

THE IMPACT OF FED MONETARY POLICY SHOCKS ON INFLATION AND ECONOMIC ACTIVITY: A VECTOR AUTOREGRESSION APPROACH

Jasurbek Nizomov

ORCID: 0009-0003-9533-1944

Diplomat University

Tashkent, Uzbekistan

jasurbejnizomov@gmail.com

Abstract

The article estimates how an unexpected change in the federal funds rate of the Federal Reserve System (Fed) affects industrial production, unemployment and consumer prices. The analysis is based on monthly US data from January 1990 to April 2026 and uses a five-variable vector autoregression (VAR) model with recursive (Cholesky) identification; the results were checked against the 1990–2007 sub-sample, an alternative price measure, the number of lags and the ordering of the variables. After a one-standard-deviation rate shock (approximately 0.12 percentage points), industrial production rose by 0.33% after about 9 months, unemployment fell by 0.17 percentage points, and consumer prices rose by 0.14% over 48 months; that is, in the simple recursive model the theoretically expected signs were not observed for output and prices. The response of unemployment was about 2.6 times smaller in the sub-sample. It is concluded that the results are sensitive to the sample period and the identification specification, and that drawing policy conclusions from such models therefore requires strengthening identification.

Keywords: monetary policy; federal funds rate; Federal Reserve System; vector autoregression; impulse response functions; inflation; price puzzle; transmission mechanism.

1. Introduction

Monetary policy is one of the central topics of modern macroeconomics, and the decisions of the US Federal Reserve System (Fed) significantly affect not only the national economy but also global financial markets. By law the Fed has a dual mandate: to achieve maximum employment and to ensure price stability. The main operational indicator of policy is the federal funds rate, whose target range is set by the Federal Open Market Committee. After the 2008 financial crisis this rate was lowered to a level close to zero (from December 2008 to December 2015, and then from March 2020 to March 2022), and from 2022 it was raised sharply over a short period in order to combat inflation. Such differing regimes make topical the question of whether the effects of rate changes on the real economy and on prices are stable.

Vector autoregression (VAR) models are the main tool for the empirical estimation of the effects of monetary policy. Sims (1980) proposed this approach as a way of studying the dynamic relationships among macroeconomic variables without imposing rigid theoretical restrictions in advance. Bernanke and Blinder (1992) showed that the federal funds rate is an information-rich indicator of Fed policy. Christiano, Eichenbaum and Evans (1999), summarising studies based on recursive identification, reported that an unexpected rise in the rate lowers output and employment, while prices respond only slowly at first. At the same time, many models show a paradoxical rise in prices after a monetary tightening (the “price puzzle”); Sims (1992) linked this to the Fed responding to information about future inflation, and including commodity prices in the model may reduce this problem.

Identification methods have also developed. Romer and Romer (2004) proposed a “narrative” measure of shocks based on Fed documents, Bernanke, Boivin and Elias (2005) developed the FAVAR model, which accounts for a large volume of information through factors, and Gertler and Karadi (2015) used high-frequency market data. Because the rate does not change during the zero lower bound period, Wu and Xia (2016) applied the “shadow rate” approach. The Taylor (1993) rule serves as a benchmark for describing

the systematic reaction of the rate to inflation and the output gap. Coibion (2012) showed that different identification methods and sample periods have a significant effect on the results.

The studies above show that the effects of policy shocks are sensitive to the estimation method and the chosen period. For this reason, this article applies a uniform, transparent and easily replicable VAR specification using open data (FRED), and compares the results in the full sample from 1990 with those in the sub-sample up to the zero-rate period (ending in December 2007).

The aim of the study is to quantify the effects of Fed monetary policy shocks (unexpected changes in the federal funds rate) on inflation, unemployment and industrial production, and to determine the sensitivity of these effects to the sample period.

To achieve this aim, the following tasks were set: (1) to test the stationarity properties of the variables and select the optimal lag length of the VAR model; (2) to estimate impulse response functions under recursive (Cholesky) identification; (3) to determine the share of policy shocks by means of variance decomposition and Granger causality tests; (4) to compare the results with the 1990–2007 sub-sample and assess their robustness.

Research hypotheses: H1 — an unexpected rise in the federal funds rate reduces industrial production and raises unemployment, with the effect appearing after a lag of several months; H2 — the response of consumer prices is initially weak and turns negative with a lag; H3 — the magnitude of the effect differs significantly between the sub-sample up to 2007 and the full sample.

2. Methods

2.1. Data

The analysis is based on monthly US macroeconomic data; the data source is the FRED database of the Federal Reserve Bank of St. Louis (Table 1). The sample covers 436 months from January 1990 to April 2026; with $p = 4$ lags taken into account, 432 observations were used in estimation. Industrial production and price indices enter as 100

times the natural logarithm, while interest rates and unemployment enter in levels. Because the consumer price index and unemployment rate values for October 2025 were not available in the database, this single month was filled by linear interpolation for those two series. The commodity price series was not included in the analysis (see the limitations in the Discussion section). The personal consumption expenditures price index (PCEPI) was used only in the robustness check.

Table 1. Variables used in the model

Symbol	FRED code	Indicator	Transformation
IP	INDPRO	Industrial production index	$100 \times \ln$
UN	UNRATE	Unemployment rate (%)	Level
CPI	CPIAUCSL	Consumer price index (all urban consumers)	$100 \times \ln$
FFR	FEDFUNDS	Effective federal funds rate (monthly average, %)	Level
GS10	GS10	10-year US Treasury yield (%)	Level
PCE	PCEPI	Personal consumption expenditures price index (for robustness)	$100 \times \ln$

Source: FRED (Federal Reserve Bank of St. Louis).

2.2. Model specification

The analysis uses a VAR model of order p :

$$Y_t = c + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + u_t$$

where $Y_t = (IP, UN, CPI, FFR, GS10)'$ is the vector of five variables and u_t is the vector of residuals. The model is estimated in levels, because, as shown by Sims, Stock

and Watson (1990), a VAR in levels preserves the consistency of inference even in the presence of unit roots; a general description of VAR models is given in Stock and Watson (2001). The lag length is chosen from a range of up to 12 months according to the Akaike (AIC), Schwarz (BIC) and Hannan–Quinn criteria; for the baseline specification, the number of lags required by AIC is used. Stationarity is assessed with the augmented Dickey–Fuller (ADF) test, the stability of the model through the moduli of the roots of the characteristic polynomial, and residual autocorrelation with the Portmanteau test.

2.3. Identification

The policy shock is isolated by the recursive (Cholesky) approach, with the variables ordered as follows: industrial production, unemployment, consumer prices, the federal funds rate and the 10-year yield. This ordering follows the tradition of Christiano et al. (1999) and embodies the assumption that real activity and consumer prices do not respond to the policy shock within the current month, whereas the rate responds to information about them; the long-term yield, as a market variable, is placed after the rate. The size of the shock equals one standard deviation of the residual in the federal funds rate equation. Impulse response functions are computed over a 48-month horizon; confidence intervals are constructed by the residual bootstrap with 2,000 replications and are shown at the 68% and 90% levels, with the mean bias of the bootstrap distribution corrected.

2.4. Robustness checks

To assess the reliability of the results, the following checks were carried out: (a) re-estimating the model on the sub-sample from January 1990 to December 2007; (b) changing the ordering of the variables (consumer prices first); (c) using the personal consumption expenditures price index (PCEPI) instead of the consumer price index; (d) changing the number of lags to 2, as required by BIC, and to 12. The calculations were performed in Python using the statsmodels and numpy libraries.

3. Results

3.1. Preliminary tests

Table 2 presents the ADF test results. For the federal funds rate, the unit-root hypothesis in levels was rejected at the 5% level ($p = 0.012$), while for the other variables it was not rejected; the first differences of all variables were stationary. The lag length was determined to be 4 by AIC, 3 by Hannan–Quinn and 2 by BIC, so the baseline model was estimated with $p = 4$. The largest modulus of the characteristic roots was 1.003. The Portmanteau test at $p = 4$ rejected the hypothesis of no residual autocorrelation ($p = 0.003$).

Table 2. ADF test results: *t*-statistic (*p*-value)

Variable	Level	First difference
IP (constant and trend)	−1.56 (0.809)	−15.35 (<0.001)
UN (constant)	−2.71 (0.073)	−12.28 (<0.001)
CPI (constant and trend)	−1.71 (0.745)	−3.96 (0.002)
FFR (constant)	−3.37 (0.012)	−4.53 (<0.001)
GS10 (constant)	−2.49 (0.117)	−10.97 (<0.001)
PCE (constant and trend)	−1.42 (0.854)	−3.47 (0.009)

Lag length selected by AIC.

3.2. Impulse response functions

Figure 1 shows the responses of the variables to a federal funds rate shock over 48 months, and Table 3 gives the values at selected horizons. A one-standard-deviation shock (approximately 0.12 percentage points in the current month) turned into a persistent rise in the rate itself that reaches 0.30 percentage points in month 9 and declines to 0.05 percentage points by month 48. Industrial production rose after the shock: the peak value was 0.33% in month 9 (68% interval: 0.22–0.44), and by month 48 the effect had

approached zero (0.01%). Unemployment fell by 0.17 percentage points in month 1 (68% interval: $-0.20 \dots -0.15$), remained at -0.17 in month 12, and returned to -0.02 percentage points by month 48. The consumer price index rose progressively: 0.08% in month 12, 0.11% in month 24 and 0.14% in month 48 (68% interval: 0.05–0.22); this response differed from zero at the 68% level, whereas the 90% interval at month 48 did not differ from zero. The 10-year yield reached 0.075 percentage points in month 19.

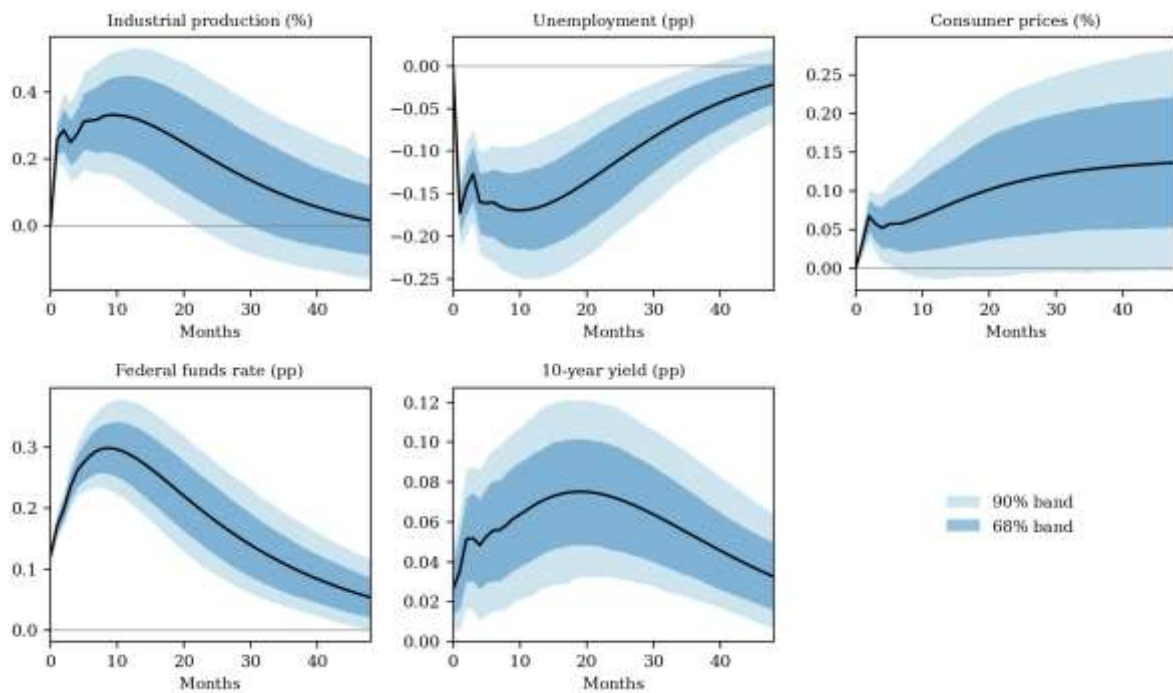


Figure 1. Impulse responses to a federal funds rate shock, 1990–2026 ($p = 4$)

Table 3. Impulse responses (value and 68% confidence interval)

Indicator	Sample	Month 6	Month 12	Month 24	Month 48
Industrial production	1990–2026	0.32 [0.22; 0.41]	0.32 [0.20; 0.45]	0.20 [0.05; 0.35]	0.01 [–0.09; 0.12]

Indicator	Sample	Month 6	Month 12	Month 24	Month 48
Industrial production	1990–2007	0.11 [0.03; 0.20]	0.09 [–0.03; 0.21]	0.01 [–0.12; 0.14]	–0.13 [–0.20; –0.05]
Unemployment	1990–2026	–0.16 [–0.20; –0.12]	–0.17 [–0.22; –0.12]	–0.11 [–0.16; –0.07]	–0.02 [–0.04; 0.00]
Unemployment	1990–2007	–0.06 [–0.08; –0.04]	–0.06 [–0.09; –0.04]	–0.03 [–0.06; 0.00]	0.03 [0.02; 0.05]
Consumer prices	1990–2026	0.06 [0.02; 0.09]	0.08 [0.03; 0.13]	0.11 [0.04; 0.19]	0.14 [0.05; 0.22]
Consumer prices	1990–2007	0.08 [0.04; 0.11]	0.10 [0.05; 0.15]	0.12 [0.06; 0.17]	0.13 [0.08; 0.19]

Units: percent for IP and CPI, percentage points for UN; the shock is one standard deviation of the federal funds rate residual.

3.3. Sub-sample (1990–2007)

Figure 2 compares the results for the full sample and the sub-sample. In the 1990–2007 sample the response of unemployment was much smaller: –0.06 percentage points in month 12 (–0.17 in the full sample); by month 48 the sign changed, reaching +0.03. The response of industrial production was 0.09% in month 12 (the 68% interval included zero) and shifted to –0.13% (68% interval: –0.20...–0.05) by month 48. The consumer price response had the same direction and a similar magnitude in both samples (0.13% in the sub-sample and 0.14% in the full sample at month 48).

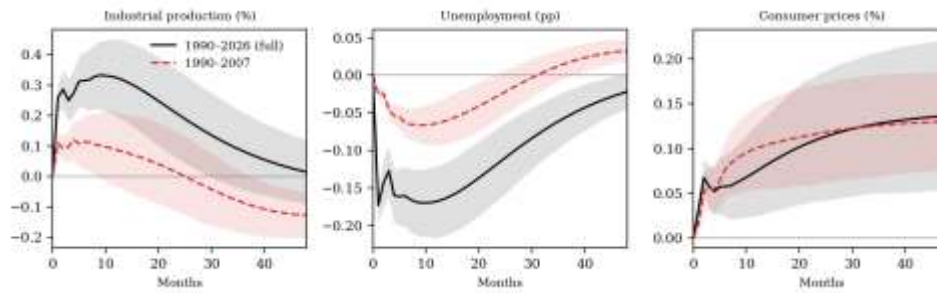


Figure 2. Responses in the full (1990–2026) and sub-sample (1990–2007), with 68% interval

3.4. Variance decomposition and causality

Table 4 presents the share of forecast error variance attributable to the rate shock. Over a 48-month horizon, the federal funds rate shock explained 21.7% of the variance of unemployment, 20.3% of the variance of the 10-year yield, 6.3% of the variance of consumer prices and 8.4% of the variance of industrial production. In the Granger causality tests, the rate Granger-caused industrial production ($F = 8.55$; $p < 0.001$), unemployment ($F = 13.64$; $p < 0.001$) and consumer prices ($F = 3.82$; $p = 0.004$), but not the 10-year yield ($F = 1.21$; $p = 0.31$). In the reverse direction, industrial production ($F = 4.46$; $p = 0.001$), unemployment ($F = 5.57$; $p < 0.001$), consumer prices ($F = 2.65$; $p = 0.032$) and the 10-year yield ($F = 10.17$; $p < 0.001$) Granger-caused the rate.

Table 4. Share of forecast error variance attributable to the rate shock (%)

Indicator	12 months	24 months	48 months
Industrial production	9.7	10.5	8.4
Unemployment	15.7	21.0	21.7
Consumer prices	2.3	3.9	6.3
Federal funds rate	68.4	64.7	59.1
10-year yield	7.4	15.1	20.3

Full sample, $p = 4$.

3.5. Robustness checks

When PCEPI was used instead of the consumer price index, the responses of production (+0.33% in month 9) and unemployment (−0.17 percentage points in month 1) were almost unchanged, while the price response was smaller, at +0.08% in month 48 (68% interval: 0.03–0.17). With 2 lags, production responded by +0.49% in month 5, unemployment by −0.26 percentage points in month 5 and prices by +0.17% in month 48; with 12 lags the corresponding responses were +0.27% (month 11), −0.18 percentage points (month 1) and +0.13% (month 29). When the ordering of the variables was changed (consumer prices first), the results coincided completely. In all variants, the signs of the peak responses were the same as in the baseline results.

4. Discussion

The aim of the study was to estimate the effects of Fed rate shocks on production, unemployment and prices and to determine the sensitivity of these effects to the sample period. The results did not confirm hypotheses H1 and H2, while H3 was confirmed.

H1 was rejected: after an unexpected rise in the rate, production did not fall but rose, and unemployment fell. This contradicts the results summarised by Christiano et al. (1999). H2 was also not confirmed: consumer prices did not fall with a lag but rose progressively over 48 months, which is consistent with the “price puzzle” described by Sims (1992). In our view, such signs indicate that the “shock” isolated by recursive identification is in fact not exogenous: the Fed may have raised the rate in response to information about future activity and inflation that is not contained in the model. The Granger test also supports this, since causality was found in both directions. Nevertheless, this explanation was not separately tested in this study and remains a conjecture.

H3 was confirmed: in the 1990–2007 sample the response of unemployment is about 2.6 times smaller than in the full sample, and the response of production changes sign at long horizons. This is consistent with the conclusion of Coibion (2012) about the sensitivity of results to the sample period and specification. At the same time, the fact that

the signs of the peak responses did not change in the robustness checks shows that the results depend not on model details (the number of lags, the ordering, the price index) but on the identification idea itself. The share of the rate shock in the variance was highest for unemployment and the long-term yield, and remained relatively low for prices and production.

The limitations of the study are as follows. First, because the commodity price series was not available, the standard remedy for mitigating the price puzzle was not applied; the 10-year yield, being placed after the rate, cannot perform this function. Second, about a quarter of the full sample (109 months) falls in zero-lower-bound periods, during which changes in the rate do not fully reflect the policy shock (Wu & Xia, 2016). Third, at $p = 4$ it cannot be claimed that residual autocorrelation is absent, as the Portmanteau test rejected that hypothesis ($p = 0.003$), and the largest characteristic root is slightly greater than 1 (1.003); with 12 lags the signs of the main responses did not change, but this check does not fully resolve the issue either. Fourth, two series were interpolated for October 2025. Fifth, the analysis is based on the monthly average rate.

In practical terms, the results mean that caution is needed when drawing policy conclusions about the effects of rate shocks from a simple recursive VAR, since the results depend on the chosen period. In future research it would be advisable to strengthen identification, for example through the narrative shocks of Romer and Romer (2004), the high-frequency measures of Gertler and Karadi (2015), the FAVAR approach of Bernanke et al. (2005) or the shadow rate of Wu and Xia (2016), and to include commodity prices in the model.

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