

# Inattention and the Impact of Monetary Policy\*

Zidong An<sup>†</sup>

Salem Abo-Zaid<sup>‡</sup>

Xuguang Simon Sheng<sup>§</sup>

February 22, 2022

## Abstract

We measure aggregate inattention as the common component in agents' inattentiveness to many economic variables. Applying this measure to the U.S. Survey of Professional Forecasters enables us to establish the following empirical evidence. Professional forecasters update their information sets every five months on average, but do so more frequently in response to high inflation and unemployment, as well as rising market volatility and policy uncertainty. Monetary policy shocks have larger real effects when the degree of inattention is higher. To explain our empirical findings, we propose a general equilibrium model with state-dependent information rigidity in both the production and household sectors. High levels of inattention among firms amplify the real impact of monetary policy while household inattention weakens and delays the response of output to monetary policy shocks.

**JEL classification:** E32; E52

**Keywords:** Inattentive Firms, Inattentive Households, Monetary Policy, State Dependence, Sticky Information

---

\*This paper was presented at AEA, IAAE, FFC, ISF, National Bank of Poland, George Washington University and American University. We thank John Rogers for sharing their monetary policy shock measure, and Philippe Andrade, Matt Klepacz, Jonathan Wallen, and conference participants for helpful comments.

<sup>†</sup>Renmin University of China

<sup>‡</sup>University of Maryland-Baltimore County

<sup>§</sup>American University. Corresponding author. Mailing address: Department of Economics, 4400 Massachusetts Avenue, NW, Washington, DC 20016, USA. Tel: (202) 885-3782. Email: sheng@american.edu.

# 1 Introduction

The current resurgence of interest in the expectation formation process builds upon a long tradition of research on imperfect information; see [Mankiw and Reis \(2010\)](#) and [Gabaix \(2019\)](#) for surveys. These frictions are important for explaining why economic agents may be inattentive to news and have divergent views. Despite a growing body of work on quantifying information frictions, it remains a great challenge in directly estimating the degree of inattention and exploring its impact on macroeconomic dynamics.

To address this challenge, we extend the [Andrade and Le Bihan \(2013\)](#) measure of inattention based on a single variable to multiple variables. A forecaster's inattention to an economic variable is the probability that the forecaster does not update the information on the variable in a given period. Aggregate inattention is defined as the common component in professional forecasters' inattentiveness to many economic variables. Applying this definition to the U.S. Survey of Professional Forecasters (SPF) during 1970Q1-2021Q1, we find that these professionals update their information sets every five months on average. Inattention is highly pro-cyclical, as inattention significantly declines during periods of recession, high inflation, and high market volatility. We then explore how state-dependent inattention alters the impact of monetary policy, finding that monetary policy shocks have much larger real effects when economic agents pay less attention.

To match these stylized facts, we develop a dynamic stochastic general equilibrium (DSGE) model with inattentive households and firms. This model mostly resembles a standard New Keynesian framework, but with sticky information replacing sticky prices. Each period, only a fraction of households and firms update their information sets and make rational plans based on current information, while the remaining households and firms make their decisions based on outdated information. The key innovation of our model is to allow for inattention to be endogenous. [Dotsey et al. \(1999\)](#) build a framework for state-dependent price setting, and we modify their setup to an environment with state-dependent information processing.<sup>1</sup> Facing the fixed cost of collecting and processing information, households and firms in our model choose to update their information sets if and only if the benefit from updating exceeds that from not updating.

---

<sup>1</sup>[Dotsey et al. \(1999\)](#) is an important paper showing how to solve a menu cost model in a tractable general equilibrium. This model was used in other fields to obtain seminal results. For example, [Thomas \(2002\)](#) applies this modeling strategy to capital and shows for the first time the neutrality of micro-adjustment friction for aggregate capital dynamics.

To our knowledge, this is the first paper applying Dotsey et al. (1999) for information frictions. This modeling strategy is simple, parsimonious, fast to compute and there is a data counter-part. We calibrate the model to the U.S. economy. Our simulation results show that when information rigidity is higher, a monetary policy shock has a much larger impact on output. Furthermore, inattention in both production and household sectors matters. High levels of inattention among firms amplify the real impact of monetary policy. Inattentive households lead to delayed and weaker responses of output to monetary policy shocks. By incorporating both firm and household inattention, our model can match the data well, while a model with sticky prices and inattentive households fails to do so.<sup>2</sup>

Our paper builds on the literature that estimates information rigidity through survey data. One approach uses aggregate forecasts together with a set of auxiliary assumptions about the economy to estimate a structural parameter of information frictions (Mankiw et al., 2003; Coibion and Gorodnichenko, 2015).<sup>3</sup> Another approach explores the expectation formation process based on individual-level survey data (Andrade and Le Bihan, 2013; Dräger and Lamla, 2017; Giacomini et al., 2020).<sup>4</sup> Following the latter approach, we use micro data on forecast revisions to estimate inattention. We differ from these studies by defining information frictions in a multivariate context, rather than inattentiveness to a particular variable such as inflation. This is important, because the univariate measurement would substantially over- or under-estimate the degree of information stickiness.

Taking advantage of the long sample period of the aggregate inattention measure during 1970Q1-2021Q1, we are able to analyze its potential determinants. We find that economic agents pay close attention during recessions, high inflation and unemployment, as well as rising market volatility and policy uncertainty episodes. This allows us to generalize the results that inattention declines

---

<sup>2</sup>Rational inattention, proposed by Sims (2003), is an alternative framework to have endogenous information processing. Mackowiak and Wiederhold (2015) develop a DSGE model with rational inattention. Zhang (2017) considers a rational inattention model with volatility uncertainty and endogenous information formation, finding that firms optimally process more information when uncertainty rises. Afrouzi and Yang (2021) link monetary non-neutrality and the slope of the Phillips curve to inattention.

<sup>3</sup>Mankiw et al. (2003) find about ten months of information frictions from the Livingston survey. Coibion and Gorodnichenko (2015) identify an information lag of six to seven months using U.S. SPF data.

<sup>4</sup>Andrade and Le Bihan (2013) find four months of inattentiveness using European Central Bank SPF data. Dräger and Lamla (2017) document more than six months of consumer inattentiveness using the Michigan Survey of Consumers. Giacomini et al. (2020) find that, on average, 40% to 50% of market participants update at least once a month. See also Broer and Kohlhas (2018), Fuhrer (2018) and Bordalo et al. (2020) that use individual data from the U.S. SPF to study the role of cognitive limits in the expectation formation process.

after large shocks such as the Great Recession ([Andrade and Le Bihan, 2013](#)), 9/11 ([Coibion and Gorodnichenko, 2015](#)), or natural disaster shocks ([Baker et al., 2020](#)), as well as to better understand the factors driving the variations of inattention over time.

Finally, our paper contributes to the vast literature on the transmission of monetary policy shocks. We show both empirically and theoretically that inattention, like nominal rigidities, amplifies the response of the economy to a given set of monetary policy shocks ([Mankiw and Reis, 2002](#); [Ball et al., 2005](#); [Reis, 2009](#); [Christiano et al., 2021](#)).<sup>5</sup> What is not readily recognized in the literature is that the impact on output is larger with state-dependent inattention than with constant inattention. When economic agents pay less attention, monetary policy has larger real impacts. Since inattention falls during recessions and periods of high uncertainty, our results provide a new explanation for why monetary shocks have less impact on output during these episodes ([Caggiano et al., 2014](#); [Tenreyro and Thwaites, 2016](#); [Aastveit et al., 2017](#); [Afrouzi and Yang, 2021](#)).

The paper proceeds as follows. Section 2 proposes the measure of aggregate inattention, empirically estimates it using the U.S. SPF dataset, explores the potential determinants of its variation, and studies how inattention affects the transmission of monetary policy. Section 3 outlines a general equilibrium model with inattentive firms and households with both constant and state-dependent inattention. Section 4 demonstrates, through calibration and simulation, how inattention alters the effect of monetary policy on economic dynamics, and provides a comparison between the model predictions and the empirical findings. Section 5 concludes. Additional empirical estimation results and theoretical analyses are relegated to an online appendix.

## 2 Measuring Inattention

This section starts with developing a new measure of inattention in a multivariate context. Applying this measure to surveys of professional forecasters and households, we explore the properties of aggregate inattention and study its role in amplifying the impact of monetary policy.

---

<sup>5</sup>In response to the weakness of the New Keynesian model with sticky prices, [Mankiw and Reis \(2002\)](#) assume that a certain fraction of firms do not update their information sets periodically. They show that the New Keynesian model with sticky information generates results that are consistent with the empirical evidence on the effects of monetary policy on the economy. [Ball et al. \(2005\)](#) consider information stickiness in the price setting and study its implication for optimal monetary policy. [Reis \(2009\)](#) considers a more general information stickiness across firms, consumers, and workers, and studies the impact of sticky information on the response to monetary policy shocks and on the optimal targeting rules. [Christiano et al. \(2021\)](#) show that information rigidity is crucial for generating the delayed response of households' expenditures on durable and nondurable goods to monetary policy shocks.

## 2.1 A Multivariate Measure of Inattention

Ideally, a measure of attentiveness should directly measure information updates. Though agents' information sets are not directly observable, forecast revisions offer an observable proxy for information updates. In line with the literature, we interpret no forecast revision as no update to the information set. It is possible that a forecaster updates information set and nevertheless keeps prediction constant due to misreporting/rounding errors. This is an inherent limitation of using forecast revisions as a proxy for information updates. However, as discussed in [Andrade and Le Bihan \(2013\)](#), the economic conditions are complicated, and the new information is highly unlikely to lead to the same forecast. Another complication in using forecast revisions as a proxy for information updates arises when professional forecasters are motivated to make small revisions due to strategic reasons.<sup>6</sup> This is less of a concern, since the forecasters in our surveys are anonymous. A third concern arises when using the unbalanced panel in the survey to measure inattention. The compositional changes in the Survey of Professional Forecasters do not seem to have any meaningful impact on our inattention measure.<sup>7</sup>

We extend the [Andrade and Le Bihan \(2013\)](#)'s approach by going beyond whether or not agents revise a single variable to measure inattention based on forecast revisions of multiple variables. Specifically, let  $F_{ith}^m$  be the forecast made by individual  $i$  at time  $t$ , for the target variable  $m$  at  $h$  period ahead. Then an indicator function  $I_{ith}$  for forecast revision is defined as:

$$I_{ith}^m = \begin{cases} 1 & \text{if } F_{ith}^m = F_{it-1,h+1}^m; \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

Using this indicator, we define forecaster's inattention to a single variable  $m$  as:

$$IA_{th}^m = \frac{1}{N} \sum_{i=1}^N I_{ith}^m. \quad (2)$$

---

<sup>6</sup>For example, the “peer pressure” and pressure from clients were modeled by [Ehrbeck and Waldmann \(1996\)](#), in which forecasters are incentivized to make small, superfluous revisions in an environment of noisy signals so that clients perceive their forecasts as new. Professionals might shade their forecasts towards the consensus to avoid unfavorable publicity when wrong, or deviate in order to stand out as discussed in [Giacomini et al. \(2020\)](#).

<sup>7</sup>Ideally, the set of forecasters are randomly selected from the population at any given point in time. We cannot verify this property in the survey. To explore the possibility that more attentive forecasters are added to the survey during recessions, we regress the number of forecasters, the forecasters who enter the survey, or the forecasters who exit from the survey on recession dummies. None of the coefficients on recession are significant, and thus, we can safely rule out the possibility of forecaster selection bias. For brevity, these results are not reported here and are available upon request.

Then forecaster's aggregate inattention,  $IA_{th}$ , can be expressed as the averaged inattention across variables:

$$IA_{th} = \frac{1}{M} \sum_{m=1}^M IA_{th}^m. \quad (3)$$

The novel feature of this definition is that aggregate inattention is not equal to inattention to a single variable. Instead, it is a measure of the common variation in inattention to many series. This common variation is critical for the study of business cycles because imperfect information theories typically require the existence of inattention for economic agents, not their inattention to any single variable. As far as the underlying information processes of these economic variables have commonalities, professionals should have common time variations in information rigidities. Our inattention measurement complements the recent studies that emphasize the multivariate nature of expectation formation, such as [Banterghansa and McCracken \(2009\)](#), [Dovern \(2015\)](#) and [Andrade et al. \(2016\)](#).<sup>8</sup> This distinction is important since some univariate measurements would substantially over or underestimate the degree of agents' information stickiness, as shown in the next subsection.

## 2.2 Professionals Update their Information Every Five Months on Average

Our main dataset comes from the U.S. Survey of Professional Forecasters (SPF), provided by the Federal Reserve Bank of Philadelphia. Survey data on professionals fit the study of information rigidity due to a variety of strengths. Professional forecasters have access to a wide range of macroeconomic news and data, and they have a comparative advantage in allocating resources to process the news, relative to other economic agents. Furthermore, [Carroll \(2003\)](#) describes how the expectations of professionals affect households via news media. Due to these characteristics, inattention of professional forecasters is expected to be the lowest, and consequently, represents conservative estimates of inattention for firms.<sup>9</sup>

The SPF survey is anonymous, and each survey participant is assigned a unique identification

---

<sup>8</sup>[Banterghansa and McCracken \(2009\)](#) analyze the level of multivariate disagreement among individual members of the Federal Open Market Committee. [Dovern \(2015\)](#) documents multivariate forecast disagreement among professional forecasters of the Euro area economy and modifies models of heterogeneous expectation formation by introducing learning mechanisms and heterogeneous signal-to-noise ratios. To match the entire term structure of disagreement, [Andrade et al. \(2016\)](#) enrich the benchmark expectations formation model by (i) disentangling low-frequency shifts in the fundamentals of the economy from short-term fluctuations, and (ii) taking into account the dynamic interactions between variables when making forecasts.

<sup>9</sup>[Meyer et al. \(2021\)](#) present the new evidence from the Atlanta Fed's business survey that firms' inflation expectations are similar to those of professional forecasters.

number. According to [Engelberg et al. \(2011\)](#), the Federal Reserve Bank of Philadelphia must decide, based on judgment, whether a particular identification number should follow a forecaster when she changes employer. The number of respondents is about 26 before 1991 and 36 afterward on average. Respondents are typically banks, securities firms, econometric modelers, industrial corporations, and independent forecasters. The survey panelists make fixed-horizon forecasts in the middle month of each quarter, with forecast horizons ranging from 1- to 4-quarter ahead. Our sample covers six variables, namely, real GDP growth, inflation (based on GDP deflator), unemployment rate, corporate profits after tax, industrial production and housing starts from the first quarter of 1970 to the first quarter of 2021. We use the forecast revisions from all respondents in our main analysis.

Table 1: Summary Statistics of Inattention Estimates

Horizon	AGGR	RGDP	PGDP	U	C PROF	IP	HOU
4Q ahead	0.36 (0.12)	0.49 (0.21)	0.62 (0.20)	0.20 (0.13)	0.19 (0.12)	0.45 (0.17)	0.21 (0.10)
	0.34 (0.11)	0.46 (0.22)	0.62 (0.20)	0.20 (0.13)	0.18 (0.11)	0.43 (0.16)	0.19 (0.10)
3Q ahead	0.30 (0.10)	0.41 (0.22)	0.58 (0.20)	0.19 (0.10)	0.17 (0.12)	0.38 (0.16)	0.14 (0.09)
	0.23 (0.08)	0.28 (0.18)	0.46 (0.19)	0.19 (0.13)	0.13 (0.10)	0.26 (0.14)	0.04 (0.05)
1Q ahead							

*Notes:* Aggregate inattention (AGGR) is constructed based on equation (3), which is the average of inattention to each of six macroeconomic variables: real GDP growth (RGDP), GDP deflator inflation (PGDP), unemployment rate (U), corporate profits after tax (C PROF), industrial production (IP) and housing starts (HOU). Inattention to each individual variable is defined in equation (2) as the proportion of forecasters who do not revise their forecasts of such a target variable. Standard deviations of aggregate inattention are reported in parentheses. Survey data come from the U.S. SPF from the first quarter of 1970 to the first quarter of 2021.

Table 1 provides summary statistics. At the 4-and 3-quarter ahead, about 36% of professionals do not revise their forecasts within a quarter, implying their overall inattentiveness of about 4-5 months on average.<sup>10</sup> Inattention varies across variables, ranging from 19% in forecasting after-tax corporate profits to 62% in forecasting GDP deflator inflation. Taking inflation as an example, one would conclude that professional forecasters update their information sets about 7-8 months on average. On the other hand, focusing on corporate profits alone would yield an inattention of only

<sup>10</sup>Frequency of updating is calculated as  $4.7 = 3/(1 - 0.36)$ . Note that, in the quarterly SPF survey, respondents cannot revise more frequently than every 1 quarter. The survey frequency forms a lower bound for the degree of inattention; see also [Binder \(2017\)](#).

3-4 months. These results support measuring inattention in a multivariate context, because the univariate measurement would substantially overestimate or underestimate the degree of information stickiness.<sup>11</sup>

Table 2: Correlation between Aggregate and Variable-specific Inattention

Panel A. Unconditional Correlation							
	RGDP	PGDP	U	C PROF	IP	HOU	AGGR
RGDP	1						
PGDP	0.73	1					
U	0.43	0.41	1				
C PROF	0.53	0.52	0.33	1			
IP	0.57	0.51	0.39	0.47	1		
HOUSING	0.39	0.36	0.26	0.28	0.33	1	
AGGR	0.88	0.85	0.62	0.69	0.76	0.54	1
Panel B. Conditional Correlations							
	Probability of updating						
	RGDP	PGDP	U	C PROF	IP	HOU	
Given revising							
RGDP	1	0.49	0.91	0.85	0.62	0.82	
PGDP	0.60	1	0.91	0.85	0.63	0.83	
U	0.50	0.37	1	0.83	0.56	0.81	
C PROF	0.57	0.41	0.83	1	0.59	0.83	
IP	0.60	0.42	0.83	0.87	1	0.83	
HOUSING	0.52	0.38	0.81	0.84	0.57	1	

*Notes:* This table shows unconditional and conditional correlations between aggregate (AGGR) and variable-specific inattention. Aggregate inattention is constructed based on equation (3), which is the average of inattention to each of six macroeconomic variables: real GDP growth (RGDP), GDP deflator inflation (PGDP), unemployment rate (U), corporate profits after tax (C PROF), industrial production (IP) and housing starts (HOU). Inattention to each variable is defined in equation (2) as the proportion of forecasters who do not revise their forecasts of such a target variable. Conditional correlations are calculated using equation (1). Survey data come from the U.S. SPF from the first quarter of 1970 to the first quarter of 2021.

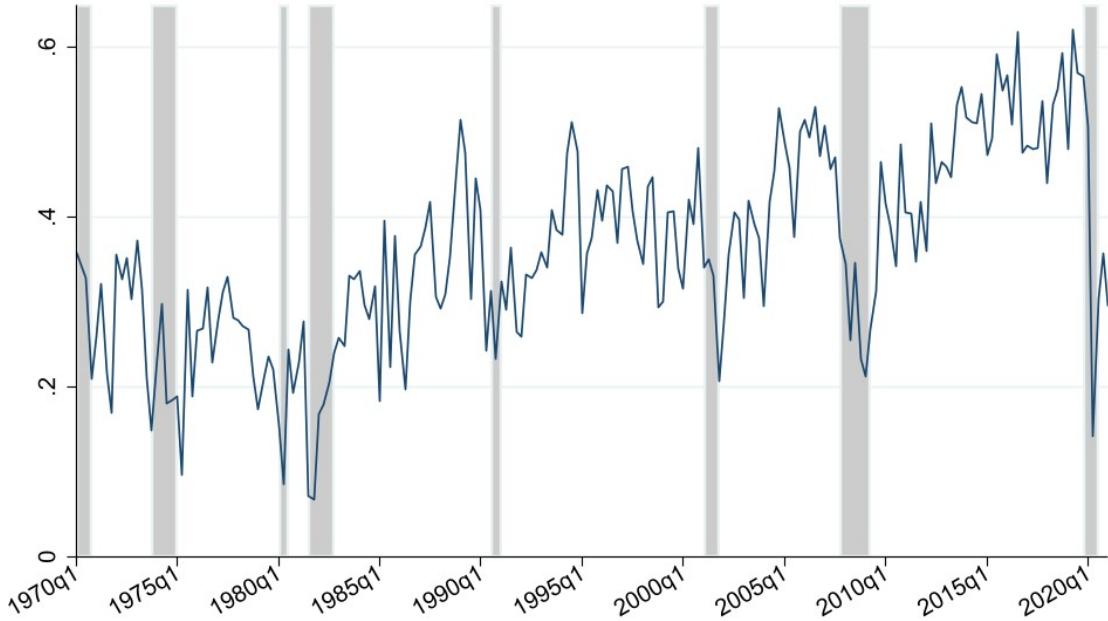
At 1- and 2-quarter ahead, more than 70% revise their forecasts at least once within a quarter, possibly due to the arrival of relevant information regarding the target variables in these short horizons. Despite these differences, professionals on average update their forecasts in about 3.9-4.3 months at 1- and 2-quarter ahead, compared to 4.5-4.7 months at 3- and 4-quarter ahead. And, the estimated degrees of inattention are highly correlated across the four different horizons.<sup>12</sup> For these reasons, we focus on aggregate inattention at 4-quarter ahead in our analysis below.

<sup>11</sup>Inattention at the forecaster level is significantly positively related to the corresponding forecast error, where the multivariate forecast errors are measured as the Mahalanobis distance between the vector of forecasts and the vector of actual values.

<sup>12</sup>Inattention at 4-quarter ahead is highly correlated with inattention at 3-quarter ahead (0.93), with inattention at 2-quarter ahead (0.89) and with inattention at 1-quarter ahead (0.81); see Table A.1 and Figure A.1.

The degrees of inattention across variables are imperfectly correlated, as shown in Table 2, and the correlation between inflation and real GDP is the highest (panel A). The movement in aggregate inattention is not driven by inattention to any single variable; see Figure A.2. In particular, the correlations between aggregate inattention and variable-specific inattention range from 0.54 for housing start to 0.88 for real GDP. Turning to conditional correlation (panel B), the probability of revising unemployment forecasts given the revision of GDP forecasts is 0.91. Similar results hold for the probability of revising unemployment forecasts given the revision of inflation forecasts. These results suggest that a substantial proportion of participants form expectations consistent with the Okun law and the Phillips curve; see also [Dräger et al. \(2016\)](#).

Figure 1: Aggregate Inattention



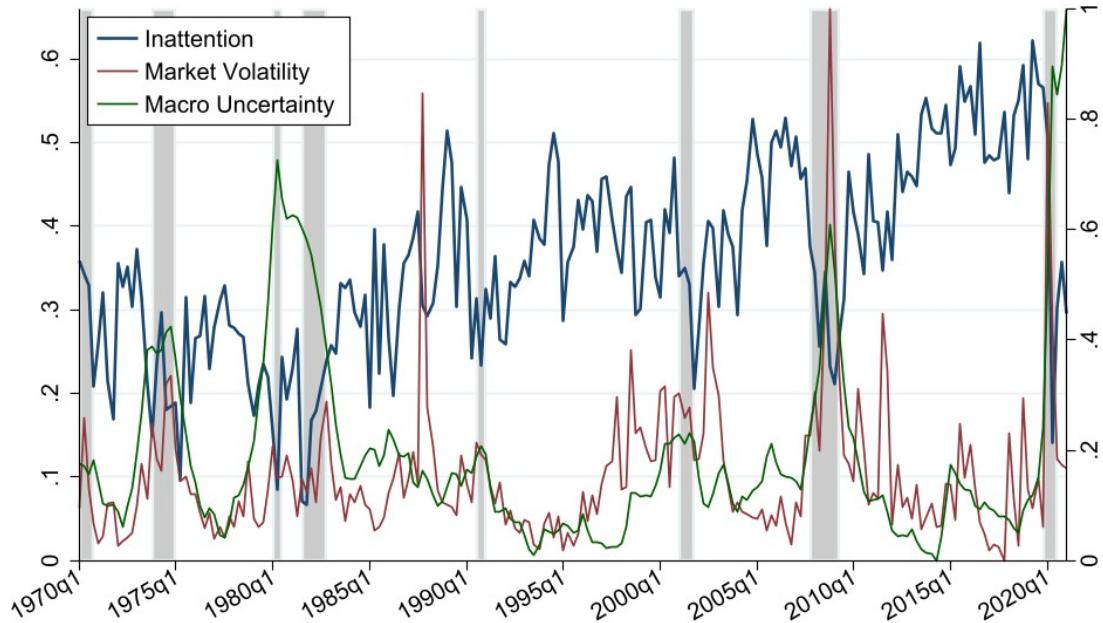
*Notes:* This figure plots quarterly aggregate inattention from the first quarter of 1970 to the first quarter of 2021. It is constructed based on equation (3), which is the average of inattention to the six individual variables: real GDP growth, GDP deflator inflation, unemployment rate, corporate profits after tax, industrial production and housing starts. Inattention to each individual variable is defined in equation (2) as the proportion of forecasters who do not revise their forecasts of such a target variable. The baseline inattention measure is based on 4-quarter ahead forecasts from the U.S. SPF.

### 2.3 Inattention is Pro-cyclical

Inattention varies over time, as illustrated in Figure 1. Three points are worth noting. First, inattention shows substantial variations at multiple frequencies. Inattention changes a lot at quarterly

intervals, but also shows variations that last over several years. Second, inattention is pro-cyclical. Professionals pay close attention during recessions, especially during the 2007-09 and the COVID-induced recessions. Third, the degree of inattention steadily increases after the Great Recession and remains elevated till 2019. To better understand this upward trend, note that both market volatility and macro uncertainty have been low since 2009 (Figure 2), and so professionals pay less attention. A similar trend is also observed from surveys of consumers, despite the fact that consumers are much more inattentive to macro conditions relative to professional forecasters; see Figure 3. According to the University of Michigan Surveys of Consumers, households update their information sets every eight months on average.

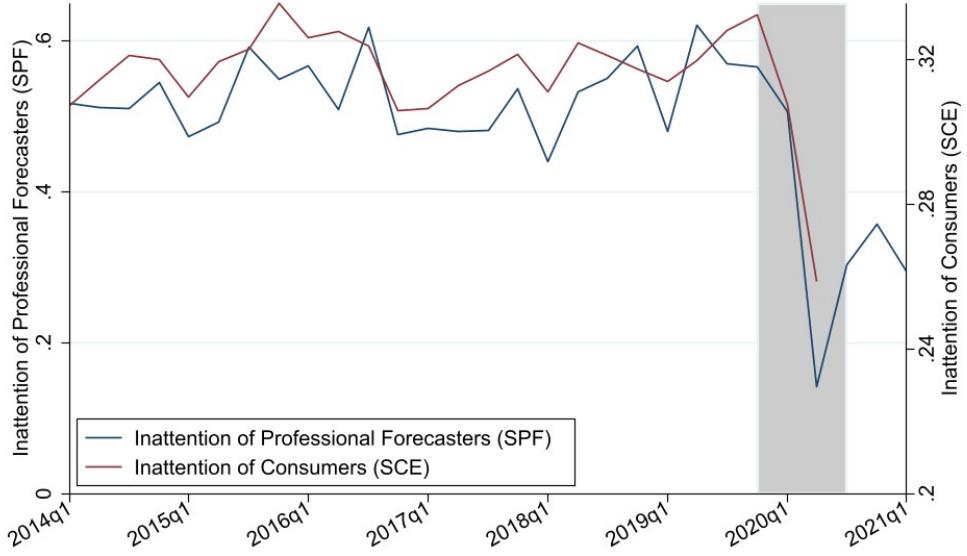
Figure 2: Inattention, Market Volatility, and Macro Uncertainty



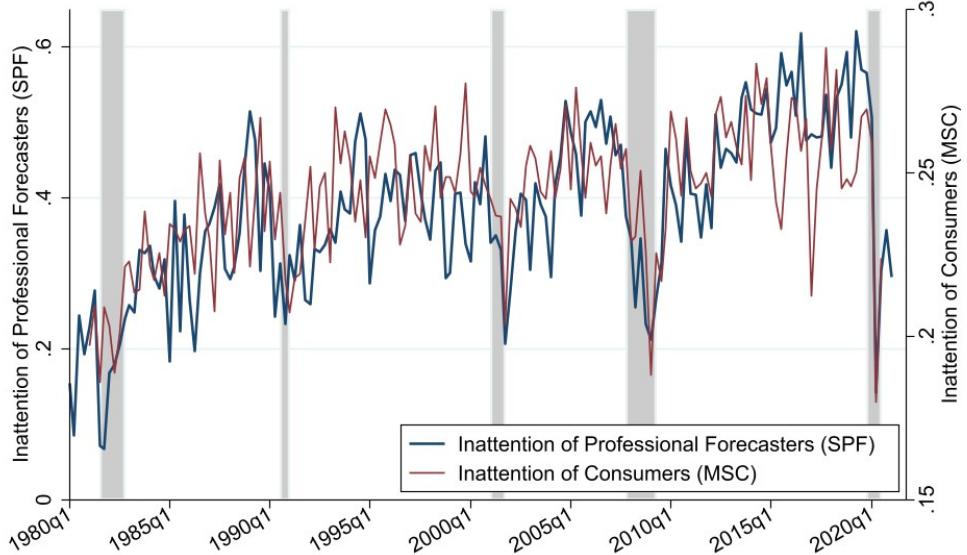
*Notes:* The figure plots inattention against stock market volatility, measured as the standard deviation of market return in the S&P 500 index within each quarter, and macro uncertainty proposed by Jurado et al. (2015). The shaded areas represent NBER designated recessions.

Figure 3: Inattention of Professional Forecasters and Consumers

(a) New York Fed Survey of Consumer Expectations (SCE)



(b) University of Michigan Surveys of Consumers (MSC)



*Notes:* The upper panel plots the inattention of consumers from 2014Q1 to 2021Q1, measured using the New York Fed's Survey of Consumer Expectations (SCE). Each month since 2013, the SCE reports one-year ahead forecasts for 7 major variables (growth rate in price level, home price, earnings, household income, household spending, personal taxes and government debt) of 1,300 consumers on average. Each consumer is associated with a unique ID number, based on which the forecast revisions can be calculated. SCE reports fixed-horizon forecasts, hence each forecast revision overlaps 11 out of 12 months. Quarterly inattention is calculated as the averaged monthly inattention. The lower panel plots the inattention of consumers from 1980Q1 to 2021Q1, measured using the Michigan Survey of Consumers (MSC). Every month since January 1981, MSC reports one-year ahead forecasts for 5 major variables (growth rate in price level and family income, if business conditions will be better or worse, if unemployment and interest rates will go up or down) of 500 consumers on average. Each consumer is associated with a unique ID number, based on which the forecast revisions can be calculated. The MSC reports fixed-horizon forecasts, and the rotating panel is taken semiannually. Hence each forecast revision overlaps only 6 out of 12 months.

Importantly, the independent variation in our measure suggests that we capture a novel dimension of macroeconomic salience that is not subsumed in existing volatility and uncertainty measures. This result holds in a variety of robustness checks by (i) weighting the variable-specific inattention by the 10-year rolling window standard deviation of each target variable, (ii) including nine additional variables available in the SPF since 1981, (iii) measuring inattention as the proportion of forecasters who do not revise their forecasts of any target variables in real GDP growth, inflation or unemployment rate, (iv) restricting the analysis to regular forecasters who participated in the survey for at least five or ten years, and (v) measuring inattention across financial versus non-financial sectors. See Figures A.3-A.7 in the appendix for details.

Next, we examine what drives the fluctuations in inattention over time. According to the sticky information model, more volatile shocks lead to more frequent updating since inattention is more costly in a world that is rapidly changing. We observe a sharp decline of inattention during recessions. Other factors might also explain the dynamics of inattention. To assess the relative importance of potential determinants, we regress aggregate inattention on two groups of variables. The first group includes macroeconomic fundamentals and policy, such as output growth, inflation, unemployment rate, and monetary policy shock. The second group focuses on market volatility and uncertainty. Specifically, we include the volatility of the S&P 500 index, calculated as the standard deviation of daily returns for the period, to identify economic news reflected in market price changes. In periods of high market volatility, sticky information theory would imply that professional forecasters, especially those associated with financial institutions, are more attentive to new information. Similar to the expected negative association between financial market volatility and inattentiveness, higher policy and macro uncertainty may also motivate professionals to pay more attention to news. Accordingly, the next two variables in this block are the policy uncertainty by [Baker et al. \(2016\)](#) and macro uncertainty by [Jurado et al. \(2015\)](#). Finally, we include market returns, calculated as the log value of the end-of-period price over the end-of-previous-period price, as one would expect high inattentiveness in periods of high returns due to complacency.

Since the dependent variable is a fractional variable, we use the quasi-maximum likelihood method in [Papke and Wooldridge \(1996\)](#) to estimate the nonlinear model:

$$E(IA_t | \mathbf{X}_{t-1}) = G(\beta \mathbf{X}_{t-1}) \quad (4)$$

where  $G(\cdot)$  is the logistic function. In equation (4),  $IA_t$  denotes inattention at time  $t$  and is bounded between 0 and 1,  $\mathbf{X}_{t-1}$  is a vector of lagged macroeconomic and financial market variables as discussed above. The correlations among these explanatory variables are modest, ranging from -0.49 to 0.46 at the quarterly frequency.

Table 3: Sources of Inattention

	High Frequency			Low Frequency		
	(1)	(2)	(3)	(4)	(5)	(6)
Growth	0.231** (0.097)	0.039 (0.093)		-0.073 (0.087)		-0.333*** (0.097)
Inflation	-0.336*** (0.130)	-0.250** (0.105)		-0.804*** (0.092)		-0.745*** (0.105)
Unemployment	-0.063*** (0.013)	-0.040*** (0.014)		-0.015* (0.008)		0.007 (0.010)
MP Shock	-0.223 (0.145)	-0.016 (0.167)		-1.037*** (0.226)		-0.728*** (0.212)
Volatility		-0.622*** (0.209)	-0.606*** (0.220)		0.147 (0.249)	-0.435* (0.264)
Return		0.013 (0.150)	-0.063 (0.152)		0.082 (0.207)	-0.112 (0.166)
Policy U		-0.408* (0.237)	-0.430 (0.307)		-0.581* (0.307)	-0.588* (0.311)
Macro U		-2.114*** (0.374)	-1.690*** (0.511)		-2.204*** (0.397)	-1.092*** (0.393)
Recession	-0.489*** (0.086)	-0.228*** (0.074)	-0.277*** (0.082)	-0.427*** (0.058)	-0.267*** (0.083)	-0.325*** (0.067)
Pseudo $R^2$	0.69	0.73	0.75	0.65	0.70	0.69
Obs	200	205	200	200	202	200

*Notes:* For columns (1) - (3), the dependent variable is the quarterly aggregate inattention series from the first quarter of 1970 to the first quarter of 2021. It is constructed based on equation (3), which is the average of inattention to six individual variables. For columns (4) - (6), the dependent variable is the 4-quarter moving average of aggregate inattention. The monetary policy shock is from [Bu et al. \(2021\)](#), measured as 100 basis points decrease in their shock series. Stock market volatility is measured as the standard deviation of daily market return in the S&P 500 index within each quarter. Market returns are calculated as the log value of the end-of-period price over the end-of-previous-period price. Policy uncertainty is from [Baker et al. \(2016\)](#), and macro uncertainty is from [Jurado et al. \(2015\)](#). Recession, as designated by the NBER, is a dummy variable. All regressions control for the time trend. \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% level, respectively.

Table 3 presents the estimated marginal effects evaluated at the mean level of explanatory variables. Columns (1)-(3) study quarterly variations in the aggregate inattention series. High output growth is positively associated with inattention, but high inflation and unemployment are negatively related to inattention, confirming the idea that “bad” news decreases inattention. Jumps

in policy uncertainty, macro uncertainty and market volatility significantly decrease inattention, consistent with the argument from sticky information theory that agents update their information more frequently in response to high volatility and uncertainty. The impact of market returns on inattention takes the expected positive sign, though not statistically significant. Inattention declines significantly during recessions, again pointing to the pro-cyclical nature of information rigidity.<sup>13</sup>

Columns (4)-(6) report the results with the four-quarter moving average of aggregate inattention as the dependent variable. Inattention tends to be low following expansionary monetary policy shocks, during recessions, and in episodes of high inflation, rising market volatility, policy and macro uncertainty. This allows us to generalize the results that inattention declines after large shocks such as the Great Recession ([Andrade and Le Bihan, 2013](#)), 9/11 ([Coibion and Gorodnichenko, 2015](#)), or natural disaster shocks ([Baker et al., 2020](#)), as well as to better understand the factors driving the variations of inattention over time. The next subsection explores the role of the dynamics of inattention in the transmission of monetary policy.

## 2.4 Inattention Amplifies the Impact of Monetary Policy

We empirically investigate how inattention alters the impact of monetary policy. To this end, we adopt the local projections method by [Jordà \(2005\)](#), specified as follows:

$$y_{t+h,t} = \beta_h MPS_t + \phi_h(L)z_{t-1} + \alpha_h + \varepsilon_{t+h} \quad \text{for } h = 0, 1, 2, \dots \quad (5)$$

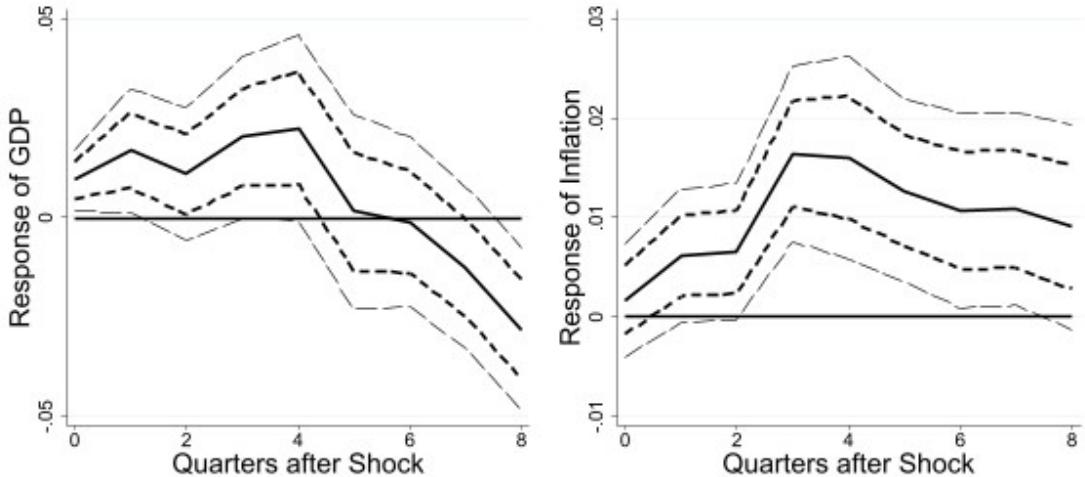
where  $y_{t+h,t}$  measures the cumulative cyclical component, through the [Hamilton \(2018\)](#)'s filter, of real GDP and CPI inflation. Our monetary policy shock series,  $MPS_t$ , comes from [Bu et al. \(2021\)](#), denoted as BRW hereafter. The BRW measure can be thought of as an average effect of Federal funds rate changes, forward guidance, and asset purchases following the FOMC meeting. Compared to the existing measures, the BRW shock series has a very mild data requirement to construct, covers a long sample period from 1972Q1 to 2019Q3, and is free of the Fed information effect.  $z_{t-1}$  is a vector of control variables, including lags of monetary policy shocks, cyclical

---

<sup>13</sup>In Tables A.2 and A.3, we analyze the factors driving inattention to each of six variables, one at a time, including real GDP growth, inflation, unemployment rate, corporate profits after tax, industrial production and housing starts. We find that unemployment is a driver of the inattention not only to unemployment, but also to inflation and housing starts. Similarly, inflation is also a driver of the inattention to real GDP growth, unemployment and industrial production. These results confirm the multivariate nature of expectation formation and support measuring inattention at the aggregate level.

components of real GDP and CPI inflation, commodity prices inflation, and change in excess bond premium. We include commodity prices to control for price puzzle (Christiano et al., 1996) and the excess bond premium in light of its ability to explain business cycles (Gilchrist and Zakrjšek, 2012). We estimate equation (5) using the OLS method with Newey-West standard errors. The Akaike information criterion indicates two lags for the control variables. Figure 4 plots the impact of monetary policy shock (i.e.  $\beta_h$ ) at each horizon  $h$ , together with 68% and 90% confidence intervals. Following an expansionary monetary policy shock, measured as 100 basis points decrease in the BRW shock series, output increases and reaches the peak in about a year. The response of inflation is significantly positive and persistent.

Figure 4: Impact of Monetary Policy



*Notes:* This figure shows the impulse response of real GDP and inflation to an expansionary monetary policy shock, measured as 100 basis points decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1972Q1-2019Q3. The dashed and dotted lines indicate the 90% and 68% confidence intervals produced by the Newey-West method.

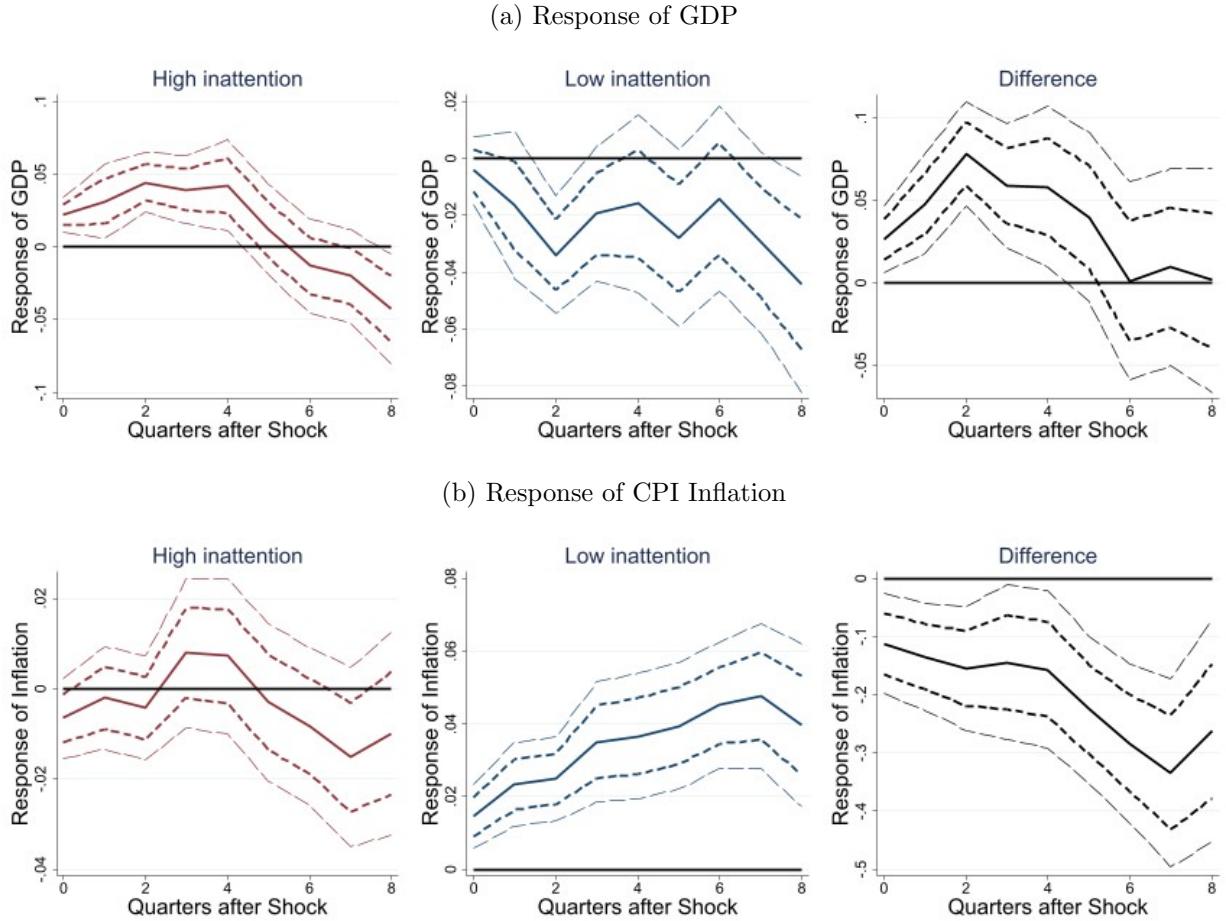
We now add inattention interacted with the monetary policy shock to an otherwise standard local projections model. As shown earlier, inattention tends to be low during episodes of high uncertainty and recessions. Furthermore, the transmission of monetary policy shocks is state dependent (Tenreyro and Thwaites, 2016), as well as affected by the level of uncertainty (Aastveit et al., 2017; Pellegrino, 2021). To ensure that it is inattention and not uncertainty that alters the effect of monetary policy, we first regress inattention on a recession dummy and uncertainty measures, including both Baker et al. (2016)'s policy uncertainty and Jurado et al. (2015)'s macro

uncertainty. We obtain the residual from this regression, denoted by  $I_t$ , and include it in the local projections model:

$$y_{t+h,t} = \beta_{a,h} MPS_t + \phi_{a,h}(L)z_{t-1} + \beta_{b,h} MPS_t * I_t + \phi_{b,h}(L)z_{t-1} * I_{t-1} + \gamma_h * I_t + \alpha_h + \varepsilon_{t+h}. \quad (6)$$

The coefficient  $\beta_{b,h}$  measures the extent to which inattention alters the impact of monetary policy. After estimating equation (6), we construct impulse response functions under different levels of inattention. Periods of high inattention are identified as the episodes in which inattention is above the 90th percentile and low inattention as those below the 10th percentile.

Figure 5: Inattention and the Impact of Monetary Policy: Baseline Result



*Notes:* This figure shows the impulse response of real GDP and inflation to an expansionary monetary policy shock, measured as 100 basis points decrease in the BRW shock series. The impulse responses are estimated based on the sample period during 1972Q1-2019Q3. We identify high inattention as the top 10% of the inattention series, and low inattention as the bottom 10%. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

With high inattention, an expansionary monetary policy shock brings up real GDP, reaches its maximum impact in two quarters and its effect dies out in about five quarters (Figure 5). In contrast, monetary policy does not have a sizable real impact with low inattention. As further illustrated in the right panel of Figure 5, the differential responses of real GDP between high and low inattention scenarios are statistically significant and economically meaningful. The opposite results hold for inflation: monetary policy shocks have a larger and more persistent effect when inattention is lower.

We perform a battery of robustness checks and find that our baseline results in Figure 5 still hold; see Appendix B. First, we follow [Auerbach and Gorodnichenko \(2012\)](#) and [Ramey and Zubairy \(2018\)](#) and estimate the smooth transition path between high and low inattention states as  $G_t = \exp(-\gamma I_t) / [1 + \exp(-\gamma I_t)]$ , where  $\gamma = 1.5$  and  $I_t$  is the measure of inattention normalized to have zero mean and unit variance. With this specification, we allow the coefficients to vary with the levels of inattention. The results, reported in Figure B.1, display the same pattern as our baseline. Second, related to the first exercise, we re-estimate the probability of high and low inattention using the Markov switching model and use the fitted smooth transition path to explore the effect of monetary policy shocks across two scenarios. Our main result on the differential real impacts of monetary policy between high versus low inattention still holds (Figure B.2). Third, we define dummy variables for high, medium and low inattention scenarios, where the threshold values for high and low inattention are defined as above the 90th percentile and below the 10th percentile, respectively. Including these dummy variables and their interactions into the local projection specification yields the same results as our baseline (Figure B.3). Fourth, as an alternative to the standard delta method, we follow [Mertens and Ravn \(2013\)](#) and [Cloyne et al. \(2020\)](#) to compute the confidence intervals using the bootstrap method. The confidence intervals now become slightly wider. Yet, the statistical significance still remains (Figure B.4). Fifth, we augment equation (6) by adding an additional interaction term of inattention and large monetary policy shocks, measured as those above the 90th percentile or below the 10th percentile of the BRW shock series. Inattention, like nominal rigidities, plays an even larger role in amplifying the real impact of large monetary policy shocks (Figure B.5). Sixth, we experiment with the [Romer and Romer \(2004\)](#)'s monetary policy shocks during 1972Q1-2007Q4. The results, presented in Figure B.6, are consistent with our baseline results for real GDP. For inflation, however, there is no significant difference between high

and low inattention scenarios. Finally, we construct monthly inattention series from January 1990 to August 2020 using the Consensus Forecasts data and redo the estimation by replacing quarterly real GDP with monthly industrial production. As shown in Figure B.7, high inattention still amplifies the real impact of monetary policy, though the differences across high and low inattention scenarios become less significant.

### 3 Quantitative Model

In this section, we outline a quantitative model with sticky information to show that the effects of monetary policy on output depend on the level and cyclicity of inattention. The model mostly resembles a standard New Keynesian framework, but with sticky information replacing sticky prices. The economy is populated by a continuum of infinitely-lived households, intermediate-good firms and final-good firms. Intermediate-good firms are monopolistically-competitive that produce differentiated products and sell them to final-good firms. Final-good firms operate in a perfectly competitive environment; they transform intermediate goods into final goods using a constant return to scale technology. Households and intermediate-good firms update their information sets in a staggered fashion.

In the first subsection, we assume that inattention is constant over the business cycle. We relax this assumption in the second subsection by allowing for endogenous information processing for both firms and households. This modeling strategy is motivated by our empirical evidence and builds on the frameworks of state-dependent price setting in [Dotsey et al. \(1999\)](#), [Bakhshi et al. \(2007\)](#) and [Nakov and Thomas \(2014\)](#).

#### 3.1 Constant Sticky Information

In this subsection, we consider the case with constant inattention both in the households and production sectors.

##### 3.1.1 Households

In each period  $t$ , household  $i$  derives utility from consumption ( $c_{i,t}$ ), supplies labor ( $n_{i,t}$ ) and holds bonds ( $b_{i,t}$ ). Furthermore, only a fraction  $\lambda^h$  of households update their information sets each

period. Therefore, in what follows,  $(1 - \lambda^h)$  measures the degree of household inattention. The problem of household  $i$  is then given by:

$$\max_{\{b_{i,t}, c_{i,t}, n_{i,t}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{c_{i,t}^{1-\sigma}}{1-\sigma} - \chi \frac{n_{i,t}^{1+\nu}}{1+\nu} \right) \quad (7)$$

with  $\beta \in (0, 1)$  being the subjective discount factor of the household,  $\sigma$  is the consumption curvature parameter,  $\nu$  is the inverse of the labor supply elasticity,  $\chi$  is the disutility-of-labor parameter and  $\mathbb{E}_t$  is the expectations operator. Maximization is subject to the sequence of budget constraints (in real terms):

$$c_{i,t} + b_{i,t} = w_{i,t} n_{i,t} + \frac{R_{t-1} b_{i,t-1}}{\pi_t} \quad (8)$$

where  $w_{i,t}$  is the real wage,  $R_t$  is the gross nominal interest rate on bonds and  $\pi_t$  is the gross inflation rate. Optimization over consumption, labor and bond holdings by a household with the most up-to-date information gives:

$$c_{0,t}^{-\sigma} = \beta R_t \mathbb{E}_t \left( \frac{c_{0,t+1}^{-\sigma}}{\pi_{t+1}} \right) \quad (9)$$

$$\chi n_{0,t}^{\nu} c_{0,t}^{\sigma} = w_{0,t} \quad (10)$$

with equations (9)-(10) being the standard consumption Euler condition and the labor supply condition, respectively.

For the inattentive household who last updated information  $i$  period ago, the labor supply and Euler conditions read:

$$c_{i,t}^{-\sigma} = \mathbb{E}_{t-i} (c_{0,t}^{-\sigma}) \quad (11)$$

$$\frac{n_{i,t}^{\nu}}{w_{i,t}} = \mathbb{E}_{t-i} \left( \frac{n_{0,t}^{\nu}}{w_{0,t}} \right) \quad (12)$$

As such, the inattentive household sets the marginal utility of consumption at time  $t$  to be equal to her expectation of the marginal utility of consumption of the attentive household. Similarly, for the inattentive household, the marginal disutility of supplying an additional unit of labor relative to the marginal benefit of an additional unit of labor equals the expected ratio of the attentive household.

### 3.1.2 Final-Good Firms

Firms in this sector purchase a continuum of intermediate goods from intermediate-good producers, indexed by  $j \in (0, 1)$ , and assemble them into final goods using the following technology:

$$y_t = \left( \int_0^1 y_{j,t}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (13)$$

with  $y_{j,t}$  being the quantity of intermediate-good  $j$  that is purchased by a final-good firm and  $\varepsilon > 1$  is the elasticity of substitution between two differentiated types of intermediate goods. Profit maximization gives the following downward-sloping demand function for the product variety  $j$ :

$$y_{j,t} = \left( \frac{P_{j,t}}{P_t} \right)^{-\varepsilon} y_t \quad (14)$$

where  $P_t$  is the aggregate price level.

### 3.1.3 Intermediate-Good Firms

Firms in this sector hire labor as the only production input. They operate in an environment of fully flexible prices but may not update their information sets every period. Each period  $t$ , a fraction  $\lambda^f$  of firms update their information sets. Therefore, in what follows,  $(1 - \lambda^f)$  measures the degree of firms' inattention.

A firm that last updated its information set  $j$  periods ago sets its price  $P_{j,t}$  and hires labor  $n_{j,t}$  from households to:

$$\max_{\{n_{j,t}, P_{j,t}\}_{t=0}^{\infty}} \mathbb{E}_{t-j} \left[ \frac{P_{j,t}}{P_t} y_{j,t} - w_{j,t} n_{j,t} \right] \quad (15)$$

subject to the demand curve for the firm's product (14) and the production technology:

$$y_{j,t} = z_t n_{j,t}^{1-\alpha} \quad (16)$$

with  $z_t$  being total factor productivity (which is common to all firms). Profit maximization gives the following demand condition for labor:

$$mc_{j,t} = \frac{w_{j,t}}{(1 - \alpha) z_t n_{j,t}^{-\alpha}} \quad (17)$$

where  $mc_{j,t}$  is the real marginal cost of firm  $j$ . As expected, the firm hires labor so that the marginal product of labor is a markup over the real wage. With a linear production function ( $\alpha = 0$ ), this condition becomes  $mc_{j,t} = \frac{w_{j,t}}{z_t}$ , as is standard in the New Keynesian model with linear-in-labor

technology.

A firm that last updated its information set  $j$  periods ago will choose the following price:

$$P_{j,t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\mathbb{E}_{t-j} \left( w_{j,t} y_{j,t}^{\frac{1}{\alpha}} z_t^{-\frac{1}{\alpha}} \right)}{\mathbb{E}_{t-j} (\alpha y_{j,t} / P_t)} \quad (18)$$

and then the aggregate price level is given by:

$$P_t = \lambda^f \sum_{j=0}^{\infty} (1 - \lambda^f)^j P_{j,t}. \quad (19)$$

The inflation rate, defined as  $\pi_t = P_t / P_{t-1}$  in our model, replaces the inflation that is governed by the forward-looking sticky-price New Keynesian Phillips curve.

### 3.2 State-Dependent Sticky Information

In this subsection, we derive the probability that firms and households update their information sets by solving optimization problems. Specifically, we assume that firms and households face fixed costs of collecting and processing information, which are distributed *i.i.d.* across firms and over time.

Let  $f(\kappa_t^f)$  and  $F(\kappa_t^f)$  denote the probability density function and cumulative distribution function of the firm's fixed cost, respectively.  $\kappa_t^f$  is measured in units of labor time so that the total cost of updating information by a firm is  $\kappa_t^f w_{j,t}$ . Let also  $V_{0,t}^f$  be the value of a firm with the most up-to-date information set (i.e. the firm has updated its information in period  $t$ ), and let  $V_{j,t}^f$  denote the value of a firm that updated its information  $j$  periods ago (a vintage- $j$  firm), with  $j = 1, \dots, J-1$ , and  $J$  being the number of vintages. A vintage- $j$  firm will update its information set only if the value of updating,  $V_{0,t}^f - \kappa_t^f w_{j,t}$ , is greater than the value of not updating,  $V_{j,t}^f$ . Therefore, only firms with a draw of  $\kappa_t^f < \frac{V_{0,t}^f - V_{j,t}^f}{w_{j,t}}$  will update. As such, the probability that a vintage- $j$  firm updates its information set in period  $t$  is given by:

$$\theta_{j,t}^f = F \left( \frac{V_{0,t}^f - V_{j,t}^f}{w_{j,t}} \right) \quad (20)$$

with  $j = 1, \dots, J-1$ . We further assume that after  $J$  periods, all firms update their information

sets; therefore,  $\theta_{J,t}^f = 1$ . In addition,  $\kappa_t^{f*} = \frac{V_{0,t}^f - V_{j,t}^f}{w_{j,t}}$  denotes the cut-off value of  $\kappa_t^f$  for which a firm is indifferent between updating its information and not updating.

Each period, there is a fraction  $\psi_{j,t}^f$  of vintage- $j$  firms, so that  $\sum_{j=1}^J \psi_{j,t}^f = 1$ . The total fraction of firms with the up-to-date information set is thus given by:

$$\lambda_t^f = \sum_{j=1}^J \psi_{j,t}^f \theta_{j,t}^f. \quad (21)$$

$\lambda_t^f$  in this model provides a micro-foundation for a state-dependent frequency of information update. The role of  $\lambda_t^f$  is similar to the frequency of price change in the New Keynesian model with Calvo pricing. Then, the total fraction of firms that did not update their information set in period  $t$  is given by  $1 - \lambda_t^f$ , which also measures the degree of firms' inattention in this model.

The value of firm  $j$  in case of not updating its information set is given by:

$$V_{j,t}^f = \max \mathbb{E}_{t-j} \left\{ \left[ \frac{P_{j,t}}{P_t} y_{j,t} - w_{j,t} n_{j,t} \right] + \beta Q_{t,t+1} \left[ (1 - \theta_{j+1,t+1}^f) V_{j+1,t+1}^f + \theta_{j+1,t+1}^f V_{0,t+1}^f - \Gamma_{j+1,t+1}^f \right] \right\} \quad (22)$$

with  $j = 1, \dots, J-1$ , and  $Q_{t,t+1}$  being the stochastic discount factor between periods  $t$  and  $t+1$ . Intuitively, with a probability  $(1 - \theta_{j+1,t+1}^f)$ , the firm does not update its information set in period  $t+1$  and thus has the value of not updating. With a probability  $\theta_{j+1,t+1}^f$ , the firm updates the information set in period  $t+1$  and gets the value of updating net of the cost of doing so ( $\Gamma_{j+1,t+1}^f$ ).

Similarly, the value of a firm when updating information in period  $t$  is:

$$V_{0,t}^f = \frac{P_{0,t}}{P_t} y_{0,t} - w_{0,t} n_{0,t} + \beta \mathbb{E}_t \{ Q_{t,t+1} \left[ (1 - \theta_{1,t+1}^f) V_{1,t+1}^f + \theta_{1,t+1}^f V_{0,t+1}^f - \Gamma_{1,t+1}^f \right] \} \quad (23)$$

with  $V_{1,t+1}^f$  being the value of not updating the information set next period and  $V_{0,t+1}^f$  the value of updating.

On the households side, we have a similar problem, but with the fixed cost being in units of consumption. Letting  $g(\kappa_t^h)$  and  $G(\kappa_t^h)$  be the probability density function and cumulative distribution function respectively for the fixed cost  $\kappa_t^h$ . Then the probability that a vintage- $i$

household updates its information set in period  $t$  is given by:

$$\theta_{i,t}^h = G\left(\frac{V_{0,t}^h - V_{i,t}^h}{c_{i,t}}\right) \quad (24)$$

with  $i = 1, \dots, I-1$ ,  $\theta_{I,t} = 1$  and  $\kappa_t^{h*} = \frac{V_{0,t}^h - V_{h,t}^h}{c_{i,t}}$  being the cut-off value of  $\kappa_t^h$  for which a household is indifferent between updating its information and not updating. Also, there is a fraction  $\psi_{i,t}^h$  of vintage- $i$  households,  $\sum_{i=1}^I \psi_{i,t}^h = 1$ . The total fraction of households with the up-to-date information is given by:

$$\lambda_t^h = \sum_{i=1}^I \psi_{i,t}^h \theta_{i,t}^h \quad (25)$$

and, thus,  $1 - \lambda_t^h$  is the degree of inattention in households sector.

The value of household  $i$  in case of not updating its information set is given by:

$$V_{i,t}^h = \max \mathbb{E}_{t-i} \left\{ u(c_{i,t}, n_{i,t}) + \beta Q_{t,t+1} [(1 - \theta_{i+1,t+1}^h) V_{i+1,t+1}^h + \theta_{i+1,t+1}^h V_{0,t+1}^h - \Gamma_{i+1,t+1}^h] \right\} \quad (26)$$

with  $h = 1, \dots, I-1$ . With a probability  $(1 - \theta_{j+1,t+1}^h)$ , the household does not update its information set in period  $t+1$  and has the value of not updating. With a probability  $\theta_{j+1,t+1}^h$ , the household updates the information set in period  $t+1$  and gets the value of updating net of the cost of doing so ( $\Gamma_{j+1,t+1}^h$ ).

The value of a household when updating information in period  $t$  can be written as:

$$V_{0,t}^h = u(c_{0,t}, n_{0,t}) + \beta \mathbb{E}_t \{ Q_{t,t+1} [(1 - \theta_{1,t+1}^h) V_{1,t+1}^h + \theta_{1,t+1}^h V_{0,t+1}^h - \Gamma_{1,t+1}^h] \} \quad (27)$$

with  $V_{1,t+1}^h$  being the value of not updating the information set next period and  $V_{0,t+1}^h$  the value of updating.

### 3.3 Market Clearing

In equilibrium, the resource constraint of the economy reads:

$$z_t n_t^{1-\alpha} = c_t \quad (28)$$

with  $c_t$  being aggregate consumption:

$$c_t = \lambda^h \sum_{i=0}^I (1 - \lambda^h)^i c_{i,t}. \quad (29)$$

and total factor productivity (TFP) follows the following AR(1) process:

$$\ln\left(\frac{z_t}{\bar{z}}\right) = \rho_z \ln\left(\frac{z_{t-1}}{\bar{z}}\right) + \varepsilon_{z,t} \quad (30)$$

with  $\rho_z$  being the AR(1) coefficient and  $\varepsilon_{z,t} \sim \mathcal{N}(0, \sigma_z^2)$  is a shock to TFP.

The total amount of labor demand is equal to the sum of the labor demand by all firms:

$$n_t = \sum_{j=0}^J n_{j,t}. \quad (31)$$

In addition, bonds are in zero net supply.

### 3.4 Monetary Policy

Monetary policy is governed by a Taylor-type rule with interest rate smoothing whereby the nominal interest rate responds to deviations of inflation and output from their steady-state values as follows:

$$\ln\left(\frac{R_t}{\bar{R}}\right) = \rho_R \ln\left(\frac{R_{t-1}}{\bar{R}}\right) + (1 - \rho_R) \left( \rho_\pi \ln\left(\frac{\pi_t}{\bar{\pi}}\right) + \rho_y \ln\left(\frac{y_t}{\bar{y}}\right) \right) + \varepsilon_{R,t} \quad (32)$$

with  $\bar{y}$  being the steady-state value of output,  $\bar{\pi}$  being the steady-state value of the inflation rate,  $\rho_\pi > 1$  (to insure that the Taylor principle is satisfied),  $\rho_y > 0$  and  $\rho_R > 0$  being the coefficients of inflation, output and interest rate smoothing, respectively, and  $\varepsilon_{R,t} \sim \mathcal{N}(0, \sigma_R^2)$  is a shock to the nominal interest rate.

### 3.5 Analytical Analyses

To better understand the role of information rigidity in altering the impact of monetary policy, we present some analytical results first. We consider a two-period model with information rigidity in both household and firm sectors and use a log-linearized version of the model to obtain analytical results; see Appendix C for more details. In what follows, we let  $\widehat{x}_t$  denote the log deviation of any

variable ( $x_t$ ) from its steady-state value  $\bar{x}$ .

We examine the effects of cutting the nominal interest rate in period 1 ( $\widehat{R}_1 < 0$ ). It is assumed that the interest rate returns to its steady-state value in the final period ( $\widehat{R}_2 = 0$ ). Then, the model can be reduced to two Phillips curves and two IS curves as follows:

$$\widehat{\pi}_1 = \frac{\kappa\lambda^f}{1 - \lambda^f} \widehat{y}_1 \quad (33)$$

$$\widehat{\pi}_2 = -\frac{\kappa\lambda^f}{1 - \lambda^f} \widehat{y}_1 \quad (34)$$

$$\widehat{y}_1 = -\frac{\lambda^h}{\sigma} (\widehat{R}_1 - \widehat{\pi}_2) \quad (35)$$

$$\widehat{y}_2 = 0 \quad (36)$$

Combining conditions (34) and (35) gives the response of output in period 1 to a change in the interest rate:

$$\frac{\widehat{y}_1}{\widehat{R}_1} = -\frac{\lambda^h(1 - \lambda^f)}{\sigma(1 - \lambda^f) + \kappa\lambda^f\lambda^h} \quad (37)$$

Output in period 1 rises following a cut to the nominal interest rate. Furthermore, letting  $A_y^1 = \widehat{y}_1/\widehat{R}_1$ , we have:

$$\frac{\partial|A_y^1|}{\partial\lambda^h} = \frac{\sigma(1 - \lambda^f)^2}{[\sigma(1 - \lambda^f) + \kappa\lambda^f\lambda^h]^2} > 0 \quad (38)$$

$$\frac{\partial|A_y^1|}{\partial\lambda^f} = -\frac{\kappa(\lambda^h)^2}{[\sigma(1 - \lambda^f) + \kappa\lambda^f\lambda^h]^2} < 0. \quad (39)$$

In absolute value, the effect of the interest rate on output of period 1 is an increasing function of households' attention ( $\lambda^h$ ) and a decreasing function of firms' attention ( $\lambda^f$ ). Thus, firm and household information rigidity has opposing effects. In particular, information rigidity in the firm sector amplifies the real impact of monetary policy, while information rigidity in the household sector dampens. The net effect depends on firms' inattention relative to households' inattention, and we evaluate it numerically in the next section.<sup>14</sup>

---

<sup>14</sup>In Appendix C, we show that our main analytical results can be largely generalized in a model with more than two periods or with an alternative monetary policy rule.

## 4 Model-Based Numerical Results

We start with an outline of our parameter values, then turn to results from the model with constant inattention, and conclude with numerical results obtained from the state-dependent inattention model.

### 4.1 Parameterization

A summary of the parameter values is presented in Table 4. The time unit is a quarter and the discount factor  $\beta$  is set such that the steady-state annual interest rate is roughly 4%. The disutility-of-labor parameter  $\chi$  is set such that the steady-state value of  $n$  is 0.3. The parameter  $\nu$  is set such that the labor supply elasticity is 2. This value helps in capturing the volatility of total hours in a model with no extensive margin, as is the case in this paper. The consumption curvature parameter  $\sigma$  is in the middle of the standard values that are assumed in the literature.

Table 4: Values of the parameters in the benchmark analysis

Parameter	Description	Value
$\beta$	Households' discount factor	0.99
$\sigma$	Consumption curvature parameter	1.50
$\nu$	Inverse of labor supply elasticity	0.5
$1 - \lambda^h$	Households' inattention	0.62
$1 - \alpha$	Labor share of output	0.66
$\varepsilon$	Elasticity of subs. between goods	6.00
$1 - \lambda^f$	Firms' inattention	0.36
$\phi_\pi$	Coefficient of inflation in the interest-rate rule	1.50
$\phi_y$	Coefficient of output in the interest-rate rule	0.125
$\rho_R$	Interest-rate smoothing parameter	0.90

*Notes:*  $\phi_\pi = (1 - \rho_R)\rho_\pi$  and  $\phi_y = (1 - \rho_R)\rho_y$ .

The benchmark values of  $1 - \lambda^f$  and  $1 - \lambda^h$  are based on our findings about the average degrees of inattention, the value of  $\alpha$  implies a labor share of roughly two thirds,  $\varepsilon$  is consistent with a price markup of 20%, and the parameters of the Taylor rule are standard in the literature. In addition,

our benchmark results assume a steady-state inflation rate of zero, but we provide a robustness analysis with a positive steady-state inflation rate in Appendix D. Finally, since we study impulse responses to monetary policy shocks, we leave total factor productivity at its steady-state level. Therefore  $z_t = \bar{z}$ , and we normalize it to 1. In Appendix E, we consider the cases with a time-varying total factor productivity as well as with firm-level productivity shocks.

## 4.2 Numerical Results

The main numerical results are presented in this subsection. Following Nakov and Thomas (2014), we solve the full non-linear model using a first-order approximation. To ease comparison with the empirical findings, we present the cumulative effects of monetary policy on our variables of interest using the impulse response functions.

### 4.2.1 Constant Inattention

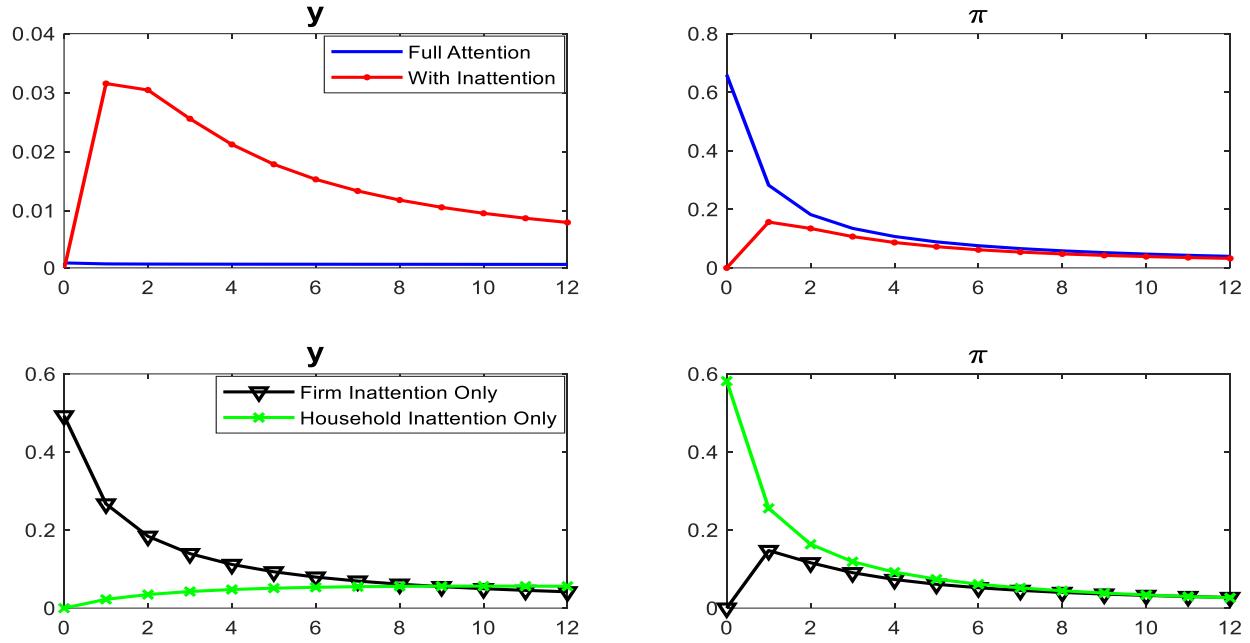
The top panel of Figure 6 presents the responses of output and inflation to a monetary policy shock for two different scenarios: the benchmark model with firm and household inattention and the model with full attention in both sectors. Without inattention, output is irresponsive to a monetary policy shock. Intuitively, since prices are fully flexible and firms are fully attentive, monetary policy is neutral. On the other hand, with inattention, output rises in a hump-shaped fashion in response to a decline in the nominal interest rate. In our model, prices are fully flexible, but rigid information renders monetary policy not neutral.

In the bottom panel of Figure 6, we show results with firm inattention or households inattention only. With firm inattention only, output rises strongly and monotonically. The addition of households inattention both dampens the response of output and leads to a hump-shaped behavior. Crucial for our study, adding inattention in both sectors leads to a bigger response of output than in the model with full attention.

On the other hand, the response of the inflation rate is smaller when inattention is higher. A possible explanation for this result is the following: if fewer firms pay attention, then fewer firms will update their prices (in particular, fewer firms will raise their prices following an expansionary monetary policy shock). Consequently, more information rigidity introduces some rigidity in prices

even though prices are not inherently rigid.<sup>15</sup> Therefore, while price rigidity and information rigidity are distinct from each other, there is some similarity in their implications for monetary policy.

Figure 6: Responses to Expansionary Monetary Policy: Constant Inattention



Notes: Responses of output ( $y$ ) and inflation ( $\pi$ ) to an expansionary monetary policy shock. Full Attention:  $1 - \lambda^f = 0, 1 - \lambda^h = 0$ . With Inattention:  $1 - \lambda^f = 0.36, 1 - \lambda^h = 0.62$ . Firm inattention only:  $1 - \lambda^f = 0.36, 1 - \lambda^h = 0$ . Household inattention only:  $1 - \lambda^f = 0, 1 - \lambda^h = 0.62$ .

The different effects of household and firm inattention on the behavior of output and inflation can be explained as follows. When firms are fully attentive and households are inattentive, firms respond immediately by raising prices (as prices are fully flexible), while consumption does not respond yet. As such, demand and output do not respond on impact. Then, as the information disseminates, consumers start raising their demand, leading to a rise in output (which peaks after roughly four quarters), at the same time when inflation starts reverting to its steady-state level.

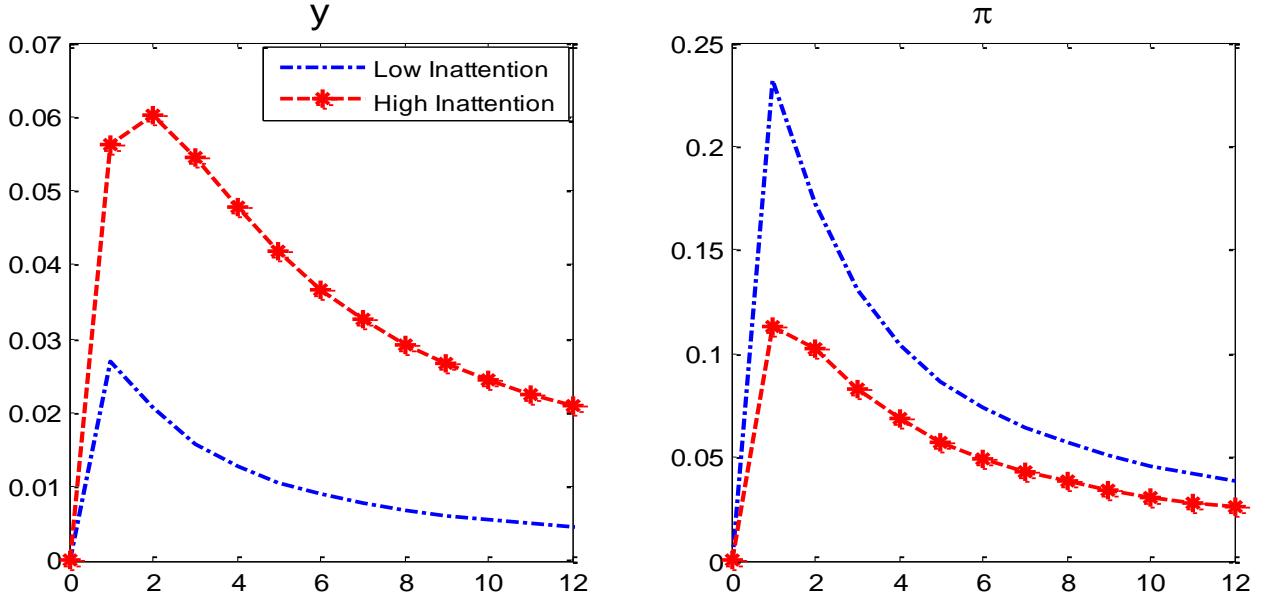
On the other hand, when consumers are fully attentive and firms are inattentive, consumers

<sup>15</sup>Anderson et al. (2017) refer to this case as “sticky plans” whereby firms do not always make pricing decisions when their information sets are old. In addition, Mackowiak and Wiederholt (2009) show that in the absence of perfect information, the response of prices to aggregate shocks is weaker and delayed compared to the scenario with perfect information. Drenik and Perez (2020) use the manipulation of inflation statistics that occurred in 2007 in Argentina to understand the effects of information frictions on price level dispersion and monetary policy. They find that monetary policy is more effective when there is less precise information, since firms assign less weight to it while setting prices. Baley and Blanco (2019) demonstrate that, when aggregate uncertainty is large, firms learn faster (e.g. because firms pay more attention). As a result, monetary policy shocks have smaller real effects. These findings also align with ours.

raise their spending on impact, which triggers an immediate increase in output. At the same time, inflation does not respond as firms are inattentive and have not yet made changes to their prices. Over time, as firms update their information, prices start to rise while the effects on output gradually decline.

So far, we have used the benchmark values of households' inattention and firms' inattention, with the former being significantly larger than the latter. In the next experiment, we set both parameters equal to each other and then consider high and low values of inattention. Specifically, we consider  $1 - \lambda^f = 1 - \lambda^h = 0.16$  (low inattention) and  $1 - \lambda^f = 1 - \lambda^h = 0.55$  (high inattention), which equal the averages of inattention for each scenario in the data. As shown in Figure 7, the response of output is significantly stronger with high inattention than with low inattention, and it lasts for a longer period of time. The response of the inflation rate, on the contrary, is clearly smaller when inattention is higher.

Figure 7: Responses to Expansionary Monetary Policy: Low vs. High Inattention

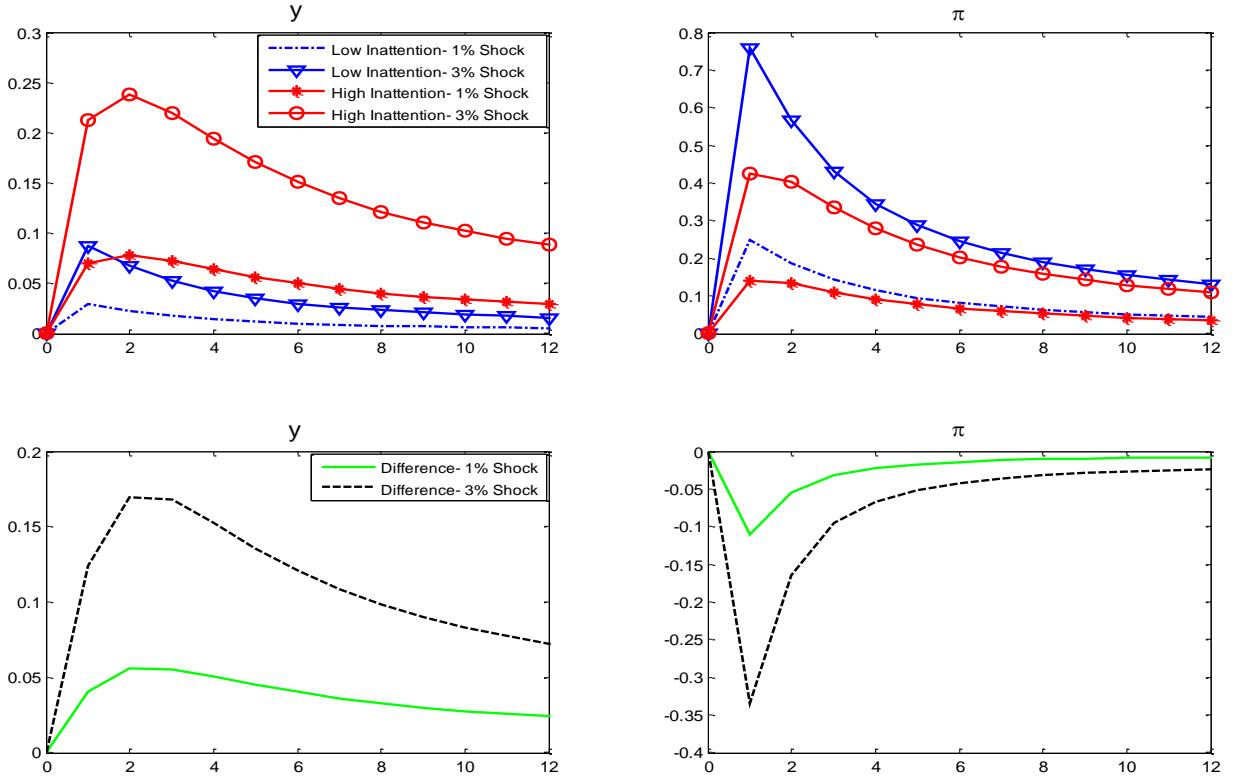


*Notes:* Responses of output ( $y$ ) and inflation ( $\pi$ ) to an expansionary monetary policy shock for two different values of the inattention parameters. Low inattention:  $1 - \lambda^f = 1 - \lambda^h = 0.16$ . High inattention:  $1 - \lambda^f = 1 - \lambda^h = 0.55$ .

In Figure 8, we consider large versus small monetary policy shocks. The top panel presents the responses of output and inflation, and the bottom panel illustrates the differences between high and low inattention scenarios. Following a large shock, the gaps between the responses of output in high inattention and low inattention environment rise. As such, the level of inattention plays a

bigger role in stimulating output following larger drops in the interest rate. Larger monetary policy shocks also induce bigger responses by the inflation rate: lower inattention coupled with a larger monetary policy shock generate a considerably larger rise in inflation compared to an environment with higher inattention (or lower inattention and a smaller monetary policy shock). These results have significant policy implications for drastic drops in the interest rate, e.g. the sharp declines in the Federal funds rate in 2008 and at the beginning of the pandemic in 2020.

Figure 8: Responses to Expansionary Monetary Policy: Large Monetary Shocks



Notes: Responses of output ( $y$ ) and inflation ( $\pi$ ) to two different sizes of monetary policy shocks (large versus small) at two different scenarios of inattention (high versus low). Top panel: the actual response for each shock size. Bottom panel: the difference in the response between high inattention and low inattention scenarios.

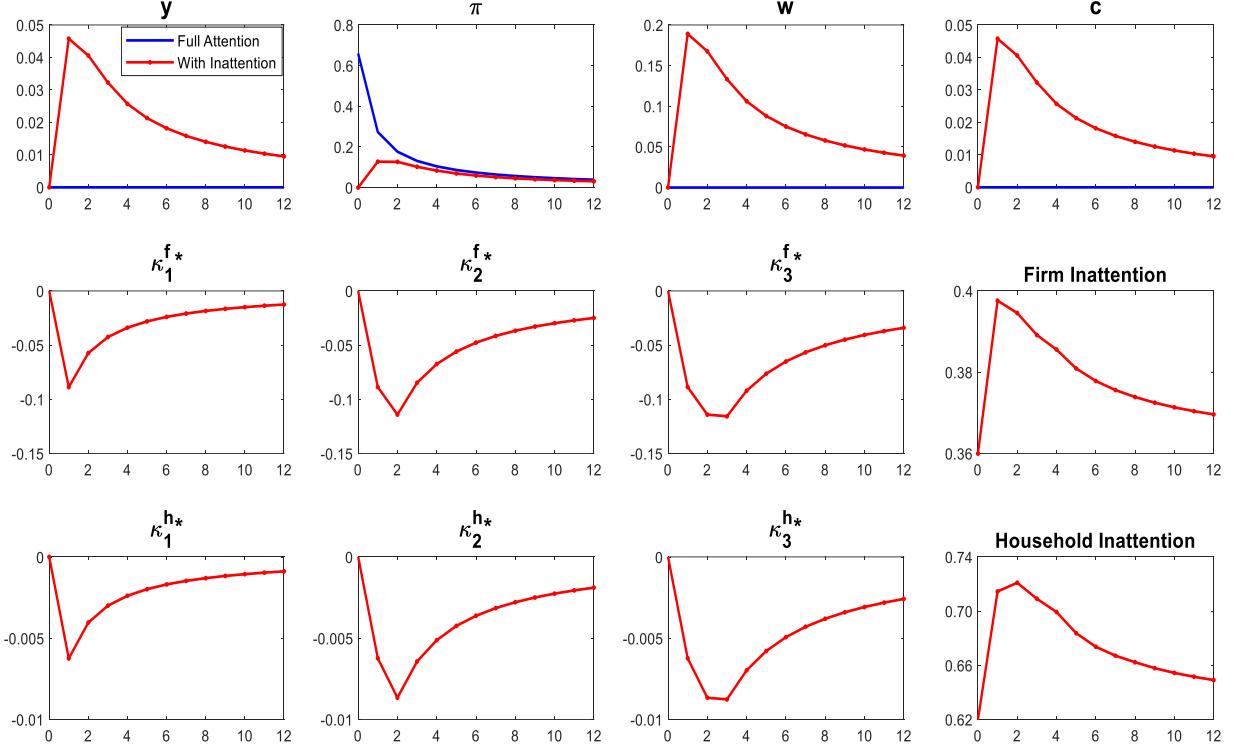
#### 4.2.2 State-Dependent Inattention

In order to solve the model, we assume  $I = J = 4$ , implying that all firms and households update their information sets within 4 periods (quarters). In addition, we let the cumulative distribution function for the cost of updating the information set by firms be:

$$F(\kappa_t^f) = \frac{\zeta^f + \kappa_t^f}{\eta^f + \kappa_t^f} \quad (40)$$

where  $\zeta^f$  and  $\eta^f$  are positive parameters and  $\zeta^f < \eta^f$ . This cumulative distribution function is bounded from below by  $\zeta^f/\eta^f$ .

Figure 9: Responses to Expansionary Monetary Policy: State-Dependent Inattention



*Notes:* Responses of output ( $y$ ), inflation ( $\pi$ ), real wage ( $w$ ) and consumption ( $c$ ) to an expansionary monetary policy shock in the model with state-dependent information rigidity. Household and firm inattention are expressed in levels.  $\kappa_j^{f*}$  is the cutoff cost for a firm of vintage  $j$  to update its information set.  $\kappa_i^{h*}$  is the cutoff cost for a household of vintage  $i$  to update its information set. Steady-state inattention:  $1 - \bar{\lambda}^f = 0.36$ ,  $1 - \bar{\lambda}^h = 0.62$ .

Using condition (20), condition (40) can be rewritten as:

$$F(\kappa_t^f) = \frac{\zeta^f + (V_{0,t}^f - V_{j,t}^f)/w_t}{\eta^f + (V_{0,t}^f - V_{j,t}^f)/w_t} \quad (41)$$

implying that the probability for the firm to update its information set is increasing in the gain from adjustment  $(V_{0,t}^f - V_{j,t}^f)$ . Note that the real wage here is not firm specific.

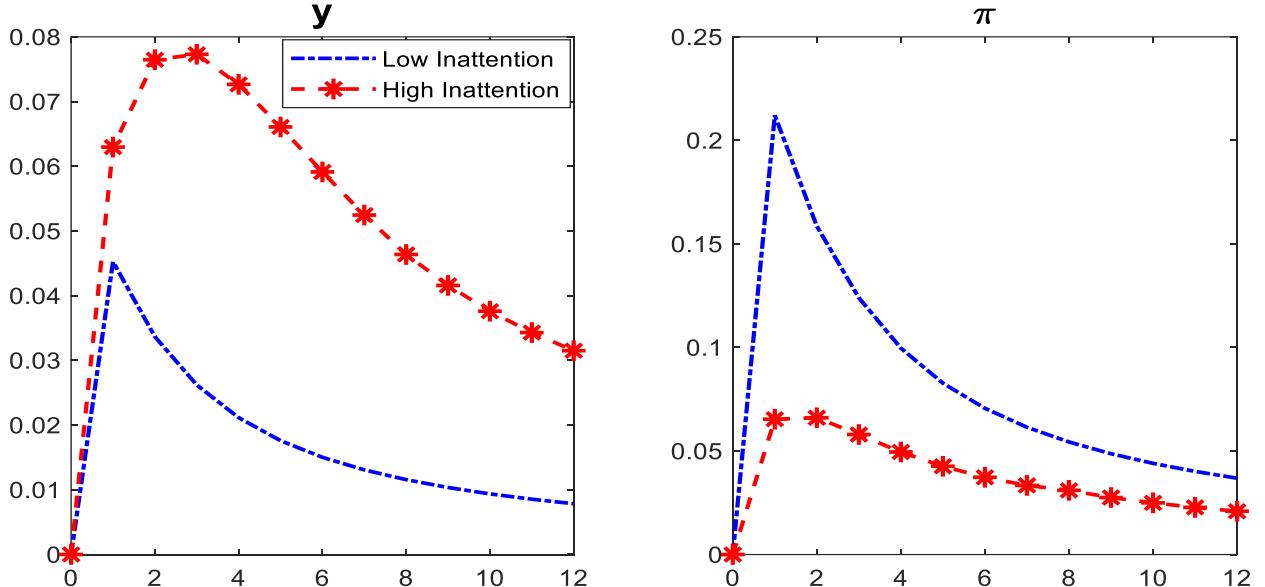
For symmetry, we assume a similar distribution function for households. Therefore:

$$F(\kappa_t^h) = \frac{\zeta^h + (V_{0,t}^h - V_{i,t}^h)/c_{i,t}}{\eta^h + (V_{0,t}^h - V_{i,t}^h)/c_{i,t}} \quad (42)$$

with the values of  $\zeta^f$ ,  $\eta^f$ ,  $\zeta^h$  and  $\eta^h$  being set so that, at the steady state,  $1 - \bar{\lambda}^f = 0.36$  and  $1 - \bar{\lambda}^h = 0.62$ , as in our analysis with constant inattention.

The findings, presented in Figure 9, confirm our conclusions from the model with constant inattention. Following the expansionary monetary policy, output and inflation rise. The real wage rises, which reduces the likelihood for firm  $j$  to update information (i.e.  $\kappa_j^{f*}$  falls), leading to a decline in the fraction of vintage- $j$  firms that choose to update their information sets. Indeed, firm inattention rises from its steady-state value of 0.36 to roughly 0.40. In the households sector, the rise in consumption reduces the probability for household  $i$  to update information; as a result, household inattention rises (from its steady-state value of 0.62 to roughly 0.72). Comparing the response of output with state-dependent inattention (Figure 9) to that with constant inattention (Figure 6) reveals another important result: with state-dependent inattention, output rises by more following a fall in the nominal interest rate. To our knowledge, this is new in the literature.

Figure 10: Responses to Expansionary Monetary Policy: Low vs. High Steady-State Inattention



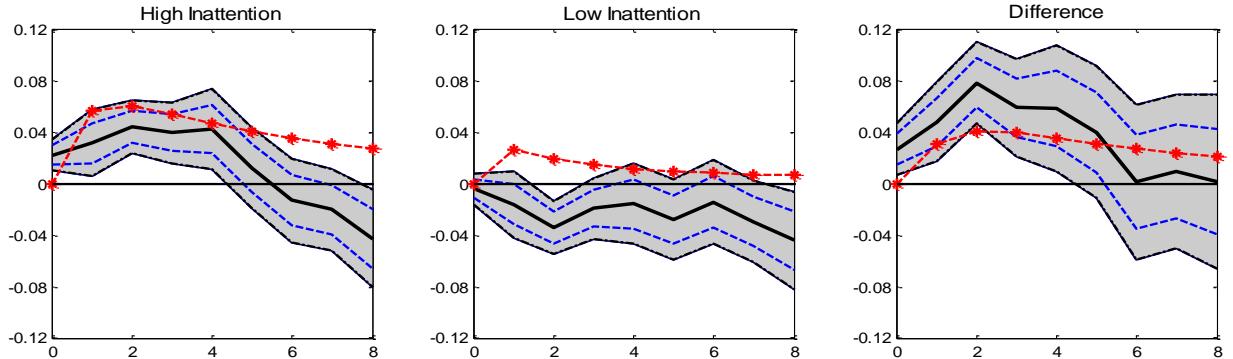
Notes: Responses of output ( $y$ ) and inflation ( $\pi$ ) to an expansionary monetary policy shock in the model with state-dependent information rigidity for two different steady-state values of the inattention parameters. Low steady-state inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.16$ . High steady-state inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.55$ .

In Figure 10 we consider the scenario where the steady-state values of inattention in both sectors are equal. Specifically, we set  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.16$  for low steady-state inattention, and  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.55$  for high steady-state inattention. Our results are very similar to those with constant inattention. With higher inattention, monetary policy has larger stimulative effects on output while the impact on inflation is weaker.

### 4.3 Taking the Model to the Data

We briefly comment on the ability of the model with state-dependent inattention to match the observed responses of output under low and high inattention. The responses of output under high inattention mostly lie inside the confidence intervals of the empirical counterpart (Figure 11). Furthermore, the difference in the responses between high and low inattention is also within the confidence intervals. For low inattention, the model predictions are mostly close to the upper bounds of the confidence intervals.

Figure 11: Responses of Output to Expansionary Monetary Policy: Model vs. Data



*Notes:* Responses of output to an expansionary monetary policy shock in the model with state-dependent information rigidity for two different steady-state values of the inattention parameters. Low steady-state Inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.16$ . High steady-state Inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.55$ . Red line with stars: the estimate from the model. Solid black line: the point estimate from the data. Shaded area: 68% and 90% confidence intervals.

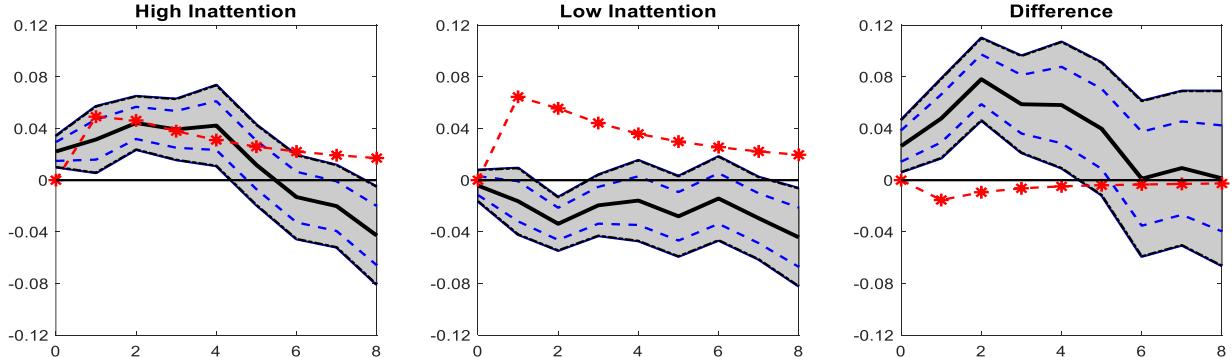
In Appendix F, we show that if the steady-state inattention is reduced to 0.07 (which is the lowest value documented in the empirical part and corresponds to updating information about 3 months on average), then the model better accounts for the response of output. Therefore, to fit the data for the low inattention scenario, it appears that a very low inattention level suffices, and no further modifications to the model are necessary.

#### 4.4 The Role of Sticky Prices

In this subsection, we consider a model with sticky prices, but no sticky information, in the production sector.<sup>16</sup> In particular, each period a fraction  $1 - \lambda^p$  of firms do not adjust their prices. Furthermore, we continue to assume that households are inattentive.

The results are summarized in Figure 12. With sticky prices, monetary policy is not neutral. Output responds to monetary policy shocks even if all firms are attentive. While the model continues to perform well with high inattention, it fails to account for the response of output under the scenario of low inattention. Specifically, contrary to the empirical findings, the response of output with low inattention *exceeds* that with high inattention. Thus, sticky information on the firm side is crucial for replicating the basic finding of this paper (i.e. monetary policy is more effective in raising output in an environment with higher inattention.) Sticky prices alone deliver the opposite result. In addition, household-side sticky information is important to match the delayed (hump-shaped) response of output to a monetary policy shock, suggesting that information rigidity in both the production and household sectors are necessary to match the response of output in the data.

Figure 12: Responses of Output to Expansionary Monetary Policy with Sticky-Price Firms and Sticky-Information Households



*Notes:* Responses of output to an expansionary monetary policy shock. A model with sticky-price firms and sticky-information households. Low steady-state Inattention:  $1 - \bar{\lambda}^h = 0.16$ . High steady-state Inattention:  $1 - \bar{\lambda}^h = 0.55$ . Price stickiness parameter:  $1 - \bar{\lambda}^p = 0.6$ , which implies a price duration of 2.5 quarters. Red line with stars: the estimate from the model. Solid black line: the point estimate from the data. Shaded area: 68% and 90% confidence intervals.

---

<sup>16</sup>More details can be found in Appendix G.

## 5 Conclusion

We propose a micro-data based measure of inattention that captures the common component in the inattentiveness of professional forecasters to multiple economic variables. Applying this measure to the U.S. SPF survey, we find that professional forecasters update their information sets every five months on average. Inattention is pro-cyclical, as professionals pay close attention during episodes of recessions, high policy uncertainty and macro uncertainty. This finding provides supportive evidence for sticky information theory in which more volatile shocks lead to more frequent updating. Using the local projections method, we show that inattention, like nominal rigidities, amplifies the response of the economy to a given set of monetary policy shocks, and the amplification effect becomes much stronger when the degree of inattention is higher.

We then develop a DSGE model with inattentive firms and households. The key innovation in our model is to allow for endogenous information processing by firms and households. Simulation results indicate that, when inattention is higher, an expansionary monetary policy has a bigger stimulative effect on output, in line with the empirical evidence. A model with sticky prices, but not sticky information, in the production sector yields the opposite results. Furthermore, the increase in output with state-dependent inattention is larger than that with constant inattention. Therefore, treating inattention as a structural parameter, as assumed in most studies, might lead to underestimation of the real impact of monetary policy.

## References

- Aastveit, K. A., G. J. Natvik, and S. Sola (2017). Economic uncertainty and the influence of monetary policy. *Journal of International Money and Finance* 76, 50–67.
- Afrouzi, H. and C. Yang (2021). Dynamic rational inattention and the Phillips curve. *SSRN Working Paper 3770462*.
- Anderson, E., B. A. Malin, E. Nakamura, D. Simester, and J. Steinsson (2017). Informational rigidities and the stickiness of temporary sales. *Journal of Monetary Economics* 90, 64–83.
- Andrade, P., R. K. Crump, S. Eusepi, and E. Moench (2016). Fundamental disagreement. *Journal of Monetary Economics* 83, 106–128.
- Andrade, P. and H. Le Bihan (2013). Inattentive professional forecasters. *Journal of Monetary Economics* 60(8), 967–982.

- Auerbach, A. J. and Y. Gorodnichenko (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy* 4(2), 1–27.
- Baker, S. R., N. Bloom, and S. J. Davis (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics* 131(4), 1593–1636.
- Baker, S. R., T. S. McElroy, and X. S. Sheng (2020). Expectation formation following large unexpected shocks. *Review of Economics and Statistics* 102(2), 287–303.
- Bakhshi, H., H. Khan, and B. Rudolf (2007). The Phillips curve under state-dependent pricing. *Journal of Monetary Economics* 105, 2321–2345.
- Baley, I. and A. Blanco (2019). Firm uncertainty cycles and the propagation of nominal shocks. *American Economic Journal: Macroeconomics* 11(1), 276–337.
- Ball, L., N. G. Mankiw, and R. Reis (2005). Monetary policy for inattentive economies. *Journal of Monetary Economics* 52(4), 703–725.
- Banterngansa, C. and M. W. McCracken (2009). Forecast disagreement among FOMC members. *St. Louis Fed Working Paper 2009-059*.
- Binder, C. (2017). Consumer forecast revisions: Is information really so sticky? *Economics Letters* 161, 112–115.
- Bordalo, P., N. Gennaioli, Y. Ma, and A. Shleifer (2020). Overreaction in macroeconomic expectations. *American Economic Review* 110(9), 2748–2782.
- Broer, T. and A. Kohlhas (2018). Forecaster (mis-) behavior. *CEPR Discussion Paper DP12898*.
- Bu, C., J. H. Rogers, and W. Wu (2021). A unified measure of Fed monetary policy shocks. *Journal of Monetary Economics* 118, 331–349.
- Caggiano, G., E. Castelnuovo, and N. Groshenny (2014). Uncertainty shocks and unemployment dynamics in US recessions. *Journal of Monetary Economics* 67, 78–92.
- Carroll, C. D. (2003). Macroeconomic expectations of households and professional forecasters. *Quarterly Journal of Economics* 118(1), 269–298.
- Christiano, L. J., M. Eichenbaum, and C. Evans (1996). The effects of monetary policy shocks: Some evidence from the flow of funds. *Review of Economics and Statistics* 78(1), 16–34.
- Christiano, L. J., M. Eichenbaum, and C. Evans (2021). Lumpy durable consumption demand and the limited ammunition of monetary policy. *Econometrica* 89(6), 2717–2749.
- Cloyne, J., C. Ferreira, and P. Surico (2020). Monetary policy when households have debt: New evidence on the transmission mechanism. *Review of Economic Studies* 87(1), 102–129.
- Coibion, O. and Y. Gorodnichenko (2015). Information rigidity and the expectations formation process: A simple framework and new facts. *American Economic Review* 105(8), 2644–2678.
- Dotsey, M., R. G. King, and A. L. Wolman (1999). State-dependent pricing and the general equilibrium dynamics of money and output. *Quarterly Journal of Economics* 114(2), 655–690.

- Dovern, J. (2015). A multivariate analysis of forecast disagreement: Confronting models of disagreement with survey data. *European Economic Review* 80, 16–35.
- Dräger, L. and M. J. Lamla (2017). Imperfect information and inflation expectations: Evidence from microdata. *Oxford Bulletin of Economics and Statistics* 79(6), 933–968.
- Dräger, L., M. J. Lamla, and D. Pfajfar (2016). Are survey expectations theory-consistent? The role of central bank communication and news. *European Economic Review* 85(C), 84–111.
- Drenik, A. and D. J. Perez (2020). Price setting under uncertainty about inflation. *Journal of Monetary Economics* 116, 23–38.
- Ehrbeck, T. and R. Waldmann (1996). Why are professional forecasters biased? Agency versus behavioral explanations. *Quarterly Journal of Economics* 111(1), 21–40.
- Engelberg, J., C. F. Manski, and J. Williams (2011). Assessing the temporal variation of macroeconomic forecasts by a panel of changing composition. *Journal of Applied Econometrics* 26(7), 1059–1078.
- Führer, J. C. (2018). Intrinsic expectations persistence: Evidence from professional and household survey expectations. *Boston Fed Working Paper* 18-9.
- Gabaix, X. (2019). Behavioral inattention. In D. Bernheim, S. DellaVigna, and D. Laibson (Eds.), *Handbook of Behavioral Economics*, Volume 2, pp. 261–343. Elsevier.
- Giacomini, R., W. P. Gaglianone, J. V. Issler, and V. Skreta (2020). Incentive-driven inattention. *Forthcoming in Journal of Econometrics*.
- Giacomini, R., V. Skreta, and J. Turen (2020). Heterogeneity, inattention and Bayesian updates. *American Economic Journal: Macroeconomics* 12(1), 282–309.
- Gilchrist, S. and E. Zakravsek (2012). Credit spreads and business cycle fluctuations. *American Economic Review* 102(4), 1692–1720.
- Hamilton, J. D. (2018). Why you should never use the Hodrick-Prescott filter. *Review of Economics and Statistics* 100(5), 831–843.
- Jordà, Ò. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review* 95(1), 161–182.
- Jurado, K., S. C. Ludvigson, and S. Ng (2015). Measuring uncertainty. *American Economic Review* 105(3), 1177–1216.
- Mackowiak, B. and M. Wiederholt (2009). Optimal sticky prices under rational inattention. *American Economic Review* 99(3), 769–803.
- Mackowiak, B. and M. Wiederholt (2015). Business cycle dynamics under rational inattention. *Review of Economic Studies* 82(4), 1502–1532.
- Mankiw, N. G. and R. Reis (2002). Sticky information versus sticky prices: A proposal to replace the new Keynesian Phillips curve. *Quarterly Journal of Economics* 117(4), 1295–1328.

- Mankiw, N. G. and R. Reis (2010). Imperfect information and aggregate supply. In B. Friedman and M. Woodford (Eds.), *Handbook of Monetary Economics*, Volume 3A, pp. 183–230. Elsevier.
- Mankiw, N. G., R. Reis, and J. Wolfers (2003). Disagreement about inflation expectations. *NBER Macroeconomics Annual* 18, 209–248.
- Mertens, K. and M. O. Ravn (2013). The dynamic effects of personal and corporate income tax changes in the United States. *American Economic Review* 103(4), 1212–47.
- Meyer, B. H., N. B. Parker, and X. S. Sheng (2021). Unit cost expectations and uncertainty: Firms' perspectives on inflation. *Atlanta Fed working paper 2021-12a*.
- Nakov, A. and C. Thomas (2014). Optimal monetary policy with state-dependent pricing. *International Journal of Central Banking* 10(3), 49–94.
- Papke, L. E. and J. M. Wooldridge (1996). Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *Journal of Applied Econometrics* 11(6), 619–632.
- Pellegrino, G. (2021). Uncertainty and monetary policy in the US: A journey into non-linear territory. *Economic Inquiry* 59, 1106–1128.
- Ramey, V. A. and S. Zubairy (2018). Government spending multipliers in good times and in bad: Evidence from US historical data. *Journal of Political Economy* 126(2), 850–901.
- Reis, R. (2009). Optimal monetary policy rules in an estimated sticky-information model. *American Economic Journal: Macroeconomics* 1, 1–28.
- Romer, C. D. and D. H. Romer (2004). A new measure of monetary shocks: Derivation and implications. *American Economic Review* 94(4), 1055–1084.
- Sims, C. A. (2003). Implications of rational inattention. *Journal of Monetary Economics* 50(3), 665–690.
- Tenreyro, S. and G. Thwaites (2016). Pushing on a string: US monetary policy is less powerful in recessions. *American Economic Journal: Macroeconomics* 8(4), 43–74.
- Thomas, J. K. (2002). Is lumpy investment relevant for the business cycle? *Journal of Political Economy* 110(3), 508–534.
- Zhang, F. (2017). Rational inattention in uncertain business cycles. *Journal of Money, Credit and Banking* 49(1), 215–253.

# Inattention and the Impact of Monetary Policy: Online Appendix

Zidong An\*

Salem Abo-Zaid†

Xuguang Simon Sheng‡

This online appendix includes seven sections. Appendix A presents various robustness checks in measuring inattention. Appendix B presents the results from a battery of robustness checks on the role of inattention in altering the impact of monetary policy. Appendix C shows analytical results in a multiple-period model. Appendix D presents the numerical analyses by allowing for a positive steady-state inflation rate. Appendix E shows the numerical results with time-varying productivity. Appendix F presents additional results on the model fit across high versus low inattention scenarios. Appendix G discusses a model with both sticky information and sticky prices.

---

\*Renmin University of China

†University of Maryland-Baltimore County

‡American University. Corresponding author. Mailing address: Department of Economics, 4400 Massachusetts Avenue, NW, Washington, DC 20016, USA. Tel: (202) 885-3782. Email: sheng@american.edu.

## A Measuring Inattention: Robustness Checks

Table A.1: Inattention at Different Forecast Horizons

	4-quarter ahead	3-quarter ahead	2-quarter ahead	1-quarter ahead
Panel A: Summary Statistics				
Average	0.36	0.34	0.30	0.23
St Dev	(0.12)	(0.11)	(0.10)	(0.08)
In months	4.7	4.5	4.3	3.9
Panel B: Correlation Coefficients				
4-quarter ahead	1			
3-quarter ahead	0.93	1		
2-quarter ahead	0.89	0.91	1	
1-quarter ahead	0.81	0.82	0.83	1

*Notes:* This table shows summary statistics (Panel A) and unconditional correlation coefficients (Panel B) in aggregate inattention across different forecast horizons. Aggregate inattention is constructed as the average of inattention to the 6 variables. Inattention to each variable is defined as the proportion of forecasters who do not revise their forecasts for such a target variable. The dataset comes from the Philadelphia Fed Survey of Professional Forecasters during 1970Q1-2021Q1.

Table A.2: Sources of Quarterly Inattention to A Single Variable

	(1) AGGR	(2) RGDP	(3) PGDP	(4) U	(5) CPROF	(6) IP	(7) HOU
Growth	0.039 (0.093)	-0.265 (0.170)	0.027 (0.180)	0.084 (0.189)	-0.347 (0.246)	0.418** (0.165)	0.163 (0.158)
Inflation	-0.250** (0.105)	-0.603*** (0.185)	-0.032 (0.180)	0.424 (0.288)	-0.384 (0.257)	-0.480** (0.201)	-0.334 (0.218)
Unemploy	-0.040*** (0.014)	-0.031 (0.025)	-0.054** (0.027)	-0.140*** (0.032)	0.018 (0.031)	-0.018 (0.025)	-0.087*** (0.027)
MP Shock	-0.016 (0.167)	-0.039 (0.294)	0.740*** (0.275)	-0.895 (0.745)	0.615* (0.326)	-0.505* (0.261)	-0.417 (0.418)
Volatility	-0.606*** (0.220)	-0.698* (0.378)	-0.502 (0.334)	-1.299** (0.546)	-0.955 (0.587)	-1.354** (0.530)	-0.061 (0.620)
Return	-0.063 (0.152)	0.313 (0.283)	0.188 (0.275)	-0.550 (0.355)	-0.260 (0.334)	-0.495* (0.276)	0.166 (0.279)
Policy U	-0.430 (0.307)	-0.824 (0.518)	-0.812 (0.577)	-0.339 (0.662)	-0.833 (0.756)	-0.012 (0.475)	0.110 (0.593)
Macro U	-1.690*** (0.511)	-2.687** (1.068)	-3.969*** (0.897)	-1.000 (1.210)	-1.764 (1.140)	0.270 (0.947)	-1.374 (1.126)
Recession	-0.277*** (0.082)	-0.265 (0.181)	-0.09 (0.167)	-0.751*** (0.226)	-0.346 (0.228)	-0.503*** (0.168)	-0.201 (0.180)
Pseudo $R^2$	0.75	0.71	0.70	0.30	0.41	0.40	0.19
Obs	200	200	200	200	200	200	200

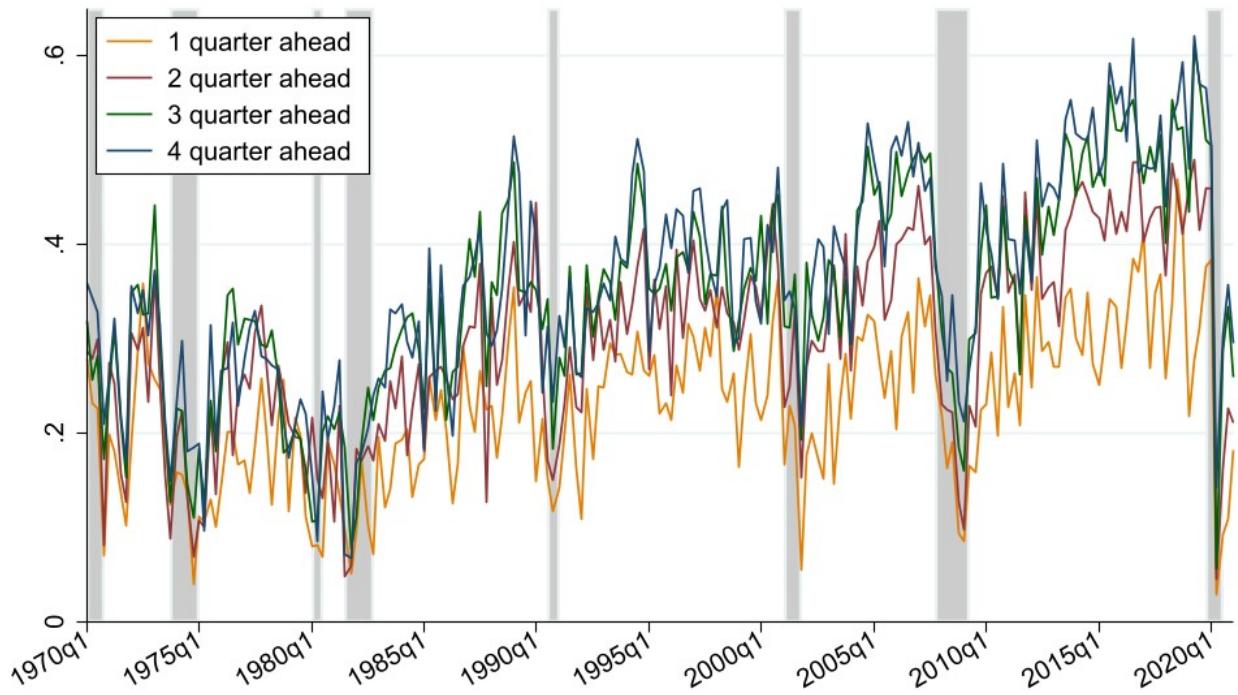
*Notes:* The dependent variable is the quarterly aggregate inattention (AGGR in Column 1) and inattention to each of six variables (Columns 2-7): real GDP growth (RGDP), GDP deflator inflation (PGDP), unemployment rate (U), corporate profits after tax (CPROF), industrial production (IP) and housing starts (HOU). The monetary policy shock is from [Bu et al. \(2021\)](#), measured as 100 basis points decrease in their shock series. Stock market volatility is measured as the standard deviation of market return in the S&P 500 index within each quarter. Market returns are calculated as the log value of the end-of-period price over the end-of-previous-period price. Policy uncertainty is from [Baker et al. \(2016\)](#), and macro uncertainty is from [Jurado et al. \(2015\)](#). Recession, as designated by the NBER, is a dummy variable. All regressions control for the time trend. \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% level, respectively.

Table A.3: Sources of Four-Quarter Moving Average of Inattention to A Single Variable

	(1) AGGR	(2) RGDP	(3) PGDP	(4) U	(5) CPROF	(6) IP	(7) HOU
Growth	-0.333*** (0.097)	-0.975*** (0.157)	-1.043*** (0.162)	0.423* (0.239)	-0.625*** (0.168)	0.011 (0.163)	0.245 (0.212)
Inflation	-0.745*** (0.105)	-1.109*** (0.169)	-0.770*** (0.174)	-0.122 (0.213)	-0.512*** (0.194)	-1.306*** (0.150)	-0.525*** (0.173)
Unemploy	0.007 (0.010)	0.021 (0.022)	0.005 (0.019)	-0.067*** (0.018)	0.080*** (0.016)	0.030 (0.019)	-0.030* (0.016)
MP Shock	-0.728*** (0.212)	-1.097*** (0.371)	0.283 (0.358)	0.084 (0.496)	-0.864** (0.359)	-1.552*** (0.326)	-1.360*** (0.385)
Volatility	-0.435* (0.264)	-0.890** (0.363)	-0.099 (0.353)	0.516 (0.635)	-0.617* (0.322)	-2.122*** (0.381)	0.317 (0.436)
Return	-0.112 (0.166)	0.016 (0.299)	0.214 (0.329)	-0.473 (0.472)	-0.847** (0.332)	-0.506* (0.290)	0.305 (0.396)
Policy U	-0.588* (0.311)	-0.766 (0.680)	-1.075** (0.468)	-1.054* (0.590)	-1.129*** (0.417)	0.540 (0.481)	-0.569 (0.569)
Macro U	-1.092*** (0.393)	-1.946** (0.759)	-3.912*** (0.724)	-1.137 (0.937)	-1.717*** (0.642)	2.145*** (0.594)	-0.580 (0.675)
Recession	-0.325*** (0.067)	-0.276** (0.136)	-0.214* (0.115)	-0.867*** (0.173)	-0.576*** (0.101)	-0.476*** (0.071)	-0.280*** (0.088)
Pseudo $R^2$	0.69	0.68	0.66	0.24	0.39	0.34	0.16
Obs	200	200	200	200	200	200	200

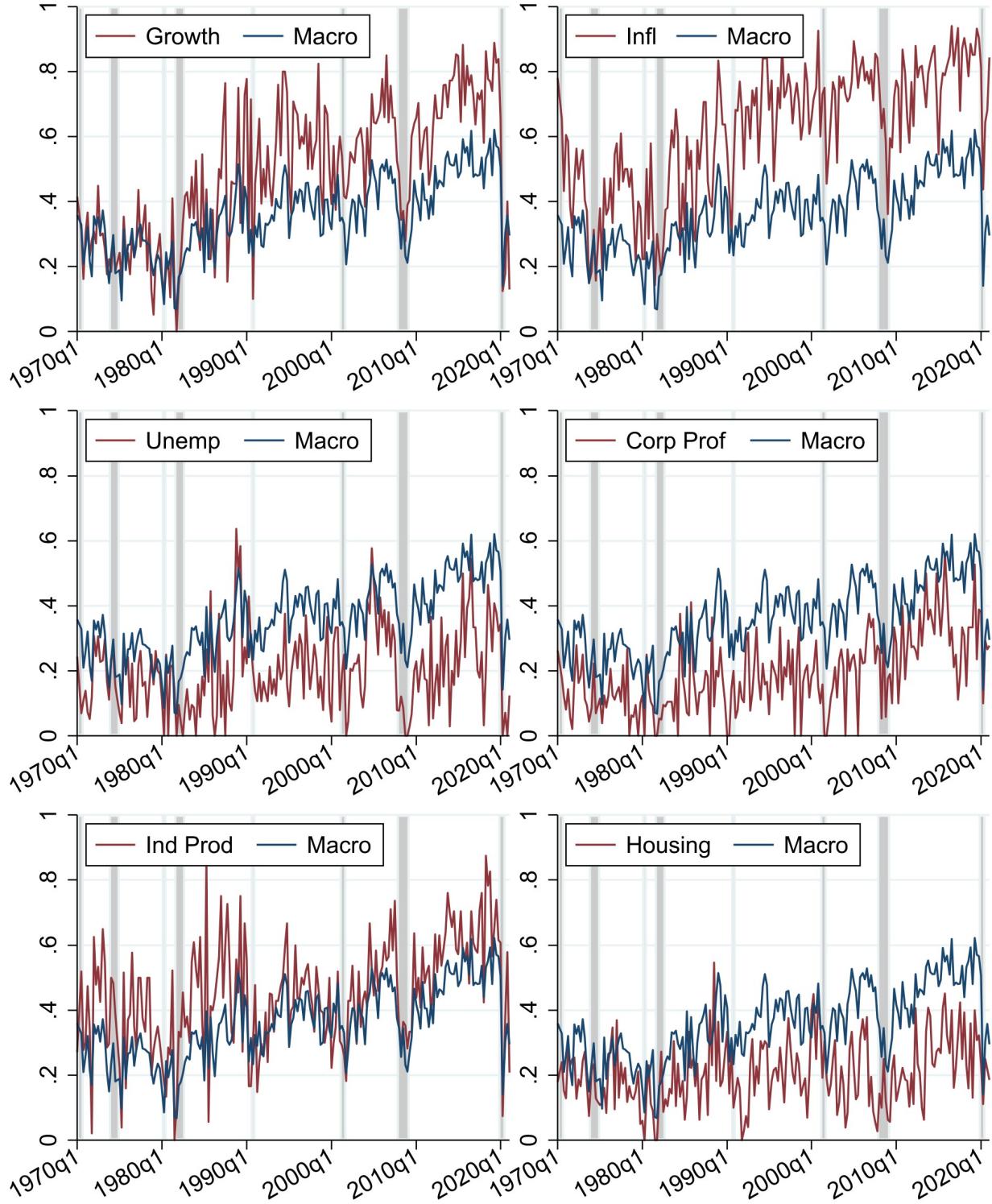
*Notes:* The dependent variable is the 4-quarter moving average of aggregate inattention (AGGR in Column 1) and inattention to each of six variables (Columns 2-7): real GDP growth (RGDP), GDP deflator inflation (PGDP), unemployment rate (U), corporate profits after tax (CPROF), industrial production (IP) and housing starts (HOU). The monetary policy shock is from [Bu et al. \(2021\)](#), measured as 100 basis points decrease in their shock series. Stock market volatility is measured as the standard deviation of market return in the S&P 500 index within each quarter. Market returns are calculated as the log value of the end-of-period price over the end-of-previous-period price. Policy uncertainty is from [Baker et al. \(2016\)](#), and macro uncertainty is from [Jurado et al. \(2015\)](#). Recession, as designated by the NBER, is a dummy variable. All regressions control for the time trend. \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% level, respectively.

Figure A.1: Inattention at Different Forecast Horizons



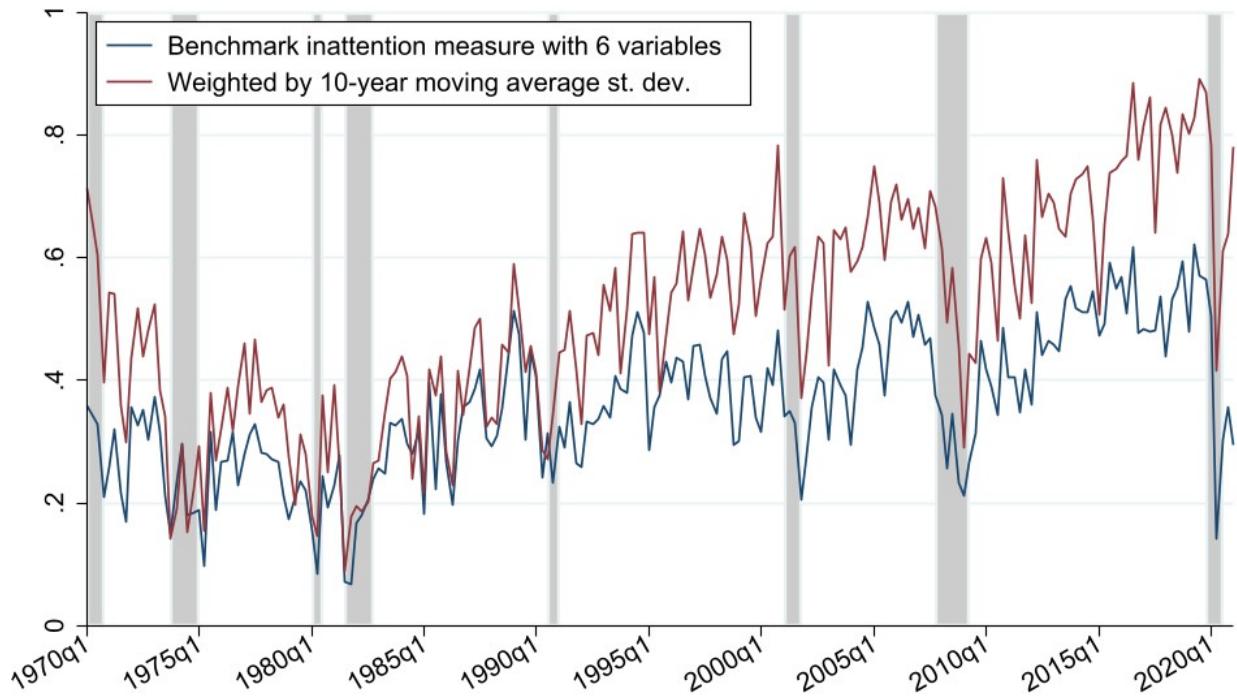
*Notes:* This figure shows the aggregate inattention measures with forecast horizons ranging from 4- to 1-quarter ahead. Aggregate inattention is constructed as the average of inattention to the 6 variables. Inattention to each variable is defined as the proportion of forecasters who do not revise their forecasts for such a target variable. The dataset comes from the Philadelphia Fed Survey of Professional Forecasters during 1970Q1-2021Q1.

Figure A.2: Aggregate Inattention versus Variable-specific Inattention



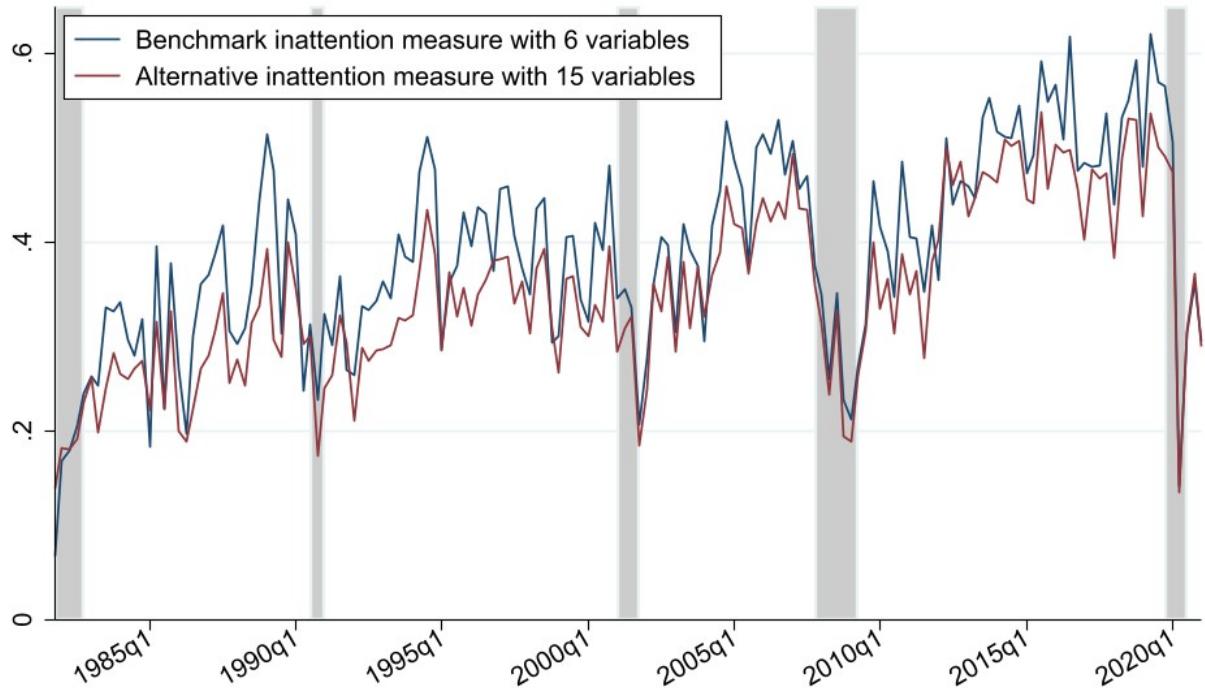
*Notes:* This figure compares aggregate inattention with variable-specific inattention based on 4-quarter ahead forecasts from the Philadelphia Fed Survey of Professional Forecasters. Aggregate inattention is constructed as the average of inattention to the 6 variables. Inattention to each variable is defined as the proportion of forecasters who do not revise their forecasts for such a target variable.

Figure A.3: Aggregate Inattention: Simple versus Weighted Average of Variable-specific Inattention



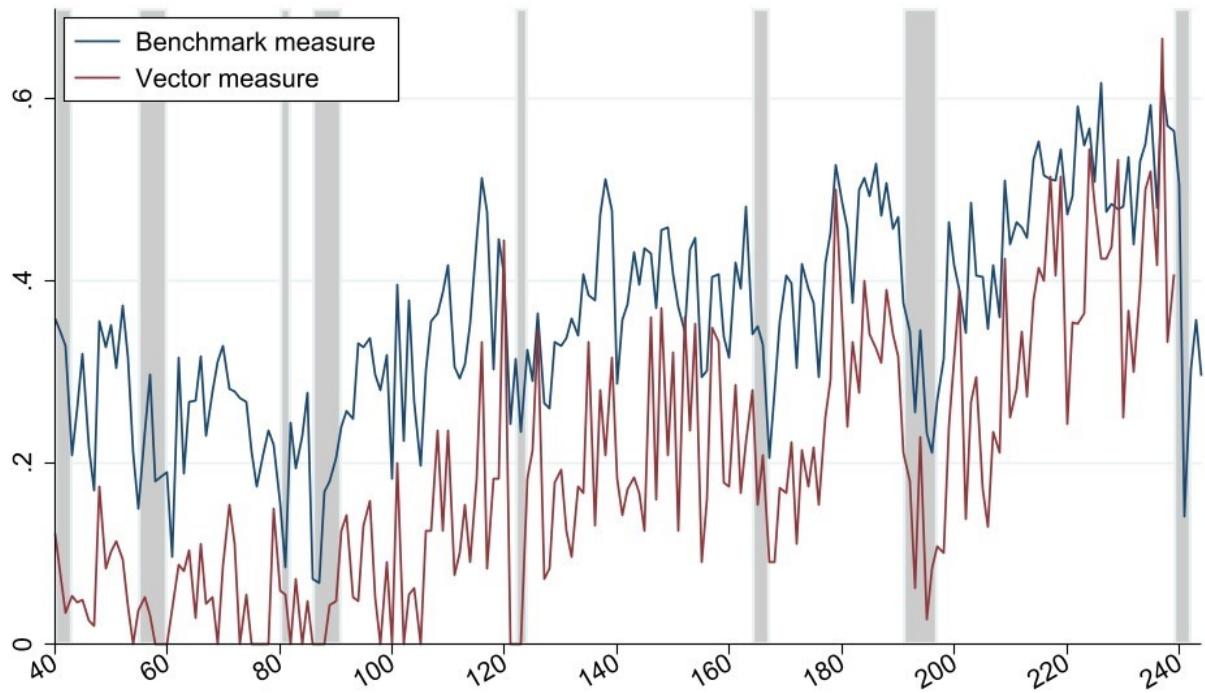
*Notes:* This figure compares the simple average with the weighted average of variable-specific inattention series from the first quarter of 1970 to the first quarter of 2021, and their correlation is 0.88. The benchmark inattention measure is constructed as an equally-weighted average of inattention to the 6 individual variables (real GDP, GDP deflator, corporate profits after tax, industrial production, housing starts, and unemployment rate). The weighted-average measure of inattention uses the rolling window of the previous ten-year standard deviation of each target variable as the weight.

Figure A.4: Inattention: Role of Additional Variables



*Notes:* This figure compares the benchmark with the alternative inattention measure based on 15 variables, and their correlation is 0.94. Besides the 6 variables (real GDP, GDP deflator, corporate profits after tax, industrial production, housing starts, and unemployment rate) included in the benchmark measure available since 1970, the SPF added another 9 variables (real consumption, residential fixed investment, nonresidential fixed investment, real federal government expenditures, real state, and local government expenditures, real private inventories, real net exports, CPI inflation, and 3-month treasury bill rate) since the fourth quarter of 1981. Aggregate inattention is constructed as the average of inattention to the 6 or 15 variables. Inattention to each variable is defined as the proportion of forecasters who do not revise their forecasts for such a target variable.

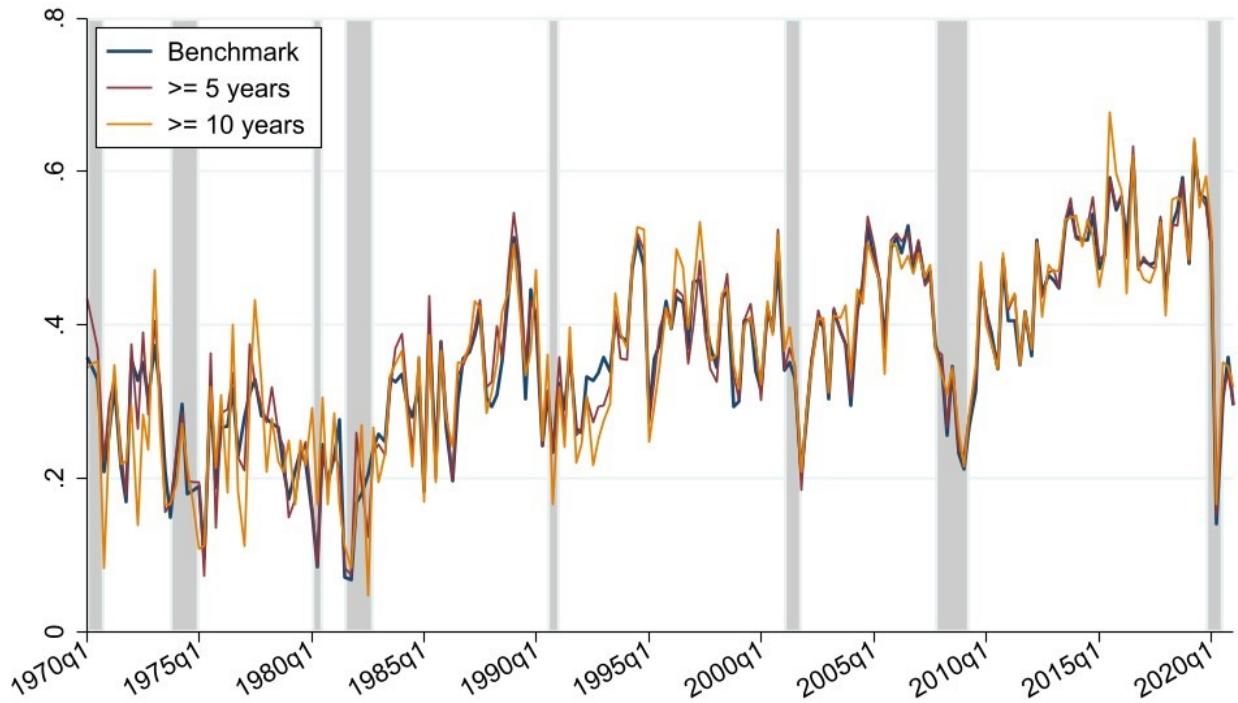
Figure A.5: Inattention: Benchmark versus Vector Measure



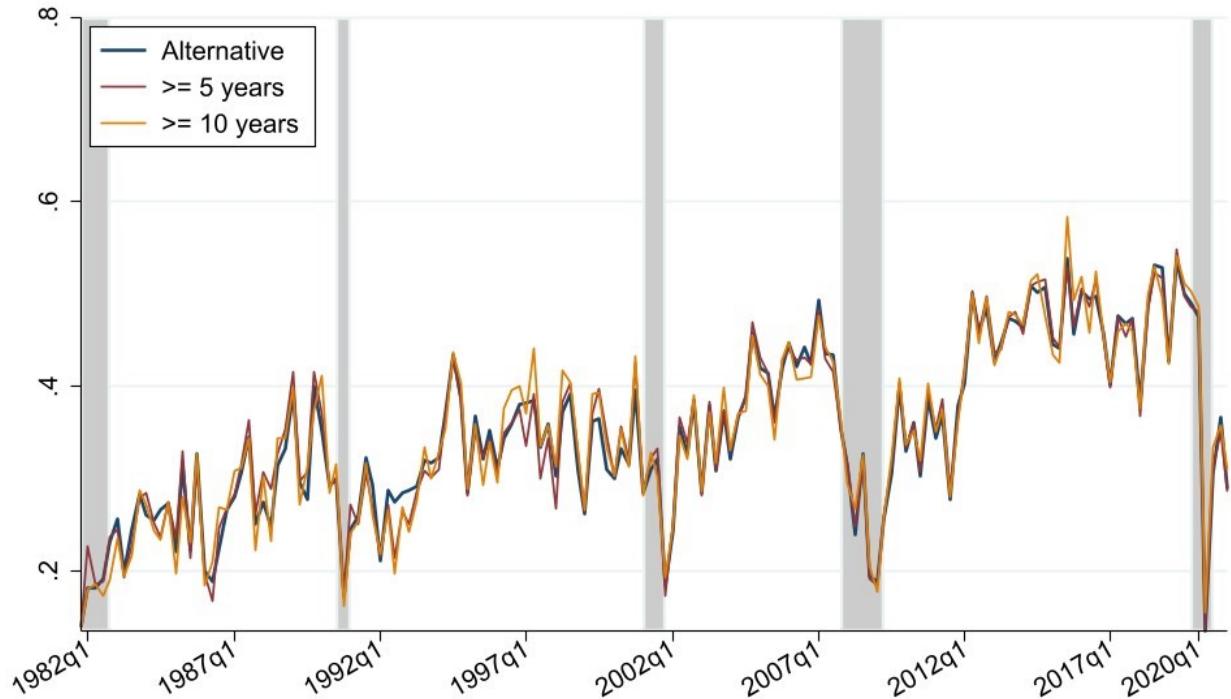
*Notes:* This figure compares the benchmark inattention with an alternative measure based on a vector of three variables during 1970Q1-2021Q1, and their correlation is 0.86. The benchmark inattention measure is constructed as an equally-weighted average of inattention to the 6 individual variables (real GDP, GDP deflator, corporate profits after tax, industrial production, housing starts, and unemployment rate). Inattention to each variable is defined as the proportion of forecasters who do not revise their forecasts for such a target variable. The alternative measures inattention as the proportion of forecasters who do not revise their forecasts of *any* target variables in real GDP growth, inflation, or unemployment rate.

Figure A.6: Inattention: All versus Regular Forecasters

(a) Inattention Measure based on 6 Variables



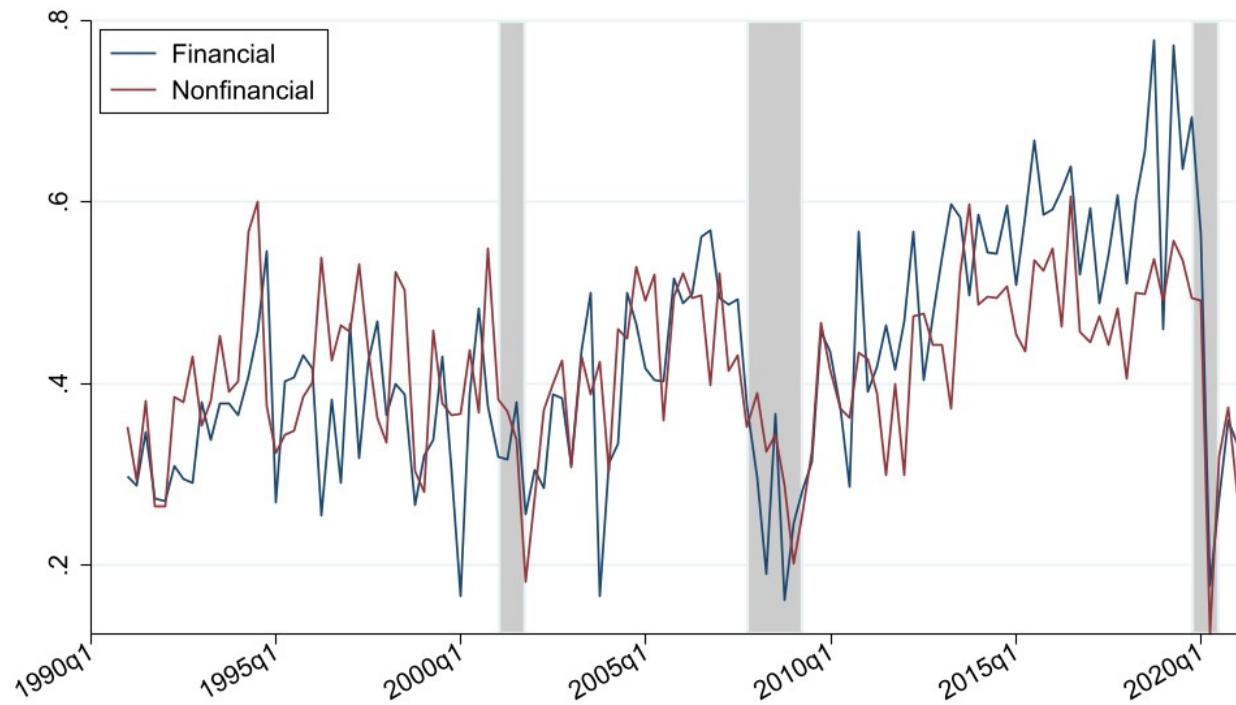
(b) Inattention Measure based on 15 Variables



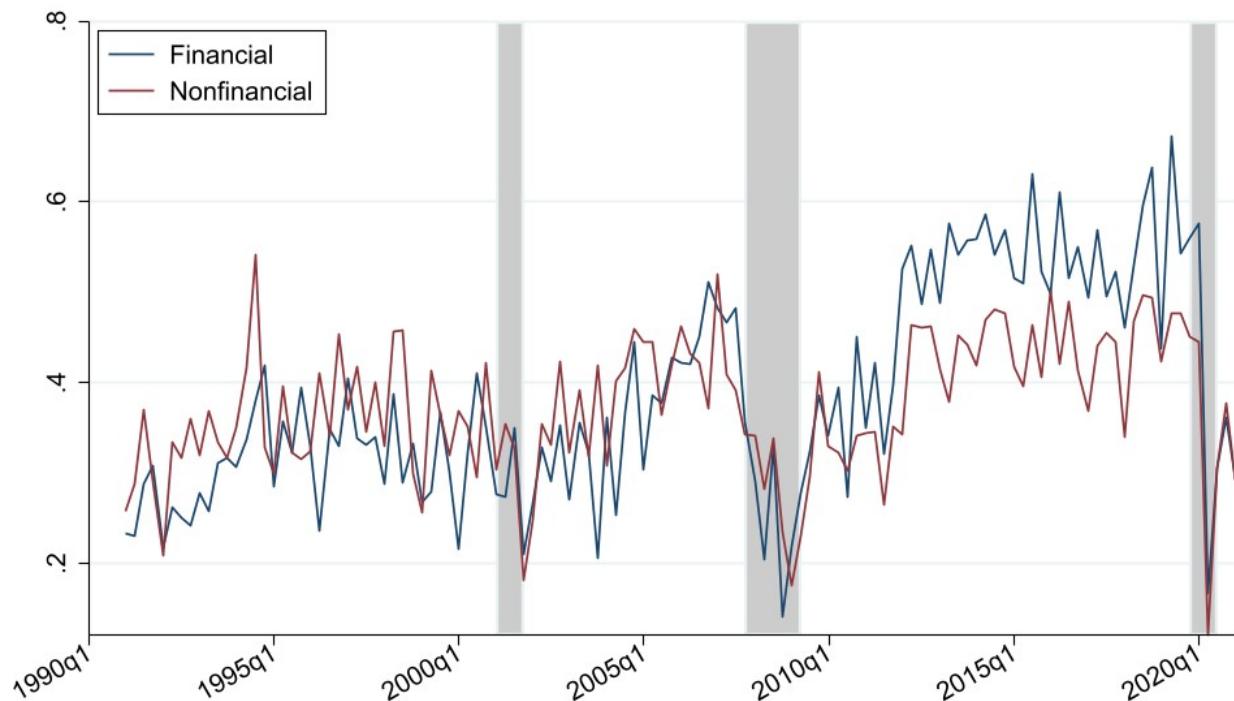
Notes: This figure compares the inattention with all forecasters to regular forecasters who participated at least 5 years or 10 years.

Figure A.7: Inattention: Financial versus Nonfinancial Sectors

(a) Inattention Measure based on 6 Variables



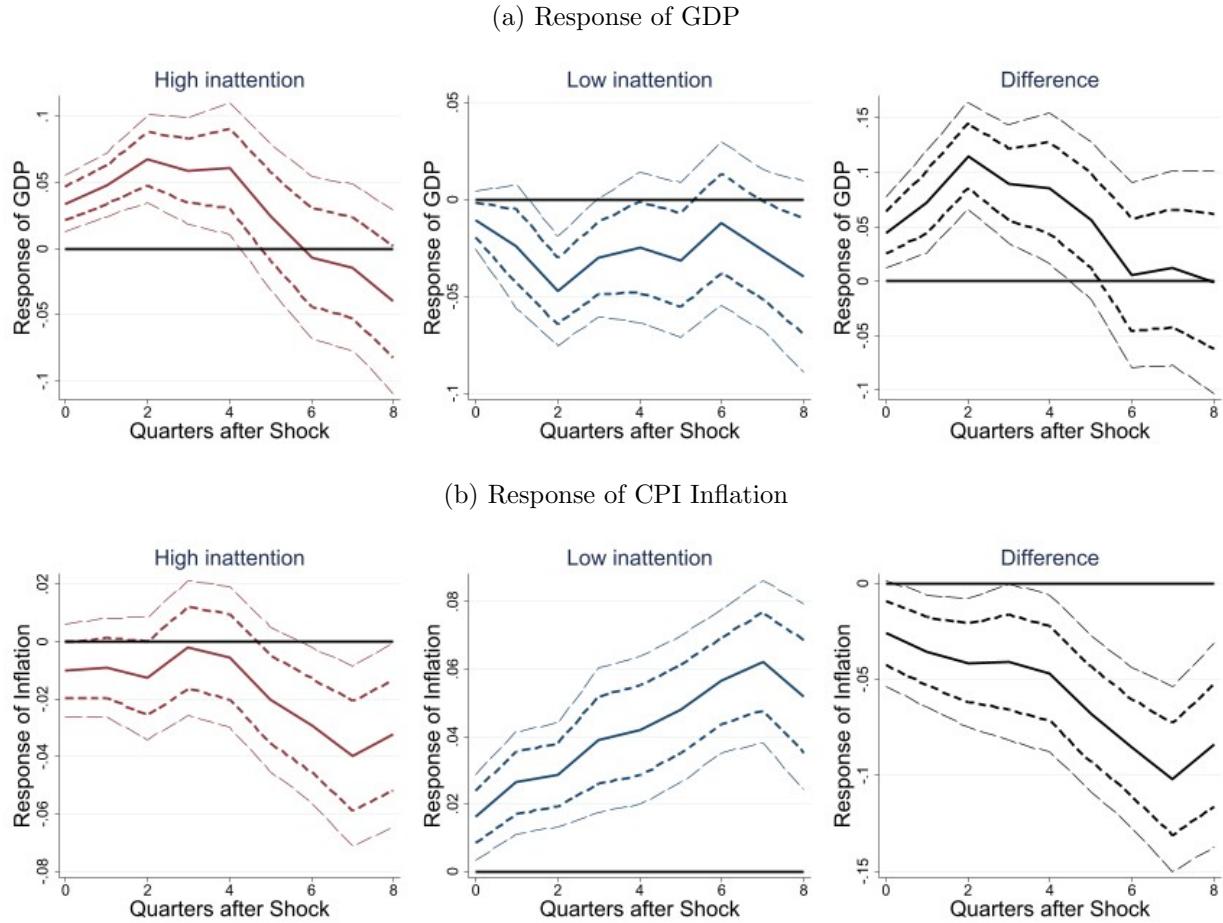
(b) Inattention Measure based on 15 Variables



Notes: This figure compares the inattention between financial and nonfinancial sectors.

## B Inattention and the Impact of Monetary Policy: Robustness Checks

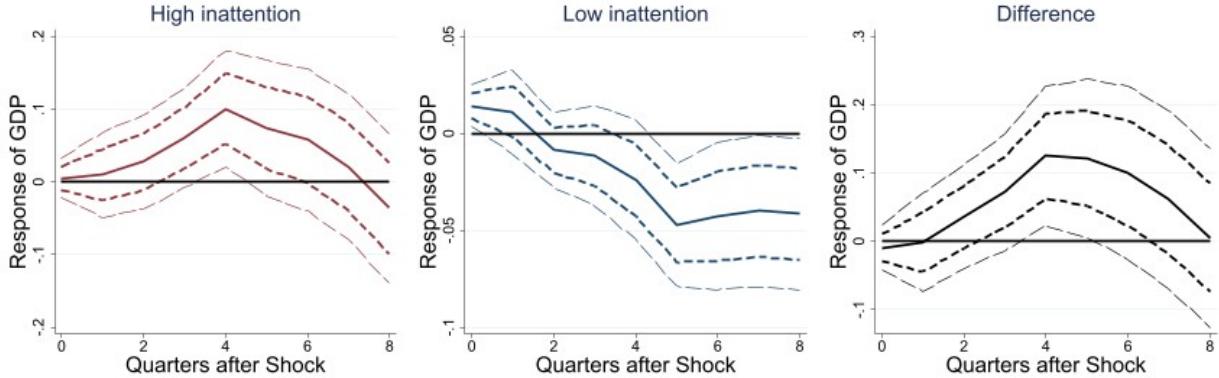
Figure B.1: Inattention and the Impact of Monetary Policy: Smooth Transition Model



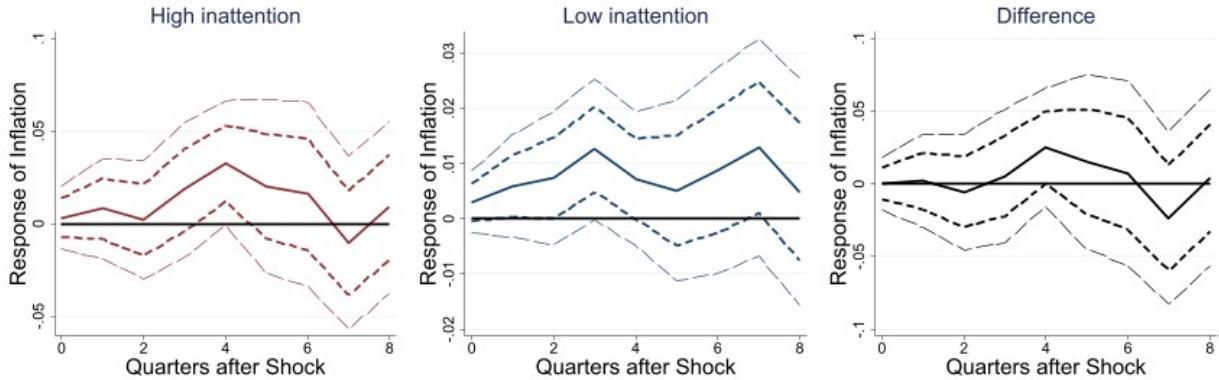
*Notes:* This figure shows the impulse response of real GDP and inflation to an expansionary monetary policy shock, measured as 100 basis points decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1975Q1-2019Q3. The probabilities of high- and low-inattention states are estimated through a smooth transition model. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

Figure B.2: Inattention and the Impact of Monetary Policy: Markov-switching Model

(a) Response of GDP

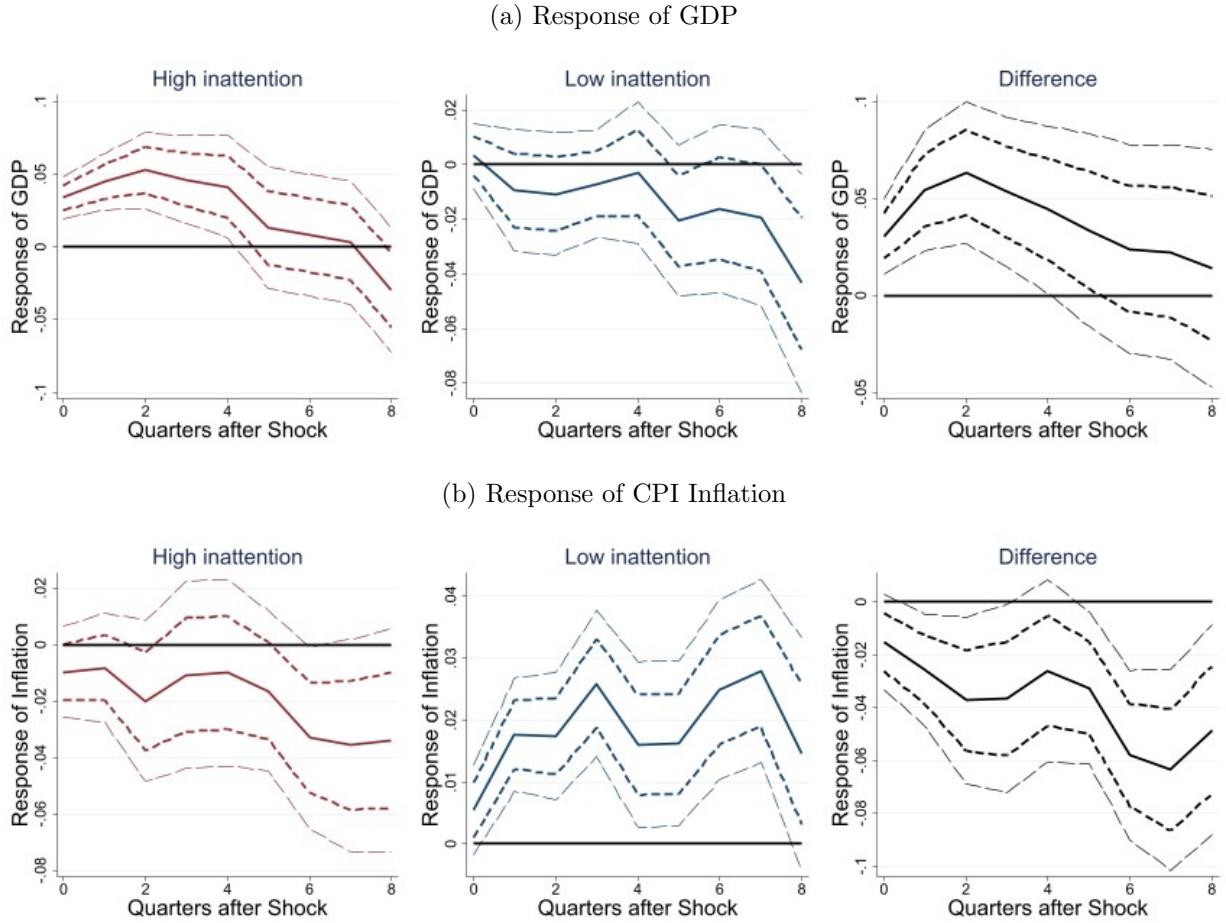


(b) Response of CPI Inflation



*Notes:* This figure shows the impulse responses of real GDP and inflation to an expansionary monetary policy shock, measured as a 100 basis point decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1972Q1-2019Q3. High and low inattention scenarios are estimated using the Markov-switching model. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

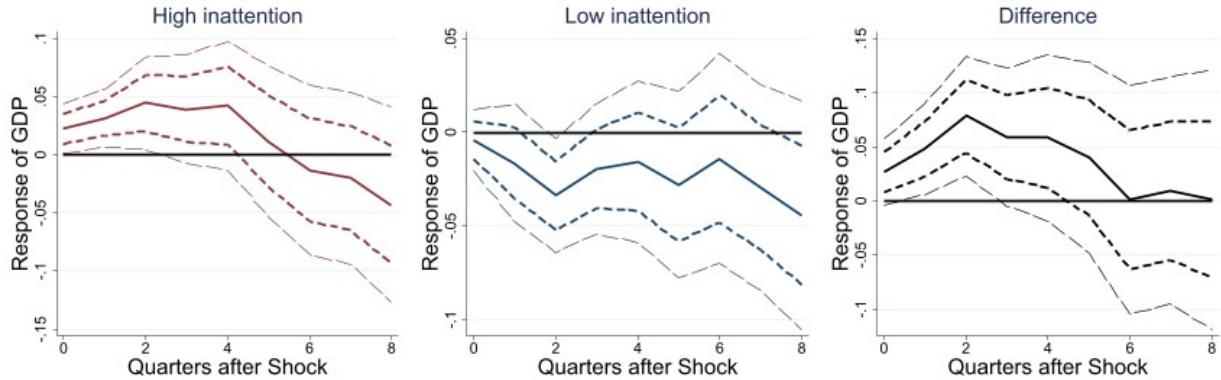
Figure B.3: Inattention Measure: High, Medium and Low-inattention Scenarios



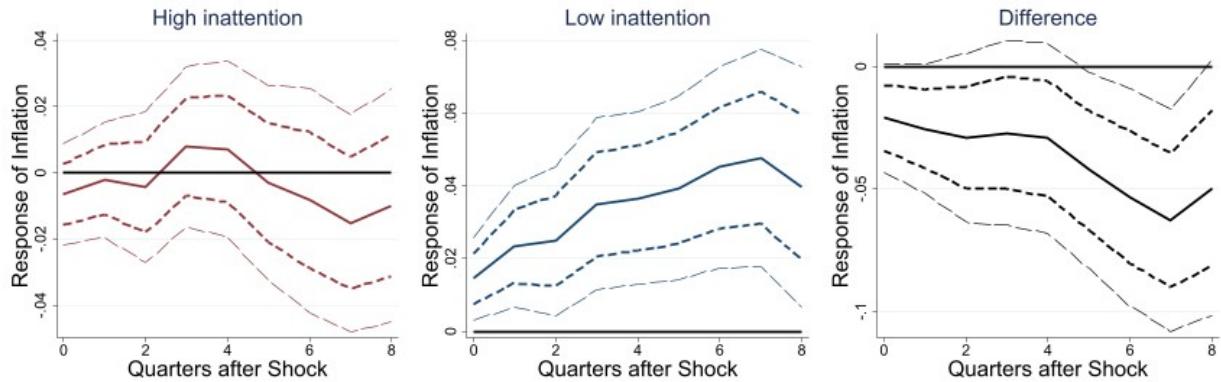
*Notes:* This figure shows the impulse responses of real GDP and inflation to an expansionary monetary policy shock, measured as a 100 basis point decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1972Q1-2019Q3. We identify high inattention episodes as those above the top 10% of the inattention series, and low inattention episodes as those below 10%. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

Figure B.4: Confidence Intervals: Bootstrap Method

(a) Response of GDP



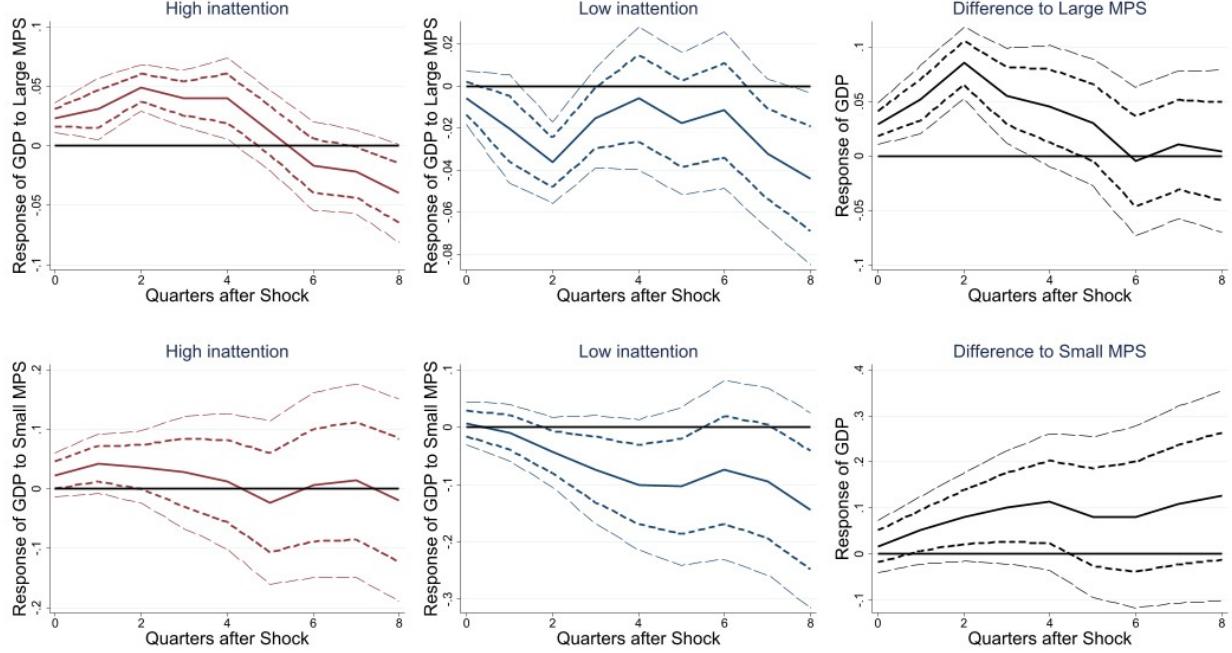
(b) Response of CPI Inflation



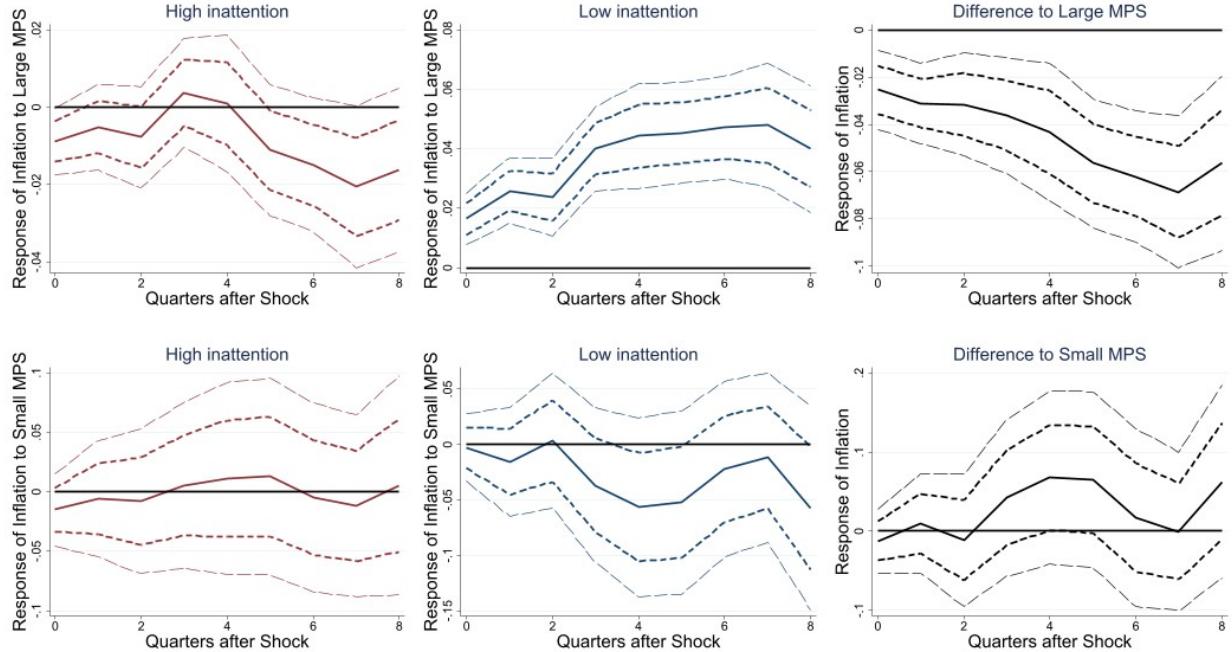
*Notes:* This figure shows the impulse responses of real GDP and inflation to an expansionary monetary policy shock, which is measured as a 100 basis point decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1972Q1-2019Q3. The dashed and dotted lines indicate the 90% and 68% confidence intervals produced by the bootstrap method.

Figure B.5: Size of Monetary Policy Shocks: Large versus Small

(a) Response of GDP



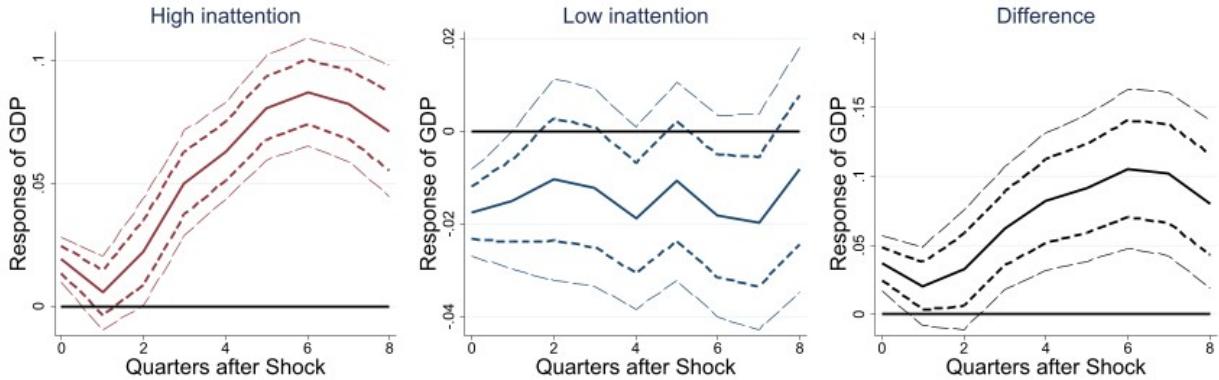
(b) Response of CPI Inflation



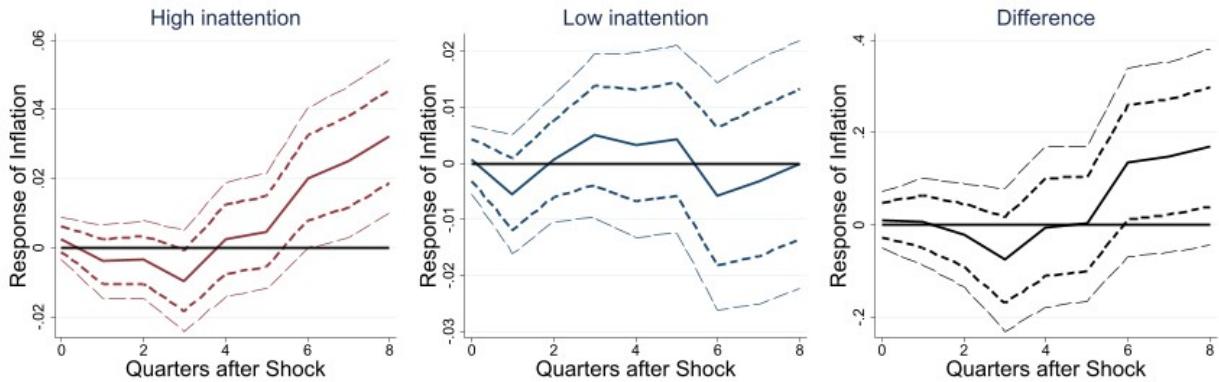
*Notes:* This figure shows the impulse responses of real GDP and inflation to an expansionary monetary policy shock, measured as a 100 basis point decrease in the BRW monetary policy shock series. The impulse responses are estimated based on the sample period 1972Q1-2019Q3. Large monetary policy shocks are defined as those above the 90th percentile or below the 10th percentile of the BRW shock series. We add an additional interaction term of inattention and large versus small monetary policy shocks (binary variables) to the local projections specification. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

Figure B.6: Alternative Measure of Monetary Policy Shock: Romer and Romer (2004)

(a) Response of GDP



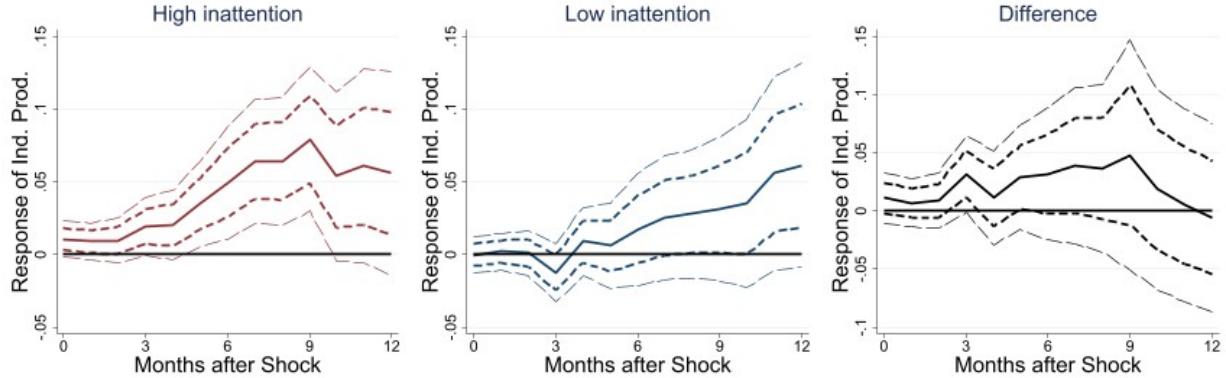
(b) Response of CPI Inflation



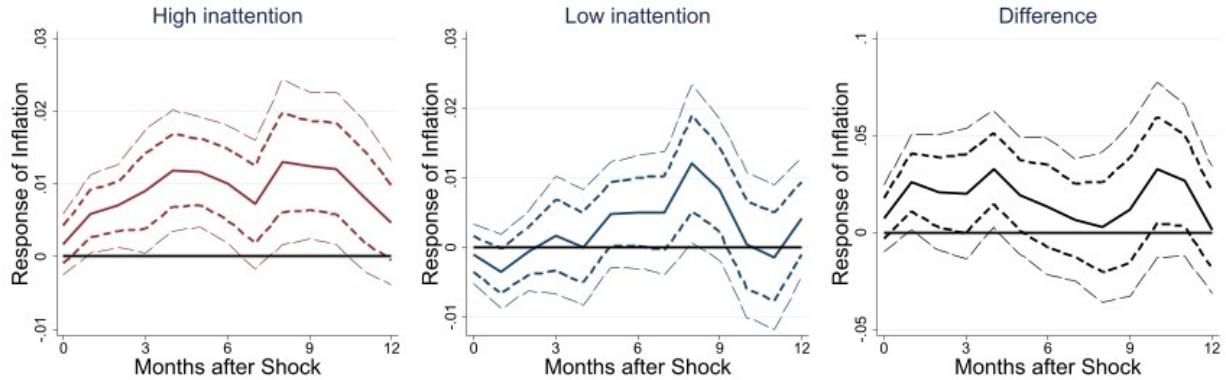
*Notes:* This figure shows the impulse responses of real GDP and inflation to an expansionary monetary policy shock, proposed by Romer and Romer (2004). The impulse responses are estimated based on the sample period 1972Q1–2007Q4. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

Figure B.7: Alternative Measure of Inattention based on Monthly Data

(a) Response of Industrial Production



(b) Response of CPI Inflation



*Notes:* This figure shows the impulse responses of industrial production and inflation to an expansionary monetary policy shock, measured as a 100 basis point decrease in the BRW monetary policy shock series. The inattention is constructed based on monthly survey data from the Consensus Economics covering January 1990 to August 2020. The dashed and dotted lines indicate the 90% and 68% confidence intervals constructed by the Newey-West method.

## C Analytical Analyses

To obtain analytical analyses, we consider a two period model using a log-linearized version of the model with household and firm information rigidity. For illustration, we assume perfect foresight. In general, in a model with information rigidity in both sectors, the Phillips curve (or aggregate supply) and the IS curve (or aggregate demand curve) can, respectively, be written as follows:

$$\widehat{\pi}_t = \frac{\lambda^f}{1 - \lambda^f} \kappa \widehat{y}_t + \lambda^f \sum_{j=0}^{\infty} (1 - \lambda^f)^j \mathbb{E}_{t-j-1} (\widehat{\pi}_t + \kappa(\widehat{y}_t - \widehat{y}_{t-1})) \quad (\text{C.1})$$

$$\widehat{y}_t = \lambda^h \sum_{i=0}^{\infty} (1 - \lambda^h)^i \mathbb{E}_{t-i} \left( \widehat{y}_f - \frac{1}{\sigma} \widehat{R}_t + \frac{1}{\sigma} \widehat{\pi}_{t+1} \right) \quad (\text{C.2})$$

with  $\widehat{x}_t$  being the log deviation of a any variable ( $x_t$ ) from its steady-state value  $x$ , and  $\widehat{y}_f$  being the output gap in the flexible price (and flexible information) model. In this case, we have  $\widehat{y}_f = 0$ .

For the two-period model, we can write:

$$\widehat{\pi}_1 = \frac{\lambda^f \kappa}{1 - \lambda^f} \widehat{y}_1 \quad (\text{C.3})$$

$$\widehat{\pi}_2 = \frac{\lambda^f \kappa}{1 - \lambda^f} \widehat{y}_2 + \lambda^f \mathbb{E}_1 (\widehat{\pi}_2 + \kappa(\widehat{y}_2 - \widehat{y}_1)) \quad (\text{C.4})$$

$$\widehat{y}_1 = -\frac{\lambda^h}{\sigma} (\widehat{R}_1 - \widehat{\pi}_2) \quad (\text{C.5})$$

$$\widehat{y}_2 = -\frac{\lambda^h}{\sigma} \left[ \mathbb{E}_2 (\widehat{R}_2 - \widehat{\pi}_3) + (1 - \lambda^h)^1 \mathbb{E}_1 (\widehat{R}_2 - \widehat{\pi}_3) + (1 - \lambda^h)^2 \mathbb{E}_0 (\widehat{R}_2 - \widehat{\pi}_3) \right] \quad (\text{C.6})$$

Since there are no periods 0 or period 3, Equation (C.15) can be written as:

$$\widehat{y}_2 = -\frac{\lambda^h}{\sigma} \left[ \mathbb{E}_2 (\widehat{R}_2) + (1 - \lambda^h)^1 \mathbb{E}_1 (\widehat{R}_2) \right] \quad (\text{C.7})$$

Next, we assume that the interest rate falls in the first period ( $\widehat{R}_1 < 0$ ) but returns to its steady-state value in the second period ( $\widehat{R}_2 = 0$ ). Then, Equation (C.7) gives:  $\widehat{y}_2 = 0$ . Substituting this result in Equation (C.13), under the assumption of perfect foresight, then gives us the following system of equations:

$$\widehat{\pi}_1 = \frac{\kappa \lambda^f}{1 - \lambda^f} \widehat{y}_1 \quad (\text{C.8})$$

$$\widehat{\pi}_2 = -\frac{\kappa \lambda^f}{1 - \lambda^f} \widehat{y}_1 \quad (\text{C.9})$$

$$\widehat{y}_1 = -\frac{\lambda^h}{\sigma} (\widehat{R}_1 - \widehat{\pi}_2) \quad (\text{C.10})$$

$$\widehat{y}_2 = 0 \quad (\text{C.11})$$

which are conditions (33)-(36) in the text.

### C.1 A Two-Period Model: Alternative Monetary Policy Rule

We consider now an alternative monetary policy rule. As in Eggertsson and Garga (2019), we let  $\widehat{\pi}_t = 0$  for  $t > 1$ . In our case, that implies  $\widehat{\pi}_2 = 0$ . Since we only have two periods, we can write:

$$\widehat{\pi}_1 = \frac{\kappa\lambda^f}{1-\lambda^f}\widehat{y}_1 \quad (\text{C.12})$$

$$\widehat{\pi}_2 = \frac{\kappa\lambda^f}{1-\lambda^f}\widehat{y}_2 + \lambda^f \mathbb{E}_1 \left( \widehat{\pi}_2 + \kappa(\widehat{y}_2 - \widehat{y}_1) \right) \quad (\text{C.13})$$

$$\widehat{y}_1 = \frac{\lambda^h}{\sigma}(\widehat{R}_1 - \widehat{\pi}_2) \quad (\text{C.14})$$

$$\widehat{y}_2 = -\frac{\lambda^h}{\sigma} \left[ \mathbb{E}_2(\widehat{R}_2) + (1-\lambda^h)^1 \mathbb{E}_1(\widehat{R}_2) \right] \quad (\text{C.15})$$

Then, conditions (C.14)- (C.15), together with  $\widehat{\pi}_2 = 0$ , give:

$$\frac{\widehat{y}_1}{\widehat{R}_1} = -\frac{\lambda^h}{\sigma} \quad (\text{C.16})$$

$$\frac{\widehat{y}_2}{\widehat{R}_1} = -\frac{\lambda^h(1-\lambda^f)}{\sigma(2-\lambda^f)} \quad (\text{C.17})$$

Therefore, in absolute value, the response of output in both periods to a change in the interest rate is bigger when households pay more attention (a higher  $\lambda^h$ ). On the other hand, more attention among firms (a higher  $\lambda^f$ ) make monetary policy less effective in raising output (of the second period). Note also that since  $\lambda^f$  is within the  $[0,1]$  interval, the effect of monetary policy on output in period 2 is weaker than in period 1.

### C.2 A Three-Period Model

We now extend the model to three periods, where we assume that the interest rate falls in the first two periods, but returns to its steady-state level in the final period:  $\widehat{R}_1 < 0$ ,  $\widehat{R}_2 < 0$ ,  $\widehat{R}_3 = 0$ . Assume also that  $\widehat{R}_2 = p\widehat{R}_1$ , with  $0 < p < 1$ .

In this case, the aggregate supply and aggregate demand conditions are given by:

$$\widehat{\pi}_1 = \frac{\kappa\lambda^f}{1-\lambda^f}\widehat{y}_1 \quad (\text{C.18})$$

$$\widehat{\pi}_2 = \frac{\kappa\lambda^f}{1-\lambda^f}\widehat{y}_2 + \lambda^f \mathbb{E}_1 \left( \widehat{\pi}_2 + \kappa(\widehat{y}_2 - \widehat{y}_1) \right) \quad (\text{C.19})$$

$$\widehat{\pi}_3 = \frac{\kappa\lambda^f}{1-\lambda^f}\widehat{y}_3 + \lambda^f \mathbb{E}_2 \left( \widehat{\pi}_3 + \kappa(\widehat{y}_3 - \widehat{y}_2) \right) + \lambda^f(1-\lambda^f) \mathbb{E}_1 \left( \widehat{\pi}_3 + \kappa(\widehat{y}_3 - \widehat{y}_2) \right) \quad (\text{C.20})$$

$$\widehat{y}_1 = \frac{\lambda^h}{\sigma}(\widehat{R}_1 - \widehat{\pi}_2) \quad (\text{C.21})$$

$$\widehat{y}_2 = -\frac{\lambda^h}{\sigma} \left[ (\widehat{R}_2 - \widehat{\pi}_3) + (1-\lambda^h)^1 \mathbb{E}_1(\widehat{R}_2 - \widehat{\pi}_3) \right] \quad (\text{C.22})$$

$$\widehat{y}_3 = -\frac{\lambda^h}{\sigma} \left[ \widehat{R}_3 + (1-\lambda^h)^1 \mathbb{E}_2(\widehat{R}_3) + (1-\lambda^h)^2 \mathbb{E}_1(\widehat{R}_3) \right] \quad (\text{C.23})$$

Since  $\widehat{R}_3 = 0$ , condition (C.23) gives  $\widehat{y}_3 = 0$ . Then, substituting this result into (C.20), under the assumption of perfect foresight, yields:

$$\widehat{\pi}_3 = -\frac{\kappa(\lambda^f)^2}{(1-\lambda^f)^2} \widehat{y}_2 \quad (\text{C.24})$$

Substituting this result in (C.22) and using  $\widehat{R}_2 = p\widehat{R}_1$  gives:

$$\frac{\widehat{y}_2}{\widehat{R}_1} = -\frac{p\lambda^h(2-\lambda^h)(1-\lambda^f)^2}{\sigma(1-\lambda^f)^2 + \kappa\lambda^h(2-\lambda^h)(\lambda^f)^2} \quad (\text{C.25})$$

which suggests that output in period 2 will respond to a shock in period 1 if the interest rate remains lower in the second period ( $p > 0$ ), households pay attention ( $\lambda^h > 0$ ) and firms are not fully attentive ( $\lambda^h < 1$ ). When all households are inattentive ( $\lambda^h = 0$ ) or all firms are attentive ( $\lambda^f = 1$ ), output of period 2 does not respond to a monetary policy shock.

Next, condition (C.19) can be re-written as:

$$\widehat{\pi}_2 = \frac{\kappa\lambda^f(2-\lambda^f)}{(1-\lambda^f)^2} \widehat{y}_2 - \frac{\kappa\lambda^f}{1-\lambda^f} \widehat{y}_1 \quad (\text{C.26})$$

Combining conditions (C.25) and (C.26) then gives:

$$\frac{\widehat{y}_1}{\widehat{R}_1} = -\lambda^h(1-\lambda^f) \frac{(1-\lambda^f)^2 + \kappa\lambda^h(2-\lambda^h)(\lambda^f)^2 + p\lambda^h(1-\lambda^h)(1-\lambda^f)^2}{[(1-\lambda^f)^2 + \kappa\lambda^h(2-\lambda^h)(\lambda^f)^2][\sigma(1-\lambda^f) + \kappa\lambda^f\lambda^h]} \quad (\text{C.27})$$

Once more, if all households are inattentive ( $\lambda^h = 0$ ) or all firms are attentive ( $\lambda^f = 1$ ), output of period 1 does not respond to a monetary policy shock. Therefore, as in the two-period model, household and firm inattention have opposing effects on output. In particular, firm inattention raises the response of output while household inattention reduces it.

Note also that if we set  $p = 0$ , we obtain:

$$\frac{\widehat{y}_1}{\widehat{R}_1} = -\frac{\lambda^h(1-\lambda^f)}{\sigma(1-\lambda^f) + \kappa\lambda^f\lambda^h} \quad (\text{C.28})$$

which is the response of output of period 1 that we have obtained in the two-period model.

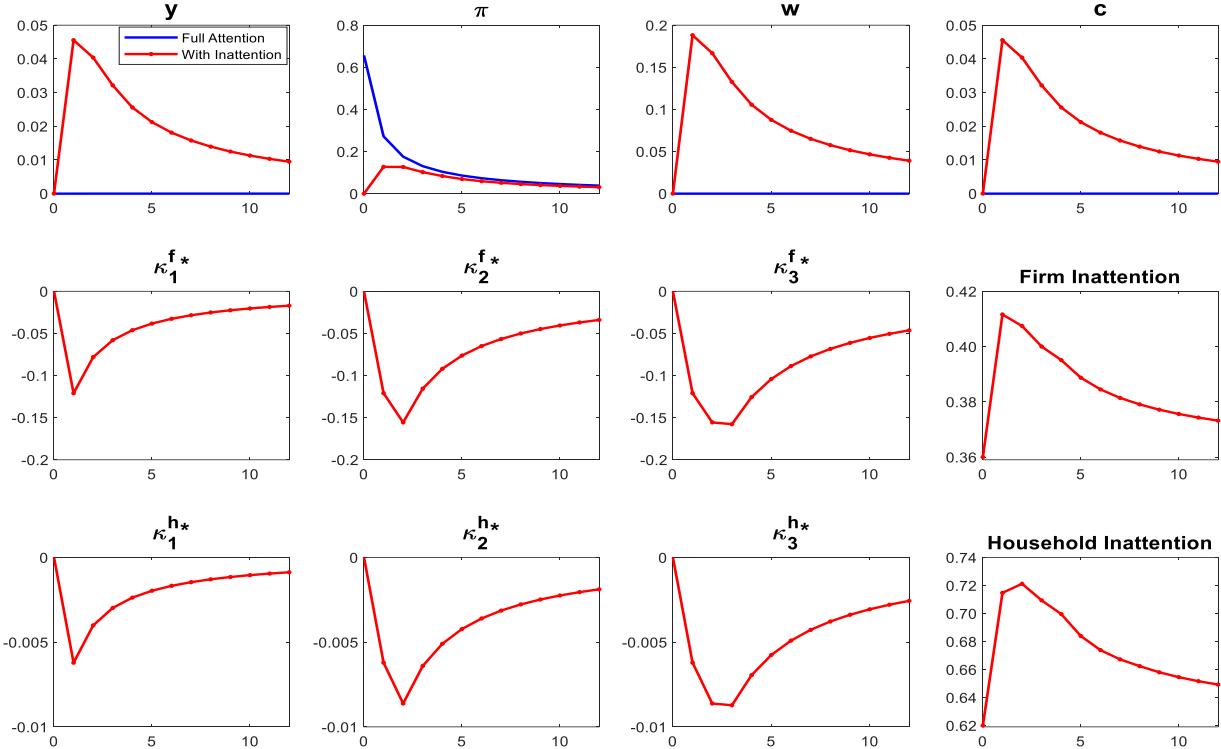
Finally, one can extend this model to more than three periods in a similar fashion (with the interest rate returning to the steady state at some terminal period  $T$ , which could be the final period), and obtain similar qualitative results.

## D Numerical Analyses- Positive Steady-State Inflation Rate

In this section, we provide brief analyses for a model with state-dependent information rigidity and positive steady-state inflation rate. In particular, we set  $\widehat{\pi} = 1.005$ , implying an annual inflation rate of 2%. The reason for introducing positive steady-state inflation rate is that it gives firms reasons to, at some point, update information.<sup>1</sup>.

Our results are summarized in Figure D.1, and they are very similar to what we present in the text (the only noticeable difference is in the response of the cut-offs values of firms and a slightly higher increase of firm inattention compared to the benchmark analysis). Therefore, this assumption is not necessary since, in the benchmark model, we already assume that in the last period ( $J$ ), firms update their information sets.

Figure D.1: Responses to Expansionary Monetary Policy: State-Dependent Inattention



*Notes:* Responses to an expansionary monetary policy shock in the model with state-dependent information rigidity. The model with positive steady-state inflation rate ( $\widehat{\pi} = 1.005$ ). Household and firm inattention are expressed in levels.  $\kappa_j^{f*}$  is the cutoff cost for a firm of vintage  $j$  to update its information set.  $\kappa_i^{h*}$  is the cutoff cost for a household of vintage  $i$  to update its information set.

<sup>1</sup>See Dotsey et al. (1999) for a discussion in the case of state-dependent pricing

## E Numerical Analyses- Time-Varying Productivity

In our model with state-dependent inattention, we assumed only total factor productivity (TFP). In addition, since we are studying the effects of a monetary policy shock, we set TFP to its steady-state value,  $z_t = 1$  for all  $t$ .

In this appendix, we make two modifications. First, we allow for TFP to vary. Second, we introduce firm-level productivity levels and let them be time-varying too. In both cases, we allow for supply-side effects of monetary policy that, in this case, operate through direct effects on productivity. The fact that monetary policy can alter productivity has been recently documented in [Baqae et al. \(2021\)](#).

### E.1 Total Factor Productivity

We show the results of two experiments. In one experiment, we let TFP follow an fully exogenous process as follows:

$$\ln\left(\frac{z_t}{\bar{z}}\right) = \rho_z \ln\left(\frac{z_{t-1}}{\bar{z}}\right) + \varepsilon_{z,t} \quad (\text{E.1})$$

and we let TFP be subject to a shock that is not correlated with the monetary policy shock.

In the second experiment, we let TFP be directly affected by the interest rate ( $R_t$ ), thus generating supply-side effects of monetary policy. In particular, we let TFP be governed by the following modified rule:

$$\ln\left(\frac{z_t}{\bar{z}}\right) = \rho_z \ln\left(\frac{z_{t-1}}{\bar{z}}\right) + \phi_z \ln\left(\frac{R_t}{\bar{R}}\right) + \varepsilon_{z,t} \quad (\text{E.2})$$

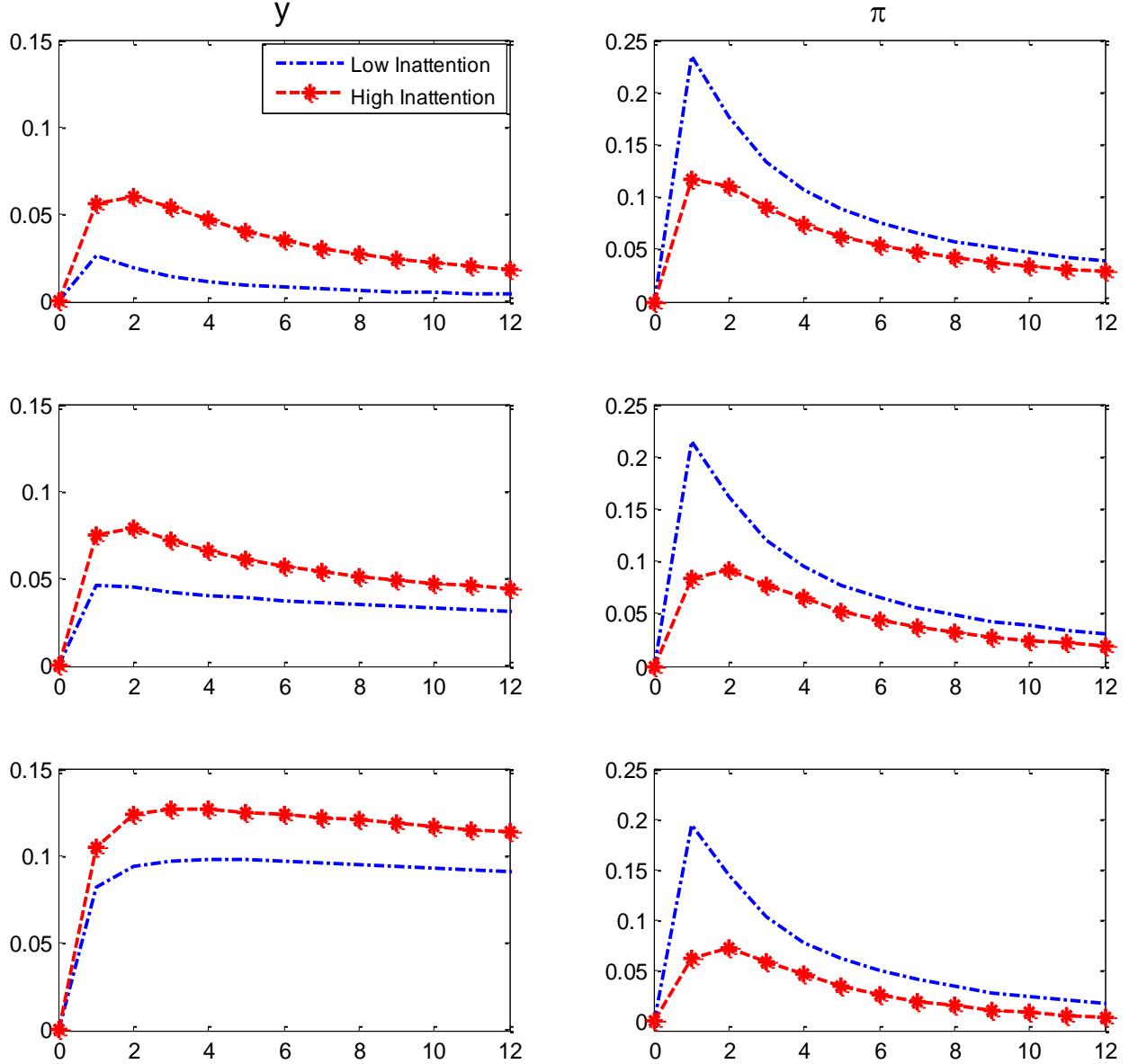
with  $\rho_z > 0$  and  $\phi_z < 0$ . Therefore, a fall in the nominal interest rate raises TFP.

For illustration purposes, we set  $\phi_z = 0.1$ , implying that a 1% fall in the nominal interest rate raises TFP by 0.1%, and then consider a stronger response of TFP to monetary policy ( $\phi_z = 0.3$ ). Other values of this parameter deliver similar qualitative results to what present in this section.

Figure E.1 presents the results. When TFP follows an exogenous process, and the shocks to TFP and monetary policy are uncorrelated, we get the same results as in the text. However, if monetary policy affects TFP, then the response of output to a monetary policy shock becomes stronger, particularly with  $\phi_z = 0.3$ . Intuitively, the demand-side effect and the supply-side effect both generate a bigger expansion in output. On the other hand, the response of inflation is weaker; the demand-side effect, in itself, raises inflation, while the supply-side effects generates a downward pressure on inflation.

Crucial to our study, in all cases, the model with high inattention induces a bigger response of output to monetary policy and a smaller response of inflation, which is consistent with our main findings. In fact, the combination of higher steady-state inattention and supply-side effects of monetary policy delivers better outcomes than when monetary policy affects only the demand side of the economy.

Figure E.1: Responses to Expansionary Monetary Policy: State-Dependent Inattention and Supply-side Effects of Monetary Policy



*Notes:* Responses to an expansionary monetary policy shock in the model with state-dependent information rigidity. Low steady-state Inattention:  $\bar{\lambda}^f = \bar{\lambda}^h = 0.75$ . High steady-state Inattention:  $\bar{\lambda}^f = \bar{\lambda}^h = 0.25$ . Top panel: exogenous process for TFP; shocks to monetary policy and TFP are uncorrelated. Middle panel: TFP responds to the interest rate as in (E.2) and  $\phi_z = 0.1$ . Bottom panel: TFP responds to the interest rate as in (E.2) and  $\phi_z = 0.3$ . We also set  $\rho_z = 0.95$ .

## E.2 Firm-Level Productivity

We now modify the production function to be:

$$y_{j,t} = A_{j,t} n_{j,t}^{1-\alpha} \quad (\text{E.3})$$

with  $A_{j,t} = z_t h_{j,t}$  and  $h_{j,t}$  being a firm-specific (or idiosyncratic) productivity.

Similar to TFP, we consider the case when firm-level productivity is an exogenous process and when it is affected by monetary policy:

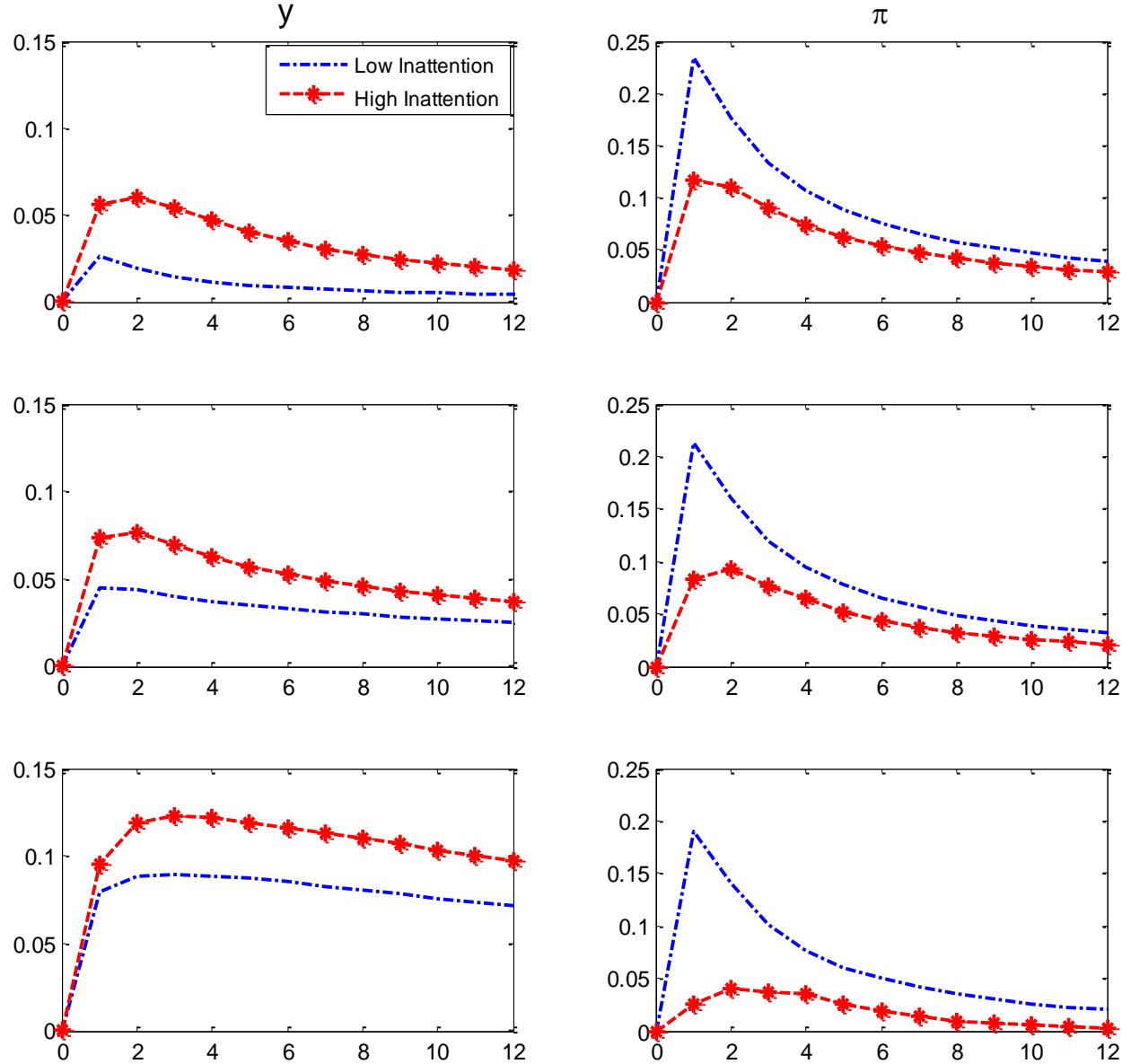
$$\ln\left(\frac{h_{j,t}}{\bar{h}}\right) = \rho_h \ln\left(\frac{h_{j,t-1}}{\bar{h}}\right) + \varepsilon_{h,t} \quad (\text{E.4})$$

$$\ln\left(\frac{h_{j,t}}{\bar{h}}\right) = \rho_h \ln\left(\frac{h_{j,t-1}}{\bar{h}}\right) + \phi_h \ln\left(\frac{R_t}{\bar{R}}\right) + \varepsilon_{h,t} \quad (\text{E.5})$$

with  $\rho_h > 0$  and  $\phi_h < 0$ .

As shown in Figure E.2, the findings are similar to what we obtain in the previous section. With supply-side effects, monetary policy is more effective in raising output, with smaller inflationary pressures, particularly for a stronger response of firm-level productivity to the interest rate ( $\phi_h$ ), and for higher steady-state inattention.

Figure E.2: Responses to Expansionary Monetary Policy: State-Dependent Inattention and Supply-side Effects of Monetary Policy

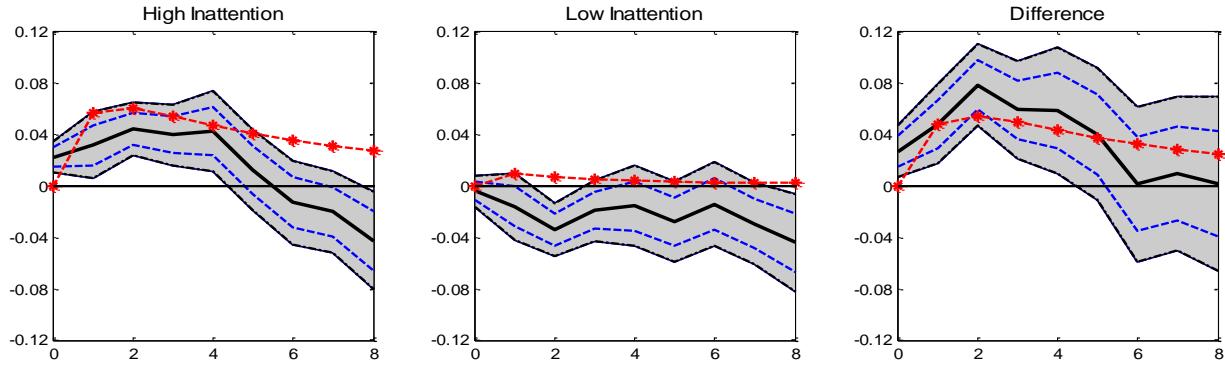


*Notes:* Responses to an expansionary monetary policy shock in the model with state-dependent information rigidity. Low steady-state Inattention:  $\bar{\lambda}^f = \bar{\lambda}^h = 0.75$ . High steady-state Inattention:  $\bar{\lambda}^f = \bar{\lambda}^h = 0.25$ . Top panel: exogenous process for the idiosyncratic productivity; shocks to monetary policy and the idiosyncratic productivity are uncorrelated. Middle panel: the idiosyncratic productivity responds to the interest rate as in (E.5) and  $\phi_h = 0.1$ . Bottom panel: the idiosyncratic productivity responds to the interest rate as in (E.5) and  $\phi_h = 0.3$ . We also set  $\rho_h = 0.9$ .

## F Robustness Analyses- Model Fit, High vs. Low Inattention

In Figure F.1, we show results when the steady-state inattention under the low inattention scenario is reduced to 0.07 (which is the lowest value that we document in this paper) while keeping the steady-state high inattention at 0.55. This modification slightly improves the ability of the model to fit the response of output under low inattention, and consequently the difference between the responses.

Figure F.1: Responses to Expansionary Monetary Policy: Model vs. Data, Low vs. High Steady-State Inattention



*Notes:* Responses to an expansionary monetary policy shock in the model with state-dependent information rigidity for two different steady-state values of the inattention parameters. Low steady-state Inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.07$ . High steady-state Inattention:  $1 - \bar{\lambda}^f = 1 - \bar{\lambda}^h = 0.55$ . Red line with stars: the estimate from the model. Solid black line: the point estimate from the data. Shaded area: confidence intervals.

## G A Model with Sticky Information and Sticky Prices

The problem of a sticky-price firm  $k$  is to:

$$\max_{\{n_{k,t}, P_{k,t}\}_{s=0}^{\infty}} \mathbb{E}_0 \sum_{s=0}^{\infty} (\beta(1 - \lambda^p))^s \frac{C_{t+s}^{-\sigma}}{C_t^{-\sigma}} \left( \frac{P_{k,t}}{P_{t+s}} n_{k,t+s}^{1-\alpha} - w_{t+s} N_{k,t+s} \right) \quad (\text{G.1})$$

subject to:

$$y_{j,t} = z_t n_{j,t}^{1-\alpha} \quad (\text{G.2})$$

$$y_{j,t} = \left( \frac{P_{j,t}}{P_t} \right)^{-\varepsilon} y_t \quad (\text{G.3})$$

The first-order condition that yields the optimal price chosen by the firm  $(P_{k,t}^*)$  is given by:

$$\frac{P_{k,t}^*}{P_t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta(1 - \lambda^p))^s C_{t+s}^{-\sigma} \left( \frac{P_{k,t+s}}{P_t} \right)^{\varepsilon} m c_{k,t+s} y_{k,t+s}}{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta(1 - \lambda^p))^s C_{t+s}^{-\sigma} \left( \frac{P_{k,t+s}}{P_t} \right)^{\varepsilon-1} y_{k,t+s}} \quad (\text{G.4})$$

Since all optimizing firms choose the same price  $(P_t^*)$ , we can re-write condition (G.4) as:

$$\frac{P_t^*}{P_t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\Psi_{1,t}}{\Psi_{2,t}} \quad (\text{G.5})$$

where  $\Psi_{1,t}$  and  $\Psi_{2,t}$  take the following recursive forms:

$$\Psi_{1,t} = C_t^{-\sigma} m c_t y_t + \beta(1 - \lambda^p) \mathbb{E}_t(\Psi_{1,t+1} \pi_{t+1}^{\varepsilon}) \quad (\text{G.6})$$

$$\Psi_{2,t} = C_t^{-\sigma} y_t + \beta(1 - \lambda^p) \mathbb{E}_t(\Psi_{2,t+1} \pi_{t+1}^{\varepsilon-1}) \quad (\text{G.7})$$

Substituting for  $P_t^*$  using condition (G.5) and using the definition of the aggregate price level,  $P_t^{1-\varepsilon} = \lambda^p (P_t^*)^{1-\varepsilon} + (1 - \lambda^p) P_{t-1}^{1-\varepsilon}$ , then gives:

$$(1 - \lambda^p) \pi_t^{\varepsilon-1} = 1 - \lambda^p \left( \frac{\varepsilon}{\varepsilon - 1} \frac{\Psi_{1,t}}{\Psi_{2,t}} \right)^{1-\varepsilon} \quad (\text{G.8})$$

As usual with Calvo pricing, the fact that not all firms can adjust their prices each period leads to a price dispersion, which is given by:

$$\Delta_t = \int_0^1 \left( \frac{P_{k,t}}{P_t} \right)^{-\varepsilon} dk \quad (\text{G.9})$$

Defining  $\pi_t^* = \frac{P_t^*}{P_{t-1}}$ , condition (G.5) can be written in terms of inflation rates as follows:

$$\frac{\pi_t^*}{\pi_t} = \frac{\varepsilon}{\varepsilon - 1} \frac{\Psi_{1,t}}{\Psi_{2,t}} \quad (\text{G.10})$$

Then, the price dispersion evolves according to the following equation:

$$\Delta_t = \lambda^p \left( \frac{\pi_t^*}{\pi_t} \right)^{-\varepsilon} + (1 - \lambda^p) \pi_t^{\varepsilon} \Delta_{t-1} \quad (\text{G.11})$$

As expected,  $\Delta_t = 1$  if all firms update prices (i.e.  $\lambda^p = 1$ , in which case  $P_t^* = P_t$ ).

## References

- Baker, S. R., N. Bloom, and S. J. Davis (2016). Measuring economic policy uncertainty. *Quarterly Journal of Economics* 131(4), 1593–1636.
- Baqae, D., E. Farhi, and K. Sangani (2021). The supply-side effects of monetary policy. *NBER Working Paper 28345*.
- Bu, C., J. H. Rogers, and W. Wu (2021). A unified measure of Fed monetary policy shocks. *Journal of Monetary Economics* 118, 331–349.
- Dotsey, M., R. G. King, and A. L. Wolman (1999). State-dependent pricing and the general equilibrium dynamics of money and output. *Quarterly Journal of Economics* 114(2), 655–690.
- Eggertsson, G. B. and V. Garga (2019). Sticky prices versus sticky information: Does it matter for policy paradoxes? *Review of Economics Dynamics* 31, 363–392.
- Jurado, K., S. C. Ludvigson, and S. Ng (2015). Measuring uncertainty. *American Economic Review* 105(3), 1177–1216.