European Economic Review 66 (2014) 39–62

Contents lists available at ScienceDirect

European Economic Review

journal homepage: www.elsevier.com/locate/eer

Optimal monetary policy when agents are learning

Krisztina Molnár [a,*], Sergio Santoro [b]

[a] Norwegian School of Economics (NHH), Bergen, Norway
[b] Economic Outlook and Monetary Policy Department, Bank of Italy, Rome

ARTICLE INFO

Article history:
Received 30 October 2012
Accepted 27 August 2013
Available online 13 November 2013

JEL classification:
C62
D83
D84
E52

Keywords:
Optimal monetary policy
Learning
Rational expectations

ABSTRACT

We derive optimal monetary policy in a sticky price model when private agents follow adaptive learning. We show that this slight departure from rationality has important implications for policy design. The central bank faces a new intertemporal trade-off, not present under rational expectations: it is optimal to forego stabilizing the economy in the present in order to facilitate private sector learning and thus ease the future intratemporal inflation-output gap trade-offs. The policy recommendation is robust: the welfare loss entailed by optimal policy under learning if the private sector actually has rational expectations is much smaller than if the central bank mistakenly assumes rational expectations when in fact agents are learning.

1. Introduction

> *Monetary policy makers can affect private-sector expectations through their actions and statements, but the need to think about such things significantly complicates the policymakers' task.* (Bernanke, 2004)

Optimal monetary policy design is extensively studied under the assumption of rational expectations (REs). Despite the fact that the role of deviations from RE is emphasized in several theoretical and empirical papers,[1] the influence of less-than-rational expectations on the optimal policy conduct is not yet well understood. Instead, earlier literature examined the robustness of Taylor rules derived under RE and have shown that slight deviations from rationality are important for policy design. Taylor rules that are optimal or guarantee determinacy under RE, can lead to instability if private expectations follow adaptive learning (see Bullard and Mitra, 2002; Evans and Honkapohja, 2003a, 2003b, 2006).

In this paper, we investigate the interaction between departures from RE and monetary policy from a different angle: instead of examining the asymptotic behavior of Taylor rules, we address the issue of how a rational central bank (CB) should optimally conduct monetary policy if the private sector forms expectations with adaptive learning. We assume that the CB is rational within the model, knows how private agents form their expectations and takes their expectation formation scheme into account when solving its control problem. We conduct our analysis in a standard dynamic stochastic general equilibrium (DSGE) model with nominal rigidities in order to facilitate comparison with the earlier literature.

* Corresponding author. Tel.: +47 559 59368.
E-mail addresses: krisztina.molnar@nhh.no (K. Molnár), sergio.santoro@bancaditalia.it (S. Santoro).

[1] See for example Marcet and Nicolini (2003), Milani (2007), and Slobodyan and Wouters (2012).

0014-2921/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.euroecorev.2013.08.012

The main contribution of this paper is to derive the optimal solution analytically. The advantage of closed-form solutions is to provide a better understanding of policy trade-offs. There is a well known *intratemporal* inflation-output gap trade-off. We show that a slight departure from RE introduces a new *intertemporal* trade-off. In period t the CB foregoes stabilizing the economy in the way that would be optimal under RE and discretion, in order to anchor future inflation expectations better, hence easing the future intratemporal inflation-output gap trade-off. Hence a slight departure from rationality is not only relevant for stability of the equilibrium, but inherently changes policy design. Our quantitative analysis shows that incorporating the intertemporal tradeoff into policymaking increases welfare substantially even if the departure from RE equilibrium is small.

Our policy recommendation is that stabilizing private inflation expectations is more important when these deviate from rationality than under RE. Earlier literature analyzing the welfare effect of different Taylor rules have also shown that the CB should act against inflation beliefs more aggressively than what is suggested by an RE model (see for example Ferrero, 2007; Orphanides and Williams, 2005b, 2005c). Our analytical solutions rationalize these earlier numerical results.

In our setup the central bank can manipulate agents' expectations, but over time expectations become consistent with the central bank's policy. Therefore in the limit the Lucas critique does not apply: the central bank cannot manipulate expectations of the private sector indefinitely, in the limit agents do not make systematic mistakes.

Our results provide a rationale for the general practice by CB to closely monitor private sector expectations. Under RE this is not justified, since expectations are pinned down by the model and the monetary policy rule. Once we depart from rationality though, expectations become a state variable, therefore optimal policy should depend on private expectations.

Assuming that the CB knows and makes active use of the exact form of private expectations is undoubtedly a very strong hypothesis. In reality, there is still a lively debate about how to model private sector expectations; we account for this by performing two kinds of robustness checks, one under Knightian and the other under probabilistic uncertainty about private expectations. We compare the optimal learning rule derived in our paper to the time consistent optimal rule derived under RE. Our result is that when the CB is uncertain about the nature of expectations formation in the sense of Knight (1921),[2] the optimal learning rules derived in our paper are more robust. When the CB has instead a probability distribution defined over the set of possible forms of private expectations, the expected welfare losses are smaller under the optimal learning rules even if the CB assigns only a very small probability to the possibility that agents use learning instead of RE.

When expectations are rational, a credible CB can manipulate them by committing to a future course of action; under adaptive learning there is no such role for promises, since beliefs are affected only by past occurrences. Nevertheless, Sargent (1999), chapter 5, obtains the remarkable result that the optimal policy in the Phelps problem[3] is such that a CB which is patient enough can replicate the commitment solution under RE asymptotically. In our setup optimal policy does not replicate the commitment solution, but there is a qualitative similarity: the impulse response to a cost-push shock is similar to the commitment case in the sense that the contemporaneous impact of a cost-push shock on inflation is small (compared to the case of discretionary policy under RE) and inflation reverts to the equilibrium in a sluggish manner. This similarity is stronger when the CB is more patient. Both under RE and learning, this pattern results from CB's ability to directly manipulate private expectations, even if the channels used are quite different. Under commitment, the policymaker uses *credible promises about the future*, while under learning, the pattern results from the impact that *past actions* have on beliefs. Thus, the ability to manipulate future private sector expectations through the learning algorithm plays a role similar to a commitment device under RE, hence eases the future short-run trade-off between inflation and the output gap.

So far there is a fairly small literature that examines optimal policy when private agents deviate from rationality in a different way then our paper. In these papers the optimization can only be done numerically, because agents learn in a nonlinear fashion. Their results support our main policy recommendation: if the private sector is not fully rational there is an increased concern for stabilizing inflation expectations. In a closely related paper, Gaspar et al. (2006) focus on the case of private agents learning about the persistence of inflation when firms index to lagged inflation. Their numerical simulations show that an optimally behaving CB aims to anchor inflation expectations better. Similar numerical findings are reported in Mele et al. (2012), where agents form their beliefs assuming that macro variables depend on lagged output gap, as in the RE equilibrium under commitment (see Clarida et al., 1999).

The rest of the paper is organized as follows. In Section 2, after briefly recalling the discretionary optimal policy when expectations are rational, we show the existence of the new intertemporal trade-off under learning. Section 3 characterizes the optimal allocations (and the interest rate rule that supports them) when agents use constant gain learning, explaining how the presence of the intertemporal trade-off increases the CB aggressiveness against inflation beliefs. Section 4 relaxes the assumption that expectations follow constant gain learning and shows that our main results remain valid under decreasing gain learning. Section 5 argues that the optimal policy rule derived in the previous sections is robust to uncertainty about the agents' expectations formation mechanism and Section 6 concludes.

[2] Knightian uncertainty refers to the impossibility of forming a probability assessment of the possible states of the world.

[3] Phelps (1967) formulates a control problem for a natural rate model with a rational CB and private agents endowed with a mechanical forecasting rule, known to the CB.