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Macroeconomic Effects of Inflation Target Uncertainty Shocks

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Abstract

This note studies the macroeconomic effects of uncertainty shocks on the inflation target (IT). The IT is assumed to change over time and its stochastic volatility is modeled as an autoregressive process. We show that an IT uncertainty shock, namely a shock on its volatility) resembles an aggregate demand shock, a robust qualitative result for different Taylor-type rules. The magnitude of real and nominal variables responses depend crucially on the Taylor rule considered: an empirical plausible degree of interest rate smoothing leads output, unemployment, and inflation to react more strongly causing the recession to be more severe and deflationary.

Keywords: Uncertainty shocks, Inflation target, Monetary policy.

JEL Classification: E31; E32; E52; E58.

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1 Introduction

In this note we study the macroeconomic effects of uncertainty shocks with an emphasis on the inflation target (IT) stochastic volatility. Building on the literature that analyzes the economic implications of real and nominal uncertainty shocks, in particular, Born and Pfeifer (2014); Leduc and Liu (2016); Fasani and Rossi (2018), we develop a dynamic stochastic general equilibrium (DSGE) model with two distinct features: (i) the IT changes over time and follows an exogenous stochastic process (Ireland, 2007; Cogley et al., 2010) and (ii) the standard deviations of the innovations in the IT are time-varying and follow an autoregressive process. Moreover, our modeling approach is in line with recent evidence on the importance of the time-varying and stochastic volatility of the IT - several studies have drawn attention to the fact that a monetary authority IT might vary over time (see, e.g., Stock and Watson (2007); Ireland (2007); Cogley and Sbordone (2008); Cogley et al. (2010)), and others have emphasized the importance of the IT stochastic volatility (e.g, see Stock and Watson (2007); Chan et al. (2018)).

We show that an inflation target uncertainty shock resembles an aggregate demand shock, a robust qualitative result for different Taylor-type rules. We find no evidence of inflation bias and an IT uncertainty shock is a demand shock regardless the monetary policy reactiveness - a result different than Fasani and Rossi (2018) that show that an uncertainty shock could be either a demand or supply shock depending on the monetary authority interest rate rule. However, the magnitude of real and nominal variables responses depend crucially on the Taylor rule considered. While a more reactive rule, for instance, as studied in Leduc and Liu (2016), imply a less severe recession and deflation, an empirical plausible degree of interest rate smoothing, on the other hand, leads unemployment, output and inflation to react more strongly causing the recession to be more severe and deflationary.

There exists a growing literature on the macroeconomic implications of uncertainty shocks. Bloom (2009); Fernández-Villaverde et al. (2011); Gilchrist et al. (2014); Bloom et al. (2018); Katayama and Kim (2018); Kozeniauskas et al. (2018) find that economic uncertainty has significant impacts on different sets of macroeconomic variables and that the increase in the uncertainty level contributed to slow economic recoveries and persistence of high levels of unemployment rates (Stock and Watson, 2012; Baker et al., 2016). Annicchiarico et al. (2011) and Annicchiarico and Rossi (2015) find a non-negligible relationship between uncertainty and long-run growth, which depends on the monetary authority interest rate (Taylor rule) being considered and, in particular, its smoothing parameter. According to Susanto and Brent (2017), increases in uncertainty have larger negative effects on the economy if the monetary authority is constrained by the zero lower bound on nominal interest rates. Neri and Ropele (2015) show that as the uncertainty regarding the central bank's IT increases, persistent disinflationary shocks exert more destabilizing effects on inflation and output. Allowing for stochastic changes not only in the monetary authority IT but also in its own volatility this note contributes to a better understanding of the macroeconomics effects of nominal uncertainty shocks. And, to some extent, our results may offer a potential structural explanation of statistical findings in the literature, for instance, as in Stock and Watson (2007) and Chan et al. (2018).

2 A Model with Inflation Target (IT) Uncertainty Shocks

The model is identical to Leduc and Liu (2016)'s except that, instead of assuming a constant inflation target, the IT follows an exogenous stochastic process and its stochastic volatility an autoregressive process.[1]

The monetary authority follows a standard Taylor rule aiming to stabilize inflation using the short run nominal interest rate as the main instrument as follows:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi_t^*}\right)^{\gamma_\pi} \left(\frac{Y_t}{\overline{Y}}\right)^{\gamma_y}\right]^{(1-\rho_R)} e^{z_t^r}, \tag{1}$$

where R_t is the short run nominal interest rate, R represents the steady state interest rate, π_t is the inflation rate, Y_t is the real output, $\overline{Y}$ is the output in the steady state, z_t^r is a monetary policy shock and γ_y, γ_π, and ρ_R are parameters defined in Section 3. The IT π_t^* varies over time and we assume that it follows an exogenous (autoregressive) stochastic process, as in Ireland (2007); Cogley et al. (2010):

$$\log \pi_t^* = (1-\rho^{\pi^*}) \log \pi + \rho^{\pi^*} \log \pi_{t-1}^* + \sigma_t^{\pi^*} \epsilon_t. \tag{2}$$

The parameter ρ^{π^*} measures the persistence of the IT shock, the term ϵ_t is an innovation and is a standard normal process.[2] The term $\sigma_t^{\pi^*}$ is the time-varying standard deviation of the innovations which follows an autoregressive process:

$$\log \sigma_t^{\pi^*} = (1-\rho^U) \log \sigma^{\pi^*} + \rho^U \log \sigma_{t-1}^{\pi^*} + \sigma^U \epsilon_t^U, \tag{3}$$

where ϵ_t^U follows a $N(0,1)$ process and the parameter σ^U is the standard deviation of the innovations.

With a time-varying IT, the firms' adjustment cost is not the same as the one considered in Leduc and Liu (2016). Since these costs affect the economy's resource constraint through the goods market clearing condition, allowing the IT to change over time has important implications for the optimal behavior of firms and the equilibrium conditions of the model. In particular, the optimal price-setting decision of retail firms implies that, in a symmetric equilibrium with $P_t(j) = P_t$ for

[1] These assumptions imply important changes in the monetary authority Taylor rule and the economy Phillips curve. For more details, see Leduc and Liu (2016) and this paper Supplemental Material.

[2] As Cogley et al. (2010), there are many reasons that the central bank's inflation target might vary over time. Their favorite one is that the central bank adjusts its target as it learns about the structure of the economy. Then, they approximate outcomes of this learning process by an exogenous random variable similar to equation (2).

all j firms, the relative price of intermediate goods is as follows:

$$q_t = \frac{\eta - 1}{\eta} + \frac{\Omega_p}{\eta}\left[\frac{\pi_t}{\pi_t^*}\left(\frac{\pi_t}{\pi_t^*} - 1\right) - E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t}\frac{Y_{t+1}}{Y_t}\frac{\pi_{t+1}}{\pi_{t+1}^*}\left(\frac{\pi_{t+1}}{\pi_{t+1}^*} - 1\right)\right] \tag{4}$$

3 Economic Implications of IT Uncertainty Shocks

Using the core PCE inflation rate for the U.S., period 1960:Q1-2017:Q4, we estimate the persistence parameters ρ^U and ρ^{π^*} and the standard deviation of the IT uncertainty σ^U.[3] We fit an AR(1) process to the difference of the IT from the steady-state (i.e. the mean of the sample), so as to estimate the persistence of the IT process ρ^{π^*}. We set $\rho^{\pi^*} = 0.991$ in line with Cogley et al. (2010)'s value of 0.995. We calibrate the standard deviation of the innovation to IT uncertainty $\sigma_t^{\pi^*}$ following Cesa-Bianchi and Fernandez-Corugedo (2018). An AR(1) process is estimated as in equation (3) resulting in a persistence estimate $\rho^U = 0.952$ and a standard deviation $\sigma^U = 0.156$. All other parameters are taken from Leduc and Liu (2016) and summarized in Table I.

Table I: Benchmark parameter calibration

Parameter	Description	Value
β	Household's discount factor	0.99
χ	Scale of disutility of working	0.547
h	Habit persistence	0
η	Elasticity of substitution between differentiated goods	10
α	Share parameter in matching function	0.5
μ	Matching efficiency	0.645
ρ	Job separation rate	0.10
ϕ	Flow benefit of unemployment	0.25
κ	Flow cost of vacancy	0.14
b	Nash bargaining weight	0.5
γ	Real wage rigidity	0.8
Ω_p	Price adjustment cost	112
π	Steady-state inflation (or IT)	1.005
ρ_R	Interest smoothing	0.8
γ_π	Taylor rule inflation	1.5
γ_y	Taylor rule output	0.2
ρ^{π^*}	Persistence of IT	0.991
σ^{π^*}	Standard deviation of IT	0.00084
ρ^U	Persistence of IT uncertainty	0.952
σ^U	Standard deviation of IT uncertainty	0.156

As Leduc and Liu (2016)'s model, search frictions and nominal rigidities have important interactions that can amplify the macroeconomic effects of uncertainty shocks. This mechanism works through an interaction between an option-value channel that arises from labor search frictions and

[3] The Personal Consumption Expenditures excluding Food and Energy (chain-type price index) used is from the Federal Reserve Economic Data (FRED) database of the Federal Reserve Bank of St. Louis.

an aggregate-demand channel associated with nominal rigidities. We illustrate this in Figure 1 that displays the response of economic variables to an IT uncertainty shock for an economy with (i) search frictions and nominal rigidities (benchmark), (ii) nominal rigidities, low search frictions, (iii) search frictions, no nominal rigidities, or (iv) habit formation. We follow Fernández-Villaverde et al. (2011) to compute the impulse response functions, where the responses of real variables (unemployment, output, consumption) to an IT uncertainty shock in the benchmark model is larger than those in a economy with flexible prices or low search frictions. This relatively small impact of uncertainty on real economic activity in low search frictions economy is in line with Born and Pfeifer (2014); Leduc and Liu (2016) findings of the impact of real uncertainty shocks in an economy without search frictions. This result suggests that when the option-value channel and the demand channel are simultaneously operating they interact to amplify the effects of uncertainty shocks. Habit formation appears as an intermediate case relative to our benchmark economy and an economy with no nominal rigidities. To the extent that agents care about their previous consumption level (i.e., habit persistence) the macroeconomic effects of an IT uncertainty shock are less pronounced vis-a-vis in the benchmark economy, which is in line with real shock effects studied in Leduc and Liu (2016).

Next, we consider the benchmark model (search frictions and nominal rigidities) under alternative interest rate (IR) rules: (i) IR Rule with Smoothing (IRRS): $\gamma_\pi = 1.5$; $\gamma_y = 0.2$; $\rho_R = 0.8$; (ii) IRRS with a Muted response to output (IRRSMY): $\gamma_\pi = 1.5$; $\gamma_y = 0$; $\rho_R = 0.8$; (iii) Leduc and Liu (2016) IR Rule (LLIRR): $\gamma_\pi = 1.5$; $\gamma_y = 0.2$; $\rho_R = 0$. Responses of the model economy to a one-standard deviation increase in the volatility (σ^U, equation (3)) of the time-varying IT are presented in Figure 2. Under the standard and empirically plausible Taylor rule (IRRS), an inflation target uncertainty shock resembles an aggregate demand shock. The IT uncertainty increases the overall uncertainty in the economy affecting aggregate demand negatively - output falls due to a reduction in consumption and investment, which leads to lower prices. In the benchmark model, IT volatility generates an increase in unemployment that with sticky prices induces a fall in inflation as aggregate demand declines. With search frictions, the option-value channel prevails over the precautionary saving effects, leading to an overall recession with a lower match value and a higher unemployment rate. As demand falls, the relative price of intermediate goods declines, reducing firms' profit and the value of a job match. Job finding rate declines and the unemployment rate rises. As more workers are unemployed, household income falls, reinforcing the initial decline in aggregate demand and further amplifying the recessionary effects of uncertainty on macroeconomic activity (Leduc and Liu (2016)). Facing decreasing inflation and output gaps, the monetary authority responds to lessen this negative demand shock by lowering its nominal (real) interest rate.

Notice that, under IRRS, the interest rate adjustment occurs more gradually than, for instance, under the LLIRR and the macroeconomic effects under IRRSMY are similar (qualitatively) to those observed under the IRRS. IT uncertainty has little to no impact on the real economy if

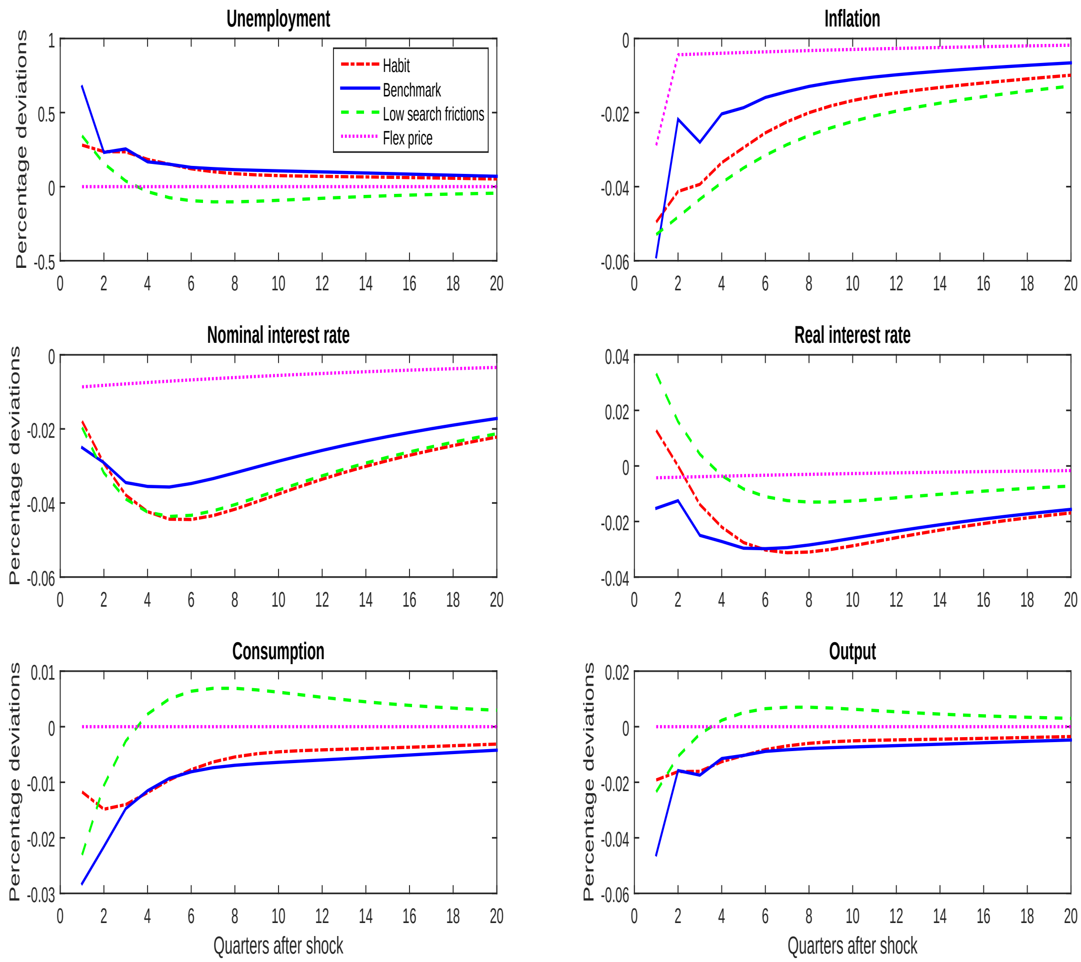

Figure 1: Amplification mechanisms for IT uncertainty shock

the monetary authority adopts a LLIRR ($\gamma_\pi = 1.5$; $\gamma_y = 0.2$; $\rho_R = 0$). Under the LLIRR the unemployment is unresponsive, while the inflation still falls following a rise in uncertainty. Our results show that the quantitative macroeconomic effects of IT uncertainty shocks depend crucially on how the monetary authority reacts to them and adjust its policy instrument.

In conclusion, we study the macroeconomic effects of IT uncertainty shocks, allowing for stochastic changes not only in the monetary authority IT but also in its own volatility. In our benchmark model (search frictions and nominal rigidities), we show that an increase in the volatility of the inflation target resembles a contractionary aggregate demand shock - unemployment increases, inflation falls - regardless the monetary authority interest rate rule. The inflation rate does not react positively to an IT volatility shock and, hence, this kind of uncertainty shocks do not generate the inflation bias that lowers recession, for instance, as Fasani and Rossi (2018). We show, however, that the macroeconomic effects of IT uncertainty shocks are quantitatively different and depend crucially on the Taylor-rule type adopted by the monetary authority (i.e,

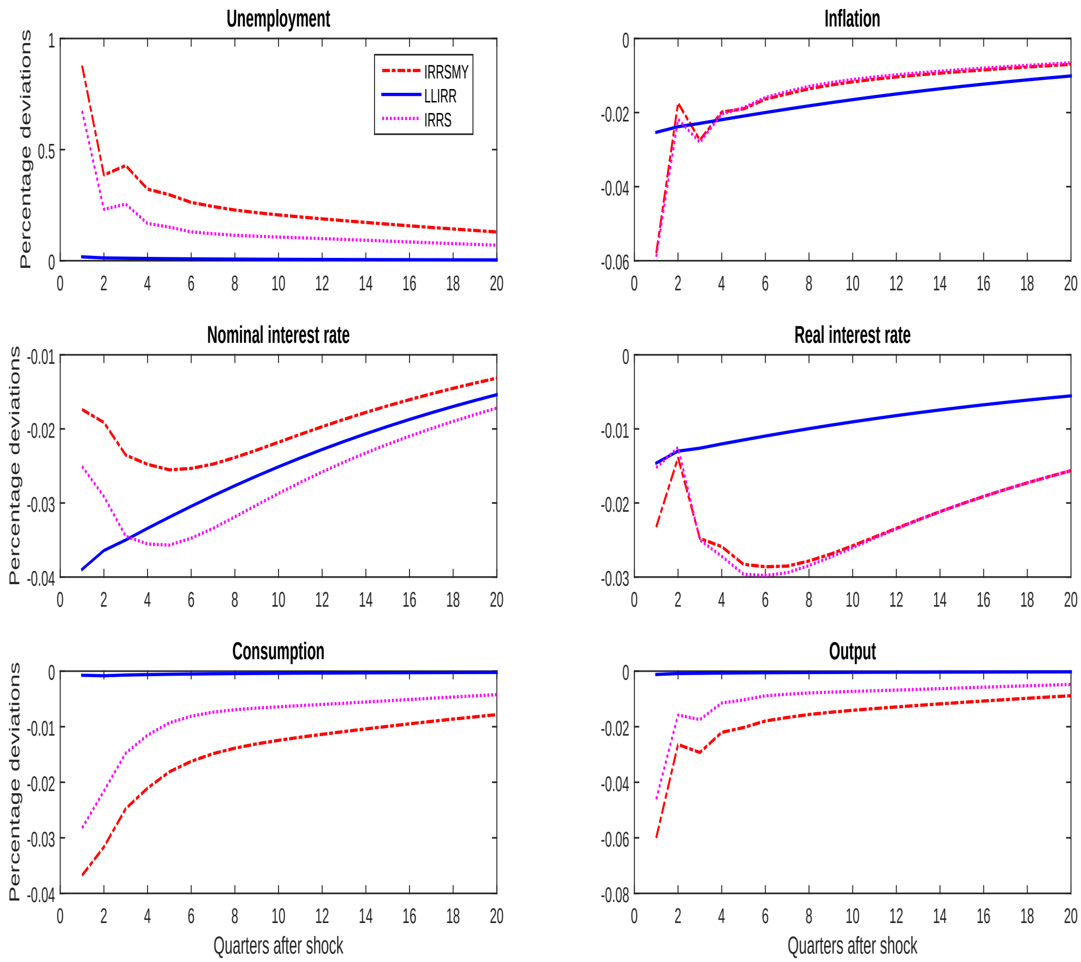

Figure 2: Impulse responses to an inflation target uncertainty shock

how the monetary authority reacts to them and adjust its policy instrument). A more reactive interest rate rule implies a less severe recession and deflation, while an empirical plausible degree of interest rate smoothing leads output, unemployment, and inflation to react more strongly causing the recession to be more severe and deflationary. From a comparison across alternative model economies (flexible prices, low search frictions and consumer habit), we observe a larger response of unemployment to an IT uncertainty shock in the presence of search friction (benchmark model), which is in line with Leduc and Liu (2016)'s findings.

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