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Managing monetary policy in a New Keynesian model with many beliefs types

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HIGHLIGHTS

- A NK model with an arbitrarily large number of agents2̌019 beliefs is considered.
- The concept of Large Type Limit allows to get analytical results on stability.
- The intensity of choice and the spread of beliefs are crucial for monetary policy.

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ABSTRACT

This paper considers a standard New Keynesian model with heterogeneous expectations on the future level of inflation and output. A biased perception of the target pursued by the Central Bank may arise due to idiosyncrasies in information processing, leading to heterogeneous beliefs about the target. We consider an arbitrarily large number of agents' beliefs and apply the concept of *Large Type Limit*. We find that an increase in the sensitivity of agents in selecting the optimal prediction strategy or in the spread of beliefs is crucial for the extent of the Central Bank to stabilize the economy. When the predictors are largely dispersed around the target, the Taylor principle is a requisite for stability since it prevents the self-fulfilling reinforcement mechanism between the realizations of the relevant macroeconomic variables and the forecasts of the agents. When the set of beliefs is somehow anchored to the target, stability can be achieved with weaker monetary policy.

1. Introduction

The recent macroeconomic literature has emphasized the role of managing private-sector expectations while addressing monetary policy. Woodford (2003) defines the activity of modern Central Bank (CB hereafter) as *management of expectations*. One theme emerging from this literature is that policy should account for its effects on private-sector expectations of future policy actions. The emergence of this topic stems from models that assume a representative agent structure and homogeneous private-sector expectations. This assumption is widespread despite the increasing evidence that agents have heterogeneous, possibly boundedly rational, expectations. Several works like Branch and McGough (2010) and De Grauwe (2011), introduced dynamic predictors selection into New Keynesian (NK henceforth) models with heterogeneous expectations and examined implications for monetary policy. Recently, Anufriev et al. (2013) adopted heterogeneous expectations in a simple frictionless DSGE model to investigate inflation dynamics under alternative interest rate rules.

In this paper we follow the line of research developed in Agliari et al. (2014, 2015), trying to fill the gap between the two works. In the first contribution authors presented a NK model in which agents use their perceived target to forecast future inflation and to form their beliefs about output gap consistently with the structural equation of the canonical NK model. The Large Type Limit (LTL henceforth) developed by Brock et al. (2005) is introduced to approximate the corresponding evolutionary

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system. Authors found that the Taylor principle is not always a sufficient condition to guarantee convergence to the target. In the second paper, instead, authors considered a model with independent expectations, assuming that agents do not know the structural equations of the NK model and how inflation and output affect each other.

In the present work, we extend the latter setting applying the LTL concept and investigating the model dynamics. In particular, we analyze the stability properties of the model when the number of forecasting rules increases and approaches infinity. We investigate whether a simple interest rate rule can implement the inflation and the output level targeted by the CB in the presence of recursive evaluation of beliefs. We find that the spread of initial beliefs and the sensitivity of the mass of agents in selecting the optimal prediction strategy (the so-called intensity of choice) plays a crucial role in determining the stability properties of the equilibrium. When the predictors are largely dispersed around the target, the Taylor principle is a requisite for stability since it prevents the self-fulfilling reinforcement mechanism between the realizations of the relevant macroeconomic variables and the forecasts of the agents. When the set of beliefs is somehow anchored to the target, stability can be achieved with weaker monetary policy.

The remainder of the paper is organized as follows: Section 2 recalls the NK setting with heterogeneous biased beliefs; Section 3 presents the LTL dynamics; Section 4 concludes.

2. Model

We consider a NK model along the lines of Clarida et al. (1999), which is extended to accommodate for heterogeneous beliefs (heuristics). The equations describing the demand and the supply side of the economy are the standard dynamic IS equation and the NK Phillips Curve:

$$y_t = E_t y_{t+1} + \sigma^{-1}(E_t \pi_{t+1} - i_t) \quad (1)$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t \quad (2)$$

where σ, β, κ are model parameters (set as in Clarida et al., 1999), y_t denotes the output gap, i_t is the nominal (risk free) interest rate, π_t is the inflation rate and $E = \int_i \hat{E}$ denotes the average expectation across agents (indexed by i), which might have heterogeneous beliefs due to the presence of idiosyncrasies in information processing.[1]

We close the model with a Taylor-type rule, whereby the nominal rate of interest reacts to contemporaneous values of inflation and output, assuming that the CB has a zero target for output and inflation:

$$i_t = \varphi_\pi \pi_t + \varphi_y y_t \quad (3)$$

where $\varphi_\pi, \varphi_y > 0$.

2.1. Evolutionary model with constant belief types

We assume agents do not fully understand how macroeconomic variables are determined and hence have biased beliefs. As a result of such cognitive limitations, there are differences in the use of information and thus heterogeneity in individual forecasts that may arise.

We refer to the works of Anufriev et al. (2013) and Agliari et al. (2015) to describe the evolutionary part of the model, namely the updating mechanism of agents' beliefs, addressing the cited papers for major details. Agents roughly know the fundamental steady state of the economy whereas they disagree about the correct value of the fundamental output and inflation steady state. They can choose among $2H + 1$ different symmetric constant forecasting rules,[2] where positive and negative biases are exactly balanced around the target equilibrium.[3]

Agents may overestimate the target by an amount b and d for output and inflation respectively, underestimate the target by an amount $-b$ and $-d$, or have correct beliefs about the target. The correct belief about the target is:

$$\hat{E}_{0,t} y_{t+1} = \hat{E}_{0,t} \pi_{t+1} = 0. \quad (4)$$

The other biased belief types are defined as:

$$b_h = \hat{E}_{h,t} y_{t+1} = \begin{cases} \dfrac{b}{h} & \text{if } 1 \le h \le H \\ -\dfrac{b}{2H+1-h} & \text{if } H+1 \le h \le 2H \end{cases}$$

$$d_h = \hat{E}_{h,t} \pi_{t+1} = \begin{cases} \dfrac{d}{h} & \text{if } 1 \le h \le H \\ -\dfrac{d}{2H+1-h} & \text{if } H+1 \le h \le 2H. \end{cases}$$

The fraction of agents choosing strategy h is given by the discrete choice model (see Brock and Hommes, 1997):

$$w_{h,t} = \frac{e^{\gamma U_{h,t-1}}}{\sum_{h=1}^{H} e^{\gamma U_{h,t-1}}} \quad (5)$$

$$z_{h,t} = \frac{e^{\gamma V_{h,t-1}}}{\sum_{h=1}^{H} e^{\gamma V_{h,t-1}}} \quad (6)$$

where γ represents the *intensity of choice* and reflects the sensitivity of agents in selecting the optimal strategy.[4] The higher

[1] Notice that this is the standard approach followed in the literature on monetary policy with different forecasting strategies (see, e.g., Brazier et al., 2008, De Grauwe, 2011, and Arifovic et al., 2013, among others). Micro-founded NK models consistent with heterogeneous expectations have been developed by Branch and McGough (2009), Kurz (2011), Kurz et al. (2013) and Massaro (2013). Eqs. (1) and (2) correspond to the model studied by Branch and McGough (2009) or to the model derived in Kurz (2011) and Kurz et al. (2013). We point out that in Kurz (2011) and Kurz et al. (2013) there are additional components in the demand and supply equations, representing respectively the deviation of the average of agents' forecasts of their individual future consumption from the average forecast of aggregate consumption $\int_i (E_{i,t} c_{i,t+1} - E_{i,t} c_{t+1})$ and a similar term for price forecast $\int_i (E_{i,t} p_{i,t+1} - E_{i,t} p_{t+1})$. We regard these differences as i.i.d. disturbances (see Cornea et al., 2012, for an empirical assessment) and investigate the dynamics of the deterministic skeleton of the model.

[2] Anufriev et al. (2013) use a similar modeling approach. A finite class of forecasting rules seems reasonable, as boundedly rational agents may exhibit digit preference and restrict their inflation predictions to values in integer numbers (see e.g. Assenza et al., 2011). Within an ecology of simple constant prediction rules, agents are allowed to get different conclusions when processing information, as well as biases and idiosyncrasies. This assumption is quite general in the sense that individual (point) predictions can be seen as the result of an underlying mental process or estimation technique. Learning to forecast laboratory experiments with human subjects have shown that individuals use very simple rules, including constant predictors (see Assenza et al., 2011, 2014a,b; Hommes, 2011). Despite this evidence, in a world where the number of individuals is large, the economy can be well represented by the LTL approach, since it can be shown that the dynamics of the two settings are almost indistinguishable. Additionally, this technique allows us to derive an analytically tractable system with a unique equilibrium, which is desirable from a policy maker view point.

[3] Under the assumption of "symmetric" beliefs, the target is among the equilibria of the system and this allows us to address questions about its stability. However we remark that symmetry of beliefs is not essential for many qualitative features of the model.

[4] In principle $\gamma_1 \neq \gamma_2$ (where γ_1 and γ_2 represent the intensity of choice in output and inflation forecasts). For computational tractability, we consider $\gamma_1 = \gamma_2 = \gamma$ as in Anufriev et al. (2013).