Discussion

Craig Burnside

Eva Ortega and Nooman Rebei's paper characterizes optimal monetary policy reaction functions for a small open economy, with a particular focus on Canada. Using a two-sector, small open economy, dynamic stochastic, general-equilibrium (2S-SOE-DSGE) model, they measure the level of household welfare under a variety of monetary policy rules that determine the nominal interest rate as a linear function of such variables as inflation, the price level, the output gap, and lagged interest rates. An interesting aspect of their paper is its emphasis on the comparison of welfare across monetary policies that can be characterized as inflation targeting or price-level targeting.

My comments focus, first, on the relationship between the paper and the extensive existing literature. In this regard, Ortega and Rebei's paper is an example of frontier work on optimal policy in open economies. It uses a state-of-the-art model, solved and estimated with state-of-the-art techniques, while remaining in the tradition of the existing literature, in that it studies simple linear feedback rules for interest rates. Second, I highlight Ortega and Rebei's key results. Some of these are consistent with the literature, while others are less easily understood. Finally, I argue that the paper is in the tradition of Lucas's (1980) argument in favour of using fully specified models as laboratories in which to conduct policy analysis. On the other hand, I suggest that the authors have not gone far enough in showing that their model satisfies Lucas's requirement that a model used for policy analysis should be a useful imitation of the actual economy. This criticism is something Ortega and Rebei could consider in future work.

Relationship to the Literature

Questions regarding the correct monetary target go back well into history. My discussion centres on work in this area since 1990. In the early and mid-1990s, a considerable literature compared the performance of inflation targeting and price-level targeting. This literature looked mainly at Taylor-type rules (ones that specify linear feedback from inflation/prices and the output gap to interest rates) within the context of simple models that combined a short-run Phillips curve and an ad hoc model of the monetary authority's loss function. Much, but not all, of this literature seems to have concluded that inflation targeting is preferable.[1] Svensson (1999), on the other hand, argues that this result depends on a comparison of exogenously imposed policy rules under commitment. He argues that if rules are chosen endogenously without commitment, one can easily obtain the reverse finding, that price-level targeting would be preferred. Ortega and Rebei's paper is more in the tradition of the prior literature, in that they studied imposed monetary rules, without raising issues of commitment. They also do not address issues centring on the fact that some households have substantial portions of their incomes that are fixed in nominal terms, since their model abstracts from this concern.

A subsequent innovation in the literature was to study similar questions in the context of more formal models of the economy. An influential example is Rotemberg and Woodford's (1999) paper in which they study optimal simple interest rate rules in a linearized sticky-price DSGE model. In particular, they study interest rate rules of the form

$$\hat{r}_t = \rho \hat{r}_{t-1} + a(\hat{\pi}_t \text{ or } \hat{P}_t) + b\hat{y}_t, \tag{1}$$

where $\hat{\pi}_t$ and $\hat{P}_t$ represent deviations of inflation and the price level from target, $\hat{y}_t$ is the output gap, and $\hat{r}_t$ is the deviation of the nominal interest rate from its steady-state level implied by the monetary rule. Rotemberg and Woodford consider welfare measures based on second-order approximations to households' expected utility. They find that an interest-rate-smoothing version of the inflation-targeting rule achieves the best outcome, but the best price-level-targeting rule does nearly as well. As it turns out, both rules achieve a level of expected utility that is nearly the same as that implied by the use of optimal state-contingent monetary policy. Rotemberg and

1. Lebow, Roberts, and Stockton (1992); Fischer (1994); and Haldane and Salmon (1995), in particular, emphasize this result. Other early work related to this topic includes Crawford and Dupasquier (1994), Duguay (1994), Fillion and Tetlow (1994), Goodhart and Viñals (1994), Konieczny (1994), Scarth (1994), Haldane (1995), Svensson (1996), and Taylor (1996).

Woodford's innovation seems to have stuck, and most of the literature, including Ortega and Rebei's, follows in this tradition. Interestingly, in his textbook, Woodford (2003, 535)—while advocating the continued use of DSGE models—suggests that outcomes be evaluated using simple quadratic loss functions written in terms of policy-target variables.

On a slightly different tack, Williams (2003) studies the FRB/US model with an ad hoc quadratic loss function. He finds that simple interest-rate-smoothing rules perform nearly as well as optimal policy. But Williams also very helpfully reviews the literature on the properties of simple rules in a variety of models, including DSGE models. His general conclusion is that the best simple interest-rate-smoothing rules are nearly as good as optimal state-contingent policy. Pushing the frontier further, Juillard, Karam, Laxton, and Pesenti (2004) estimate a DSGE model for the US economy using the methods proposed by Smets and Wouters (2003). They evaluate welfare using second-order approximations to household utility, and solve the model using perturbation methods that have been shown to improve welfare measurement. An interesting result is that the best optimized simple rules lie near the Taylor frontier, i.e., the locus of best possible outcomes on the basis of an ad hoc quadratic loss function.

It is difficult to summarize this literature, but a quick summary might suggest that simple rules do nearly as well as state-contingent policy, inflation targeting is slightly preferred to price-level targeting, and rules chosen using utility-based welfare measures do not depart greatly from rules selected using ad hoc loss functions defined over inflation and the output gap.

More recently, the literature has focused somewhat more attention on models of open economies. Kollman (2002) uses a 2S-SOE-DSGE model and studies Taylor rules of the form: $i_t = i + \alpha\hat{\pi}_t - \beta\hat{y}_t$. To evaluate his model quantitatively, Kollman calibrates it and evaluates welfare using a utility-based measure. He solves the model using the second-order approximation method of Sims (2000). Kollman finds that almost complete producer price index inflation stabilization (big α, small β) is optimal, a result that is consistent with earlier results from the New Open Economy Macroeconomics literature (see Aoki 2001, Devereux and Engel 2003, and Galí and Monacelli 2004) for the case of perfect pass-through.

Smets and Wouters (2002), like Kollman, use a DSGE model of an open economy, but study policy using an ad hoc loss function. An innovation here is that they study imperfect pass-through, under which the optimal simple policy rule targets domestic and import price inflation. The relative weight in the rule is heaviest for the sector in which prices are stickiest. These results appear to reflect the somewhat different analysis in Corsetti and

Pesenti (2000) and Erceg, Henderson, and Levin (2000), who conclude that in models where prices are sticky in multiple sectors (including the labour market), the optimal simple rule typically targets both sectoral prices and weights them according to their stickiness.

In terms of econometric methodology, Ortega and Rebei's paper is a close cousin of Smets and Wouters (2003). They use Bayesian methods to estimate almost all of the model parameters, while a handful are calibrated.[2] Like Kollman, their welfare measure is utility-based, and is evaluated using perturbation methods. The authors use a DSGE model of an open economy, as do Kollman (2002) and Smets and Wouters (2002), but the authors have an even broader specification of the sectoral structure of the model, with the possibility of price stickiness in traded, non-traded, and imported goods, as well as in the labour market. Ortega and Rebei, like much of the recent literature, study simple interest rate rules.

Main Findings

Ortega and Rebei primarily study rules of the form (1), to compare inflation to price-level targeting. But they also expand the policy rule to check whether targeting wage inflation, in addition to price inflation, would be optimal. Furthermore, they examine rules where the aggregate inflation rate is replaced by measures of sectoral inflation (in particular, $\hat{\pi}_t^M$, $\hat{\pi}_t^N$, $\hat{\pi}_t^T$, the inflation rates for imported, non-traded, and imported goods), each of which enters the rule separately.

When the policy rule is restricted to take the form (1), complete CPI inflation stabilization appears optimal (i.e., a very large value of a), with inflation stabilization and CPI-level targeting achieving closely proximate, but inferior, welfare levels. This seems consistent with the previous literature. However, when wage inflation, $\hat{\pi}_t^W$, is brought into the policy rule:

$$\hat{r}_t = \rho \hat{r}_{t-1} + a\hat{\pi}_t \text{ or } b\hat{y}_t + c\hat{\pi}_t, \tag{2}$$

it turns out to be optimal to give it no weight $(c = 0)$. This seems surprising given the earlier literature. When sectoral inflation rates are entered into the policy rule,

$$\hat{r}_t = \rho \hat{r}_{t-1} + a^M \hat{\pi}_t^M + a^N \hat{\pi}_t^N + a^T \hat{\pi}_t^T, \tag{3}$$

2. One might be tempted to refer to the authors' approach as maximum likelihood. However, because diffuse priors are not used in their analysis, the results are not fully equivalent to maximum likelihood.

only non-traded-goods inflation ($\hat{\pi}_t^N$) enters with any weight in the optimal rule. This result also seems surprising, even though non-traded goods have the stickiest prices. According to the authors' estimates, prices in all sectors are sticky, so we might have expected the optimal rule to give some weight to all inflation rates.

Perhaps most striking is Ortega and Rebei's finding that the welfare levels achievable with non-traded-goods inflation targeting appear to be significantly higher than with any other rule. Furthermore, these welfare levels are significantly higher than the welfare levels possible if the price level of the non-traded goods is targeted instead. Such a striking result seems to be a rare bird indeed in the literature.

Comments

In the early 1980s, Robert E. Lucas, Jr. (1980, 696), suggested that:

> One of the functions of theoretical economics is to provide fully articulated, artificial economic systems that can serve as laboratories in which policies that would be prohibitively expensive to experiment with in actual economies can be tested out at much lower cost.

To me, the exercises in policy evaluation in Ortega and Rebei's paper are fully in the spirit of Lucas's suggestion. The recent literature, and this paper, estimate fully articulated DGSE models, using state-of-the-art econometric methods, and evaluate policies using appropriate welfare measures.

But Lucas also suggested (pp. 696–7) that

> At the same time, not all well-articulated models will be equally useful. Though we are interested in models because we believe they may help us to understand matters about which we are currently ignorant, we need to test them as useful imitations of reality by subjecting them to shocks for which we are fairly certain how actual economies, or parts of economies, would react.

In my opinion, Ortega and Rebei do not go far enough to persuade us that their model is a good laboratory, in the sense that it is a useful imitation of the Canadian economy. Although they present some volatility measures and impulse-response functions, they do not explore the general business cycle properties of the model. Does the model generate a realistic amount of volatility in consumption, hours worked, output, and investment? Since the model describes an open economy, does the trade balance behave in a manner consistent with stylized facts for Canada? Without answers to these

questions, I find it difficult to have confidence that the policy analysis is relevant. I am also somewhat disquieted by the fact that an open economy model with four sectors displaying price stickiness can have all of its parameters estimated using only aggregate data series. The authors' graphs of the posterior distributions of the parameter estimates suggest that the aggregate data inform us about sectoral-level parameters. Nonetheless, I would like to see more about the properties of the model at the sectoral level.

As I mentioned earlier, the results, in general, seem consistent with some of the previous findings in the literature. But there are two primary inconsistencies: the fact that it appears optimal to target only the inflation rate in the stickiest sector, and the fact that welfare can be increased significantly when this is done. I would like to see a more thorough explanation of these findings. In the end, this is a paper about policy, and for policy-makers to accept these results, they would need to understand them.[3]

Finally, I would like to encourage the authors not to HP-filter their data prior to model estimation. The authors use the HP-filter to render their data stationary, but do not transform the model because it is already written in stationary terms. There are two reasons not to do this. First, it is far from obvious that economic agents in Canada derive utility from deviations of consumption and labour effort from trend. Second, if one transformed the model into a non-stationary one, by adding deterministic or stochastic growth in technology, and by having regime shifts in policy, the state-space representation of the stationary model would not correspond to the ARMA (autoregressive moving average) representation of simulated (and HP-filtered) data from the non-stationary model.[4]

Conclusion

Ortega and Rebei have written a fine paper that lies at the frontier of work on the welfare implications of different monetary rules. My criticism of their paper lies mainly in the fact that they did not thoroughly explore the business cycle properties of their model and did not explain a couple of their key findings. I believe these points could easily be addressed in future work.

---

3. The results related to non-traded-goods prices are tantalizing. But an issue the authors do not grapple with is, what would policy-makers do with this result, even if they accepted it? Is there something that analysts at the Bank of Canada could identify that would specifically map to the model's concept of a non-traded-goods price?

4. Another way to put this is that there is no parameterization of the lag polynomial implicit in the stationary model's state-space representation that, when inverted and applied to the HP-filtered data, will produce white-noise errors corresponding to the shocks in the model.

References

Aoki, K. 2001. "Optimal Monetary Policy Responses to Relative-Price Changes." *Journal of Monetary Economics* 48 (1): 55–80.

Corsetti, G. and P. Pesenti. 2000. "Optimal Interest Rate Rules and Exchange Rate Pass-through." Federal Reserve Bank of New York. Unpublished manuscript.

Crawford, A. and C. Dupasquier. 1994. "Can Inflation Serve as a Lubricant for Market Equilibrium?" In *Economic Behaviour and Policy Choice Under Price Stability*, 49–80. Proceedings of a conference held by the Bank of Canada, October 1993. Bank of Canada: Ottawa.

Devereux, M.B. and C. Engel. 2003. "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange-Rate Flexibility." *Review of Economic Studies* 70 (4): 765–83.

Duguay, P. 1994. "Some Thoughts on Price Stability versus Zero Inflation." Bank of Canada. Unpublished manuscript.

Erceg, C.J., D.W. Henderson, and A.T. Levin. 2000. "Optimal Monetary Policy with Staggered Wage and Price Contracts." *Journal of Monetary Economics* 46 (2): 281–313.

Fillion, J.-F. and R. Tetlow. 1994. "Zero-Inflation or Price-Level Targeting? Some Answers from Stochastic Simulations of a Small Open Economy Macro Model." In *Economic Behaviour and Policy Choice Under Price Stability*, 129–66. Proceedings of a conference held by the Bank of Canada, October 1993. Ottawa: Bank of Canada.

Fischer, S. 1994. "Modern Central Banking." In *The Future of Central Banking: The Tercentenary Symposium of the Bank of England*, 262–308, edited by F. Capie, C. Goodhart, S. Fischer, and N. Schnadt. Cambridge: Cambridge University Press.

Galí, J. and T. Monacelli. 2004. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *Review of Economic Studies* 72 (3): 707–34.

Goodhart, C.A.E. and J. Viñals. 1994. "Strategy and Tactics of Monetary Policy: Examples from Europe and the Antipodes." In *Goals, Guidelines, and Constraints Facing Monetary Policymakers*, 139–87, edited by J.C. Fuhrer. Boston: Federal Reserve Bank of Boston.

Haldane, A.G. (ed.). 1995. *Targeting Inflation*. London: Bank of England.

Haldane, A.G. and C.K. Salmon. 1995. "Three Issues on Inflation Targets." In *Targeting Inflation*, 170–201, edited by A.G. Haldane. London: Bank of England.

Juillard, M., P. Karam, D. Laxton, and P. Pesenti. 2004. "Welfare-Based Monetary Policy Rules in an Estimated DSGE Model of the US Economy." Federal Reserve Bank of New York. Unpublished manuscript.

Kollman, R. 2002. "Monetary Policy Rules in the Open Economy: Effects on Welfare and Business Cycles." *Journal of Monetary Economics* 49 (5): 989–1015.

Konieczny, J.D. 1994. "The Optimal Rate of Inflation: Competing Theories and Their Relevance to Canada." In *Economic Behaviour and Policy Choice Under Price Stability*, 1–40. Proceedings of a conference held by the Bank of Canada, October 1993. Ottawa: Bank of Canada.

Lebow, D.E., J.M. Roberts, and D.J. Stockton. 1992. "Economic Performance under Price Stability." Working Paper No. 125, Division of Research and Statistics, Board of Governors of the Federal Reserve System, Washington, DC.

Lucas, R.E., Jr. 1980. "Methods and Problems in Business Cycle Theory." *Journal of Money, Credit and Banking* 12 (4) Part 2: 696–715.

Rotemberg, J.J. and M. Woodford. 1999. "Interest Rate Rules in an Estimated Sticky Price Model." In *Monetary Policy Rules*, 57–126, edited by J.B. Taylor. Chicago: University of Chicago Press.

Scarth, W. 1994. "Zero Inflation Versus Price Stability." In *Economic Behaviour and Policy Choice Under Price Stability*, 89–119. Proceedings of a conference held by the Bank of Canada, October 1998. Ottawa: Bank of Canada.

Sims, C.A. 2000. "Second Order Accurate Solution of Discrete Time Dynamic Equilibrium Models." Unpublished manuscript, www.princeton.edu/~sims.

Smets, F. and R. Wouters. 2002. "Openness, Imperfect Exchange Rate Pass-through and Monetary Policy." *Journal of Monetary Economics* 49 (5): 947–81.

———. 2003. "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area." *Journal of the European Economic Association* 1 (5): 1123–75.

Svensson, L.E.O. 1996. "Commentary: How Should Monetary Policy Respond to Shocks While Maintaining Long-Run Price Stability?—Conceptual Issues." In *Achieving Price Stability*, 209–27. Proceedings of a symposium held by Federal Reserve Bank of Kansas City. Kansas City: Federal Reserve Bank of Kansas City.

———. 1999 "Price-Level Targeting versus Inflation Targeting: A Free Lunch?" *Journal of Money, Credit and Banking* 31 (3): 277–95.

Taylor, J.B. 1996. "How Should Monetary Policy Respond to Shocks While Maintaining Long-run Price Stability?" In *Achieving Price Stability,* 181–95. Proceedings of a symposium held by the Federal Reserve Bank of Kansas City. Kansas City: Federal Reserve Bank of Kansas City.

Williams, J.C. 2003. "Simple Rules for Monetary Policy." *Federal Reserve Bank of San Francisco Economic Review,* 1–12.

Woodford, M. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy.* Princeton: Princeton University Press.