Oil Prices, Gasoline Prices and Inflation Expectations

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Motivation

● It is well known that survey data of household inflation expectations may differ systematically from professional inflation forecasts.

● One possible explanation is that households' inflation expectations are more responsive to fluctuations in the price of gasoline than professional inflation forecasts.

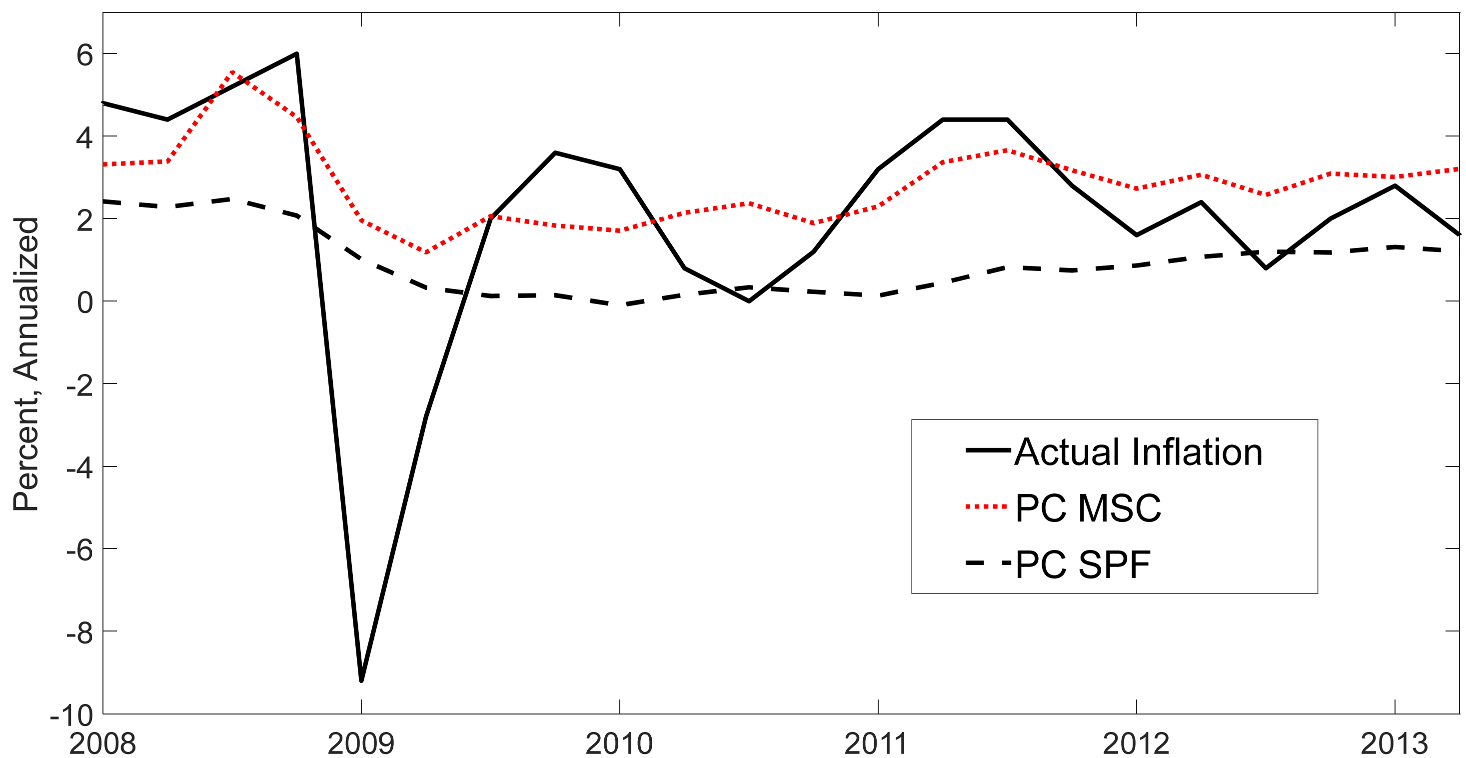
● This may be explained by the fact that gasoline prices are more visible to consumers than any other price.

Coibion and Gorodnichenko (AEJ Macro 2015):
Almost all of the short-run volatility of household inflation expectations, as measured by the Michigan Survey of Consumers, appears explained by changes in the level of the price of oil (and hence in the price of gasoline).

Why Do Macroeconomists Care?

● The conventional Phillips curve $\pi_t = \alpha + \pi_t^{\exp,SPF} + \beta ur_t$ predicts much lower inflation in 2009-13 than observed ("missing disinflation").

● Augmenting the Phillips curve with Michigan survey household inflation expectations such that $\pi_t = \alpha + \pi_t^{\exp,MSC} + \beta ur_t$ ameliorates this problem.



An overview of the regression evidence for the level of the price of oil

Dependent variable: $\pi_t^{\exp} - \pi_t^{\exp,SPF}$	1981Q3-2013Q1	1990Q1-2013Q1	2000Q1-2013Q1	1981Q3-2020Q1	1990Q1-2020Q1
$corr(\pi_t^{\exp} - \pi_t^{\exp,SPF}, O_t)$	77.9%	85.1%	84.6%	78.6%	82.8%
$\hat{\beta}$	**0.024**	0.021	0.022	0.022	0.019
$\hat{t}_\beta$	**12.91**	15.71	10.94	10.83	11.80
R^2	**60.7%**	72.4%	71.6%	61.8%	68.5%
Dependent variable: $\pi_t^{\exp}$	**1981Q3-2013Q1**	**1990Q1-2013Q1**	**2000Q1-2013Q1**	**1981Q3-2020Q1**	**1990Q1-2020Q1**
$corr(\pi_t^{\exp}, O_t)$	11.4%	35.0%	**74.4%**	3.7%	29.3%
$\hat{\beta}$	0.004	0.009	0.021	0.001	0.007
$\hat{t}_\beta$	1.01	2.16	5.38	0.29	1.68
R^2	1.3%	12.3%	55.3%	0.1%	8.6%

NOTES: Estimates based on regressions of $\pi_t^{\exp} - \pi_t^{\exp,SPF}$ and $\pi_t^{\exp}$, respectively, on an intercept and O_t. $\hat{t}_\beta$ is based on Newey-West standard errors with a truncation lag of 8.

1. Oil Price in Levels or in Log-Levels?

● Even though nominal oil and gasoline prices are expressed in dollars and cents, this does not mean that households change their inflation expectations proportionately to price changes in cents.

● Inflation is the percent change in the price level. Thus, what matters for inflation is the percent change in individual prices implied by the observed dollar price.

● This calls for the log specification

$$\pi_t^{\exp} = \alpha + \beta o_t + \varepsilon_t, \qquad (1')$$

where $o_t = \log(O_t)$.

Estimates of equations (1) and ($1'$), 1990.1-2020.4

	Level of oil price	Log-level of oil price
Correlation with $\pi_t^{\exp}$	29.4%	20.2%
R^2	8.6%	4.1%
$\hat{\beta}$	0.008	0.242
$t_{\hat{\beta}}$	1.83	1.25

NOTES: The standard errors underlying the t-statistics are computed based on Newey-West standard errors using the data-based estimator of the truncation lag proposed by Andrews (1991).

2. Is the Oil Price a Good Proxy for the Gasoline Price?

● The conventional argument is that households are likely to pay particular attention to prices they see more often when formulating their expectations of future inflation.

● This argument does not apply to the price of crude oil. Most consumers would be at a loss when asked about the current price of crude oil.

● To rescue the oil price specification, one has to assume that changes in the oil price are the only source of changes in the gasoline price and that they are being passed on proportionately.

⇨ This hypothesis is testable by repeating the exercise with U.S. gasoline prices.

Estimates of equations (1) and (1′), 1990.1-2020.4

	Level of oil price	Level of gasoline price	Log-level of oil price	Log-level of gasoline price
Correlation with $\pi_t^{\exp}$	29.4%	22.1%	20.2%	14.6%
R^2	8.6%	4.9%	4.1%	2.1%
$\hat{\beta}$	0.008	0.190	0.242	0.256
$t_{\hat{\beta}}$	1.83	1.26	1.25	0.81

NOTES: The standard errors underlying the t-statistics are computed based on Newey-West standard errors using the data-based estimator of the truncation lag proposed by Andrews (1991).

3. The Regression is Unbalanced

● The N(0,1) critical values used in the existing literature are not appropriate in this context.

● Inflation expectations are plausibly I(0). When regressing an I(0) variable on an I(1) variable (or a nonlinear transformation of an I(1) variable), the regression is "unbalanced" and the distribution of the $t_{\hat{\beta}}$-statistic may be far from N(0,1).

● This "unbalanced regression problem" is a particular concern when the dependent variable is positively serially correlated, as in the case of household inflation expectations (see Stewart 2011).

● Unbalanced regressions also render correlations and regression coefficients unstable over time.

Data Generating Process under the Null

● Consider a bivariate DGP for $\pi_t^{\exp}$ and o_t that embodies the restriction that $\beta = 0$:

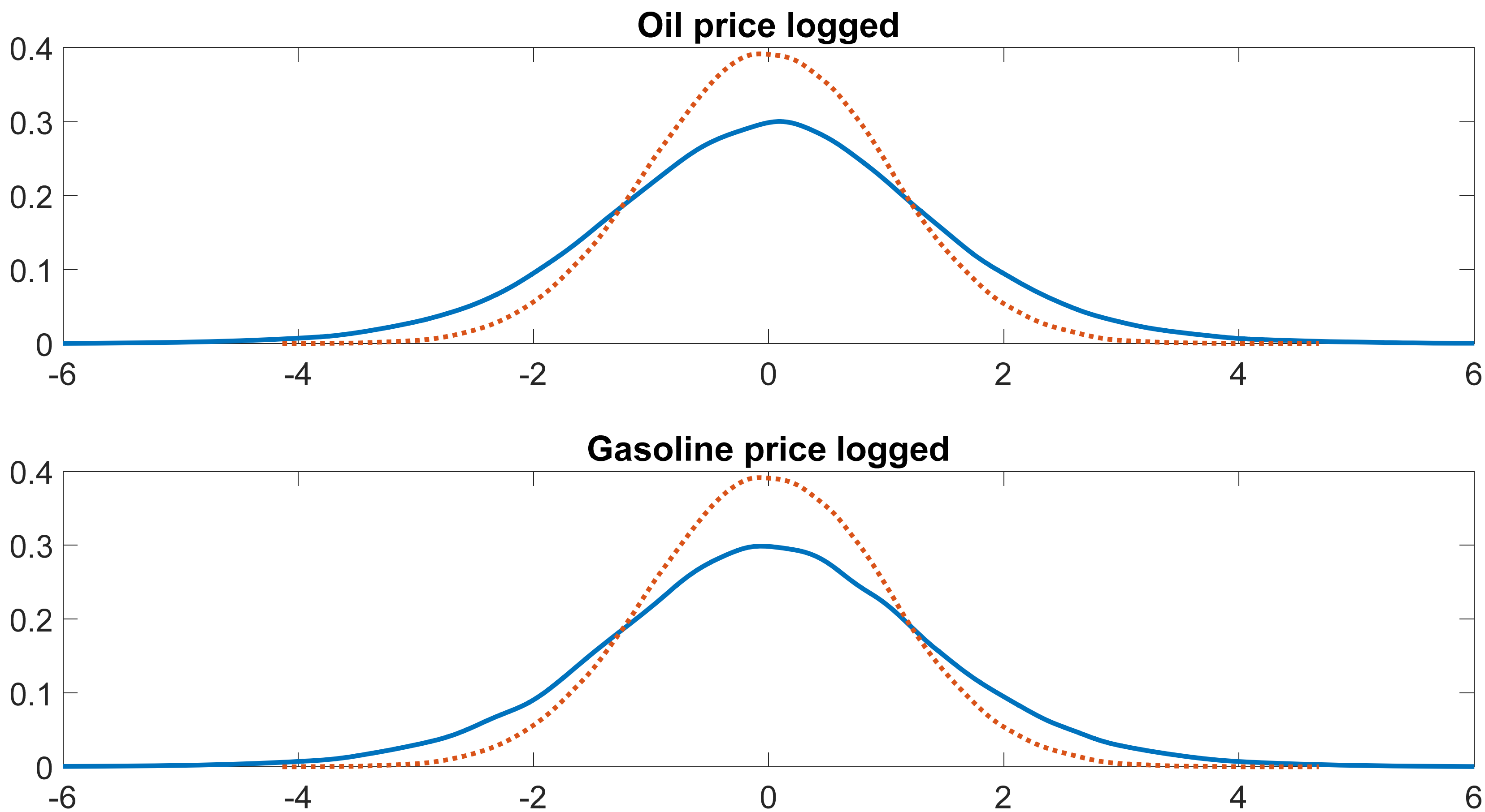
$$\pi_t^{\exp} = \alpha_0 + \alpha_1 \pi_{t-1}^{\exp} + \varepsilon_t^{\exp}, \text{ where } \varepsilon_t^{\exp} \sim N(0, \sigma_{\exp}^2).$$

$$\Delta o_t = \mu_o + \sigma_o \varepsilon_t^o, \text{ where } \varepsilon_t^o \text{ is a standardized Student-}t_4 \text{ innovation and } \Delta o_t \sim I(0).$$

The parameters of this process may be recovered from the data. The errors are independent. The same DGP may also be used to generate realizations of $O_t = \exp(o_t)$.

● Realizations of the price of gasoline may be generated analogously, by replacing the price of oil in the DGP by the price of gasoline and re-calibrating the parameters.

Finite-sample null distributions for the t-test of $H_0 : \beta = 0$



NOTES: All results based on NW(Andrews). Qualitatively similar results are obtained with fixed truncation lags. Based on 100,000 Monte Carlo trials from the data generating process described in the text.

Finite-sample p-values based on equations (1) and (1′), 1990.1-2020.4

Level of oil price	0.102
Log-level of oil price	0.179
Level of gasoline price	0.180
Log-level of gasoline price	0.274

4. An Alternative Regression Specification

Estimates of equation (1′) with Regressor Transformed to Growth Rate, 1990.1-2020.4

	Growth rate of oil price	Growth rate of gasoline price
Correlation with $\pi_t^{\exp}$	14.3%	24.5%
R^2	2.0%	6.0%
$\hat{\beta}$	1.145	3.195
$t_{\hat{\beta}}$	2.246	3.787
p-value	0.012	0.000

NOTES: The standard errors underlying the t-statistics are computed based on Newey-West standard errors using the data-based estimator of the truncation lag proposed by Andrews (1991). The asymptotic distribution is standard.

⇨ Highly significant but small effect

⇨ Gasoline price has more explanatory power, but still small R^2!

Punchline

● Neither static regressions nor reduced-form correlations are the appropriate tool for understanding the empirical relationship between oil and gasoline prices and inflation expectations.

● We instead introduce a structural vector autoregressive (SVAR) model.

● This model accommodates alternative economic interpretations of the behavioral relationship between household inflation expectations and unexpected changes in the nominal price of gasoline.

Advantages of SVAR Compared to Static Regression Analysis

1. The structural VAR model accounts for the endogeneity of the real price of gasoline with respect to domestic inflation variables.
2. It relaxes the dynamic restrictions implicit in static regression models, allowing delayed feedback to inflation expectations.
3. It is robust to various changes in the model specification and identification and the estimates are robust over time.

Structural Model

● Let $y_t = [rpgas_t, \pi_t, \pi_t^{\exp}]'$, where

$rpgas_t$ denotes the log-level of the real gasoline price
π_t is the headline CPI inflation rate
$\pi_t^{\exp}$ is the Michigan Survey of Consumers measure of households' one-year mean inflation expectations.

● We set the lag order to a conservative upper bound of 12 lags (see Kilian and Lütkepohl 2017).

Identification of the Structural Shocks

● A positive nominal gasoline price shock is assumed to raise the real price of gasoline on impact because the CPI responds more slowly than the nominal price of gasoline. It also is assumed to raise household inflation expectations, given the household-level evidence in Binder (2018).

● A positive shock to the core CPI (defined as consumer prices excluding gasoline prices) raises consumer price inflation and inflation expectations, consistent with the evidence in Binder (2018). It lowers the real price of gasoline on impact, given that the nominal gasoline price does not respond within the month to inflation shocks (see Kilian and Vega 2011).

● Idiosyncratic inflation expectations shocks reflect fears of inflationary pressures that are not reflected in current prices. Such shocks leave the real price of gasoline and headline inflation unaffected on impact because expectations shocks that move actual consumer prices are already captured by the gasoline and core CPI shocks.

Estimation and Inference

$$\begin{pmatrix} u_t^{rpgas} \\ u_t^{\pi} \\ u_t^{\pi^{\exp}} \end{pmatrix} = \begin{bmatrix} + & - & 0 \\ + & + & 0 \\ + & + & + \end{bmatrix} \begin{pmatrix} w_t^{\text{nominal gasoline price}} \\ w_t^{\text{core CPI}} \\ w_t^{\text{idiosyncratic inflation expectation}} \end{pmatrix}$$

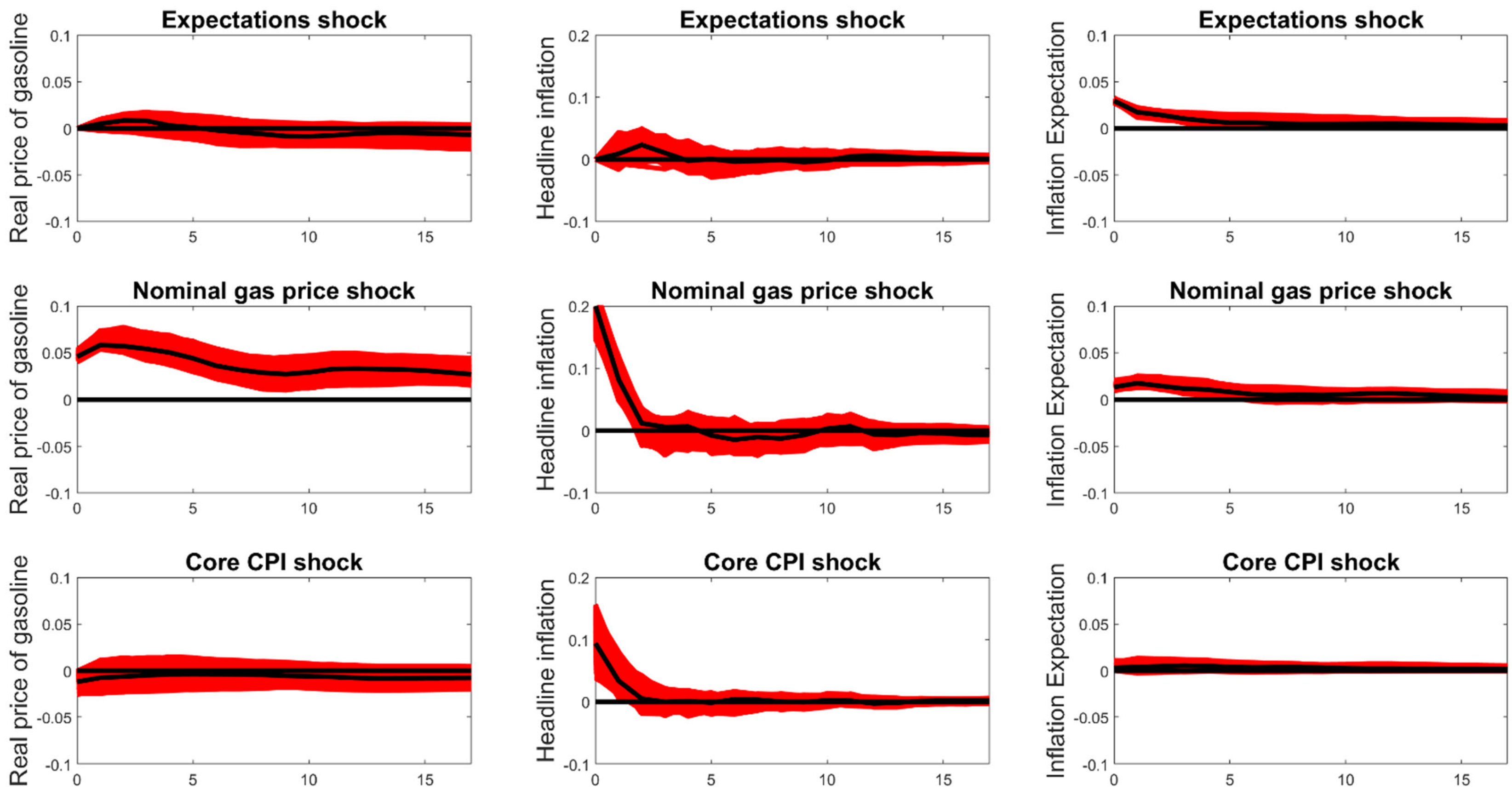
● The model is estimated by Bayesian methods using a uniform-Gaussian-inverse Wishart prior, as described in Arias, Rubio-Ramirez and Waggoner (2018).

● The reduced-form prior is a conventional Minnesota prior with zero mean for the slope parameters.

● This prior is largely uninformative for the vector of structural impulse responses and is not driving our empirical results.

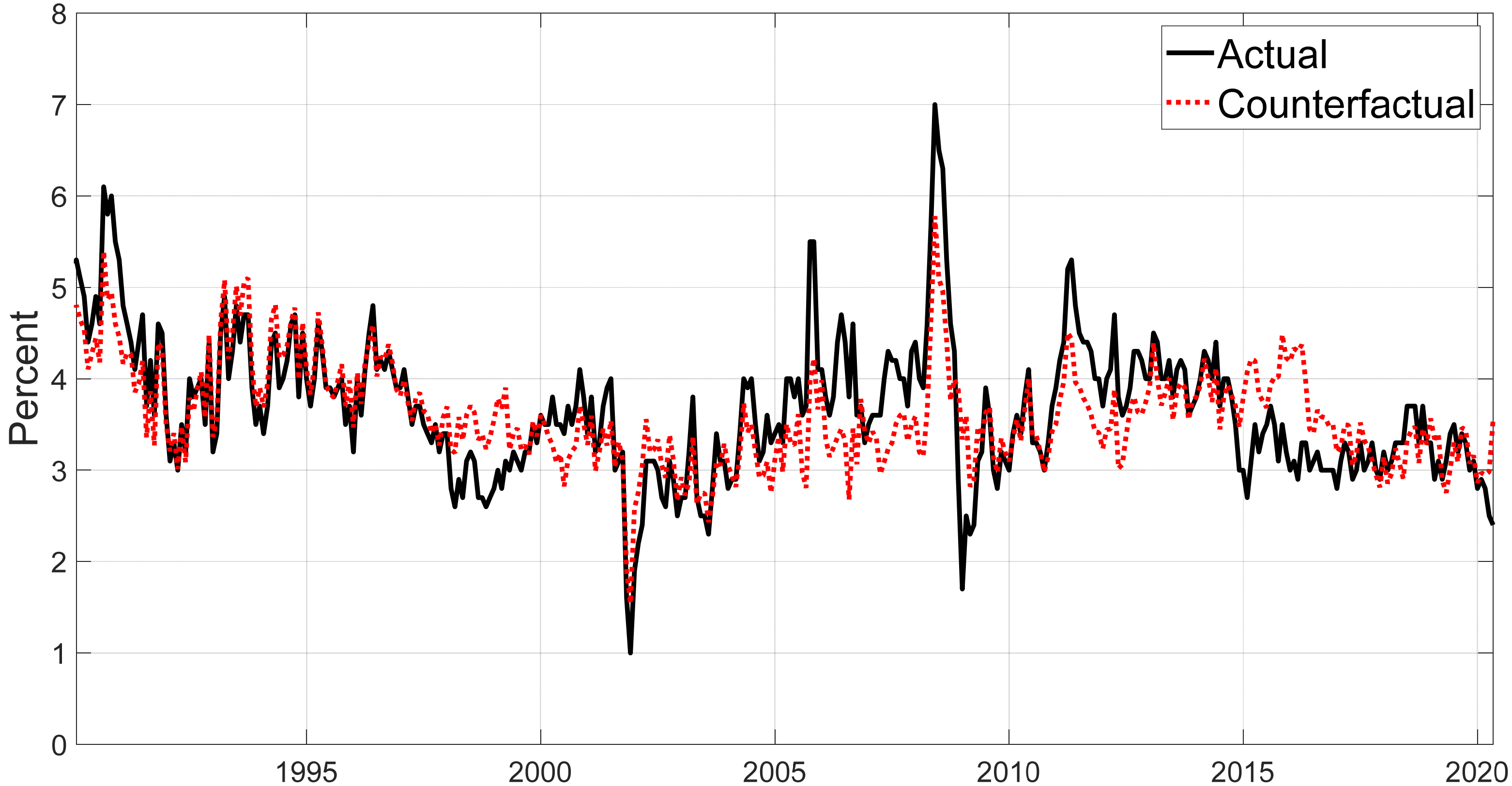
● Having simulated the posterior distribution of the structural impulse responses, we evaluate the joint impulse response distribution under absolute loss, as discussed in Inoue and Kilian (2021).

Impulse response estimates and 68% joint credible sets, 1981.7-2020.4



NOTES: The set of impulse responses shown in black is obtained by minimizing the absolute loss function in expectation over the set of admissible structural models, as discussed in Inoue and Kilian (2020a). The responses in the corresponding joint credible set are shown in a lighter shade.

Actual inflation expectations and counterfactual series in the absence of nominal gasoline price shocks, 1990.1-2020.4



NOTES: The counterfactual time series is obtained by subtracting the cumulative effect of nominal gasoline prices shocks on one-year mean household inflation expectations from the actual data.

The January 2009-March 2013 Episode

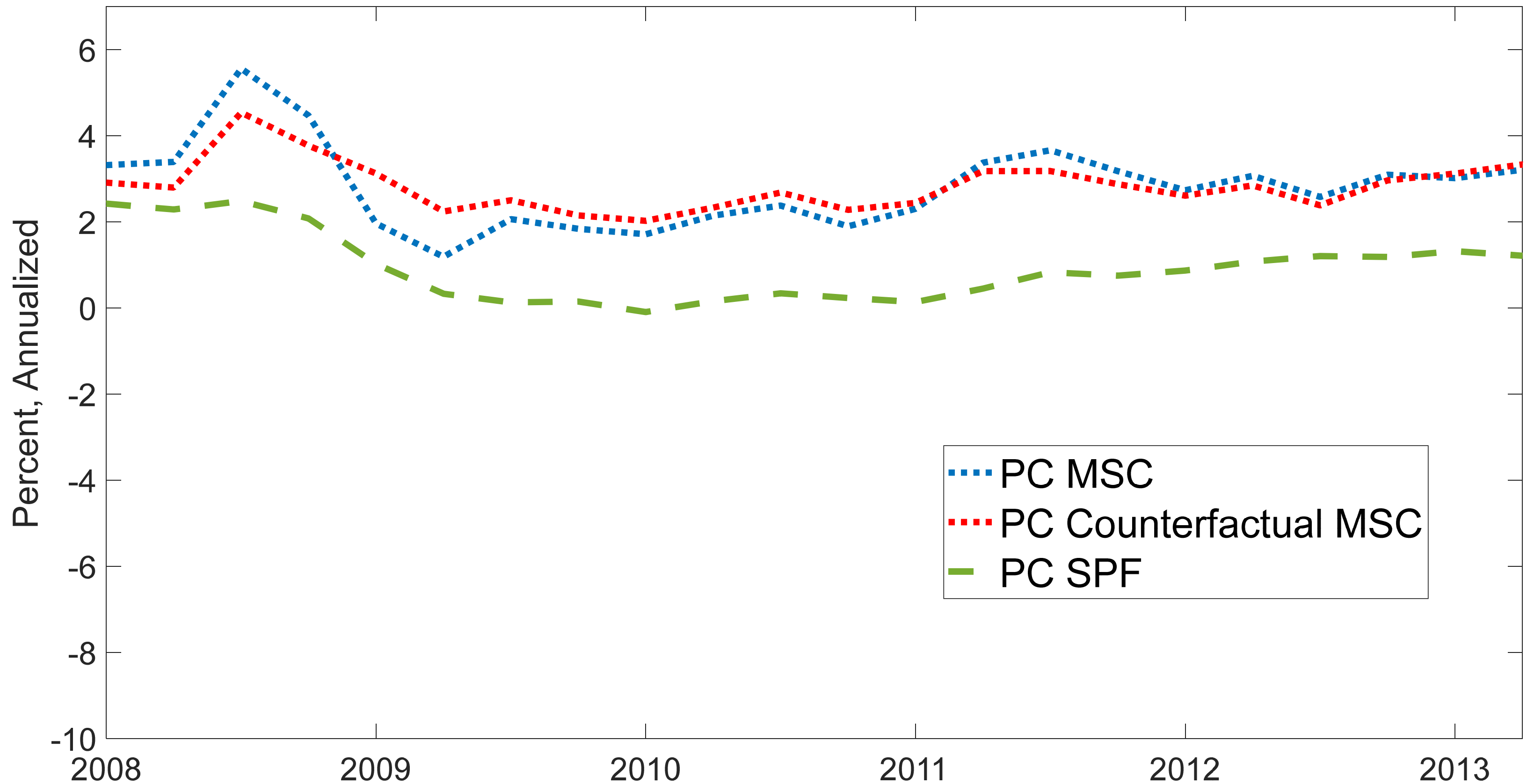
● Over this period, household survey inflation expectations increased by 1.5 percentage points, of which 1.4 percentage points are explained by nominal gasoline price shocks.

Thus, the observed increase in inflation expectations in this period is largely explained by gasoline price shocks.

● However, a variance decomposition based on the estimated model shows that, on average, gasoline price shocks account for only 42% of the variation in one-year household inflation expectations (rather than nearly 100%, as suggested in CG 2015).

● It can be shown that gasoline price shocks tend to capture domestic aggregate demand shocks, which explains their relative importance.

Gasoline Price Shocks Do Not Explain Improved Fit of PC MSC



NOTES: Based on OLS estimates of the expectations-augmented Phillips curve on quarterly data for 1981.III-2007.III. The counterfactual is based on the structural VAR estimate of how inflation expectations would have evolved in the absence of nominal gasoline price shocks.

Rule of Thumb Behavior

● Households are unlikely to disentangle demand and supply shocks using economic models.

● More likely households extrapolate from the experience of the 1970s and 1980s, when demand shocks dominated the evolution of the prices of oil and gasoline.

This rule of thumb behavior is supported by household level survey evidence (Madeira and Zafar 2015; Binder and Makridis 2020).

● The same rule of thumb also worked well during the financial crisis of 2008, for example.

Sensitivity Analysis

- Alternative partially identified structural model:

$$\begin{pmatrix} u_t^{\Delta pgas} \\ u_t^{\pi} \\ u_t^{\pi^{\exp}} \end{pmatrix} = \begin{bmatrix} + & 0 & 0 \\ & & \\ & & \end{bmatrix} \begin{pmatrix} w_t^{\text{nominal gasoline price}} \\ w_t^2 \\ w_t^3 \end{pmatrix}.$$

- Other robustness checks:

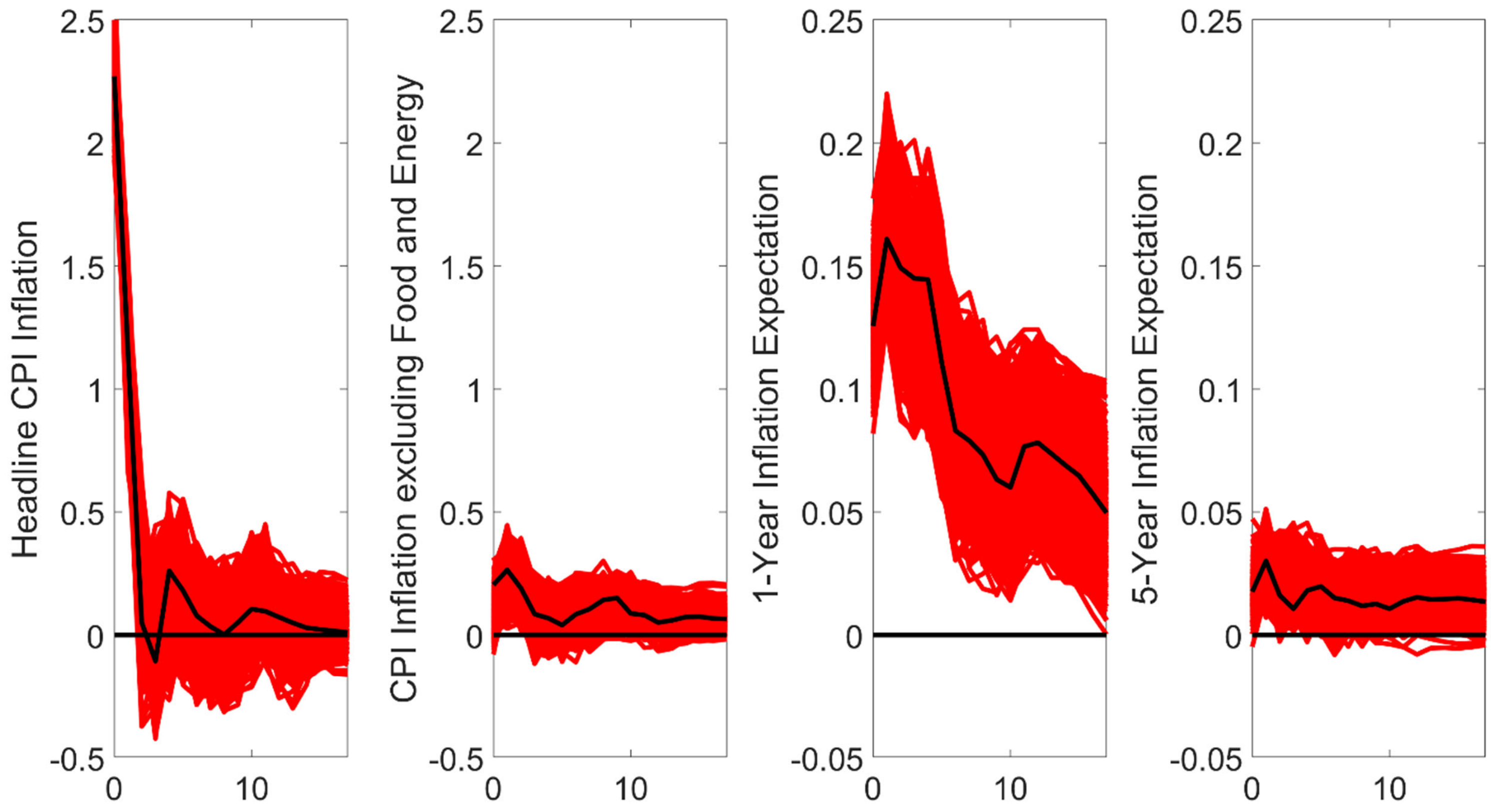
1. Dropping the sign restrictions on inflation expectations in baseline model.
2. Replacing mean by median household inflation expectations.
3. Temporal stability of baseline model (structural break in 1990, time-varying gasoline expenditure share, conditional correlation analysis)
4. Enriching the information set to include measures of economic slack.

- Impulse response estimates differ substantially from those in earlier studies on the link between crude oil prices and inflation expectations such as Wong (2015).

Examining Recent Events Using Extended Model

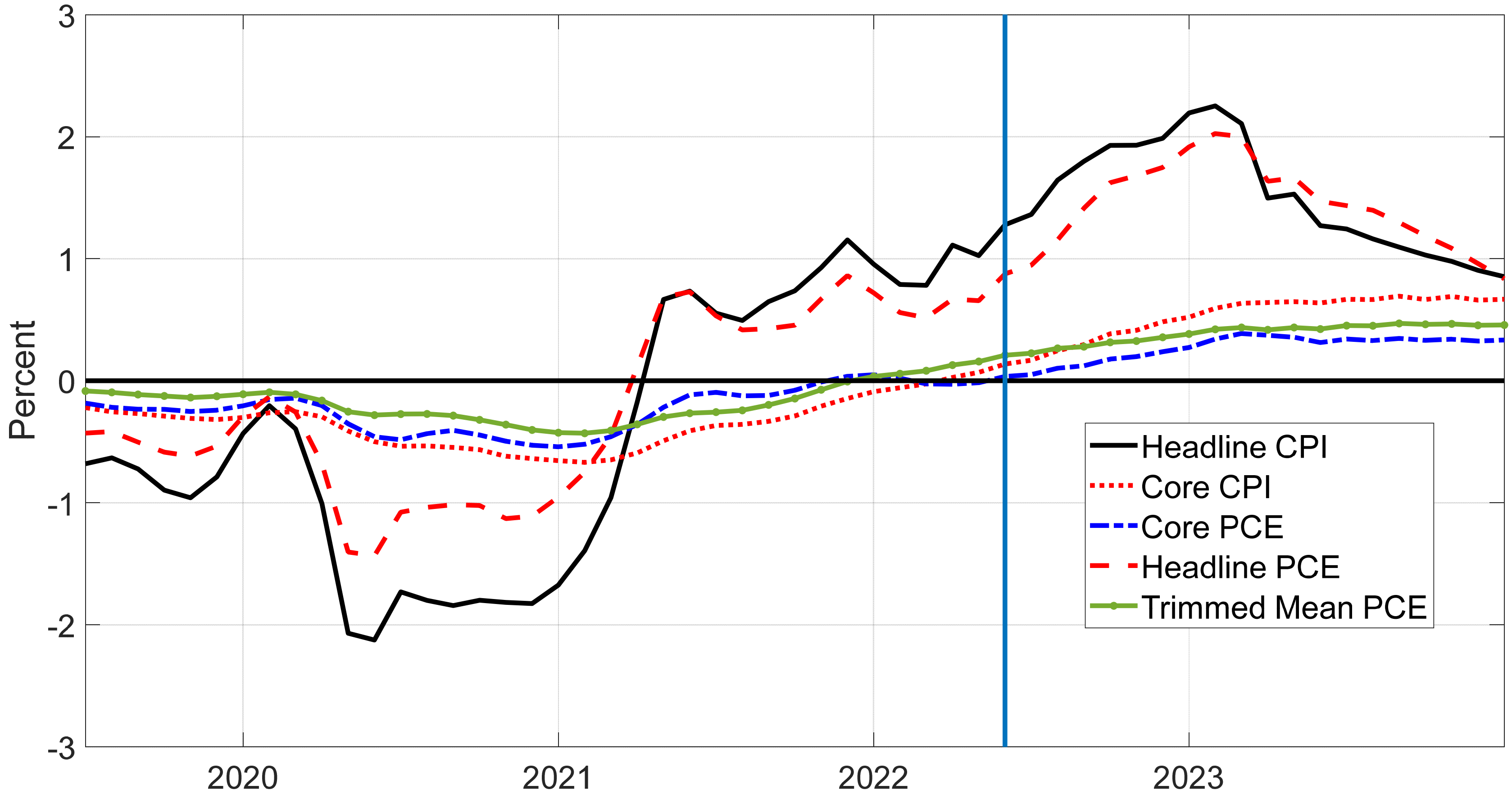
$$\begin{pmatrix} u_t^{\Delta pgas} \\ u_t^{\pi^{CPI}} \\ u_t^{\pi^{CPI,core}} \\ u_t^{\pi^{1-yr\ \exp}} \\ u_t^{\pi^{5-yr\ \exp}} \end{pmatrix} = \begin{bmatrix} + & 0 & 0 & 0 & 0 \\ & & & & \\ & & & & \\ & & & & \\ & & & & \end{bmatrix} \begin{pmatrix} w_t^{\text{nominal gasoline price}} \\ w_t^2 \\ w_t^3 \\ w_t^4 \\ w_t^5 \end{pmatrix}$$

Responses to a One-Time Gasoline Price Shock, 1990.4-2022.5



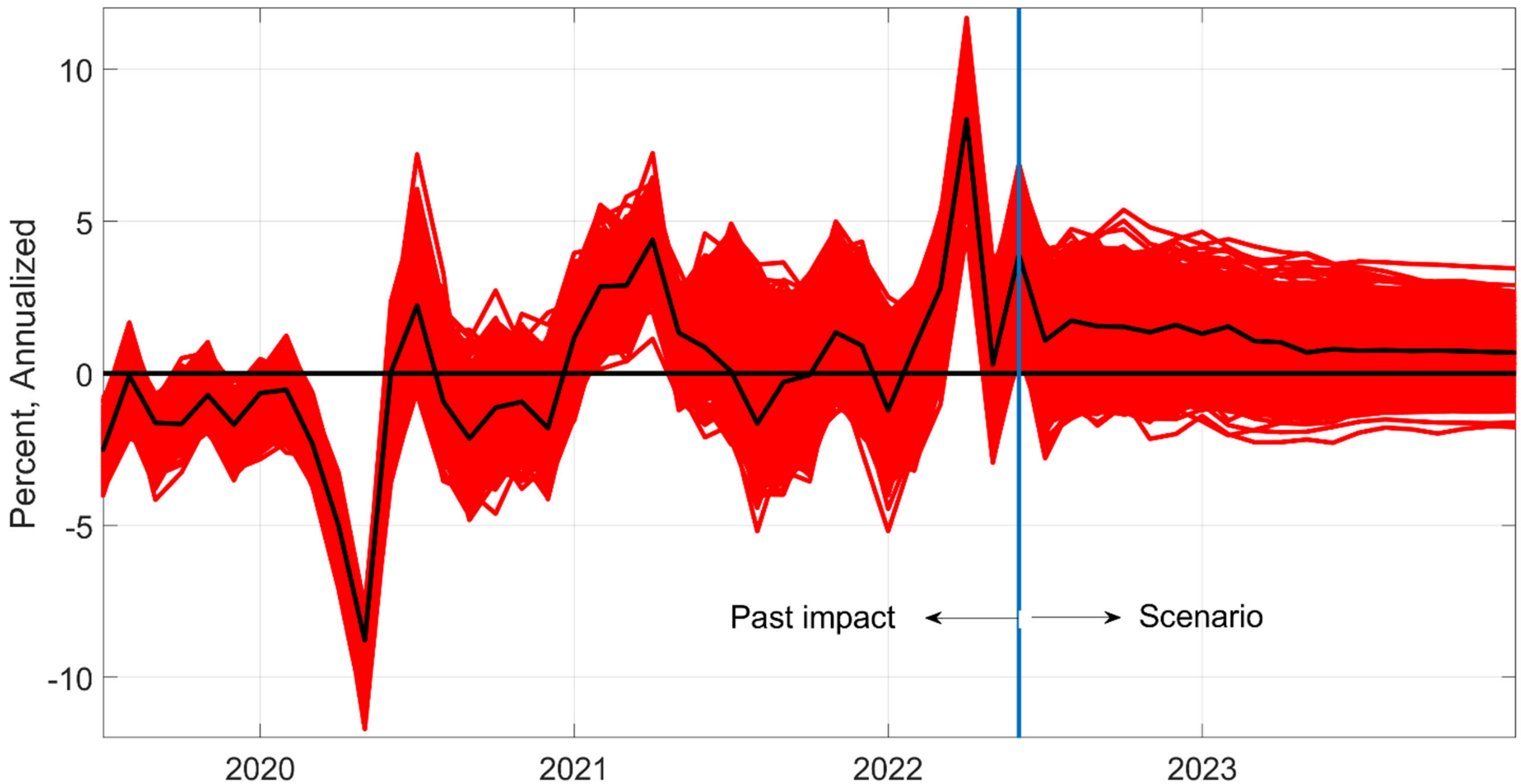
NOTES: The core and headline CPI inflation rates have been annualized. The set of impulse responses shown in black is obtained by minimizing the absolute loss function in expectation over the set of admissible structural models. The responses in the corresponding 68% joint credible set are shown in a lighter shade.

12-Month Inflation Caused by Gasoline Price Shocks, 2019.6-2023.12
$110 Oil Price Scenario Starting in June 2022



NOTES: Vertical line marks May 2022.

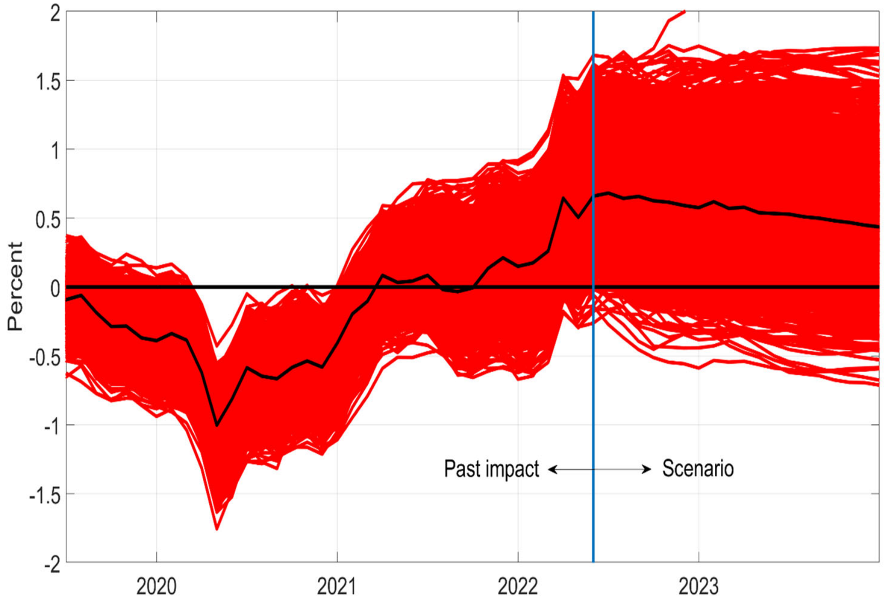
Monthly headline CPI inflation caused by gasoline price shocks, 2019.6-2023.12



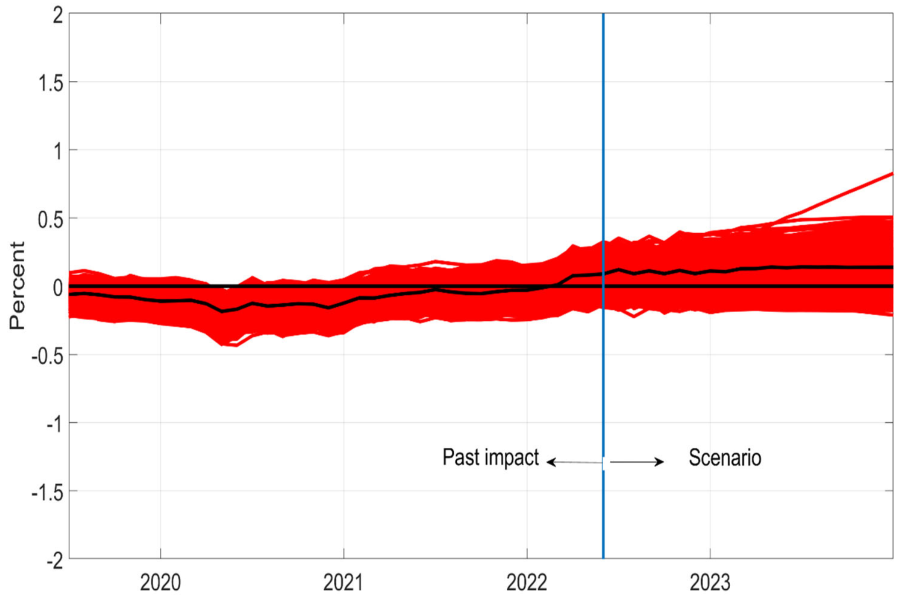
NOTES: The expected path is shown as the black line. The other lines capture the uncertainty about this path based on an approximation to the 68% joint credible set.

The Rise in Inflation Expectations Caused by Gasoline Price Shocks

1-Year Expectations



5-Year Expectations



Conclusions

- Gasoline price shocks have not been the main determinant of U.S. inflation.
- No evidence that gasoline price shocks are causing a wage-price spiral.
- No evidence that gasoline price shocks are causing long-run inflation expectations to become unanchored.
- Inflationary pressures in monthly data wane as soon as positive gasoline price shocks cease.
- Year-over-year rates look more persistent due to temporal aggregation.