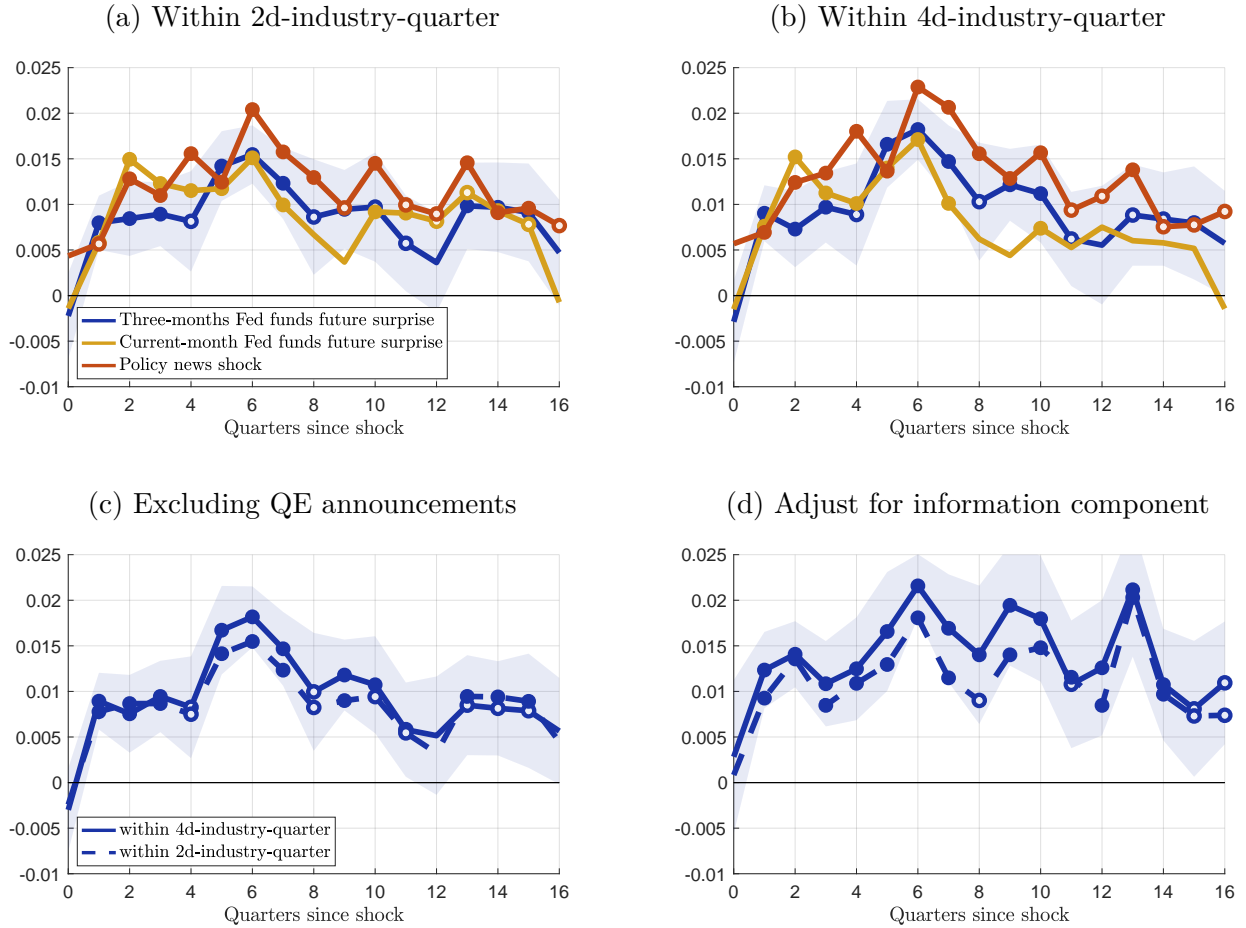
Note: This figure plots residuals from a Frisch-Waugh-Lowell procedure that isolates the effective regressors and regressands that produce our coefficient of interest,  $\beta^h$ , which is the impulse response function.

Figure 8: Responses of GDP, Federal funds rate, R&D investment



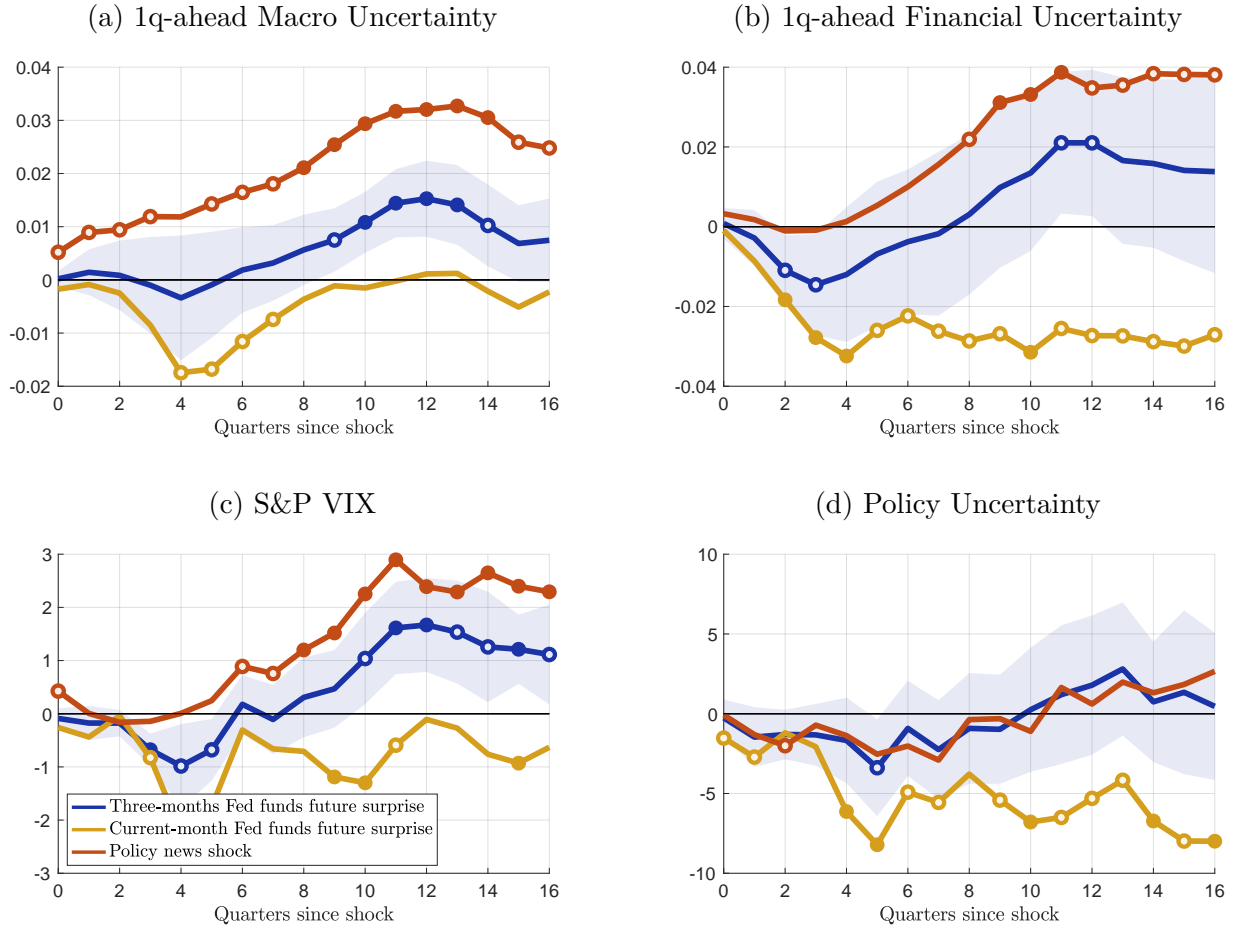
Notes: Blue lines are the baseline responses to a surprise in the 3-month federal funds future. Yellow lines show the responses to a surprise in the current-month federal funds future. The red lines show the responses to the shock in Nakamura and Steinsson (2018). All responses are scaled to have a peak impact on the federal funds rate of 25 basis points. Inference is based on Newey-West standard errors. The shaded area shows a one standard error band for the response of TFP. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

Figure 9: Robustness: Response of MPK dispersion



Notes: Blue lines are the baseline responses to a surprise in the 3-month federal funds future. Yellow lines show the responses to a surprise in the current-month federal funds future. The red lines show the responses to the shock in Nakamura and Steinsson (2018). All responses are scaled to have a peak impact on the federal funds rate of 25 basis points. Exclude QE announcements excludes any monetary policy shock on announcement dates of Quantitative Easing (QE) 1, QE 2, QE 3, and Operation Twist. Adjust for information component excludes any monetary policy shock that coincides with stock market price movements in the same direction. Inference is based on Newey-West standard errors. The shaded area shows a one standard error band for the response of TFP. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.

## APPENDIX C: ADDITIONAL EMPIRICAL RESULTS

Figure 10: Responses of *uncertainty* measures to a 25 basis points contractionary monetary policy shock

This plot shows responses of uncertainty to a contractionary monetary policy shock based on equation (3.3). The blue line shows the response to a surprise the 3-month federal funds future (as considered, for example, by [Gertler and Karadi, 2015](#)), for which the shaded area shows a one standard error band based on Newey-West. The yellow lines show the response to a surprise in the current-month federal funds future. The red line shows the response to policy news shock as in [Nakamura and Steinsson \(2018\)](#). All responses are scaled such that they increase the effective federal funds rate by 25BP at peak. Filled (unfilled) circles indicate statistical significance at the 10% (32%) level.