Data Revisions and the Effects of Monetary Policy Volatility

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Abstract

This paper evaluates the effects of monetary policy volatility by fully accounting for real-time nature of policy setting. The empirical analysis shows that the impact of real-data volatility on output is about two times lower compared to that of final data volatility. Qualitatively, the effects of the two measures of volatility are similar. These findings suggest that the business cycle implications of policy-related volatility may possibly be overstated.

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1. Introduction

A growing body of theoretical and empirical literature has highlighted the role of monetary policy volatility/uncertainty in business cycle fluctuations. Empirical estimates of policy-related volatility, however, mostly ignore the issue related to data revisions and the timeliness of information available to policymakers. More concretely, the data used in these studies have been revised relative to the data known at the time policy measures were taken, therefore the estimated policy volatility shocks may partially reflect these revisions in initial releases of variables.

In the current paper, I quantify the role of data uncertainty in the estimation of policy-related volatility. To that end, I use the real-time data for the US economy, available from the Reserve Bank of Philadelphia. The research is carried out in three steps. First, I construct policy shocks by estimating monetary policy reaction functions along the lines of Christiano et al. (1999) both for real-time and final data. The underlying recursive structure allows to estimate the policy rules by OLS.

Second, the constructed policy shocks are used to estimate time-varying policy volatility. Time varying standard deviations are modeled as an AR(1) stochastic volatility process. The latent volatilities are sampled following the algorithm of Kim et al. (1998).

Third, the historical volatility estimates are employed to evaluate the impulse responses from the policy volatility shock for the real-time and for the final data.
The findings of the paper are as follows. The real-time policy shocks are closely correlated with the final data shocks. Moreover, the two measures of policy shocks have similar impact on output. On the other hand, the impact of real-data volatility on output is about two times lower compared to that of final data volatility. This is also true for consumption, investment and unemployment. The comparison of the

impulse response functions obtained with the revised data to those obtained with the real-time data indicates that the role of policy-related volatility in short run fluctuations is somewhat overstated.

This paper is related to different strands of literature. The first strand examines the impact of monetary policy-related uncertainty on the economy. Born and Pfeifer (2014) analyze the role of monetary policy uncertainty in explaining business cycle fluctuations by using a New-Keynesian model with time-varying policy volatility. They argue that policy volatility has only minor effects on business cycle fluctuations. Mumtaz and Zanetti (2013) study the impact of the volatility of monetary policy by using a non-linear SVAR model. They show that movements in the volatility of monetary policy have an important impact on the economy. Other research related to this strand are Husted et al. (2017), Creal and Wu (2018) and Mumtaz and Surico (2018), etc.

The second strand looks at the impact of data revisions on monetary policy analysis. Orphanides (2001) shows that the real-time policy recommendations considerably differ from those obtained with the ex-post data. Moreover, he argues that policy analysis based on ex-post data yields misleading descriptions of historical policy. Evans (1998) confirms the findings in Orphanides (2001) by showing that data revisions play a significant role in justifying the fact that Taylor rule matches the path of the federal funds rate. Croushore and Evans (2006), on the other hand, show that the use of revised data in VAR analyses of monetary policy shocks is not a serious limitation for recursively identified models. Similarly, Boivin (2006) argues that inappropriate account of the real-time nature of monetary policy is not a crucial limitation in policy analysis.

This paper adds to the previous literature by quantifying the importance of data revisions in the estimation of policy-related volatility. The empirical analysis in this study shows that real-time data issues are essential in assessing the role of policy-related uncertainty in business cycle fluctuations.

The rest of the paper is structured as follows. In the second section, I construct the policy shock series for real-time and final data. I also estimate time-varying volatilities of the policy shocks. In the third section, I use the historically estimated volatility series to evaluate the impact of policy-related volatility on the economy. In the last section, I provide some concluding remarks.

2. Volatility Estimation

This section uses real-time and final data to estimate time-varying volatility of monetary policy shocks. Throughout the paper, real-time data refers to the first release of a data point, and the final data is the most recent vintage available. First, I construct monetary policy shocks (level shocks) by specifying a policy reaction function and estimating it with real-time and final data. Second, I use a non-linear filter to estimate policy-related volatility for both data sets.

2.1. Monetary Policy Shock Construction

To estimate monetary policy shocks with real-time data, I follow Croushore and Evans (2006) and specify the policy rule in the spirit of Christiano, Eichenbaum and Evans (1999). The model includes the following variables: real GDP (y), GDP deflator (p), change in commodity prices (Δpc), federal funds rate (r) and money supply, $M2$ (m). The baseline structure of the Central Bank's reaction function is given by:

$$r_t = c + A(L)r_{t-1} + D[y_t \;\; p_t \;\; \Delta pc_t]' + B(L)[y_{t-1} \;\; p_{t-1} \;\; \Delta pc_{t-1} \;\; m_{t-1}]' + \mu_t \qquad (2.1)$$

where $A(L)$ is a scalar lag polinomial, $B(L)$ is a (1×4) vector polynomial in the lag operator L, D is a (1×3) vector and c is a constant term. μ_t is an exogenous monetary policy shock. The number of lags is fixed at two, a common choice in quarterly models.

Note that practical implementation of such a rule requires timely information on macroeconomic variables. For any variable x, I use x_t to denote the final value of variable x in period t. On the other hand, $x_{t|t}$ denotes the real-time value (estimate) of x_t. Similar to Croushore and Evans (2006), I assume that:

$$x_t = x_{t|t} + \xi_t \tag{2.2}$$

where ξ_t is a measurement wedge between the final and real-time data assumed to be uncorrelated with policy shocks. The real-time policy shocks can be constructed by estimating the following model:

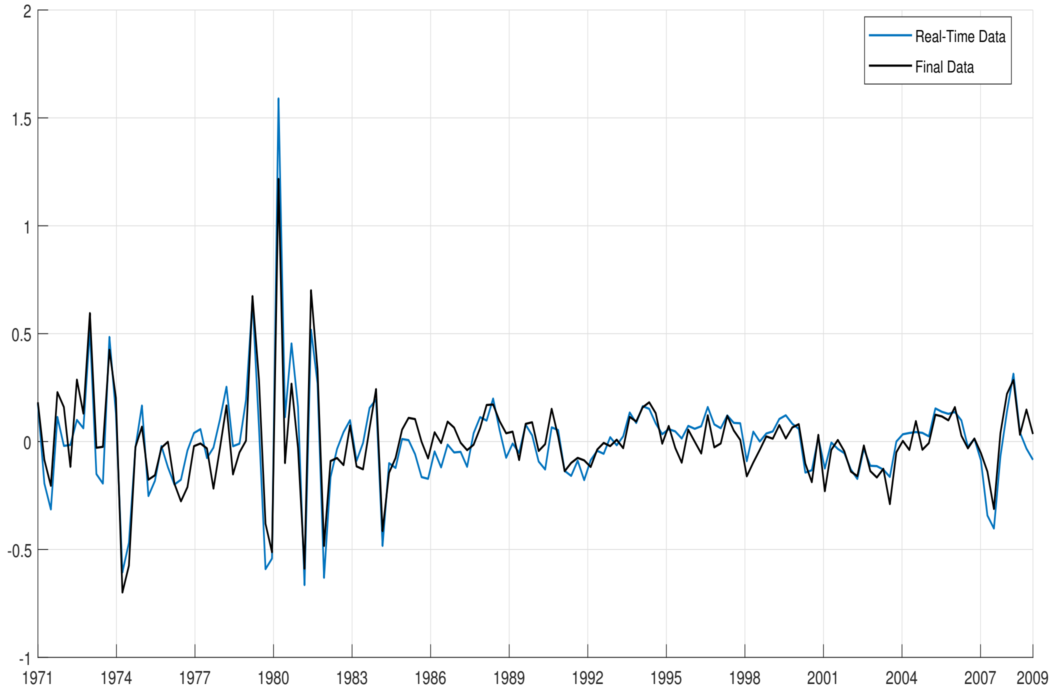
$$r_t = c + A(L)r_{t-1} + D[y_{t|t} \;\; p_{t|t} \;\; \Delta pc_t]' + B(L)[y_{t|t-1} \;\; p_{t|t-1} \;\; \Delta pc_{t-1} \;\; m_{t|t-1}]' + \mu_{t|t} \tag{2.3}$$

where $\mu_{t|t}$ denotes real-time policy shock. r and Δpc are not revised while y, p and m are subject to revisions. Before proceeding any further, it is worth stressing two important points. First, the real-time data is released with a one-period lag, i.e. $x_{t|t}$ is usually available at $t+1$. Nevertheless, the latter is included in the policy rule specification owing to the fact that when making decisions central banks use huge amounts of information sets and can estimate it with high accuracy. Second, the above structure assumes that the Central Bank only reacts to lagged real-time (i.e. first release) observables. This approach somehow underestimates the information available to the Central Bank.**However, the assumption may not be too re-**

strictive considering the fact that the later revisions are much larger than the initial ones.

Given the recursiveness assumption and independence (uncorrelatedness) of measurement errorrs and polciy shocks, (2.3) can be consistently estimated by standard OLS procedures. The data set covers the period 1971-2009.[1] The real-time measures

Figure 1. Estimated Monetary Policy Shocks for Real-time and Final Data



Notes: The black line plots the estimated policy shocks based on real-time data. The blue line shows the dynamics of policy shocks estimated with final data. Both measures are in percentage terms.

of y, p and m are obtained from the the Real-Time Data Research Center of the Federal Reserve Bank of Philadelphia's Research Department. The final data for the corresponding variables is from the FRED database. Figure 1 plots the constructed policy shocks for the real-time and the revised data.[2] The estimated series of mone-

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[1] The end date of the sample is chosen so as to exclude the zero lower bound episode.

[2] The details of estimation are provided in Appendix A.

tary policy shocks strongly co-move displaying similar timing in terms of peaks and troughs. In fact, the coefficient of contemporaneous cross-correlation between the two series is 0.91. Moreover, real-time and final-data based policy shocks have similar impact on output growth. One pp increase in real-time policy shock yields a 1.23 pp decrease in output growth after two quarters. For final-data shock, the corresponding impact value is 1.35.[3] This result is consistent with that of Croushore and Evans (2006) and Boivin (2006) who argue that the use of revised data in policy analysis may not be a serious limitation. The proceeding analysis, however, shows that this result does not hold for second order shocks.

2.2. Policy Volatility Estimation

Having constructed policy shocks, I next turn to policy volatility estimation. Time varying standard deviations are modeled as an AR(1) stochastic volatility process:

$$\mu_t = \varphi \mu_{t-1} + e^{\frac{1}{2}\sigma_t} \varsigma_t, \qquad \varsigma_t \sim N(0,1) \tag{2.4}$$

$$\sigma_t = (1-\rho)\bar{\sigma} + \rho \sigma_{t-1} + \eta \epsilon_t, \qquad \epsilon_t \sim N(0,1) \tag{2.5}$$

where μ_t is the shock to the interest rate and φ is the persistence of the policy shock process. Next, σ_t is the log of the standard deviation of the policy shock. ρ and $\bar{\sigma}$ are the persistence and the unconditional mean of the volatility process. η is the standard deviation of the volatility shock. Finally, the shock to the volatility ϵ_t, is assumed to be independent from the policy shock. The main objective, estimation of the posterior density of the volatility series is implemented following the algorithm of Kim et al. (1998). The model represented by (2.4) and (2.5) is transformed into a conditionally Gaussian form and the error term in the observation equation

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[3] See Appendix B for further details

is approximated by a mixture of seven Gaussian distributions to match its first four moments. The algorithm is applied using 50000 replications, discarding the first 10000 as burn-in.

Table 1 reports the estimation results for both series of policy shocks. The results indicate that both measures of policy volatility have considerable persistence. Also, the estimated values of standard deviations, η, show substantial evidence of uncertainty for both data sets.

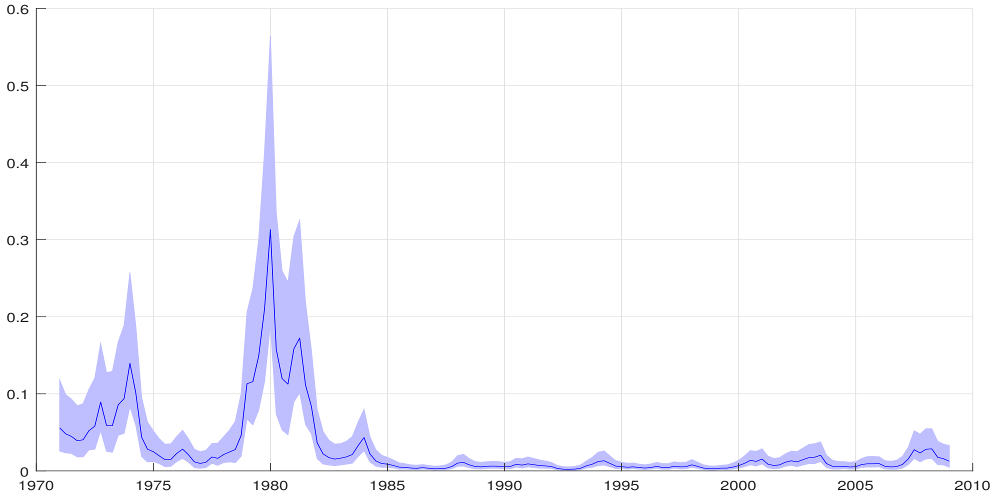
Table 1. Parameter Estimates of Shock Processes

	Final Data	Real-Time Data
φ	0.03	0.10
	[-0.01 0.07]	[0.04 0.15]
ρ	0.86	0.83
	[0.70 0.95]	[0.70 0.93]
$\overline{\sigma}$	-4.37	-4.41
	[-5.20 -3.56]	[-5.21 -3.58]
η	0.48	0.73
	[0.17 1.16]	[0.31 1.46]

Note: For each parameter, I report the posterior median and, in brackets, a 90 percent probability interval.

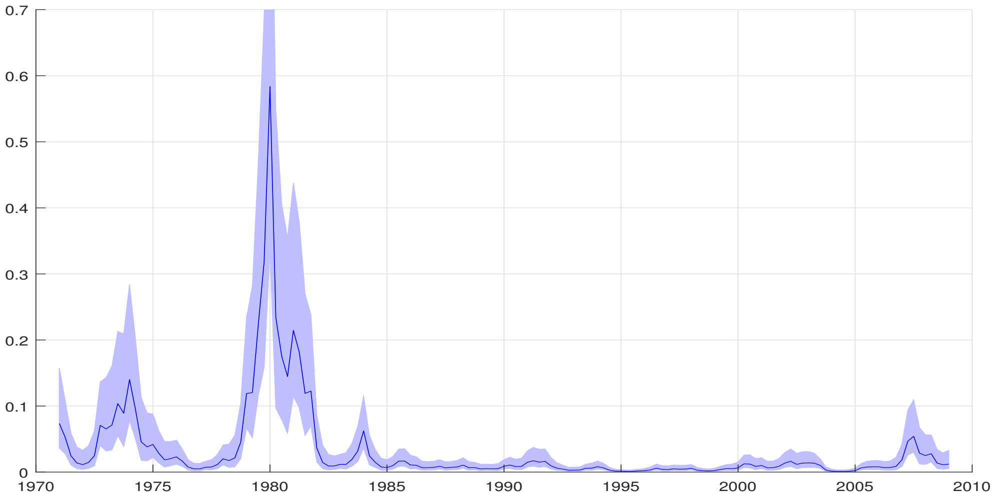
Figure 3 and Figure 4 plot the 68 percent posterior probability intervals of the filtered policy volatility shocks, e^{σ_t}, for revised and real-time data, respectively. Figure 3 shows that the final-data policy volatility decreases considerably after the 1980s recession and rises moderately during the 2001 recession and the 2008-2009 crisis. This result is in line with the previous literature (e.g., Born and Pfeifer (2012) and Mumtaz and Zanetti (2013), etc). A similar observation can be made for the real-time policy volatility series.

Figure 2. Filtered Policy Volatility: Final Data



Notes: The solid line plots the median and the shaded area is the 68 percent posterior probability interval of the filtered policy volatility shocks. The volatility measure is computed with the revised data based policy shocks

Figure 3. Filtered Policy Volatility: Real-time Data



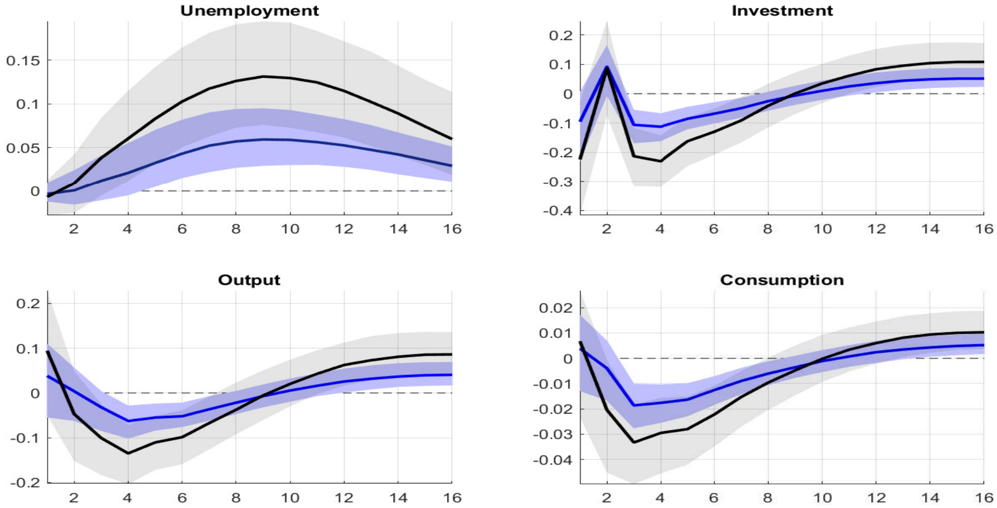
Notes: The solid line plots the median and the shaded area is the 68 percent posterior probability interval of the filtered policy volatility shocks. The volatility measure is computed with the real-time data based policy shocks.

3. The Effects of Policy Volatility

In this section, I evaluate the impact of real-time volatility shocks on final data. The objective is to assess the role of "pure" policy-related volatility in short-term fluctuations, namely whether data revisions have any qualitative and quantitative implications for the role of policy volatility in business cycle fluctuations. In particular, I study how output, its components and employment behave as a response to real-time and final-data volatility shocks. The data on the selected variables is from the FRED database. Consumption is the sum of real personal consumption expenditures for nondurable goods and services. Investment is the sum of real residential fixed investment and real nonresidentialfixed investment.

I employ structural VAR models where the volatility shocks are identified recursively. The volatility series are ordered first motivated by the view that the policy volatility shocks are exogenous. As before, the lag length in the model is set to two. Figure 5 plots the responses of selected variables to a unit increase in real-time and final-data based policy volatility shocks. The black line and gray areas correspond to the median and the 68th percentiles of responses to final-data shock volatility, whereas the blue line and blue areas represent the responses to real-time data shock volatility. We observe that both measures of policy volatility induce a significant decline in output and its components. A unit increase in final-data shock volatility leads to a 0.15 pp drop in GDP growth, followed by a recovery with a moderate overshooting. The drop in investment is more pronounced, about 0.23 pp in 4 quarters after the shock. Consumption, on the other hand, reacts moderately, dropping by about 0.03 pp. Finally, unemployment picks up by about 0.13 pp in a 2 year horizon. The fall in output growth reaches up to 0.07 percent after an increase in the real-time data based volatility shock. Consumption and investment drop by 0.02 and 0.1 pp, respec-

Figure 4. Real-Time versus Ex-Post Volatility Shocks



Notes: The black lines present the impact of final-data policy volatility shock. The blue lines show the impact of real-time policy volatility shock. The confidence intervals are bootstrapped, symmetric 68 percent bands.

tively. The rise in unemployment reaches up to 0.05 pp. We can observe that while the responses are qualitatively similar, the effects of the real-time data based policy volatility are significantly lower compared to that of the final data based measure. In fact, the impact of the real-data policy volatility shock on output is about two times lower compared to that of the final-data policy volatility shock. The latter implies that the role of policy-related uncertainty in business cycle fluctuations may be somewhat overstated. These findings are not sensitive to different orderings of variables and lag length specifications. The results of these sensitivity exercises are available in Appendix C.

4. Conclusion

This paper quantifies the role of data revisions in the estimation of monetary policy-related volatility. I first construct monetary policy shocks for real-time and final data. Consistent with the previous literature, the fist order effects of the shocks on economic activity are similar. I next estimate policy volatility shocks for both data sets. The historical volatility estimates are employed in structural VAR models to estimate the impact of volatility shocks on the economy. The impulse response functions show that the effects of real-time policy volatility are significantly lower compared to that of ex-post policy volatility. In sum, the paper shows that an improper account for data revisions may lead to a distorted picture of the impact of policy-related volatility on the economy.

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Appendix A: Policy Shock Estimation for Final and Real-Time Data

Table A1. OLS Estimation of Policy Rule: Final Data

Variable	Coefficient	Std. Error	t-Stat	Prob.
r_{t-1}	0.96	0.08	11.28	0.00
r_{t-2}	−0.10	0.08	−1.12	0.26
y_t	0.23	0.07	3.09	0.00
y_{t-1}	−0.34	0.14	−2.44	0.01
y_{t-2}	0.10	0.07	1.45	0.14
p_t	0.90	0.24	3.74	0.00
p_{t-1}	−1.56	0.46	−3.39	0.00
p_{t-2}	0.66	0.22	2.96	0.00
pc_t	0.01	0.01	1.56	0.12
pc_{t-1}	0.00	0.01	0.75	0.44
pc_{t-2}	−0.02	0.01	−1.85	0.06
m_{t-1}	0.05	0.02	1.94	0.05
m_{t-2}	−0.05	0.02	−1.96	0.05
c	−1.33	0.94	−1.41	0.16
R-squared	0.94	Mean dependent var		1.56
Adjusted R-squared	0.93	S.D. dependent var		0.88
S.E. of regression	0.22	Akaike info criterion		−0.04
Sum squared resid	7.28	Schwarz criterion		0.22
Log likelihood	17.66	Hannan-Quinn criter.		0.06
F-statistic	172.85	Durbin-Watson stat		1.92

Table A2. OLS Estimation of Policy Rule: Real-Time Data

Variable	Coefficient	Std. Error	t-Stat	Prob.
r_{t-1}	1.02	0.08	11.96	0.00
r_{t-2}	-0.14	0.08	-1.71	0.08
$y_{t\|t}$	-0.12	0.07	-1.66	0.09
$y_{t\|t-1}$	0.24	0.15	1.62	0.10
$y_{t\|t-2}$	-0.12	0.07	-1.58	0.11
$p_{t\|t}$	0.17	0.10	1.66	0.09
$p_{t\|t-1}$	-0.33	0.20	-1.62	0.10
$p_{t\|t-2}$	0.16	0.10	1.57	0.11
pc_t	0.03	0.01	2.58	0.01
pc_{t-1}	0.01	0.01	0.80	0.42
pc_{t-2}	0.00	0.01	-0.28	0.77
$m_{t\|t-1}$	0.00	0.00	1.19	0.23
$m_{t\|t-2}$	0.00	0.00	-0.93	0.34
c	-1.12	1.22	-0.91	0.36

R-squared	0.93	Mean dependent var	1.57
Adjusted R-squared	0.92	S.D. dependent var	0.89
S.E. of regression	0.24	Akaike info criterion	0.10
Sum squared resid	8.31	Schwarz criterion	0.37
Log likelihood	6.20	Hannan-Quinn criter.	0.21
F-statistic	147.14	Durbin-Watson stat	1.87

Appendix B: The Impact of Real-Time Policy Shocks on Output

To compute the impact of final and real-time policy shocks on output growth, I run the following baseline regression:

$$\Delta y_t = \alpha_1 \Delta y_{t-1} + \alpha_2 \Delta y_{t-2} + \beta_1 m_{t-1} + \beta_2 m_{t-2} + c \tag{1}$$

Consistent with the baseline policy rule, I include two lags of output growth and two lags of policy shocks. Given the recursiveness assumption, the contemporaneous values of the shock series are not included in the equation. The results for real-time and final data based policy shocks are presented in Table B1 and Table B2, respectively.

Table B1: Effects of Real-Time Policy Shocks

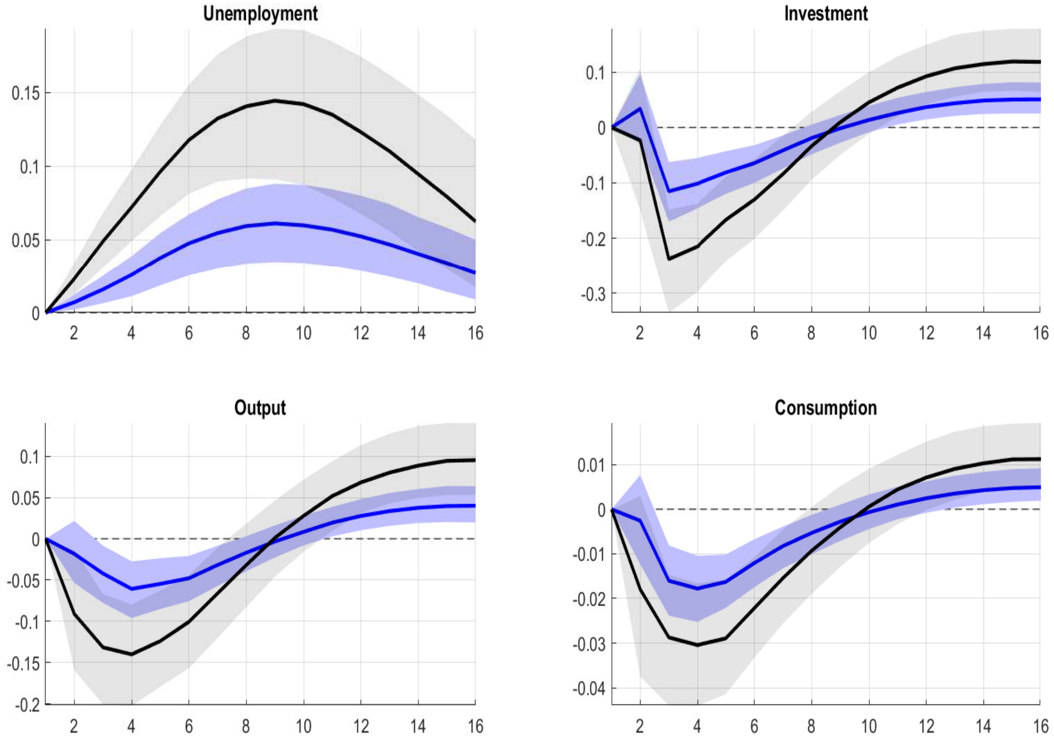
Variable	Coefficient	Std. Error	t-Stat	Prob.
Δy_{t-1}	0.32	0.07	4.19	0.00
Δy_{t-1}	0.16	0.07	2.18	0.03
$m_{t\|t-1}$	0.02	0.26	0.10	0.91
$m_{t\|t-2}$	-1.22	0.26	-4.58	0.00
c	0.37	0.08	4.24	0.00
R-squared	0.25	Mean dependent var		0.74
Adjusted R-squared	0.23	S.D. dependent var		0.86
S.E. of regression	0.75	Akaike info criterion		2.31
Sum squared resid	85.05	Schwarz criterion		2.41
Log likelihood	-172.17	Hannan-Quinn criter.		2.35
F-statistic	12.74	Durbin-Watson stat		1.94

Table B2: Effects of Final-Data Policy Shocks

Variable	Coefficient	Std. Error	t-Stat	Prob.
Δy_{t-1}	0.32	0.07	4.21	0.00
Δy_{t-2}	0.12	0.07	1.62	0.10
m_{t-1}	−0.06	0.28	−0.22	0.82
m_{t-2}	−1.35	0.28	−4.77	0.00
c	0.41	0.08	4.73	0.00
R-squared	0.26	Mean dependent var		0.74
Adjusted R-squared	0.24	S.D. dependent var		0.86
S.E. of regression	0.75	Akaike info criterion		2.30
Sum squared resid	84.12	Schwarz criterion		2.40
Log likelihood	−171.33	Hannan-Quinn criter.		2.34
F-statistic	13.29	Durbin-Watson stat		1.90

Appendix C: Robustness analysis

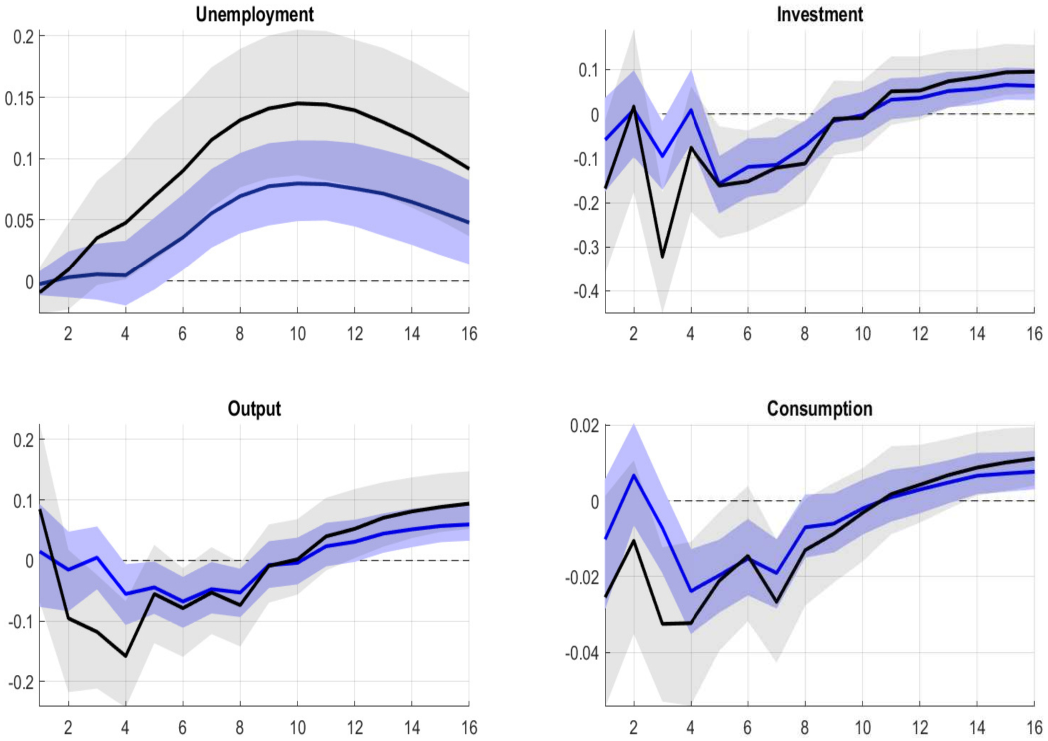
Figure C1. Real-Time versus Final Data Volatility Shocks: Volatility Series Ordered Last



Notes: The black lines present the impact of final-data policy volatility shock. The blue lines show the impact of real-time policy volatility shock. The confidence intervals are bootstrapped, symmetric 68 percent bands.

The volatility series are ordered last in the VAR estimation.

Figure C2. Real-Time versus Final Data Volatility Shocks: Four Lags of Endogenous Variables



Notes: The black lines present the impact of final-data policy volatility shock. The blue lines show the impact of real-time policy volatility shock. The confidence intervals are bootstrapped, symmetric 68 percent bands.

The model includes four lags of endogenous variables.