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Price indexation, habit formation, and the Generalized Taylor Principle

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ABSTRACT

We prove that the Generalized Taylor Principle, under which the nominal interest rate reacts more than one-for-one to a change in inflation in the long run, is a necessary and (under some extra mild restrictions on parameters) sufficient condition for determinacy in a sticky price model with interest rate smoothing in monetary policy, partial dynamic price indexation, and habit formation in consumption.

1. Introduction

One of the most important guiding principles for practical monetary policy is the Generalized Taylor Principle, which asserts that in order to ensure price stability, the nominal interest rate needs to respond more than one-for-one to a change in inflation in the long run. Indeed, Bullard and Mitra (2002), Woodford (2003), and Lubik and Marzo (2007) show that the Generalized Taylor Principle is a necessary and sufficient condition for a unique stable equilibrium in simple sticky price models when the central bank follows a Taylor rule, that is, a rule where the nominal interest rate responds to both inflation and output.

While these results are highly influential, most sticky price models that are taken to the data now routinely feature various propagation mechanisms such as habit formation and price indexation, following Christiano et al. (2005) and Smets and Wouters (2007). To the best of our knowledge, the determinacy properties of such models have been studied only numerically.

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We contribute to the literature by showing analytically that the Generalized Taylor Principle is a necessary and (under some extra mild restrictions) sufficient condition for determinacy in a more general environment than considered by previous studies.[1] In particular, we consider a sticky price model with dynamic partial price indexation and habit formation in consumption and in which the central bank follows a Taylor rule where the nominal interest rate is determined by its lag and partially responds to both contemporaneous inflation and output.[2]

We find that habit formation in consumption and interest rate smoothing in the Taylor rule do not affect the determinacy condition. This is because interest rate smoothing does not change the extent of long-run response of interest rates to inflation while habit formation does not affect the long run trade-off between inflation and output. In contrast, dynamic partial price indexation decreases the long-run trade-off, and hence requires monetary policy to respond to inflation and/or output more strongly to ensure determinacy. It is however easy to see from our analytical determinacy condition that, while dynamic partial price indexation in principle alters the exact condition, it does so minimally and hence is likely to be not relevant quantitatively.[3] The key contribution of our paper is thus to show explicitly that the conventional wisdom, with some appropriate adjustments, continues to hold both theoretically and practically even when three popular propagation mechanisms are introduced into the textbook model at once.

As an extension, we also analyze a model with an alternative monetary policy specification where the nominal interest rate responds to expectations of inflation and output. It is found as in Bullard and Mitra (2002) and Woodford (2003), who analyzed the prototypical sticky price model, that the Generalized Taylor Principle provides a lower bound for the extent to which the nominal interest rate responds to inflation and output while a second necessary condition provides an upper bound.[4] Unlike the model with the contemporaneous monetary policy rule, however, the overall determinacy condition depends on habit formation in consumption and interest rate smoothing as the upper bound is a function of the parameters that govern habit formation in consumption and interest rate smoothing.[5]

Our results can be practically applied in likelihood-based estimation of monetary models to impose parameter restrictions that lead to determinacy or indeterminacy separately. For example, in Bhattarai et al. (2012), we estimate a sticky price model under different combinations of monetary and fiscal policy regimes and where each regime (including one that features indeterminacy) is imposed by making use of the analytical boundary condition derived here. In particular, having an analytical boundary greatly aids in making the posterior simulation stable and helps substantially with convergence.

Finally, our approach of analyzing the determinacy property produces a methodological contribution. In particular, we demonstrate that the Rouché Theorem (Glicksberg, 1976) can be usefully applied when obtaining a determinacy condition is not straightforward. Our paper is a simple illustration of the method, where we employ a standard model with some propagation mechanisms as a laboratory.

2. Model

The model is based on the prototypical New Keynesian set-up in Woodford (2003), augmented with some propagation mechanisms. The detailed exposition of the model is in the Appendix. Here, we present the log-linearized equilibrium conditions and the monetary policy rule which are

$$(Y_t-\eta Y_{t-1})=(E_tY_{t+1}-\eta Y_t)-(1-\eta)(R_t-E_t\pi_{t+1})+d_t, \tag{1}$$

$$(\pi_t-\gamma\pi_{t-1})=\beta(E_t\pi_{t+1}-\gamma\pi_t)+\kappa\left[\varphi Y_t+\frac{1}{1-\eta}(Y_t-\eta Y_{t-1})\right]+u_t, \tag{2}$$

$$R_t=\rho_R R_{t-1}+(1-\rho_R)(\phi_\pi\pi_t+\phi_Y Y_t)+\varepsilon_{R,t}, \tag{3}$$

where Y is output, π is inflation, and R is the nominal interest rate.[6] The parameter $0<\eta<1$ governs habit formation, $0<\gamma<1$ governs dynamic price indexation, $0<\beta<1$ is the discount factor, $\kappa>0$ is a composite parameter that depends

[1] Our paper fits generally in the literature that analyzes determinacy properties of extended versions of the prototypical sticky price model. Carlstrom et al. (2006) show analytically that the Taylor principle is a necessary and sufficient condition for determinacy in a two-sector model where the nominal interest rate responds only to inflation while Carlstrom and Fuerst (2005) show analytically that the Taylor principle is a necessary condition for determinacy in a one-sector model with investment where the nominal interest rate responds only to (current) inflation. Moreover, Benhabib and Eusepi (2005) show numerically that nominal interest rate responding to both inflation and output is quite effective in ensuring determinacy in models with both capital and bonds. Finally, Sveen and Weinke (2005, 2007) show numerically that while the Taylor principle is not sufficient for determinacy in a sticky price model with investment when capital is firm-specific and where the nominal interest rate responds only to inflation, if the nominal interest rate also responds to output, determinacy is much more likely to be ensured.

[2] To preserve analytical tractability, we do not allow for sticky wages or investment in the model.

[3] It is well-understood that the coefficient on output in a Taylor rule – while it matters theoretically – does not affect the determinacy condition substantially because there are other parameters involved in the output-inflation trade-off. The price indexation parameter turns out to be quantitatively unimportant for a similar reason.

[4] That is, the reaction of interest rates to inflation and output cannot be very high.

[5] Again, quantitatively however, the upper bound is not likely to bind (as is the case in the prototypical model) and thus these two features do not matter practically.

[6] Y, π, and R denote the log deviation of the variables from their respective state value. To keep the presentation uncluttered, we do not use a hat to denote log deviations. Note that in the Appendix, variables with no hats denote variables in levels, not log deviations.