Endogenous Uncertainty and the Macroeconomic Impact of Shocks to Inflation Expectations

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The views expressed are those of the authors and do not necessarily reflect those of De Nederlandsche Bank.

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Research Question

What is the macroeconomic impact

of a shock that increases

short-term inflation expectations?

Research Question

1. This question is important

2. Surprisingly, the literature is silent

Why is important

- **Inflation is back!** ...and expectations become more important...
- Exogenous changes in inflation expectation do affect fundamental economic decisions by agents, such as households spending and firm's investment, employment, and pricing decisions (see Coibion et al., 2019-2022)
- Expectations about future inflation are associated with worse expected macroeconomic outcomes. (Coibion et al 2019-2022, D'Acunto et al 2022, Jain et al, 2022)

Large literature on inflation expectations

- This literature concentrates on explaining the survey microdata $\rightarrow$ focus: understanding formation, determinants, and heterogeneity in inflation expectations.
- D'Acunto et al. (2022) survey concludes agents' expectations are biased and volatile in the time series, which suggests that inflation expectations might be subject to shocks
- We take a macroeconomic perspective by assessing the macroeconomic effects of an exogenous change of short-term inflation expectations

Large literature on "news" shocks

- Large literature on 'expectational shocks' in macroeconomics
  $\rightarrow$ where exogenous changes in expectations are assumed to drive economic fluctuations, through belief, sentiment, confidence or news shocks
- *"There is a widespread belief that changes in expectations may be an important independent driver of economic fluctuations."* Beaudry and Portier (2004, Abstract)

Large literature on "news" shocks

A parallel

- Angeletos et al. (2018)
  - Shock to short-run expectations to real variables, reduced-form shock to capture a sentiment shock
  - Their short-run expectational shock different from optimism / pessimism $\rightarrow$ expected long-term TFP increases
  - Similarly, our shock is different from a 'de-anchoring' shock
- Problem: Identification of these expectational shocks: news from sentiment (e.g, Levchenko and Pandalai-Nayar, 2018, Nam and Wang, 2019, Chahrour and Jurado, 2021)
  - Similar challenge: a contribution of the paper is to propose a novel identification mechanism based on endogenous uncertainty

Related literature

- **Expectation Shocks**
  - **Milani (EJ, 2011)**: NK model with *learning* shows that expectation shocks have an important role in the business cycle.
  - **de-anchoring' shock** to long-term inflation expectations, e.g., **Clark and Davig, 2011; Diegel and Nautz, 2021; Neri, 2021** or to the inflation target of the central bank, e.g., **Ireland, 2007; Cogley et al., 2010; Haque, 2019).**
    $\rightarrow$**That's not our shock!**
- **Endogenous Uncertainty**
  - **Ludvigson et al. (AEJMacro, 2021):** Macroeconomic uncertainty plays an important role in recessions, by substantially amplifying downturns caused by other shocks
  - **Mumtaz and Theodoridis (JME, 2020):** Study the dynamic effects of monetary policy shocks on macroeconomic volatility

Our contribution

- We take a macroeconomic perspective by assessing the macroeconomic effects of an exogenous change of short-term inflation expectations.
- **We propose a novel identification mechanism** based on endogenous uncertainty.
- We show that **endogenous uncertainty and firm dynamics** are crucial for the transmission of the shock.

The paper in brief

Using **SVAR** and third-order solution of a rich medium-scale **DSGE model with firm heterogeneity and firm dynamics** to:

- **Empirically**. study the impact of inflation expectations shocks $\rightarrow$ robust to sign restriction (Canova and Paustian 2011), also on uncertainty variables, and narrative sign restriction (Antolin-Diaz and Rubio-Ramirez 2018) identifications
- **Theoretically 1**. study the contribution of endogenous uncertainty in the transmission of inflation expectations shock: IRFs matching estimation (First Order vs Third Order solution of our model)
- **Theoretically 2**. Inspecting the role of firm dynamics (Frictional vs Frictionless Entry model, both solved at the third order)
- **Theoretically 3**. study asymmetry of the effects of the shocks: IRFs matching using IRFs to positive and negative shocks to inflation expectations

Main Results

Contribution of uncertainty is relevant in response to inflation expectation shocks

- An exogenous increase in inflation expectations raises inflation, decreases output but **increases output and inflation uncertainty**
- **Uncertainty matters!** It amplifies recessionary effects of the shock
- Uncertainty is **particularly important in the presence of firm dynamics**
- The effect of the shock are asymmetric: positive shocks -that increase inflation expectations- more important than negative shocks $=>$ **larger effects in recession**

Theoretical Model

Baseline model as in Fasani, Mumtaz, and Rossi (2022).
Four agents: households, firms, a monetary and fiscal authority.
The main ingredients are:

- those of a medium-scale as in Christiano et al. (2005):
  - sticky nominal wages and prices as in Rotemberg (1982);
  - external habits in consumption;
  - convex investments adjustment costs and capacity utilization for capital;
- Firm heterogeneity and endogenous entry/exit dynamics $==>$ Key to micro-found the equity return and get amplification

Theoretical Model

- Inflation Forecast ==> follows the Rational Expectations hypothesis, but this forecast is hit by AR(1) shock.

$$E_t \pi_{t+1} = [\pi^e_{t+1}] e^{\varepsilon_{\pi,t+1}}, \tag{1}$$

with π^e_{t+1} being the rational expectation in t of $t+1$ gross inflation and $\varepsilon_{\pi,t+1}$ being an exogenous process that allows inflation expectations to deviate from their rational expectation solution.

- The exogenous process is an AR(1) with zero mean and a constant standard deviation equal to σ_π:

$$\varepsilon_{\pi,t+1} = \rho_\pi \varepsilon_{\pi,t} + \sigma_\pi u_{\varepsilon,t+1}. \tag{2}$$

Endogenous Uncertainty

As in Basu and Bundick (2017), volatility/measured uncertainty in the model refers to the heteroskedastic response of a variable, say x_t,

$$\tilde{\sigma}_{x,t} = 100 \log \left(\frac{\sigma_{x,t}}{\sigma_x} \right) \tag{3}$$

where

$$\sigma^2_{x,t} = var_t(x_t) = E_t[x_{t+1} - E_t x_{t+1}]^2, \tag{4}$$

with σ_x the stochastic steady-state standard deviation of the variable x_t. With this measure in hands, we build up a measure of:

- **output uncertainty**: volatility of expected real GDP
- **inflation uncertainty**: volatility of expected inflation
- **equity return uncertainty**: volatility of expected return on equity.

DSGE-Montecarlo simulations

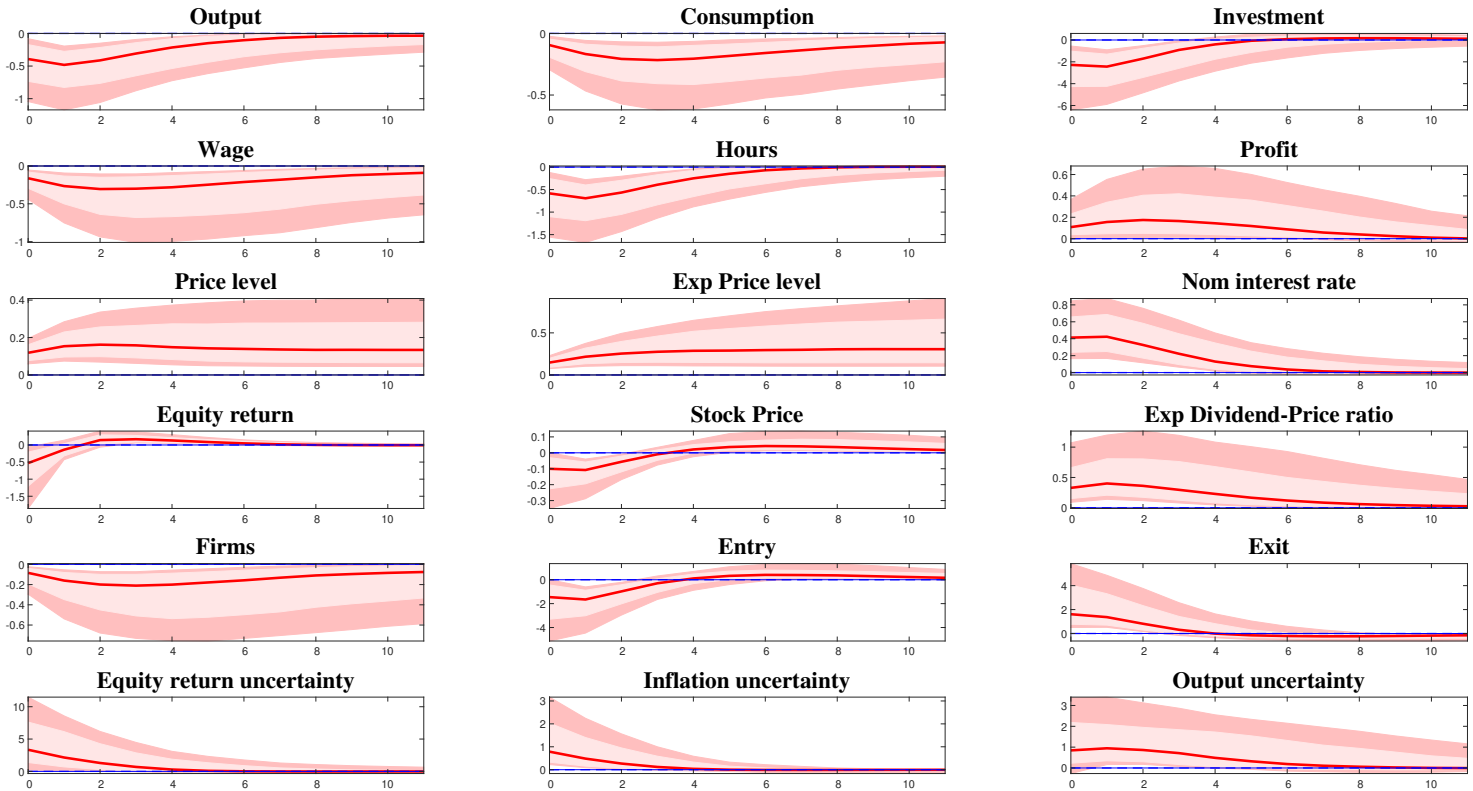


Figure: Dynamic responses to an inflation expectation shock. Montecarlo simulation of the model as in Canova and Paustian (2011).

DSGE-Montecarlo simulations

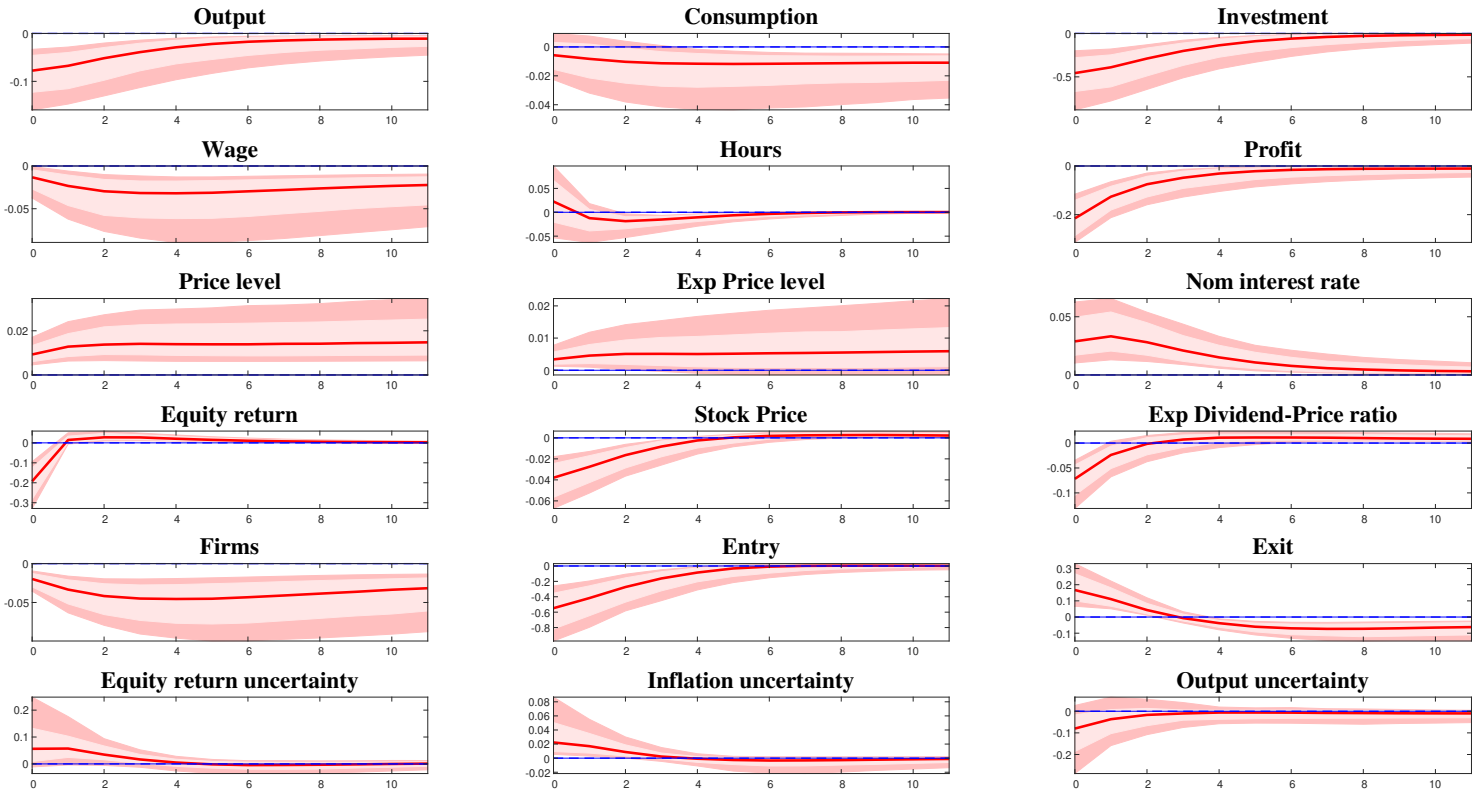


Figure: Dynamic responses to a supply shock. Montecarlo simulation of the model as in Canova and Paustian (2011). simulations to news and ist shock

SVAR Evidence

A VAR with 8 variables + sign restrictions to identify inflation expectation shocks.

$$Y = \begin{bmatrix} \text{log(RGDP)} \\ \text{log(1-q ahead forecast of GDP Deflator)} \\ \text{log(GDP Deflator)} \\ \text{Equity return} \\ \text{Dividend-to-price ratio} \\ \text{log(VXO)} \\ \text{log(1-q ahead forecast Dispersion of RGDP)} \\ \text{log(1-q ahead forecast Dispersion of GDP Deflator)} \end{bmatrix}$$

Sources:

- Forecasts: SPF - Philadelphia FED
- Equity return: Center for Research in Security Prices
- Divident to Price ratio: Shiller (2005)
- RGDP, GDP deflator, VXO: FRED-QD database corr with CPI and PCE

Sign Restrictions

Montecarlo simulations of DSGE model discipline sign restrictions in the SVAR model.

	Expectations Shock	Supply shock
log(real GDP)	$-$	$-$
log(SPF GDPD 1-q ahead forecast)	$+$	/
log(GDPD)	/	$+$
log(Equity returns)	$-$	$-$
Dividend to price ratio	$+$	$-$
log(VXO)	$+$	$+$
log(SPF Dispersion of RGDP forecast)	$+$	$-$
log(SPF Dispersion of GDPD forecast)	$+$	$+$

Table: Sign Restrictions. SPF $\rightarrow$ Survey from Professional Forecasters, GDPD $\rightarrow$ GDP Deflator, RGDP $\rightarrow$ real GDP

Signs are consistent with US data. more on the data

Narrative + Sign Restriction

- **Paul Volcker** was **nominated to fight inflation** and **this was publicly known during the nomination process and thus before Volcker actually took office**. Volcker's speech
- We impose a **Narrative sign restriction** in the spirit of Antolin-Diaz and Rubio-Ramirez (2018).
- **Narrative sign restriction:** Negative Inflation Expectations shock in Q3/1979

SVAR Evidence

VAR-IRFs to supply shock | Structural shocks | VAR with simulated data | More robustness

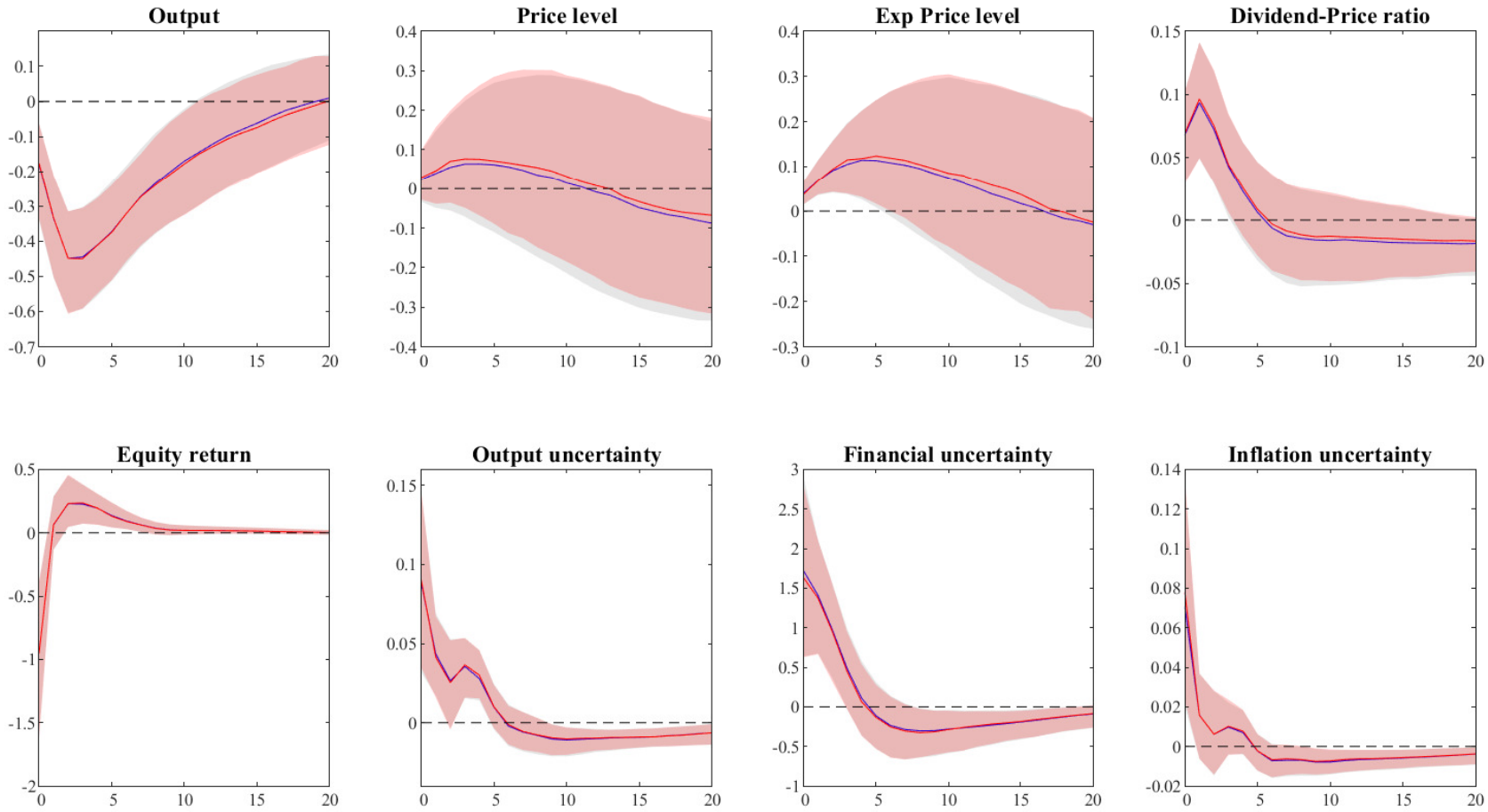


Figure: VAR responses to **inflation expectation shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative

DSGE Estimation

With SVAR-IRFs in hands, we estimate different specifications of our DSGE models to investigate

- **contribution of uncertainty**:third-order (*TO*) vs first-order (*FO*) solution
- **contribution of firm dynamics**: frictional (*TO*) vs frictionless (*TO no firms*) firm entry
- **asymmetric effects in shock transmission**: simulating positive (*TO*) and negative (*TO negative*) shocks to inflation expectations

RE solution of the model is obtained using third-order Taylor series approx. around the deterministic steady state.

Then, IRFs are computed in deviation from the stochastic steady state as in Fernández-Villaverde et al. (2015).

DSGE Estimation: contribution of uncertainty

Estimated Parameters		*TO*	*FO*
"Deep" parameters			
γ_p	Rotemberg Adjust. Cost - Price	18.9	19.1
γ_w	Rotemberg Adjust. Cost - Wage	112.8	42.6
γ_i	Investments Adjustment Cost	5.78	7.28
Shock persistence and Std.			
σ_π	Std. of Inflation Expect. shock	0.0003	0.0006
ρ_π	Persist. Inflation Expect. shock	0.7680	0.5448
Taylor rule			
ϕ_π	Coefficient Inflation	3.96	4.55
ϕ_y	Coefficient Output	0.0450	0.0189
ϕ_{dy}	Coefficient Output growth	0	0.0025
ϕ_R	Interest rate smoothing	0.3890	0.7776
Value Function		44.94	61.45

Table: Parameter Estimates through IRFs matching. FO $\rightarrow$ First Order solution; TO $\rightarrow$ Third Order solution

DSGE Estimation: contribution of uncertainty

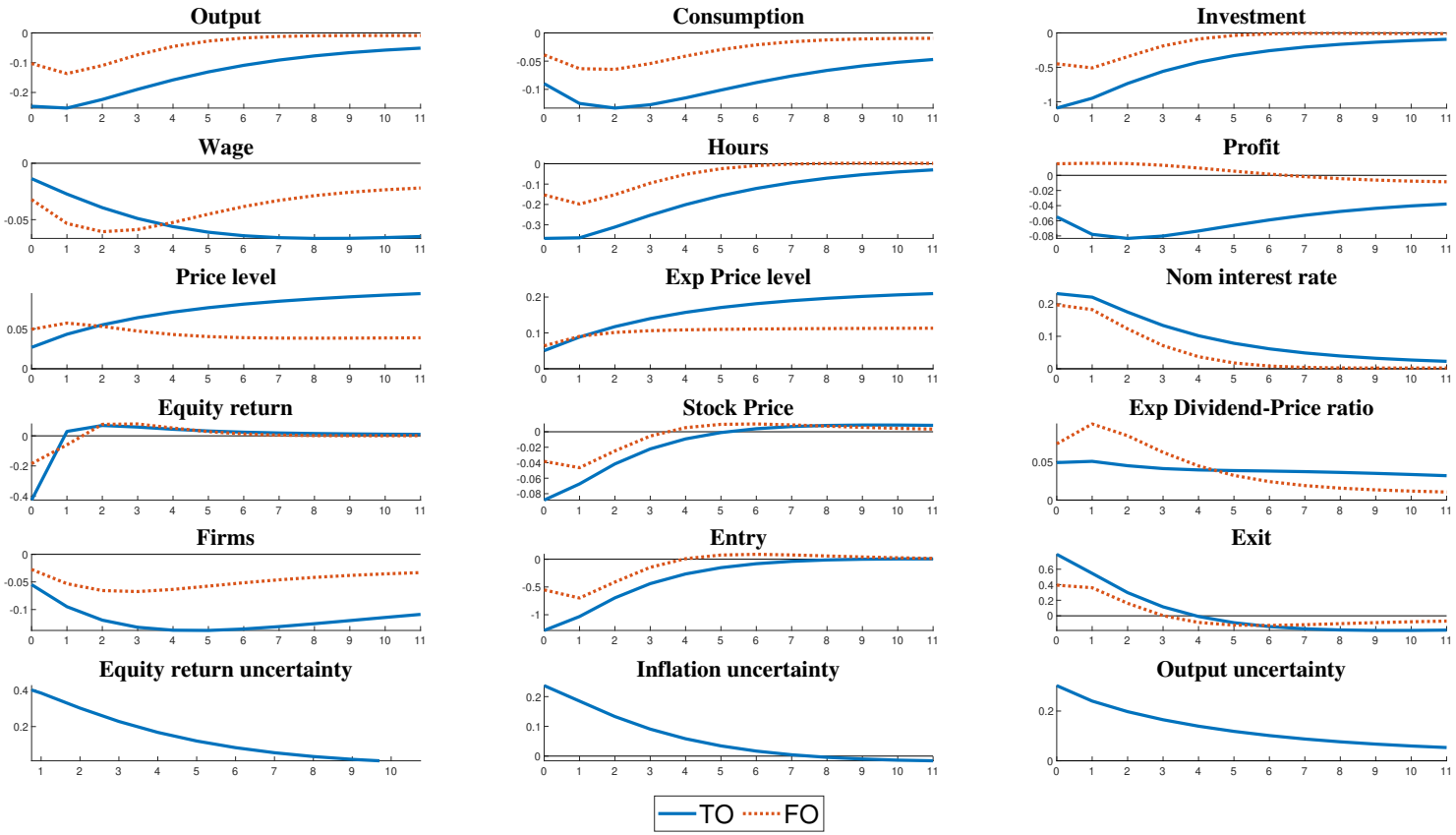


Figure: Dynamic responses to inflation shock using estimated parameters: FO vs TO model). DSGE versus VAR IRFs

DSGE Estimation: contribution of firm dynamics

Estimated Parameters		*TO*	*TO no firms*
"Deep" parameters			
γ_p	Rotemberg Adjust. Cost - Price	18.9	32.32
γ_w	Rotemberg Adjust. Cost - Wage	112.8	95.42
γ_i	Investments Adjustment Cost	5.78	2.11
Shock persistence and Std.			
σ_π	Std. of Inflation Expect. shock	0.0003	0.0006
ρ_π	Persist. Inflation Expect. shock	0.7680	0.4988
Taylor rule			
ϕ_π	Coefficient Inflation	3.96	1.98
ϕ_y	Coefficient Output	0.0450	0.0055
ϕ_{dy}	Coefficient Output growth	0	0.0943
ϕ_R	Interest rate smoothing	0.3890	0.5551
Value Function		44.94	62.24

Table: Parameter Estimates through IRFs matching. TO no firms $\rightarrow$ Third Order solution of model with no firm dynamics; TO $\rightarrow$ Third Order solution of baseline model

DSGE Estimation: contribution of firm dynamics

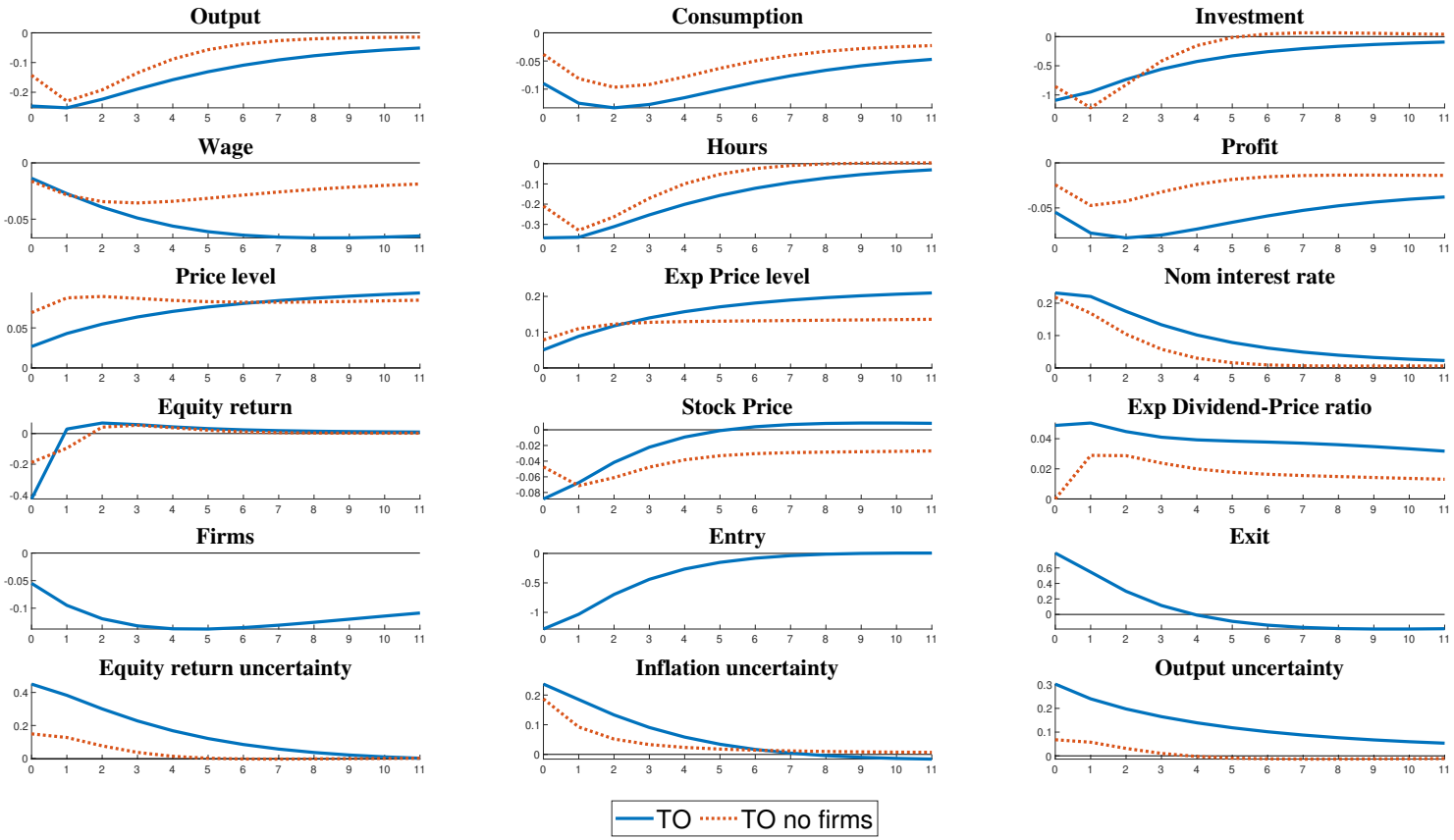


Figure: IRFs to inflation expectations shock using estimated parameters TO vs TO no firms model) DSGE versus VAR IRFs

DSGE Estimation: asymmetric effects

Estimated Parameters		*Shock*(+)	*Shock*(−)
"Deep" parameters			
γ_p	Rotemberg Adjust. Cost - Price	18.9	34.70
γ_w	Rotemberg Adjust. Cost - Wage	112.8	92.59
γ_i	Investments Adjustment Cost	5.78	6.11
Shock persistence and Std.			
σ_π	Std. of Inflation Expect. shock	0.0011	0.0006
ρ_π	Persist. Inflation Expect. shock	0.7680	0
Taylor rule			
ϕ_π	Coefficient Inflation	3.96	2.83
ϕ_y	Coefficient Output	0.0450	0.0233
ϕ_{dy}	Coefficient Output growth	0	0
ϕ_R	Interest rate smoothing	0.3890	0.7100
Value Function		44.94	70.61

Table: Parameter Estimates through IRFs matching. Notation: Shock (-) $\rightarrow$ Negative shock; Shock (+) $\rightarrow$ Positive shock.

DSGE Estimation: asymmetric effects

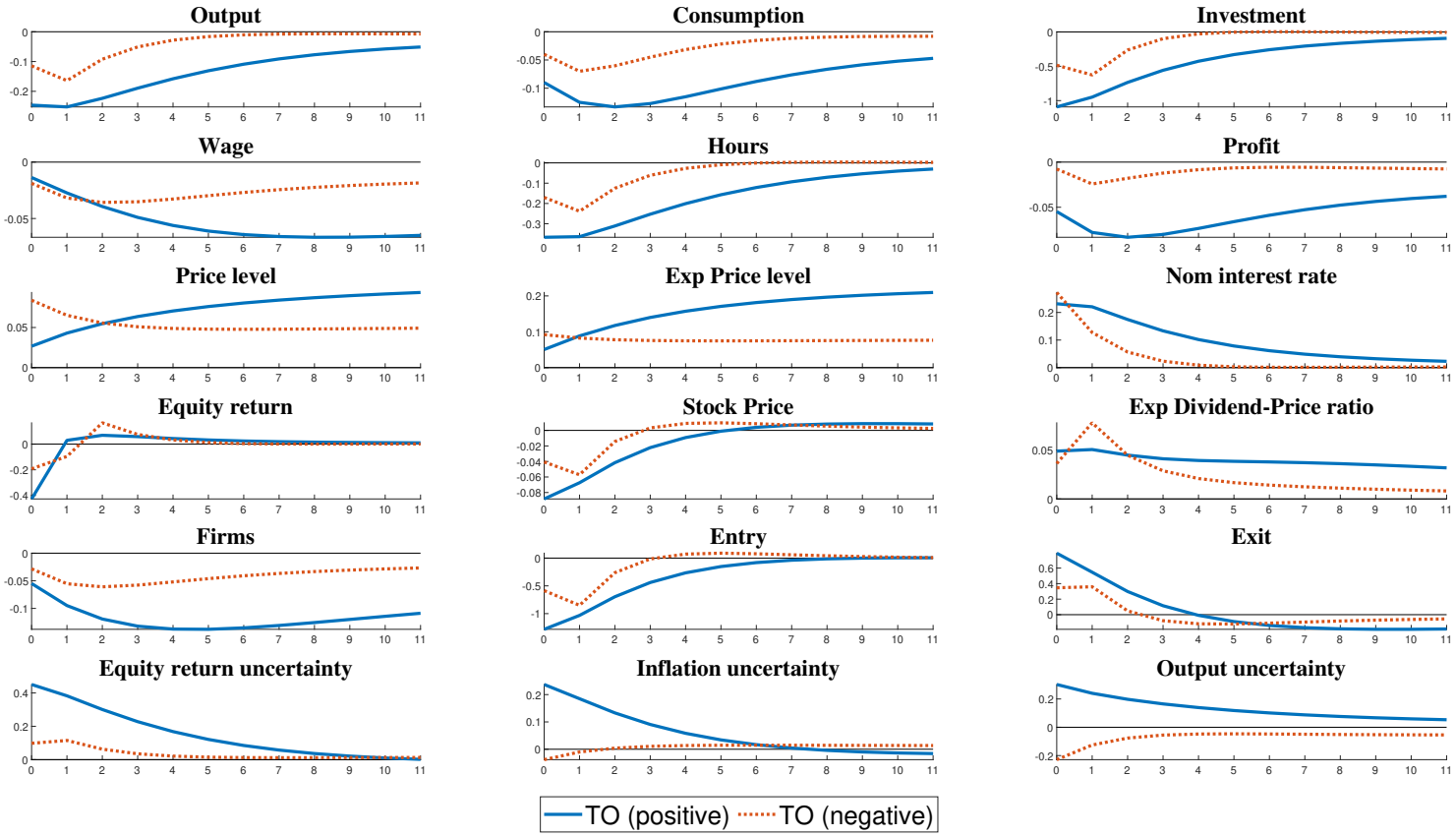


Figure: Re-estimating the model: positive (inflationary) versus negative (deflationary) inflation expectations shock (negative IRFs multiplied by -1.) DSGE versus VAR IRFs

DSGE Estimation: asymmetric effects

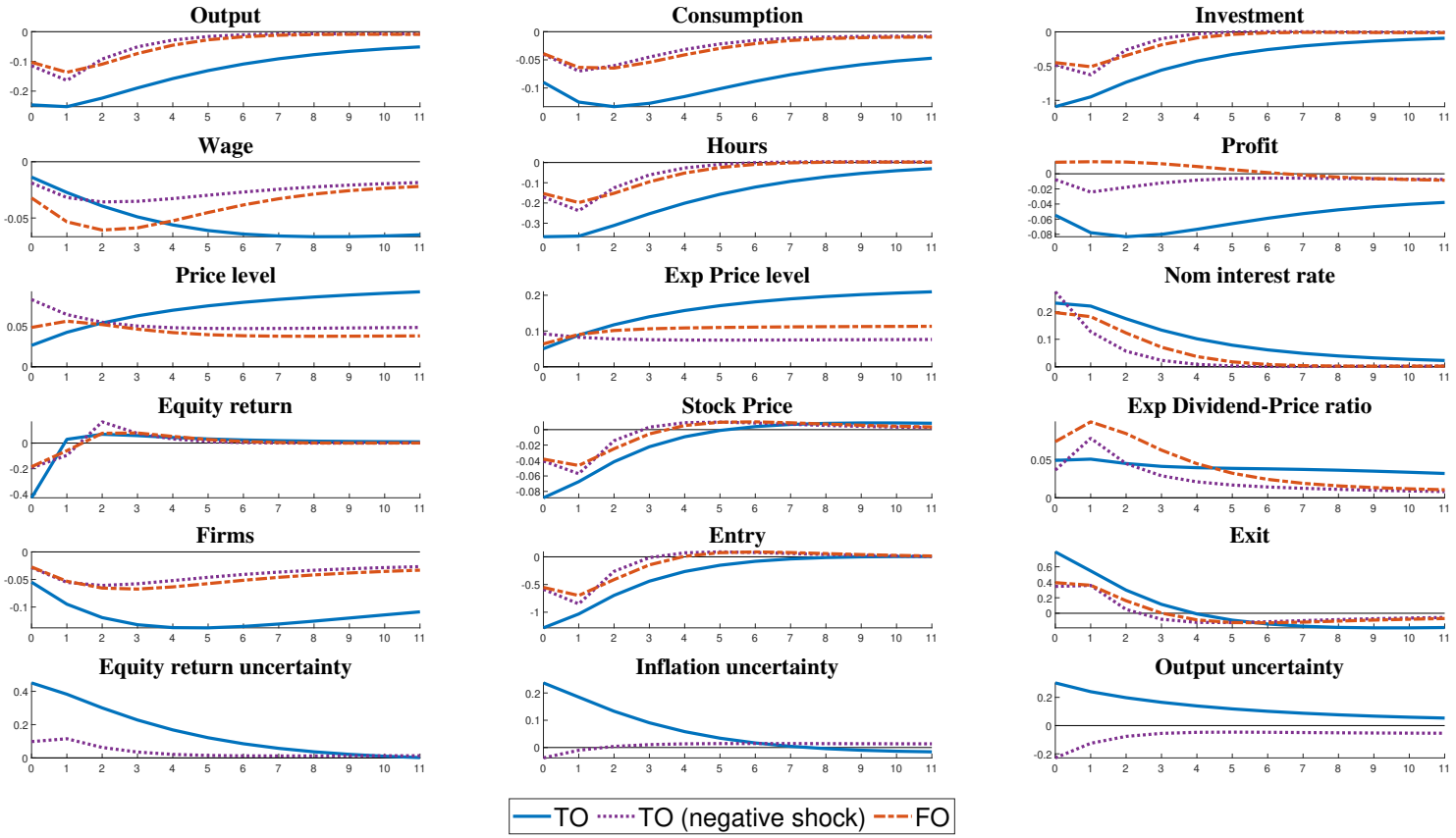


Figure: Dynamic responses to inflation shock using estimated parameters: FO vs TO with positive (inflationary) inflation expectation shock, and TO with negative (deflationary) inflation expectations shock

Local projections: asymmetric effects

- **We test asymmetric effects of inflation expectations shocks in data through local projection analysis.**
- We retrieve the structural shock estimated in our linear VAR model and regress several macroeconomic variables over it.
  1. We test VAR-irfs robustness using LP local projections irfs
  2. **To keep track of asymmetric effects**, as in Tenreyro and Thwaites (2016) we estimate $\left[\beta_h^+, \beta_h^-\right]$, with $h \in [0, H]$ estimated from the following equation:

$$y_{t+h} = \tau t + \alpha_h^b + \beta_h^+ \max\left[0, \varepsilon_t\right] + \beta_h^- \min\left[0, \varepsilon_t\right] + \gamma' \mathbf{x_t} + u_t,$$

  where $\mathbf{x_t}$ are lagged variables in linear VAR.

Local projections: asymmetric effects

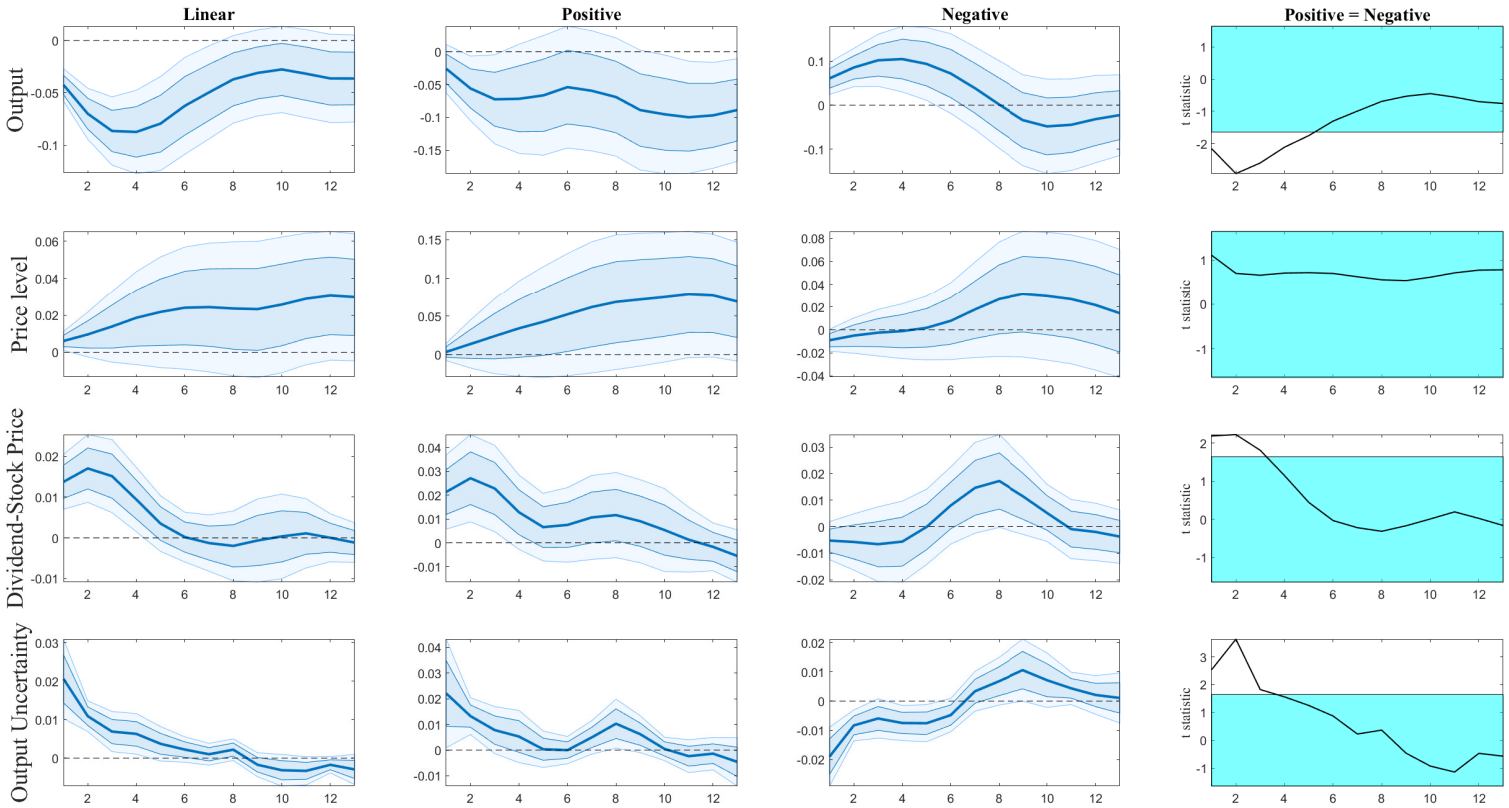


Figure: IRFs to inflation expectation shocks that increases inflation expectations by 1%. T-statistics tests the hypothesis of no differences between coefficients (Tenreyro and Thwaites 2016).

Conclusions

- **Shocks that increase inflation expectations are stagflationary**
- Shocks to inflation expectations **generate sizeable uncertainty** in output, inflation and equity return.
- **The increased uncertainty** transmits to the macroeconomic variables and **amplifies the negative effect of the shock**
- **Firm dynamics** is also essential in the transmission
- Inflation expectations shocks have **asymmetric effects**: shocks that increase inflation expectations have stronger effects than a shock that decreases inflation expectations

Appendix I
DSGE inflation expectations, supply, news, ist shocks

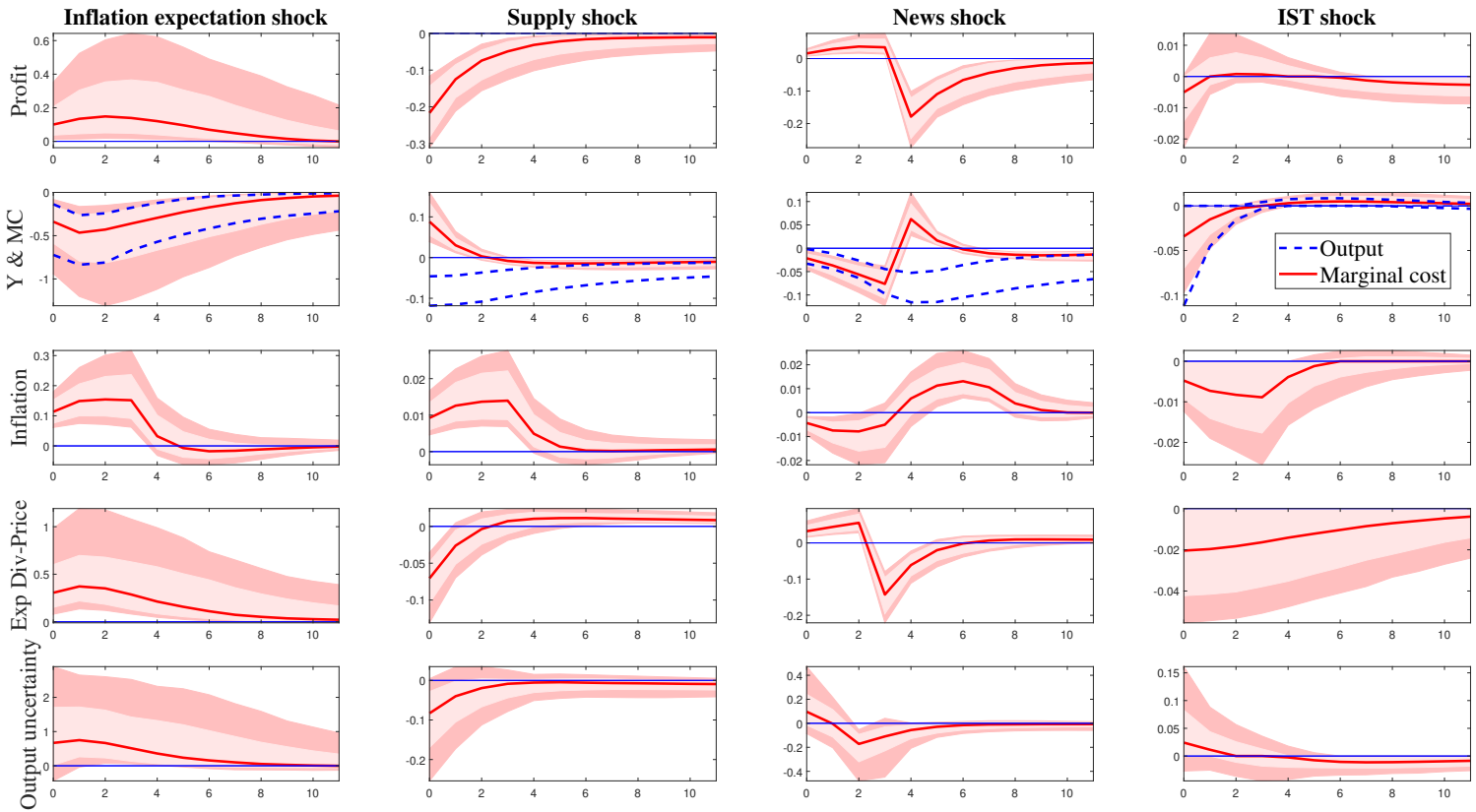
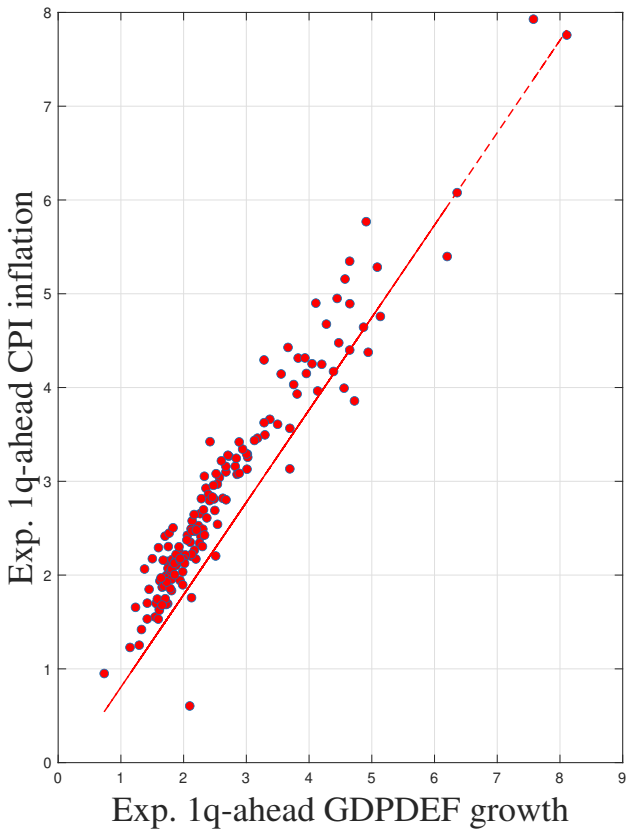


Figure: Dynamic responses to inflation expectations, supply, news, and investment-specific technology shocks. Montecarlo simulation of the model as in Canova and Paustian (2011) back

Appendix II



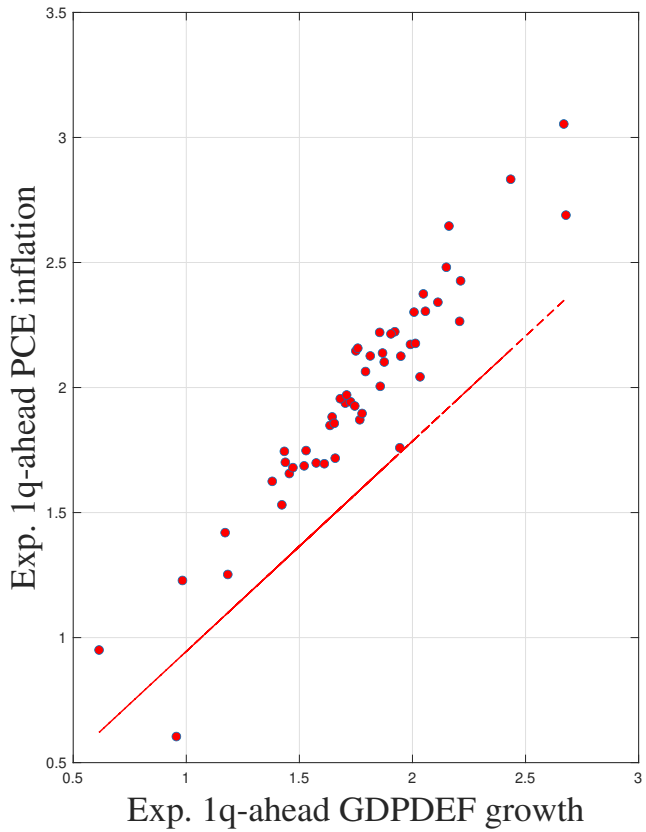


Figure: Correlation $(GDPDEF, CPI) = 0.9620$, correlation $(GDPDEF, PCE) = 0.9475$. Both are statistically significant at 1% back

Appendix III

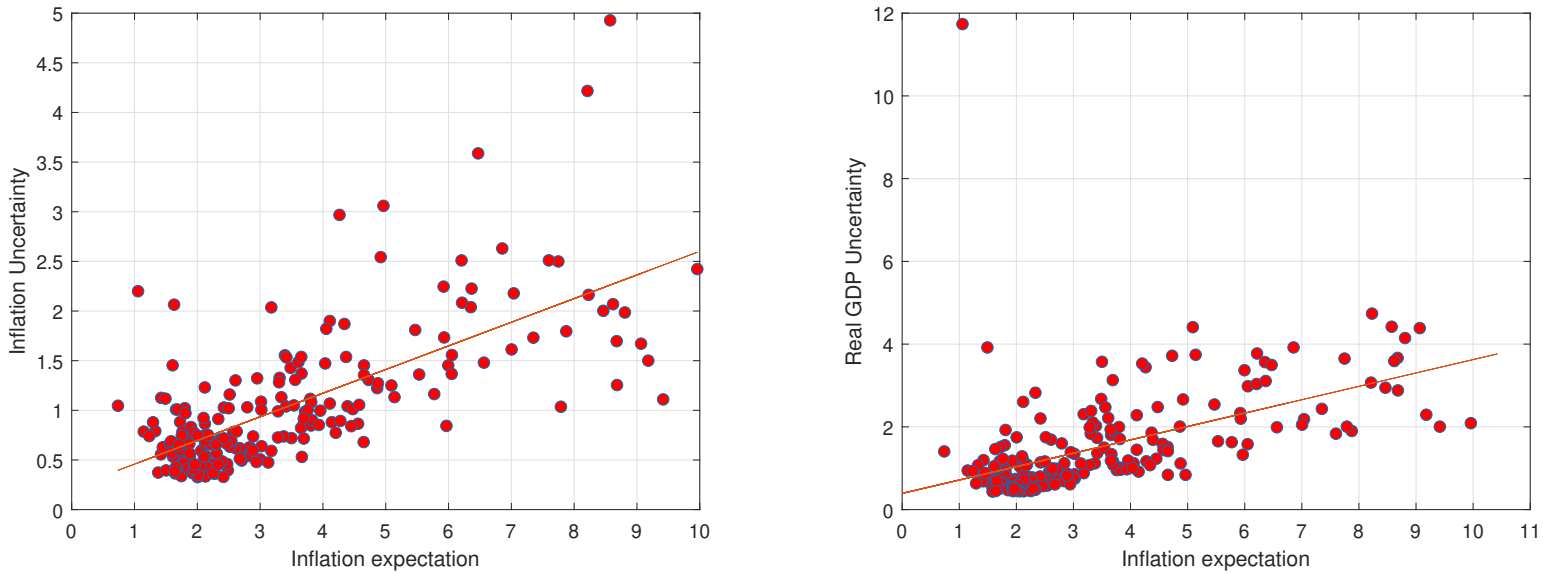


Figure: **Left**: Mean one-quarter ahead inflation expectations of the SPF and inflation uncertainty from the SPF, i.e., the standard deviation of individual point forecasts on GDP price index. **Right**: Mean one-quarter ahead inflation expectations of the SPF and GDP uncertainty from the SPF, i.e., the standard deviation of individual point forecasts on real GDP. back

Appendix IV

I have spoken out and I expect to continue to speak out on the need for stability, broadly conceived — thinking of it in terms of our domestic inflation, thinking of it in terms of the value of the dollar internationally.

I speak out of a very strong conviction that this sense of stability is necessary in order to assure the prosperity and growth of our economy at home and to deal with those problems of unemployment, poverty and all the others. I don't think we can build on a sense of instability—accelerating inflation, instability of the dollar abroad—if we want to deal constructively with those problems of the domestic economy. [1]

back

Appendix V
VAR supply shock

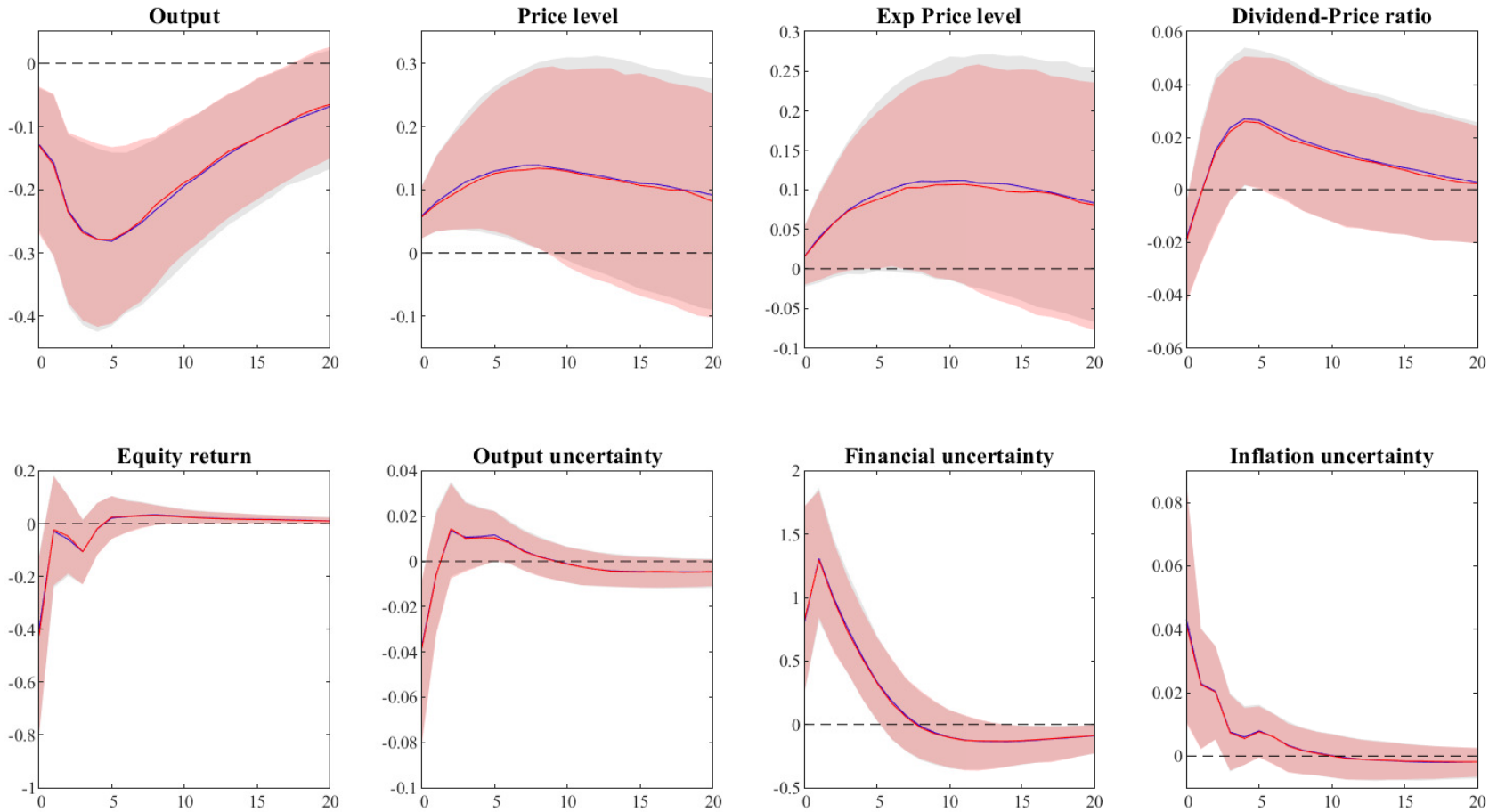


Figure: VAR responses to **supply shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative back

Appendix VI
Structural shocks

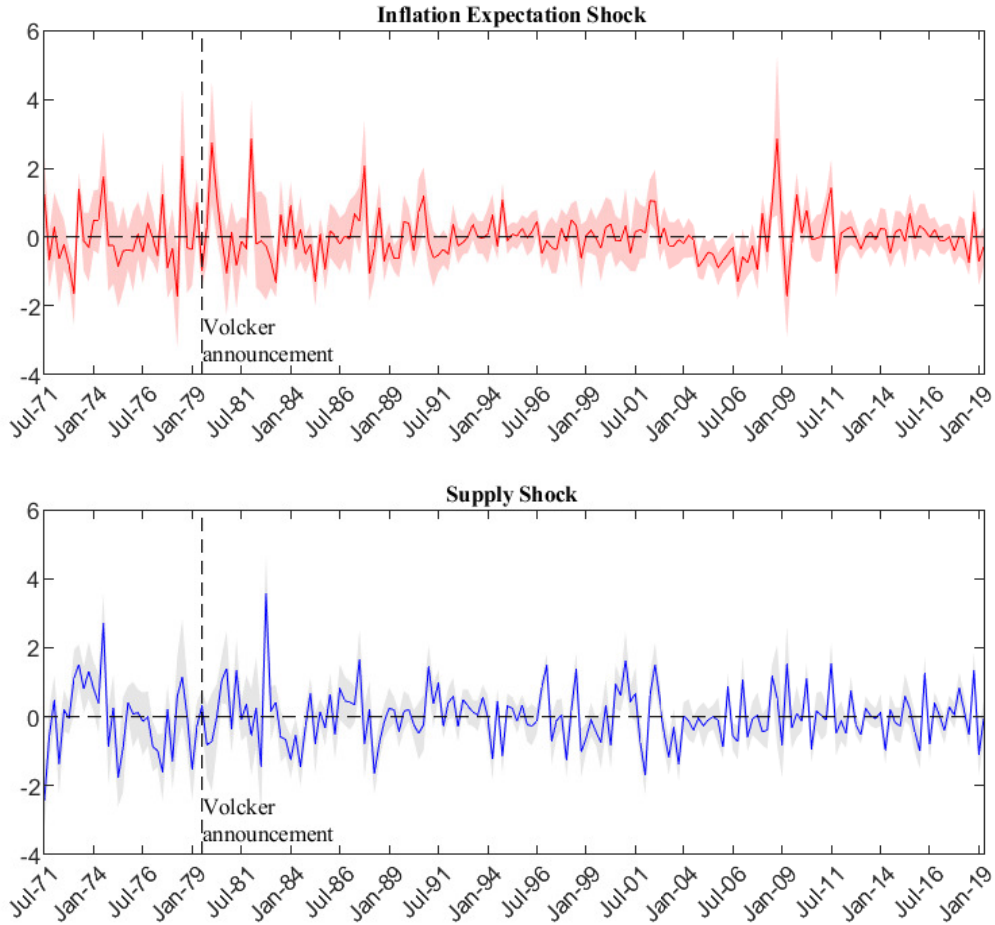


Figure: Estimated structural shocks: inflation expectation shocks and supply shock identified using sign restrictions and the narrative. back

Appendix VII
VAR simulated data

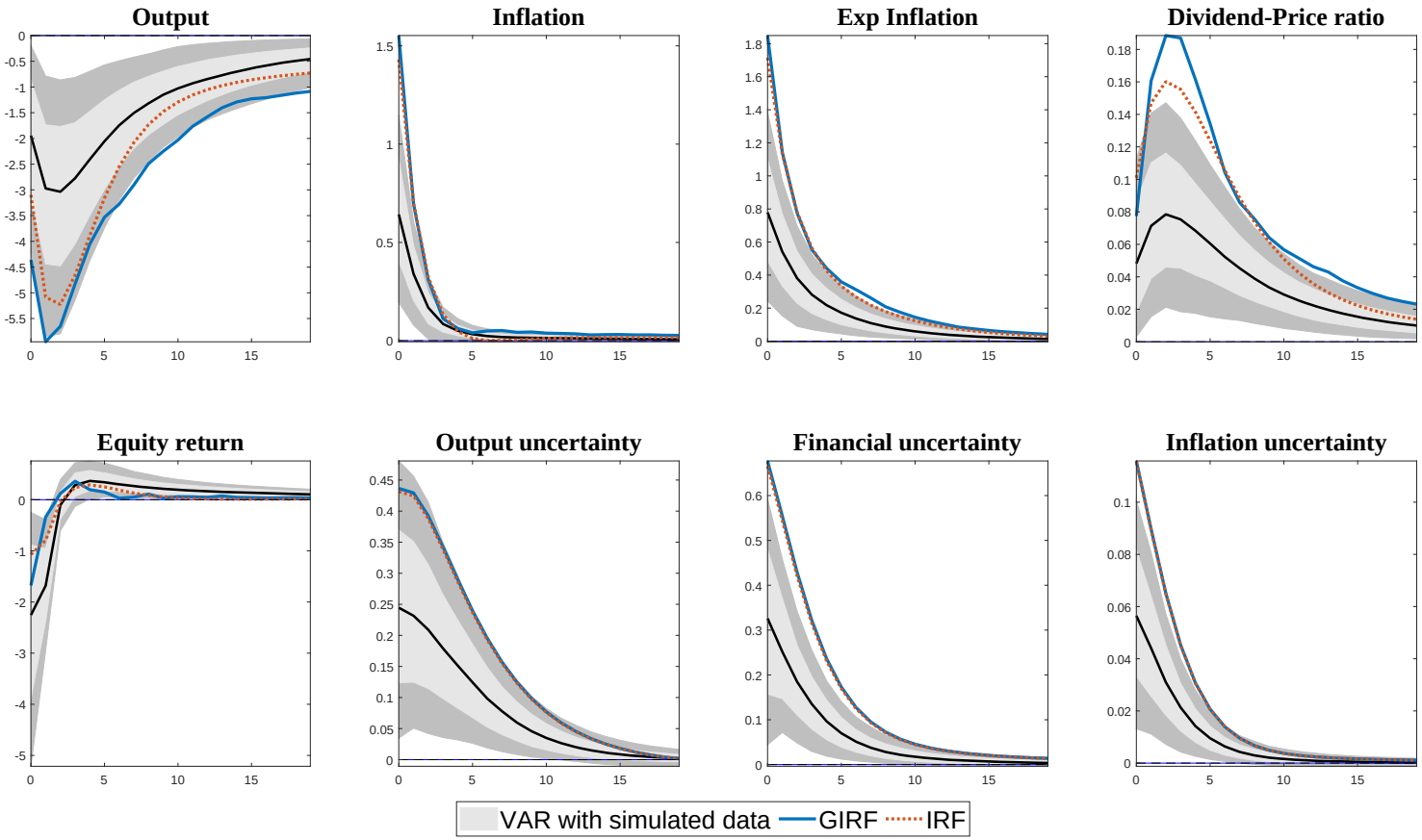


Figure: VAR responses to **inflation expectations shock** (95% percentile) using simulated data (gray area, median in black solid line), model IRFs (red dotted line), model GIRFs (blu solid line) back

Appendix VII
VAR 1971-2007: inflation expectation shock

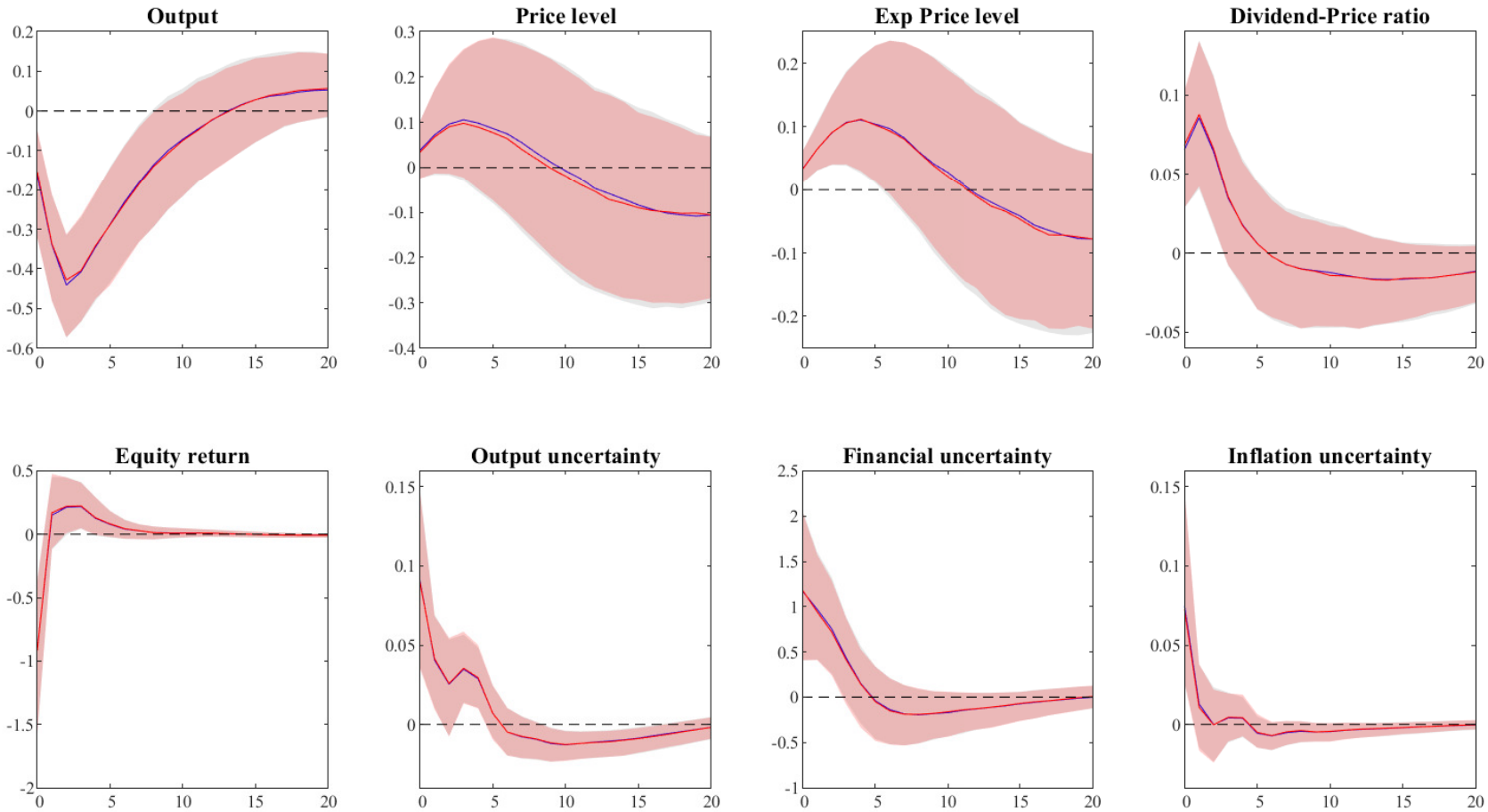


Figure: VAR responses to **inflation expectation shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative back

Appendix IX
DSGE vs VAR responses

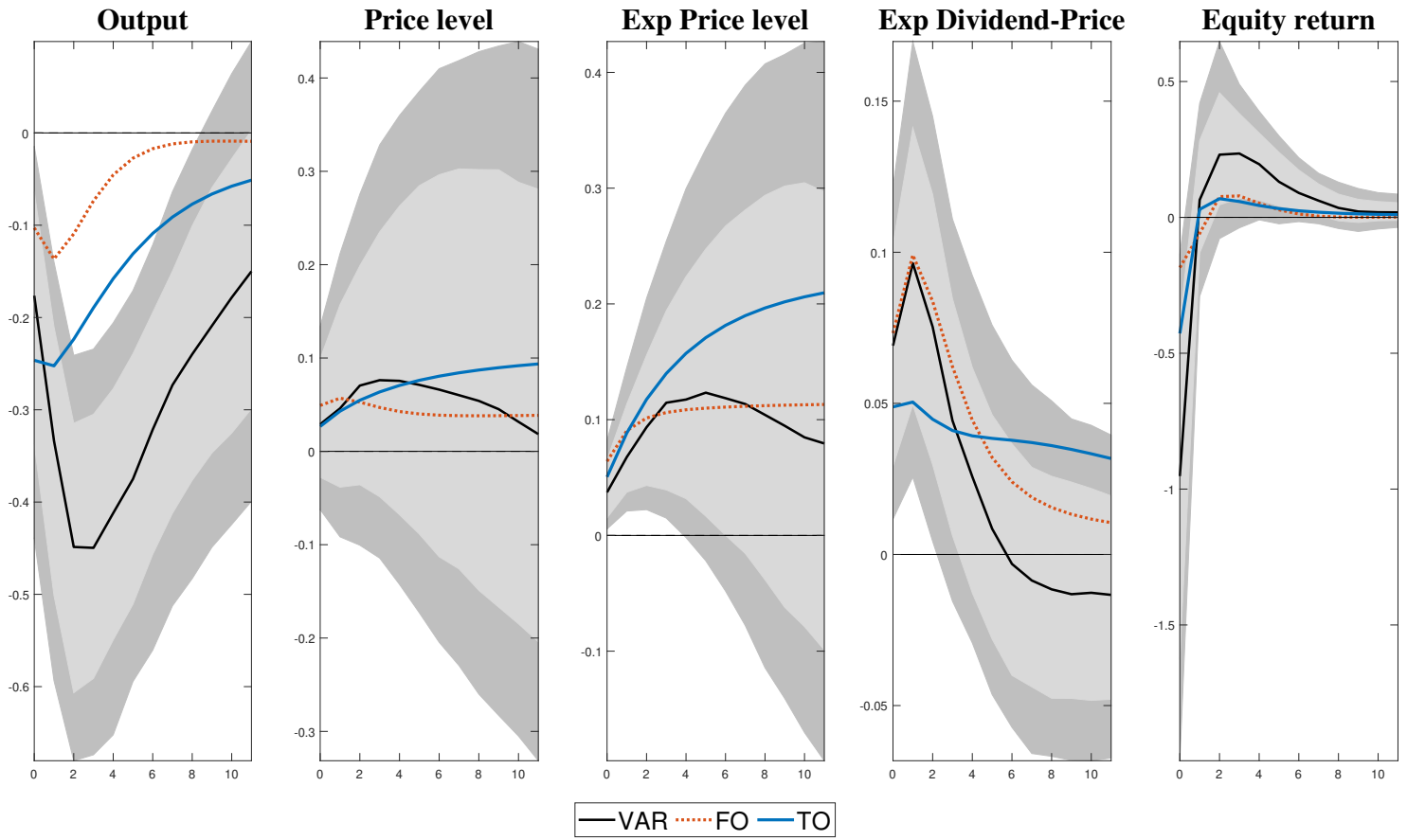


Figure: IRFs to inflation expectations: VAR-IRFs vs. IRFs implied by the estimated models, FO vs TO model. back

Appendix X
DSGE vs VAR responses

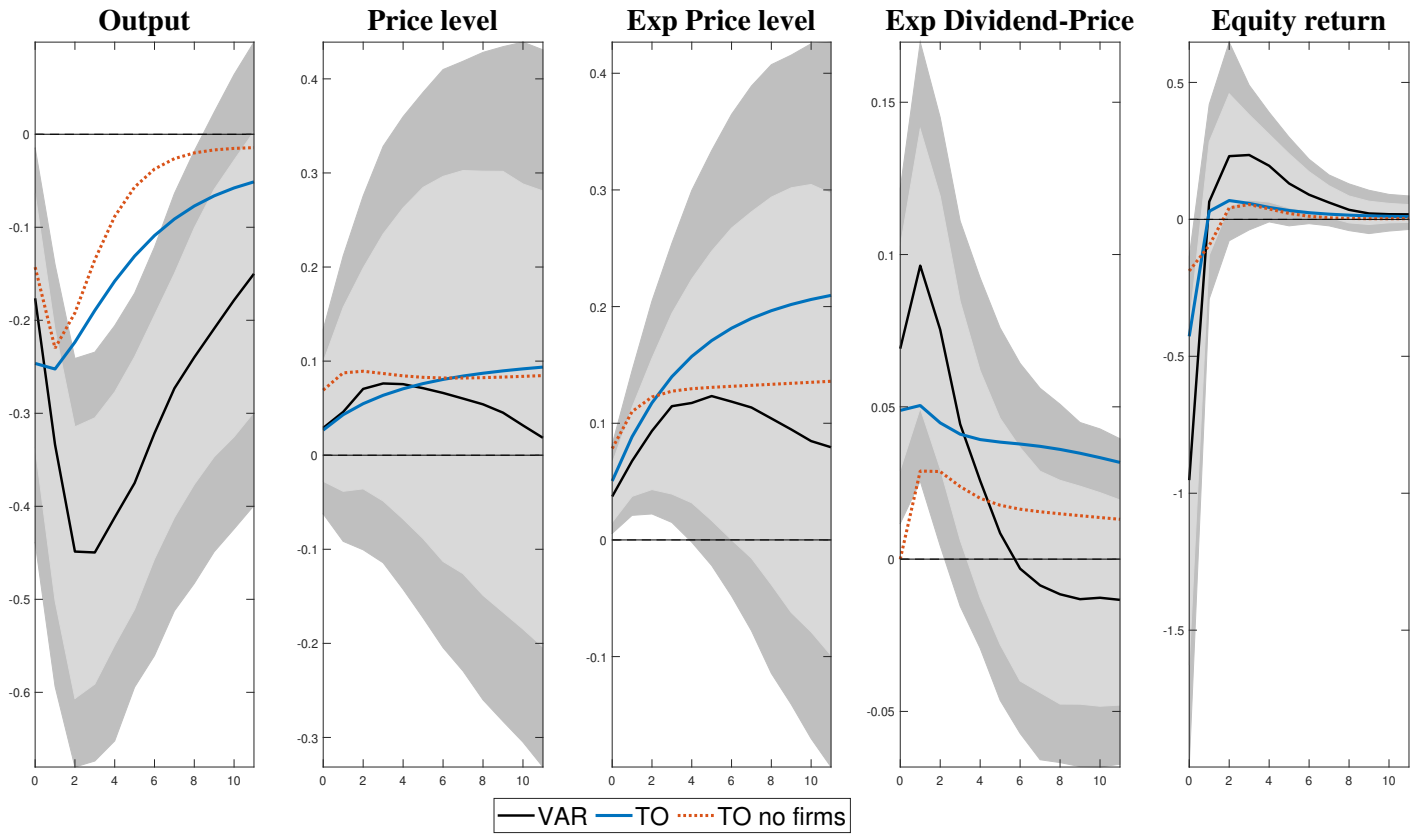


Figure: IRFs to inflation expectations shock of the matched series and those implied by the estimated models, TO vs TO no firms model. back

Appendix XI
DSGE vs VAR responses

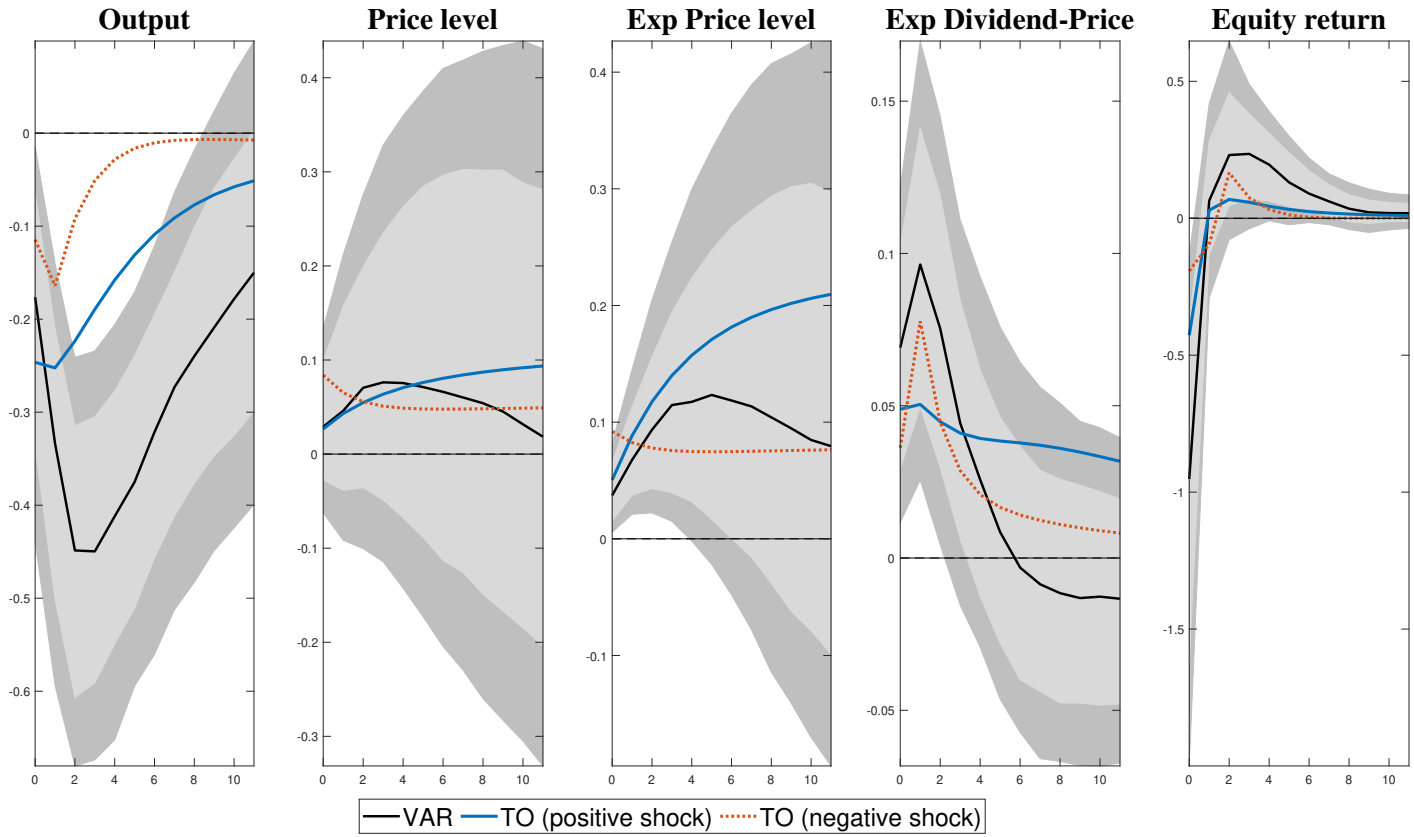


Figure: IRFs to inflation expectations shock of the matched series and those implied by the estimated models, TO (positive) vs TO (negative) model. back

Appendix XII
Local projections: replicating VAR responses

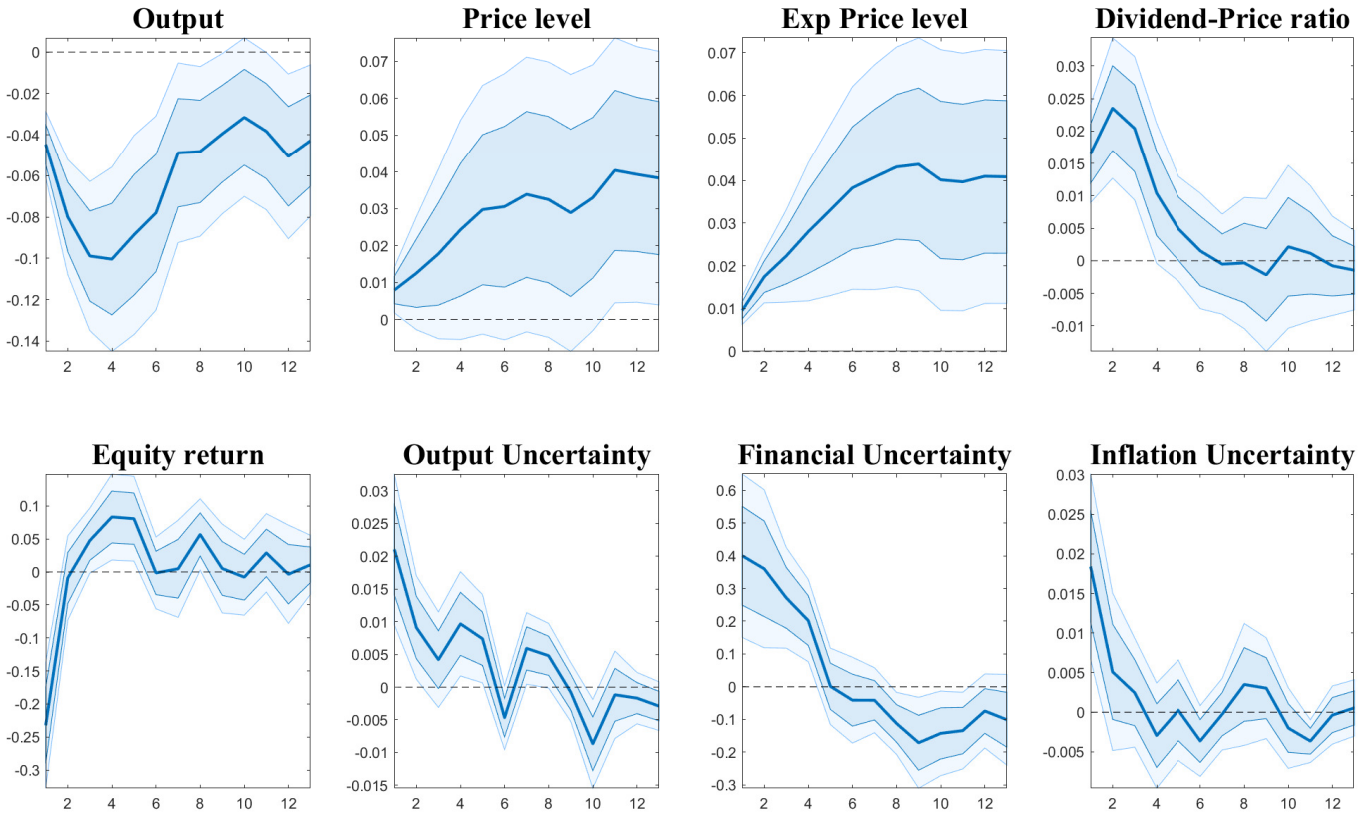


Figure: Linear model: IRFs to inflation expectations shock that increases inflation expectations by 1%.

Appendix XIII
Local projections: other macro variables

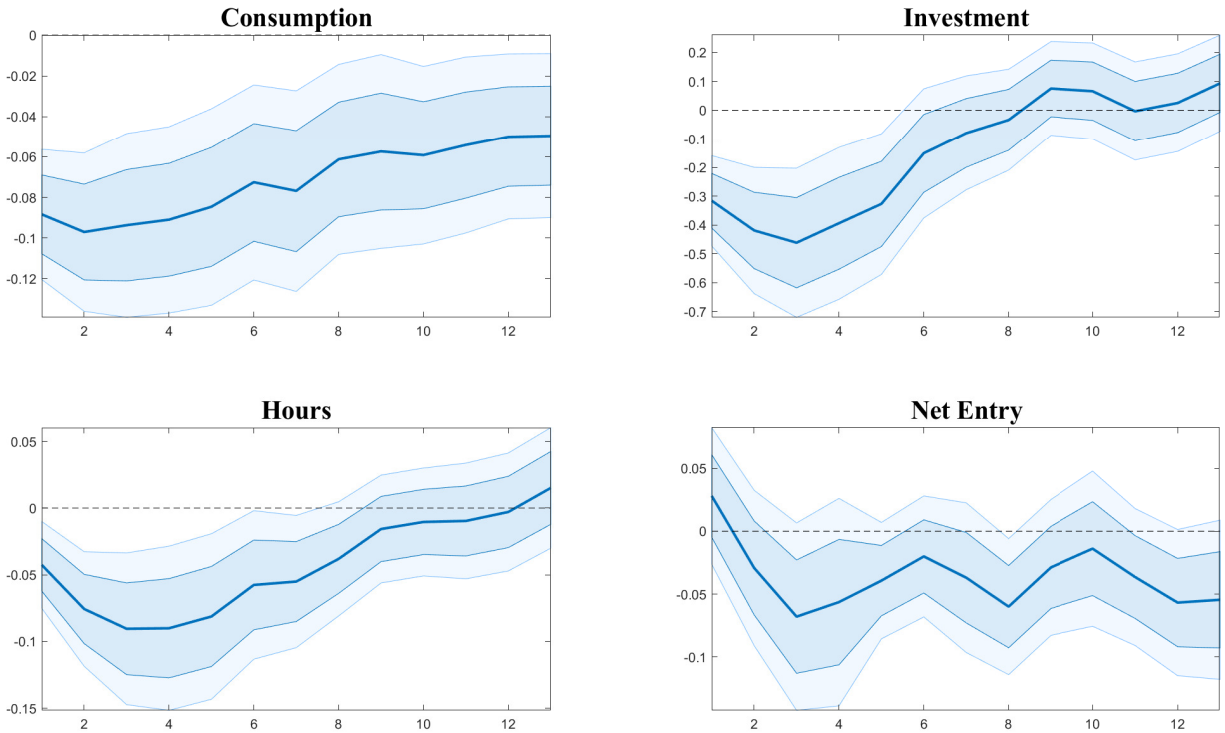


Figure: Linear model: IRFs to inflation expectation shock that increases inflation expectations by 1%. back

Appendix XIV
VAR 1971-2007: negative supply shock

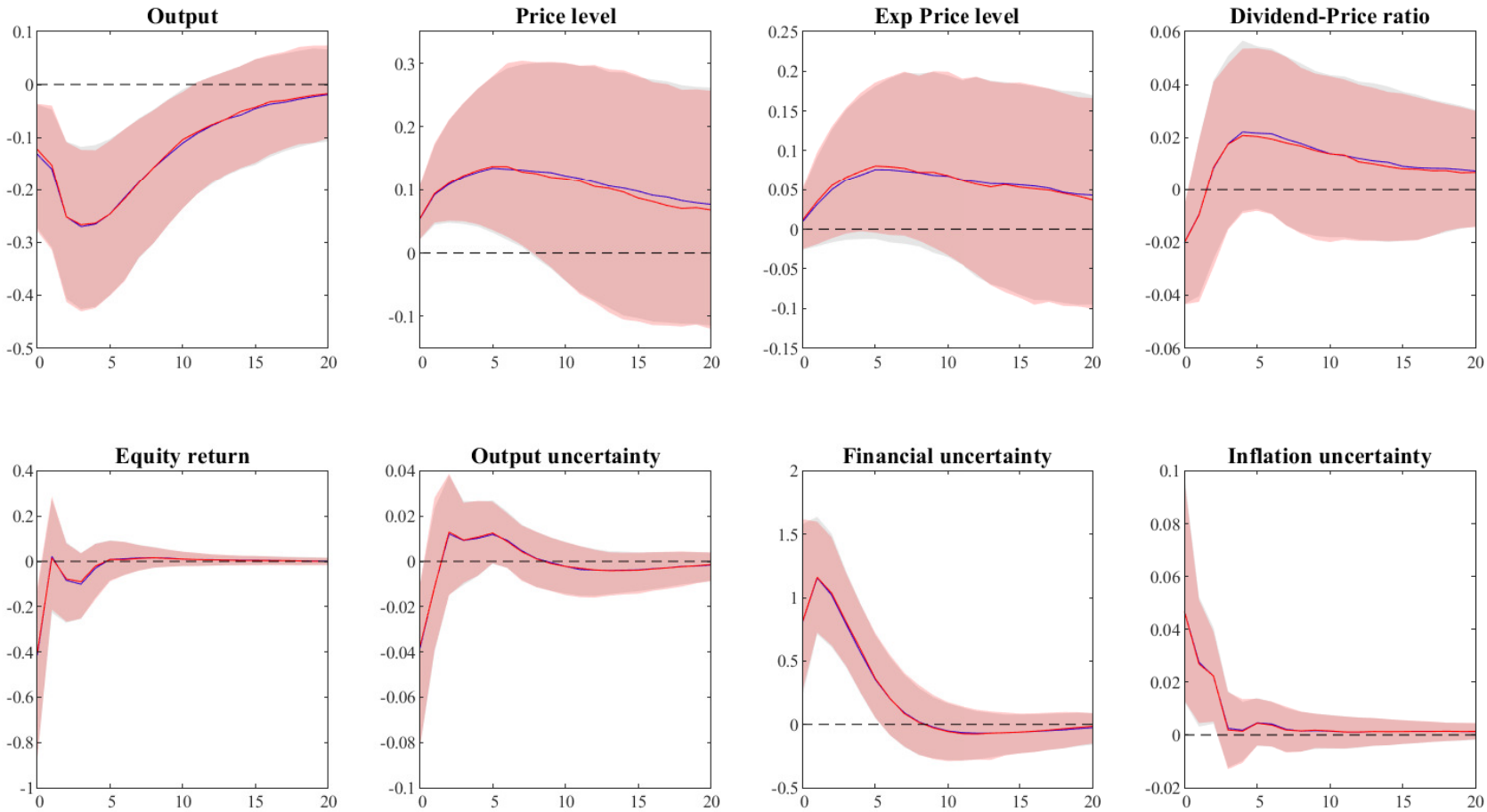


Figure: VAR responses to **supply shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative

Appendix XV
VAR 1985-2019: inflation expectation shock

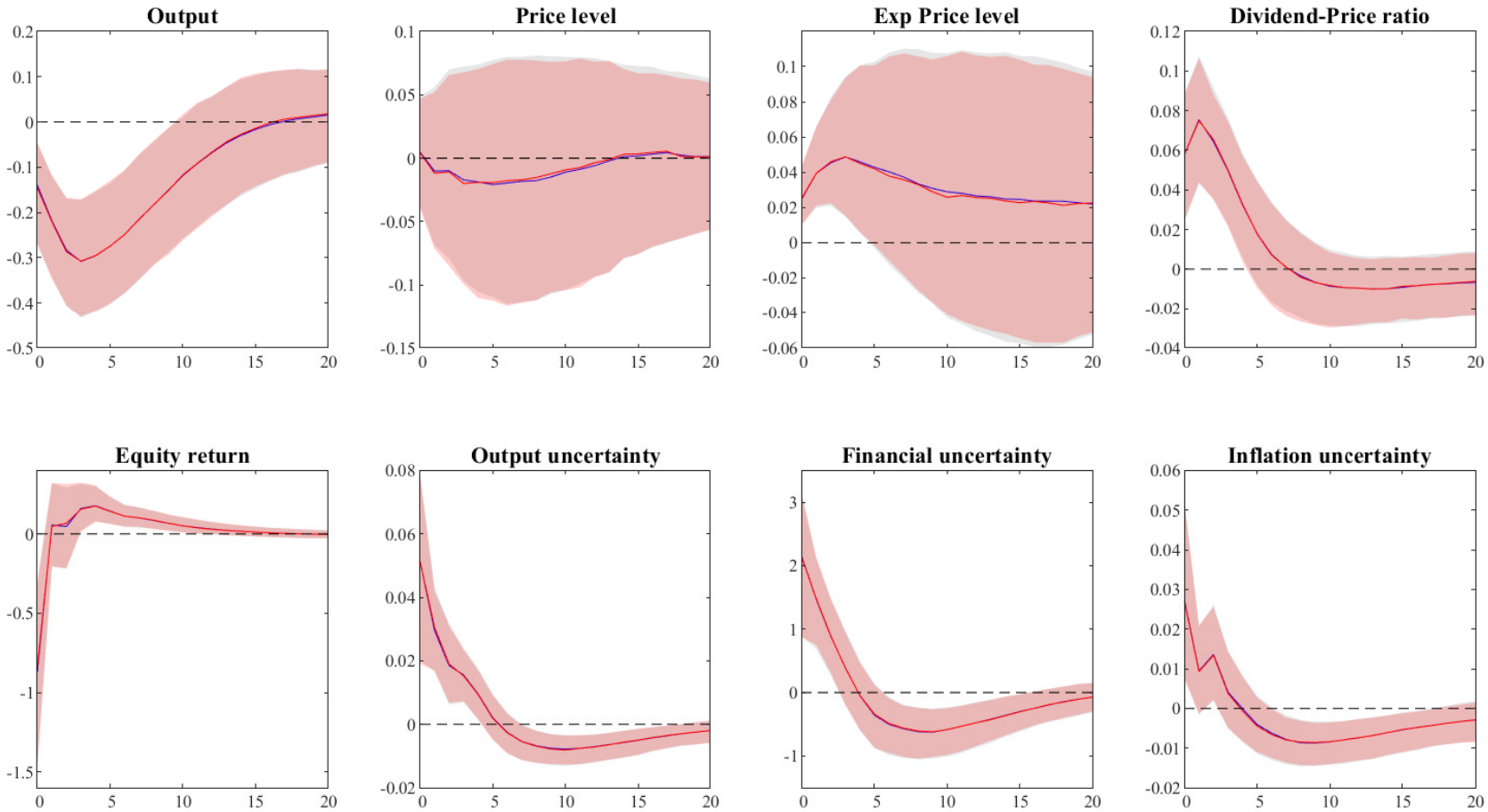


Figure: VAR responses to **inflation expectation shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative

Appendix XVI
VAR 1985-2019: negative supply shock

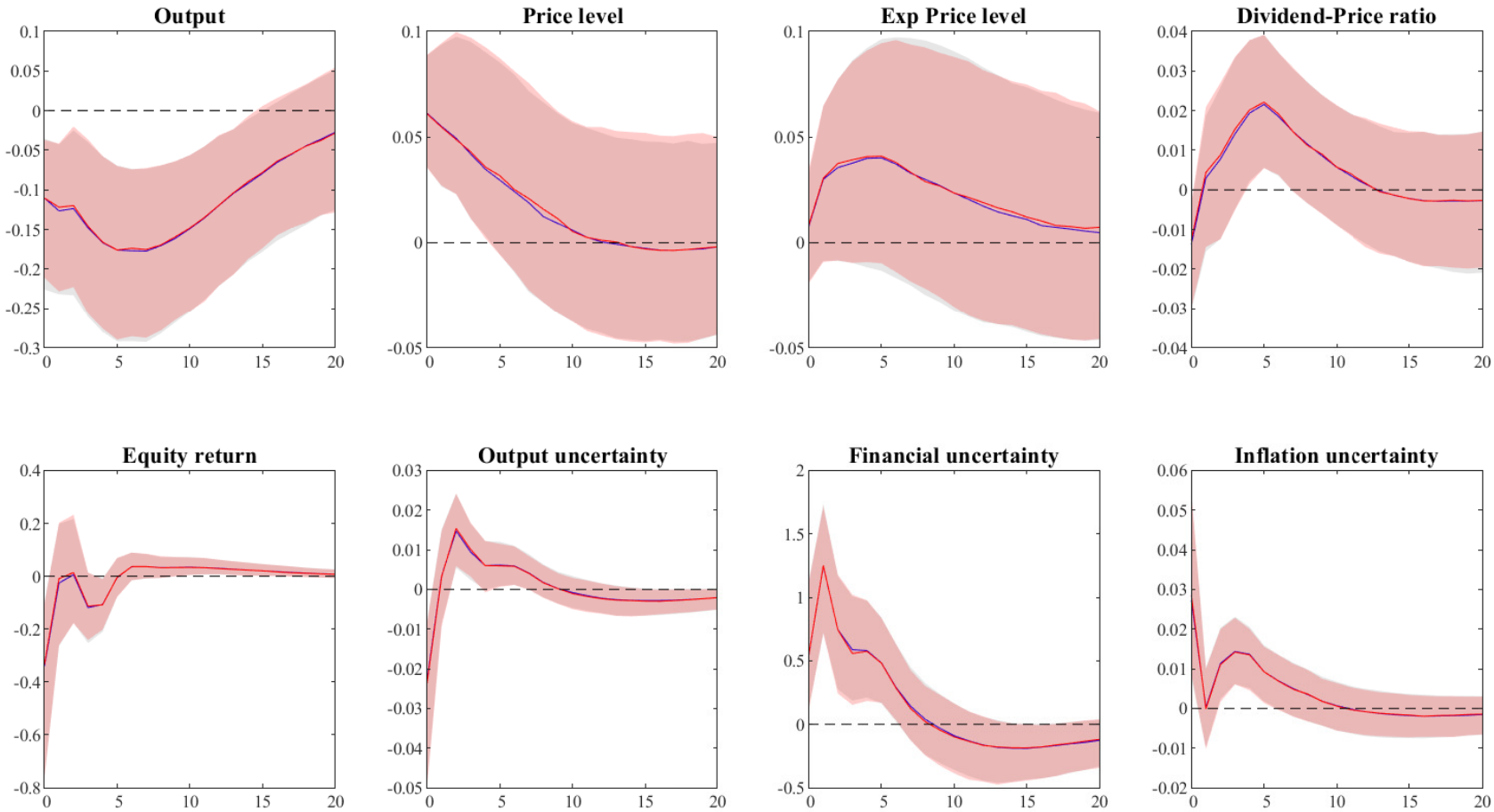


Figure: VAR responses to **supply shock** (68% percentile): in gray only sign restrictions, in red sign restrictions plus narrative