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Stabilizing Inflation in Iceland

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Abstract

This paper provides some empirical estimates on how tightly is it feasible to control inflation in a very small open economy such as Iceland. Estimated macroeconomic models of Canada, Iceland, New Zealand, the United Kingdom, and the United States are used to derive efficient monetary policy frontiers that trace out the locus of the lowest combinations of inflation and output variability that are achievable under a range of alternative monetary policy rules. These frontiers illustrate that inflation stabilization is more challenging in Iceland than in other industrial countries primarily because of the relative magnitudes of the economic shocks.

JEL Classification Numbers: E31, E32, E52, E61, E63

Keywords: Efficient policy frontier, monetary policy rules, inflation-output variability tradeoff, policy coordination

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Contents Page

I. INTRODUCTION

When economic shocks, either domestic or foreign, are large relative to the size of an economy, maintaining stability in output and prices can be a daunting challenge. This point has been aptly illustrated in Iceland. Starting in February 2005, CPI inflation repeatedly breached the upper bound of the Central Bank's tolerance range. Over 2004, aggregate demand in Iceland received enormous stimulus from investment in energy-intensive projects and innovations in financial markets. The labor income tax cuts that commenced in January 2005 amplified the effects of these developments, contributing further to excess demand pressures and high inflation over 2005 and early 2006. In part, these challenges are recognized in the structure of the inflation targeting framework adopted by the Icelandic government and the Central Bank in March 2001. The targeted rate of inflation, at 2½ percent, is slightly higher than the rate targeted by many other central banks. In addition, the tolerance range of ±1½ percentage points is also wider than the more common ±1 percentage point tolerance range of most other inflation targeting frameworks. However, the inflation performance in Iceland over 2005 and the first half of 2006 begs the question "How tightly is it feasible to control inflation in Iceland?" This paper provides some empirical insights on this question.

Since its introduction in Taylor (1979), the efficient monetary policy frontier has become widely used to estimate what a monetary authority can achieve in terms of inflation and output stability. The efficient monetary policy frontier traces out the locus of the lowest combinations of inflation and output variability that are achievable under a range of alternative rules for operating monetary policy when the economy under control is subjected repeatedly to economic disturbances. In this paper, estimated macroeconomic models for Canada, Iceland, New Zealand, the United Kingdom, and the United States are used to trace out efficient monetary policy frontiers under simple inflation-forecast-based monetary policy rules.[2] These frontiers suggest that the inflation-output variability trade-off faced by the monetary authorities in Iceland is much less favorable than those faced by the monetary authorities in many other industrial countries, even other small inflation-targeting countries like New Zealand. Although these results should be interpreted with caution because of the potential empirical limitations, they do point to directions for possible improvement. First, by effectively communicating the fact that inflation is more likely to be outside the tolerance range in Iceland than in other inflation targeting countries, the Central Bank may be able to minimize the negative impact that such tolerance-range breaches could have on inflation expectations. Second, as experience accumulates, the inflation targeting framework will need to continue to evolve, to better anchor inflation expectations. Third, consideration needs to be

[2] The authors gratefully acknowledge Philippe Karam for providing the initial code for the Bayesian estimation, Dirk Muir for providing examples of the code for constructing efficient frontiers, and the Central Bank of Iceland and the Reserve Bank of New Zealand for providing data.

given to other macroeconomic policy changes, such as greater coordination between fiscal and monetary policy, that could help improve the inflation-output variability trade-off.

The remainder of the paper is structured as follows. The small macroeconomic model used for the analysis is presented in Section II along with a very brief description of the estimation procedure. More details of the model and the estimation results are presented in the appendices. The resulting efficient policy frontiers under simple inflation-forecast-based policy rules are presented in Section III. Section IV considers how a systematically countercyclical fiscal stance can contribute to improving the inflation-output variability trade-off. Section V offers some suggestions for modifications to the monetary policy framework that could also improve the inflation-output variability trade-off. Section VI concludes.

II. The Model

The analysis is conducted using a small "New Keynesian" macroeconomic model with rational expectations. The key behavioral equations in the model consist of an output gap relation, an inflation equation, an exchange rate equation, and a monetary policy reaction function given by the following:

$$ygap_t = \beta_1 \cdot ygap_{t-1} + \beta_2 \cdot ygap_{t+1} - \beta_3 \cdot rrgap_{t-1} + \beta_4 \cdot zgap_{t-1} + \beta_5 \cdot ygap_t^* + \varepsilon_t^{ygap}, \qquad (1)$$

$$\pi_t = \delta_1 \cdot \pi_{t+4}^4 + (1-\delta_1) \cdot \pi_{t-1}^4 + \delta_2 \cdot ygap_{t-1} + \delta_3 \cdot \Delta z_t + \varepsilon_t^{\pi}, \qquad (2)$$

$$z_t = \varphi \cdot z_{t+1} + (1-\varphi) \cdot z_{t-1} - (rr_t - rr_t^*)/4 + \varepsilon_t^z / 4, \text{and} \qquad (3)$$

$$rs_t = \alpha_1 \cdot rs_{t-1} + (1-\alpha_1) \cdot (rr\_eq_t + \pi_t^4 + \alpha_2 \cdot (\pi_{t+4}^4 - \pi^T) + \alpha_3 \cdot ygap_t) + \varepsilon_t^{rs}, \qquad (4)$$

where *ygap* is the output gap, *rrgap* is the real interest rate gap, *zgap* is the real exchange rate gap, * denotes foreign variables, π is inflation, Δ is the first difference operator, z is the real exchange rate, rr is the real interest rate, rs is the nominal policy rate, rs_eq is the equilibrium nominal interest rate, ε denotes error terms and parameters are given by the βs, δs, φ, and αs.

For Canada, Iceland, New Zealand, and the United Kingdom, there are three additional behavioral equations that describe the foreign sector given by:

$$ygap_t^* = \beta_1^* \cdot ygap_{t-1}^* + \beta_2^* \cdot ygap_{t+1}^* - \beta_3^* \cdot rrgap_{t-1}^* + \varepsilon_t^{ygap*}, \qquad (5)$$

$$\pi_t^* = \delta_1^* \cdot \pi_{t+4}^{4*} + (1-\delta_1^*) \cdot \pi_{t-1}^{4*} + \delta_2^* \cdot ygap_{t-1}^* + \varepsilon_t^{\pi*}, \text{ and} \qquad (6)$$

$$rs_t^* = \alpha_1^* \cdot rs_{t-1}^* + (1-\alpha_1^*) \cdot (rr\_eq_t^* + \pi_t^{4*} + \alpha_2^* \cdot (\pi_{t+4}^{4*} - \pi^{T*}) + \alpha_3^* \cdot ygap_t) + \varepsilon_t^{rs*}. \qquad (7)$$

where * denote the foreign sector variables that are described above.

While this model is simple and abstracts from many important features of the economy, such specifications have long been the workhorse of monetary policy analysis.[3] In addition to effectively capturing the key channels of monetary policy transmission, this framework has the virtues of clarity and tractability. There are also several identities that complete the models, the details of which can be found in Appendix I.

The models' parameter values are estimated from the data using a Bayesian estimation technique. Considerable advancement in both computing power and software have made Bayesian estimation of structural rational expectations models feasible.[4] The Bayesian approach starts with prior distributions for the model parameters that are then combined with the data using the likelihood function to estimate the posterior distributions for the parameters. This approach has two important strengths. First, starting with prior distributions for the parameters allows other empirical evidence from a range of sources to enter into the estimation. Secondly, use of prior distributions makes the highly nonlinear optimization algorithm considerably more stable, making it feasible to apply the technique when sample periods are short. In addition, the estimation procedure also allows for measurement errors in the data. For Iceland this is important because the data are not seasonally adjusted and tend to be quite volatile. Some of the excess volatility in the data is thus allocated to measurement error which does not enter into the stochastic simulations that are conducted to trace out the efficient policy frontiers.

The prior distributions for the parameters have relied heavily on inputs from the associated central banks.[5] For Canada and the United States, impulse response functions from their central banks' policy models, QPM[6] and FRB/US,[7] as well as other feedback from the Bank of Canada and the Board of Governors of the Federal Reserve, as outlined in Berg, Karam, and Laxton (2006), have been used to pin down the prior distributions for the parameters. For New Zealand, the Reserve Bank of New Zealand provided priors for most model parameters based on their FPS[8] model and research work on similar small models contained in Liu (2006) and Lubik (2005). For Iceland, the starting point was the prior distributions for Canada and these were then augmented where specific Icelandic evidence was available such

[3] There is a growing literature in which models like the ones used here are derived from microeconomic optimizing foundations, for examples see Gali and Monacelli (2002) and Monacelli (2004).

[4] For a detailed description of the Bayesian estimation technique see Schorfheide (2000) and Geweke (1999). Details on the software for estimation can be found in Juillard (2004).

[5] Harrison and others (2005), which documents the Bank of England's main macroeconomic model, does not contain all the impulse response functions comparable to those in this small model so priors for the U.K. model were set equal to those for Canada.

[6] See Coletti and others (1996).

[7] See Brayton and Tinsley (1996).

[8] See Black and others (1997).

as in Pétursson (2002a) and IMF (2002). The models are estimated as open economies, where the United States is treated as the relevant foreign sector for Canada, and Iceland's foreign sector comprises an aggregate of the euro area, the United States, and the United Kingdom. New Zealand's foreign sector is described by the aggregates for the external sector used in the Reserve Bank of New Zealand's FPS model. The foreign sector for the United Kingdom is described by an aggregate of France, Germany, Italy, Norway, the Netherlands, the United States, and Japan. Details on the data, the prior distributions, and the resulting posterior distributions can be found in Appendix II.

III. Efficient Policy Frontiers and Their Implications

Using the estimates of the models' parameters and the estimated distributions for the stochastic shocks, solutions are derived for the variability in the behavioral variables under alternative monetary policy reaction functions. Here we restrict the choice set to simple inflation-forecast-based rules. Such rules have been found to be quite robust to the types of uncertainty faced by monetary policymakers,[9] can closely approximate the stabilization properties of fully optimal rules,[10] and are generally found to be appropriate characterizations of how monetary authorities actually respond.[11] The monetary policy reaction function under consideration has the following form:

$$rs_t = \alpha_1 \cdot rs_{t-1} + (1-\alpha_1)\cdot(rr\_eq_t + \pi_t^4 + \alpha_2 \cdot (\pi_{t+4} - \pi^T) + \alpha_3 \cdot ygap_t) + \varepsilon_t^{rs}. \tag{8}$$

The variance in the behavioral variables is computed for the response coefficient $\alpha_1 \in \{0.0, 0.05, ..., 0.75\}$, $\alpha_2 \in \{0.5, 0.75, ..., 15\}$ and $\alpha_3 \in \{0.5, 0.75, ..., 15\}$.[12] By varying the relative dislike for inflation versus output-gap variability (λ_π/λ_y) while minimizing a standard quadratic loss function of the form:

$$L = \sum_{t=0}^{\infty} \lambda_\pi \cdot (\pi_t - \pi^T)^2 + \lambda_y \cdot (ygap_t)^2, \tag{9}$$

the efficient policy frontier is traced out from the set of solutions. The resulting frontiers, when there are no constraints placed on interest rate variability, for Canada, Iceland, New Zealand, the United Kingdom, and the United States are presented in Figure 1.

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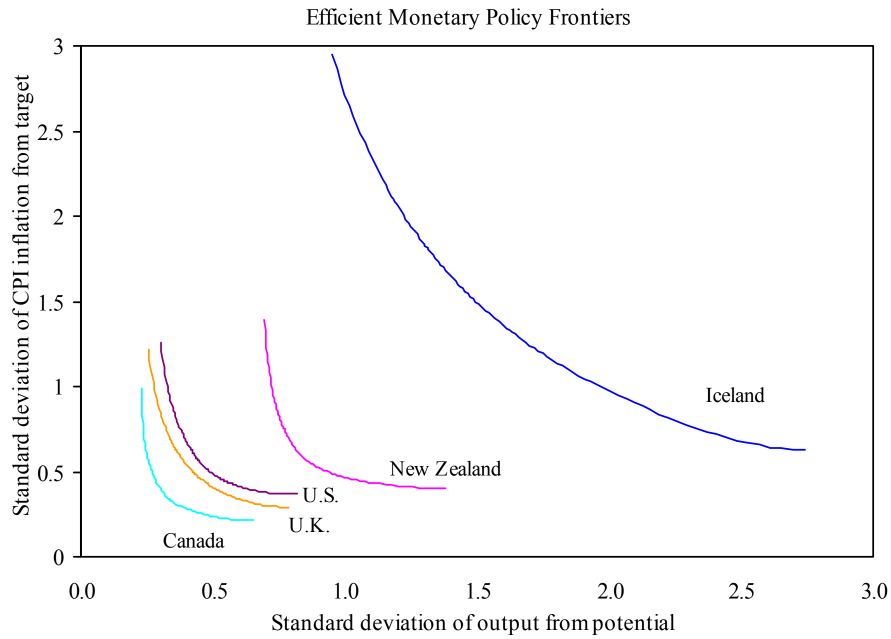
[9] See Levin, Wieland and Williams (1999) among others. More recent research such as Orphanides and Williams (2005) suggests that Taylor-type rules specified in first-difference terms may be even more robust to uncertainty.

[10] See Batini and Haldane (1999), Rudebusch and Svensson (1999) and Tetlow and von sur Muehlen (1999) among others.

[11] See for example, Clarida, Gali and Gertler (1998).

[12] In total, more than 50,000 alternative policy reaction functions are considered.

Figure 1



The efficient policy frontiers illustrate that the structure of the economy and the relative magnitudes of the economic shocks in Iceland result in a considerably less favorable inflation-output variability tradeoff than in the other industrial countries considered. Not surprisingly, the most similar country to Iceland is New Zealand, the next smallest country in the sample. A key factor determining where these efficiency frontiers lie is the magnitude of the economic disturbances to which the respective economies are subjected. Given the sample periods used for estimation, New Zealand and Iceland are both subject to bigger shocks than the other larger countries. The key difference between Iceland and New Zealand is that the inflation and exchange rate shocks in Iceland are considerably larger than those in New Zealand. Although both Canada and the United Kingdom are open economies and subject to shocks from the rest of the world, their efficient frontiers lie to the southwest of that for the United States. This reflects that fact that the estimated standard deviations of the shocks to Canadian and U.K. aggregate demand and inflation are lower than those for the United States (Appendix II).[13]

These frontiers suggest that inflation in Iceland is more likely to be outside the tolerance range than in other inflation targeting countries. For example, if Icelandic policymakers have equal dislike for inflation and output gap variability, these empirical results suggest that

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13 It also may be the case that openness can help, as it provides an additional channel, the exchange rate, through which changes in the monetary policy instrument can affect the output gap and inflation. It will be interesting to investigate this possibility in future analysis with this framework.

inflation can be kept within the 1 to 4 percent tolerance band roughly 74 percent of the time.[14] In contrast, the significantly lower variability of output and inflation in Canada and the United Kingdom suggests that inflation can be kept within these countries 1 to 3 percent tolerance band almost 100 percent of the time.[15] Even for New Zealand, these estimates suggest that inflation will be within their target band over 90 percent of the time. Based on these empirical estimates, for inflation in Iceland to lie within the tolerance range close to 90 percent of the time, the range would have to be roughly ±2¼ percentage points. For inflation to lie within the tolerance range close to 100 percent of time, the tolerance range would have to be ±4 percentage points.

Other factors not included in the above simulation analysis will shift the frontier toward the northeast, lowering the proportion of the time that inflation can be kept within the tolerance band. Other sources of uncertainty that policymakers face, and their preferences over interest rate variability (and related exchange rate variability), will shift the frontiers. Although the analysis incorporates uncertainty about future shocks, there are three other important sources of uncertainty that are missing: uncertainty about where the economy is today; uncertainty about key unobservable equilibrium variables like potential output, the neutral real interest rate, and the equilibrium real exchange rate; and uncertainty about the true structure of the economy. Research work examining the implications of these sources of uncertainty illustrates that they shift efficient monetary policy frontiers to the northeast.[16] This result is obtained primarily for two reasons. First, the uncertainty acts like another type of shock leading to additional unexpected volatility in outcomes because policy may be set inappropriately. Second, some uncertainties lead to efficient policy responses that are milder than under certainty. Less aggressive policy responses in turn result in greater variability in output and inflation. Dislike for variability in interest rates can lead to similar policy-response attenuation as illustrated in Figure 2. The thick policy frontiers are the ones that result when the policymaker's loss function is extended to include dislike for interest rate volatility as follows:

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[14] This assumes that the realizations of inflation outcomes around the midpoint of the tolerance range follow a normal distribution. The optimal point on the frontier when $\lambda_\pi = \lambda_y = 1$ yields a standard deviation in inflation around the target of 1.33 percent and a standard deviation of output around potential output of 1.62 percent. With a standard deviation of 1.33, the tolerance range of ±1.5 encompasses ±1.13 standard deviations (1.5/1.33), which, assuming normality, contains 74 percent of the distribution. This can be compared to the frequency of target range misses of 33 percent in Iceland, reported in *Monetary Bulletin* 2005/3: "Inflation target misses: A comparison of countries on inflation targets."

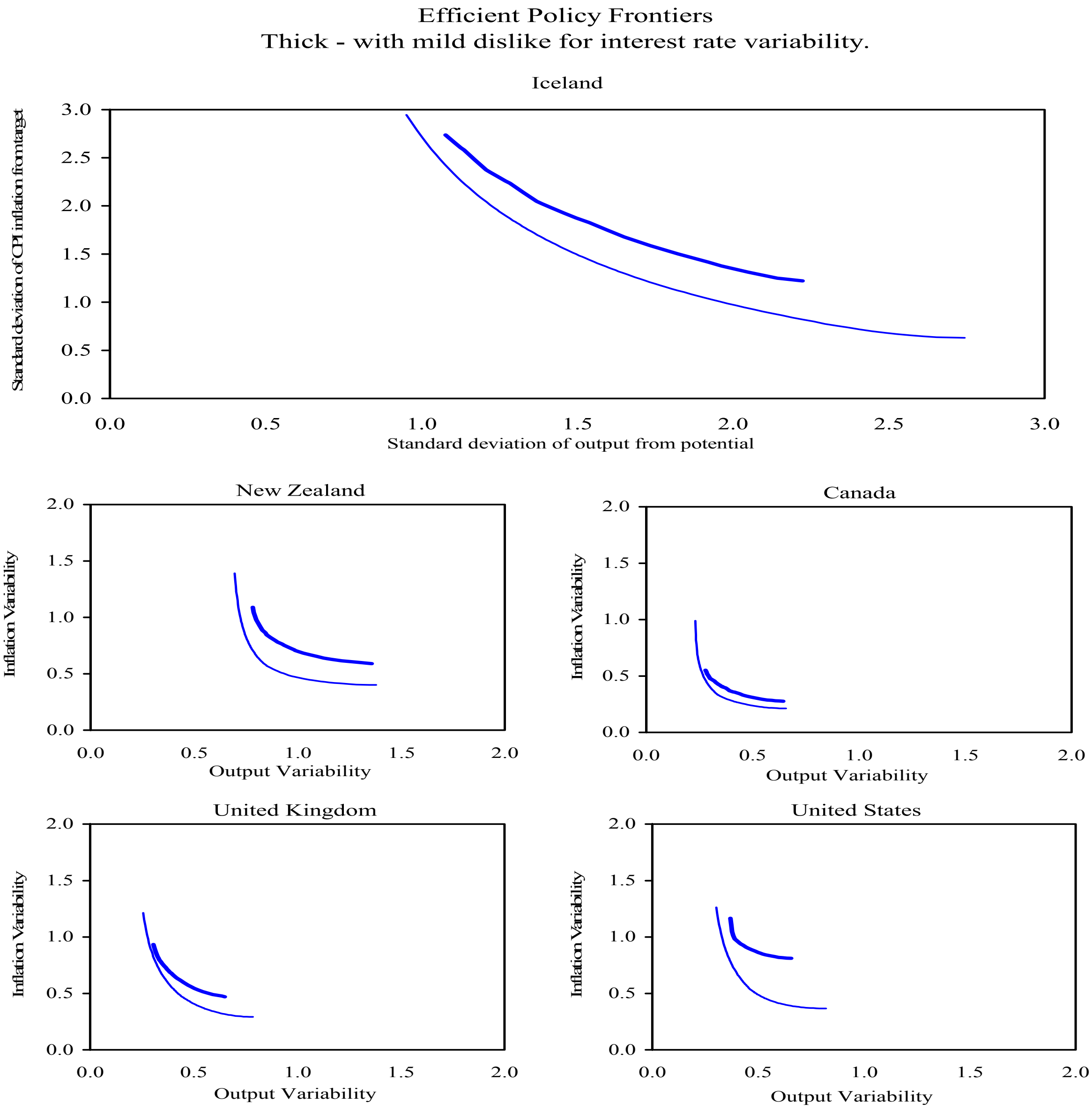
[15] For New Zealand, the standard deviation of inflation is 0.59 implying that their target band encompasses 1.69 standard deviations which contains 91 percent of the distribution. For the United Kingdom, the standard deviation of inflation is 0.43 implying their target band encompasses 2.32 standard deviations which contains 98 percent of the distribution. For Canada, the standard deviation of inflation is 0.33 implying that the target band encompasses 3.0 standard deviations which is virtually the complete distribution.

[16] For example see Levin and other (1999), Drew and Hunt (2001), Tetlow and von sur Muehlen (2002), and Hunt and Isard (2003).

$$L = \sum_{t=0}^{\infty} \lambda_{\pi} \cdot (\pi_t - \pi^T)^2 + \lambda_y \cdot (ygap_t)^2 + \lambda_{rs} \cdot (rs_t - rs_{t-1})^2, \qquad (10)$$

where λ_{rs} is the parameter that captures the degree of the policymaker's dislike for interest rate variability. The frontiers in Figure 2 are traced out with $\lambda_{rs} = 0.5$. The frontiers for all countries shift to the northeast. The dislike for interest rate variability is reflected in a decline in the magnitudes of the response coefficients in the policy rules that now lie on the frontier. Less aggressive responses to shocks are required to reduce the variability in interest rates which in turn leads to more volatility in output and inflation.

Figure 2: The Impact of Mild Dislike for Interest Rate Variability



Given the magnitude of the shift in the frontier for Iceland arising from simply limiting interest rate variability, it is conceivable that fully incorporating the impact of uncertainty could increase the achievable standard deviation of inflation to 1¾ percent or higher. This would reduce the proportion of time that inflation could be kept within the 1 to 4 percent tolerance range to 60 percent or less.

IV. The Potential Contribution of Countercyclical Fiscal Policy

While generally, the focus of fiscal policy should be on longer-term objectives, in a small open economy like Iceland subject to large shocks, rules-based countercyclical fiscal policy can play a role in reducing the high volatility in real activity, interest rates, the exchange rate, and external balance. To illustrate the potential contribution of coordinating monetary and fiscal policy, the small model is extended to allow for an endogenous countercyclical fiscal stance, and a new efficiency frontier for Iceland is computed.

The two-country model used in the previous section is extended by introducing a simple endogenous fiscal policy reaction function and incorporating the resulting fiscal balance gap into the aggregate demand equation. The new equation for the endogenous fiscal policy rule is given by:

$$fbgap_t = \theta_1 \cdot ygap_{t-1} + \theta_2 \cdot dgap_{t+1} + \varepsilon_t^{fbgap}, \quad (11)$$

where *fbgap* is the deviation of the fiscal balance as a share of GDP from its equilibrium value, *dgap* is the deviation of the government debt-to-GDP ratio from its equilibrium or target value, the θ*s* are response coefficients, and ε^{fbgap} is an estimated residual. The modified aggregate demand equation is given by:

$$ygap_t = \beta_1 \cdot ygap_{t-1} + \beta_2 \cdot ygap_{t+1} - \beta_3 \cdot rrgap_{t-1} + \beta_4 \cdot zgap_{t-1} + \beta_5 \cdot ygap_t^* - \beta_6 \cdot fbgap_{t-1} + \varepsilon_t^{ygap}, \quad (12)$$

where β_6 is an estimated parameter. The parameter estimates for this extended version of the model for Iceland are presented in Appendix III.

The fiscal rule is designed to simultaneously ensure a consistently countercyclical fiscal stance and achieve a stable public debt target. As indicated in equation (11) above, the fiscal rule is determined by a cyclical component, the output gap, and the government debt target. Fiscal policy thus responds to period t-1's output gap by reducing (adding) demand stimulus when there is positive (negative) output gap in the economy, but at the same time, it has a forward-looking component aiming at achieving the government's target for public debt. The introduction of the fiscal policy reaction function modifies the aggregate demand equation, as the countercyclical nature of the fiscal rule ensures that the fiscal balance contributes to reducing the output gap in the economy. Similar rules can be found in many industrialized countries where fiscal policy is mainly governed by automatic stabilizers while meeting targets for the level of government debt.[17] For this exercise, debt is defined as the cumulative fiscal balance, and the debt target is set equal to zero, which implies the equilibrium fiscal balance is zero and there is no debt accumulation overtime. This can be thought of as normalization around a nonzero, but constant, ratio of public debt to GDP.

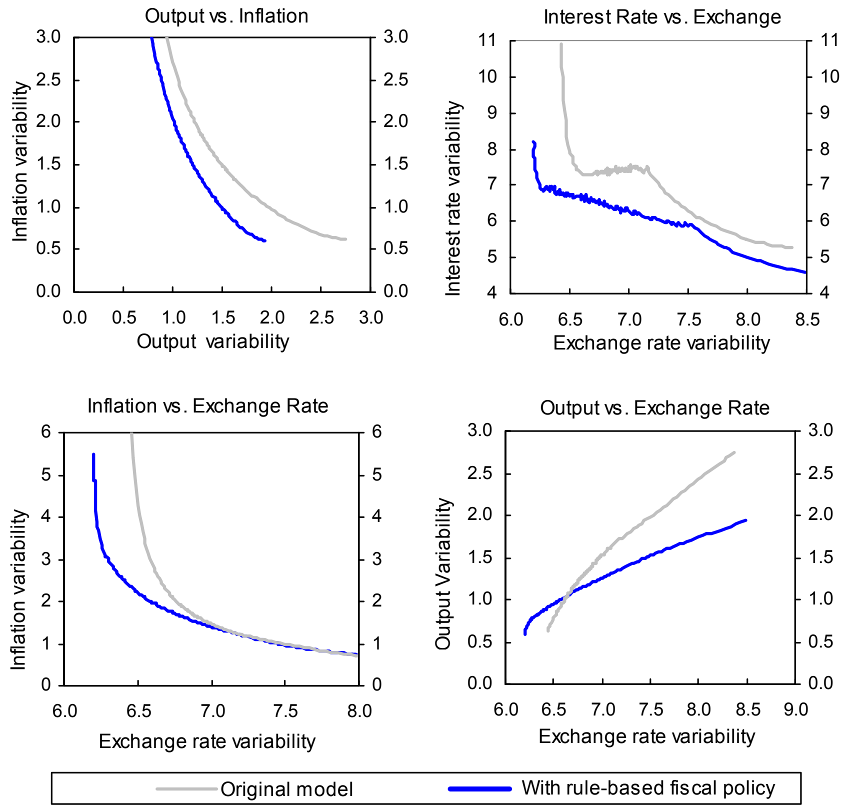
To assess how the introduction of endogenous fiscal policy changes the inflation-output variability trade-off in Iceland, a new efficient frontier is computed. The variances in the model's endogenous variables are computed under a range of alternative values for the response coefficient on lagged interest rate (α_1), the deviation of inflation from target (α_2) and the output gap (α_3) in the monetary policy reaction function, and the output gap (θ_1) in the fiscal policy reaction function. To contain the scope of the search, the coefficient on the debt gap (θ_2) was set equal to 0.1, equivalent to the estimated value of the coefficient. The search was conducted over the coefficients $\alpha_1 \in \{0.05, 0.1... 0.2\}$, $\alpha_2 \in \{0.25, 0.50 ... 15\}$, $\alpha_3 \in \{0.25, 0.50... 15\}$, and $\theta_1 \in \{0.25, 0.50... 2.0\}$.[18] More than 90,000 alternative policy rules are considered.

The improvement in the inflation-output variability trade-off is illustrated in the top left panel of Figure 3. With endogenous countercyclical fiscal policy the achievable efficient frontier shifts to the southwest. Without endogenous fiscal policy, the optimal point on the frontier where the relative dislike for inflation versus output variability is the same (equal weights in the loss function) yields a standard deviation in inflation around the target of 1.3 percent and a standard deviation of output around potential output of 1.6 percent. With the countercyclical fiscal policy, however, this is reduced to about 1 percent for inflation variability and 1.45 percent for output variability. The more favorable output-inflation variability tradeoff increases the probability of inflation remaining within the 1 to 4 percent tolerance band from 74 to 85 percent. The remaining panels in Figure 3 illustrate how interest rate and the exchange rate variability are reduced along the frontier under endogenous countercyclical fiscal policy.

[17] Examples would be the fiscal framework in the United Kingdom, New Zealand, Canada and Australia.

[18] The response of the fiscal gap to the output gap was constrained in the search to be 2 or lower to contain the response of fiscal policy to lie within a feasible range.

Figure 3. The Effects of a Rules-Based Fiscal Policy 1/



Sources. Hunt (2006) and staff estimates.
1/ Variability defined as standard deviation from target or long-run equilibrium.

V. POSSIBLE ADJUSTMENTS TO POLICY FRAMEWORK

If tolerance-range breaches are costly to credibility and thereby add to inflation variability and the real cost of maintaining price stability, these simulation results suggest that policy options to address this should be considered. Widening the tolerance range could be an option. However, these empirical estimates, combined with the additional implications of uncertainty, suggest that the tolerance range would have to be more than ± 4½ percentage points to ensure that inflation is almost always within the tolerance range. A tolerance range of this magnitude would probably be just as detrimental, if not more so, to the price-stability credibility of the Central Bank as being outside of the range. Another response could be for the Central Bank to explicitly communicate the fact that, given the magnitude of the exogenous shocks to which the economy is subjected, inflation outside the tolerance range is likely to occur more frequently in Iceland than in other inflation targeting countries.[19] At the same time, it would also be important for the Central Bank to stress that policy actions are

[19] Such an example can be found in *Monetary Bulletin* 2005/3, "Inflation target misses: A comparison of countries on inflation targets," pp. 58–62.

continually focused on stabilizing inflation at the target rate. This communication strategy could help condition inflation expectations so that tolerance-range breaches become less costly because they would not come as such a surprise nor would they necessarily imply that monetary policy had been inappropriate.

Targeting a measure of inflation that removes some of the more volatile prices that have little information about persistent price pressures could reduce the frequency of tolerance-range breaches. Currently the Central Bank's mandate specifies that it target headline CPI inflation that includes the prices of some goods that other inflation targeting countries have removed from the price indexes that are targeted. Some countries have excluded items such as energy, food, and house prices, or some combination thereof. Work should be undertaken to identify alternative price indices that are highly correlated with headline CPI inflation in the medium term, yet less volatile in the short term to consider as alternative targets. However, it will be imperative that changes of this nature to the Central Bank's objective only be implemented once the current rate of headline CPI inflation has been firmly re-anchored at the 2½ percent target rate.

Other changes to monetary policy communication could provide additional anchoring for inflation expectations and thereby improve the inflation-output variability trade-off. The introduction in late 2005 of the preannounced schedule for monetary policy meetings that conclude with a public statement regarding the Central Bank's decision regarding interest rates should contribute in this regard. The introduction in the first *Monetary Bulletin* of 2006 of the Central Bank's view of the future adjustments in interest rates likely to be required to return inflation to the target rate should also help anchor inflation expectations. However, it will be important to continue to communicate that this model-based path is conditional on the Central Bank's information about the economy at that time. As the economy evolves, the interest rate path required to stabilize inflation will undoubtedly change and the Central Bank should emphasize that paths published in the *Monetary Bulletin* should not be interpreted as a commitment on its part.

As the improvement in the inflation-output variability trade-off under endogenous fiscal policy is illustrated, more systematic coordination of monetary and fiscal policy would be extremely helpful in reducing the probability of breaching the tolerance range**.** Beyond the operation of automatic stabilizers, there is no guarantee in most economies that monetary and fiscal policy will be coordinated. For most economies, this is probably optimal given that short-run macroeconomic stabilization can be more effectively managed by monetary policy because it can respond quickly as the economy evolves. This leaves fiscal policy with more flexibility to focus on longer-term objectives to which it is better suited. However, in a small economy like Iceland, where the shocks are so large, the task faced by the monetary authorities appears to be much more challenging and the resulting volatility in real activity, interest rates and the exchange rate much higher than in other larger countries. Consequently, significant benefits would arise from implementing a rules-based approach in the fiscal budgeting process designed to simultaneously ensure a consistently countercyclical fiscal stance, commensurate with the estimated extent of demand imbalance, and the achievement of the government's target for public debt. Although such an approach would need to be designed specifically for Iceland and its particular needs, the framework used in the United Kingdom, which embodies simultaneous targets for the cumulative deficit over the business cycle as well as the level of government debt, could provide broad guidance.[20]

While the efficient frontiers presented in this paper provide motivation for considering policy improvements, it is important to be mindful of the potential empirical limitations and the fact that considerable work remains to be done to test the robustness of the findings. With the data set for Iceland encompassing two different monetary policy regimes, the resulting empirical estimates of model parameters and stochastic processes may not be as indicative of the future as they are for other countries in which the monetary regime has been stable. Further, the model is simple and may not be an accurate representation of the Icelandic economy. It would be useful to test the robustness of the results under a range of alternative priors for the model parameters as well as extending the range of countries included in the comparison set. In addition, the policy rule that is considered is simple and some researchers have found that, for small open economies, including an explicit response to developments in the exchange rate can improve macroeconomic stability.[21] This possibility should be investigated. Finally, it would be helpful to extend the analysis presented in this paper to a wider range of fiscal policy rules that would be feasible to implement in Iceland.

VI. Conclusions

Although the empirical results presented in the paper should be considered preliminary, they do suggest that Iceland faces a considerably less favorable inflation-output variability trade-off than do many other industrial countries. In part, this is recognized in the inflation targeting framework introduced by the government and the Central Bank in 2001. The midpoint of the target range, at 2½ percent, is slightly higher than that of most other inflation targeting countries and the tolerance band of ± 1½ percentage points is wider. However, the inflation–output variability trade-offs presented in this paper suggest that the proportion of time the Central Bank can reasonably be expected to keep inflation within the tolerance range may be quite low, significantly lower than the other countries considered.

A number of measures should be considered that could help minimize the cost of inflation breaching the tolerance band and help lower the probability of such events occurring. With

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[20] Gestsson and Herbertsson (2005) recommend a fiscal rule to ensure better coordination between monetary policy and fiscal policy. Research work should be undertaken to evaluate the effectiveness of alternative rules-based fiscal frameworks for possible implementation in Iceland.

[21] See for example Ball (1998).

breaches of the tolerance band requiring a public statement by the Central Bank to the government, it would be useful to try to minimize the potential negative impact on inflation expectations. On this front, it might be helpful if the Central Bank communicated to the public that tolerance-range breaches are more likely in Iceland than in other inflation targeting countries simply because of the magnitude of economic shocks relative to the size of the economy. Research should be undertaken to identify other less volatile price indices whose levels, on average, are highly correlated with the currently targeted CPI index. Once inflation has been re-anchored at the target rate, the target could then be defined in terms of an alternative, less volatile index. Further refinements in the bank's public communication could also more firmly anchor inflation expectations and thereby improve the inflation-output variability trade-off, reducing the frequency of tolerance-range breaches. Finally, the unique challenges faced by Iceland because of its size, suggest that innovative policy options need to be considered. Ensuring the systematic coordination of monetary and fiscal policy has been shown to substantially improve the inflation-output variability trade-off faced by the monetary authorities and consideration should be given to implementing a rules-based system in the fiscal budgeting process designed to achieve this.

APPENDIX I. THE COMPLETE MODEL

The following provides a complete detailed description of the open-economy model estimated for the countries considered in this paper. The model is specified in gap and rate-of-change terms so that, under inflation targeting, all variables are stationary. For simulation purposes, the equilibrium values for the real interest rate and the real exchange rate are assumed to be time invariant.

Core behavioral equations for the domestic sector

Aggregate demand

$$ygap_t = \beta_1 \cdot ygap_{t-1} + \beta_2 \cdot ygap_{t+1} - \beta_3 \cdot rrgap_{t-1} + \beta_4 \cdot zgap_{t-1} + \beta_5 \cdot ygap_t^* + \varepsilon_t^{ygap}, \qquad (1)$$

where *ygap* denotes the output gap, *rrgap* is the gap between the real interest rate and its equilibrium value, *zgap* is the gap between the real exchange rate index and its equilibrium value, *ygap** is the foreign output gap and ε^{ygap} is the stochastic error process.

Inflation

$$\pi_t = \delta_1 \cdot \pi_{t+4}^4 + (1-\delta_1) \cdot \pi_{t-1}^4 + \delta_2 \cdot ygap_{t-1} + \delta_3 \cdot \Delta z_t + \varepsilon_t^{\pi}, \qquad (2)$$

where π is the quarterly annualized rate of CPI inflation, π^4 is a four-quarter moving average of quarterly annualized CPI inflation, Δz is the first difference in the real exchange rate index, and ε^{π} is the stochastic error process.

The real exchange rate

$$z_t = \phi \cdot z_{t+1} + (1-\phi) \cdot z_{t-1} - (rr_t - rr_t^*)/4 + \varepsilon_t^z/4, \qquad (3)$$

where *z* is the log of the real exchange rate index, *rr* is the domestic real interest rate, *rr** is the foreign real interest rate, and ε^z is the stochastic error process.

The monetary policy reaction function

$$rs_t = \alpha_1 \cdot rs_{t-1} + (1-\alpha_1) \cdot (rr\_eq_t + \pi_t^4 + \alpha_2 \cdot (\pi_{t+4}^4 - \pi^T) + \alpha_3 \cdot ygap_t) + \varepsilon_t^{rs}, \qquad (4)$$

where *rs* is the annualized short-term policy rate, *rr_eq* is it equilibrium real interest rate, π^T is the target rate of inflation, and ε^{rs} is the stochastic error process.

Core behavioral equations for the foreign sector

Aggregate demand

$$ygap_t^* = \beta_1^* \cdot ygap_{t-1}^* + \beta_2^* \cdot ygap_{t+1}^* - \beta_3^* \cdot rrgap_{t-1}^* + \varepsilon_t^{ygap*}, \qquad (5)$$

where $ygap^*$ denotes the output gap, $rrgap^*$ is the gap between the real interest rate and its equilibrium value, and ε^{ygap*} is the stochastic error process.

Inflation

$$\pi_t^* = \delta_1^* \cdot \pi_{t+4}^{4*} + (1-\delta_1^*) \cdot \pi_{t-1}^{4*} + \delta_2^* \cdot ygap_{t-1}^* + \varepsilon_t^{\pi*}, \tag{6}$$

where π^* is the quarterly annualized rate of CPI inflation, π^{4*} is a four-quarter moving average of quarterly annualized CPI inflation, and $\varepsilon^{\pi*}$ is the stochastic error process.

The monetary policy reaction function

$$rs_t^* = \alpha_1^* \cdot rs_{t-1}^* + (1-\alpha_1^*) \cdot (rr\_eq_t^* + \pi_t^{4*} + \alpha_2^* \cdot (\pi_{t+4}^{4*} - \pi^{T*}) + \alpha_3^* \cdot ygap_t^*) + \varepsilon_t^{rs*}, \tag{7}$$

where rs^* is the annualized short-term policy rate, rr_eq^* is it equilibrium real interest rate, π^{T*} is the target rate of inflation, and ε^{rs*} is the stochastic error process.

Stochastic processes

$$\varepsilon_t^{ygap} = \rho^{ygap} \cdot \varepsilon_{t-1}^{ygap} + \xi_t^{ygap}, \tag{8}$$

$$\varepsilon_t^{ygap*} = \rho^{ygap*} \cdot \varepsilon_{t-1}^{ygap*} + \xi_t^{ygap*}, \tag{9}$$

$$\varepsilon_t^{\pi} = \rho^{\pi} \cdot \varepsilon_{t-1}^{\pi} + \xi_t^{\pi}, \tag{10}$$

$$\varepsilon_t^{\pi*} = \rho^{\pi*} \cdot \varepsilon_{t-1}^{\pi*} + \xi_t^{\pi*}, \tag{11}$$

$$\varepsilon_t^{rs} = \rho^{rs} \cdot \varepsilon_{t-1}^{rs} + \xi_t^{rs}, \tag{12}$$

$$\varepsilon_t^{rs*} = \rho^{rs*} \cdot \varepsilon_{t-1}^{rs*} + \xi_t^{rs*}, \tag{13}$$

Identities

$$\pi_t^4 = (\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})/4, \tag{14}$$

$$\pi_t^{4*} = (\pi_t^* + \pi_{t-1}^* + \pi_{t-2}^* + \pi_{t-3}^*)/4, \tag{15}$$

$$\pi_t^{4*} = (\pi_t^* + \pi_{t-1}^* + \pi_{t-2}^* + \pi_{t-3}^*)/4, \tag{15}$$

$$rr_t = rs_t - \pi_{t+1}, \tag{16}$$

$$rr_t^* = rs_t^* - \pi_{t+1}^*, \tag{17}$$

$$rrgap_t = rr_t - rr\_eq_t, \tag{18}$$

$$rrgap_t^* = rr_t^* - rr\_eq_t^*, \tag{19}$$

$$zgap_t = z_t - z\_eq_t. \tag{20}$$

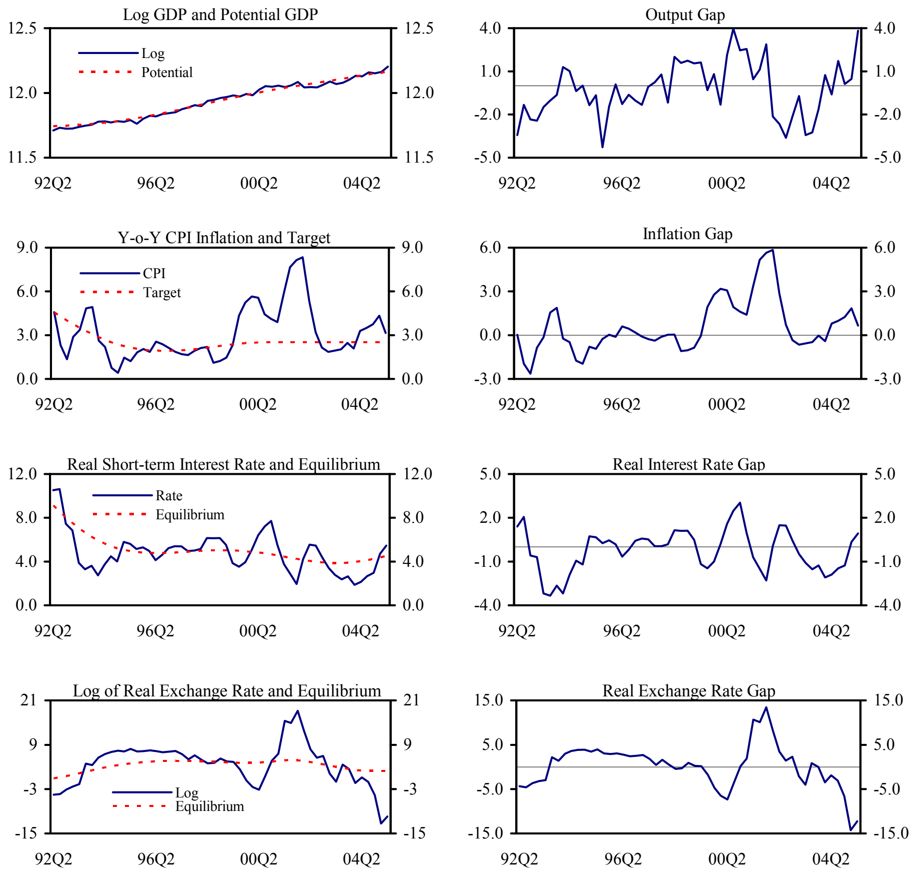
APPENDIX II. DATA AND ESTIMATION RESULTS

Charts of the data and the estimation results are presented in this appendix. For Iceland, an index comprising the euro area, the United Kingdom and the United States (over three-quarters of Iceland's foreign trade in 2005) is used to proxy foreign aggregate demand, interest rates, and CPI inflation. The trade-weighted real exchange rate index published by the Central Bank of Iceland is used for the real exchange rate. For Canada, the United States is used as the proxy for the foreign sector as roughly 85 percent of Canada's trade is with the United States. For the United Kingdom, a trade-weighted index including France, Germany, Italy, the Netherlands, Norway, the United Sates, and Japan was created for rest-of-world GDP, CPI inflation, and the 90-day policy rate. The real effective exchange rate from the Bank of England was used for the exchange rate. For New Zealand, the trade-weighted exchange rate and the rest-of-world output, inflation, and interest rates are those corresponding to the rest-of-world sector incorporated into the Reserve Bank of New Zealand's Forecasting and Policy Analysis System (FPS).

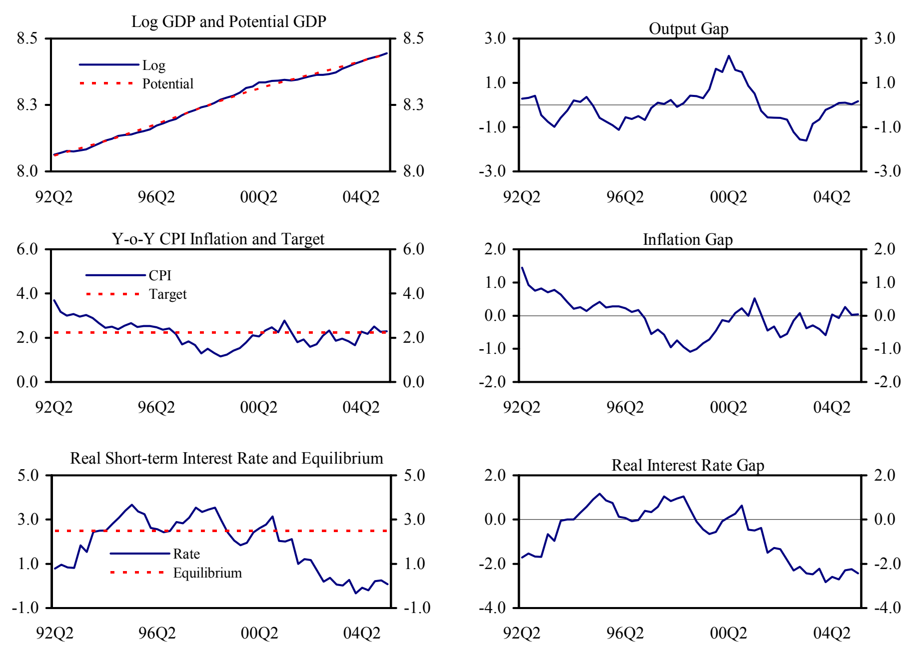
The Bayesian, full system estimation is done in DYNARE. The observable variables are output gaps (real GDP), nominal short-term interest rates (90-day treasury bills or equivalent), CPI inflation rates (headline), and logs of the real exchange rates. Equilibrium values are exogenous and are derived using a variant of the Hodrick Prescott (1997) filter that allows for additional constraints to be added to the minimization problem to prevent the resulting equilibrium value from converging to the actual observed data at the end of the sample period. These constraints can be used so that the equilibrium value converges toward some user-specified value at the end of the sample period. The observable variables used to estimate the model for Iceland are presented in Figure 1, for Canada and the United States in Figure 2, for the United Kingdom in Figure 3, and for New Zealand in Figure 4. The estimation has been done allowing for measurement error in the observable variables. The priors and the resulting estimates for Iceland and its foreign sector are presented in Tables 1 and 2. The estimates for Canada and the United States are presented in Tables 3 and 4. Tables 5 and 6 contain the estimates for the United Kingdom and its rest-of-world sector. The estimates for New Zealand and its rest-of-world sector are contained in Tables 7 and 8.

Figure 1. Data Used for Estimation: Iceland and Rest of World

Iceland



Rest of World



Sources: Central Bank of Iceland; and staff estimates.

Table 1. Iceland: Model Parameter Estimation Results
Sample period 1992Q2 to 2005Q2

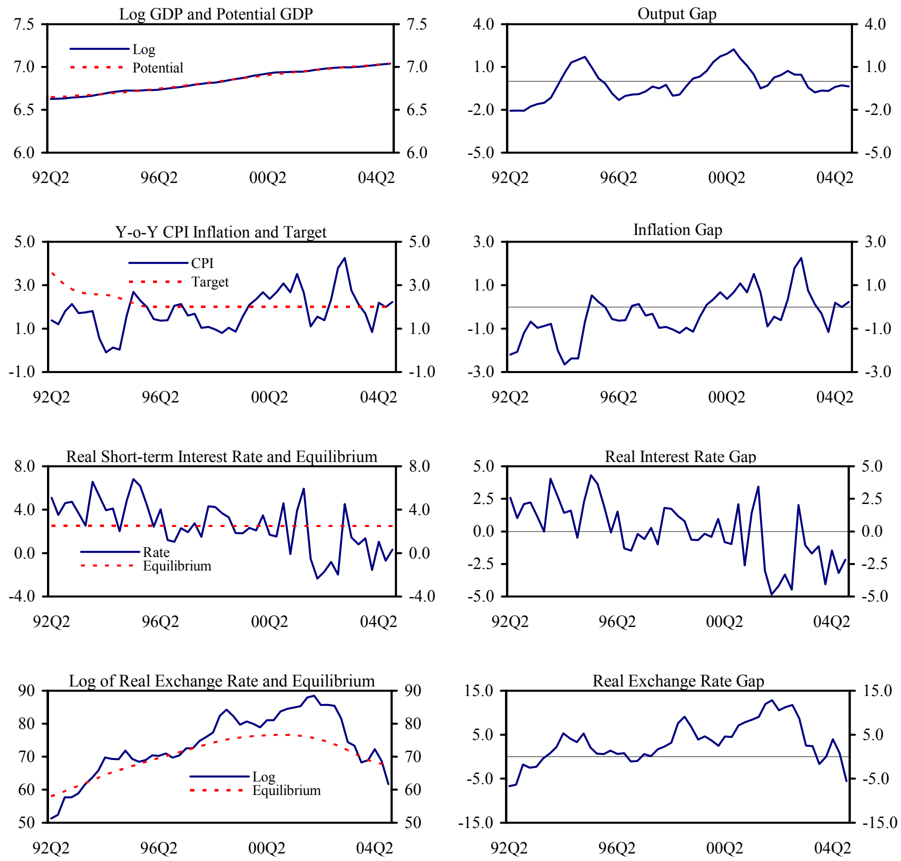
Parameter	**Prior Mean**	**Distribution**	**Posterior Mean**
Domestic			
β_1 (coefficient on own lag in *ygap*)	0.85	Gamma	0.576
β_2 (coefficient on own lead in *ygap*)	0.10	Beta	0.096
β_3 (coefficient on *rrgap* in *ygap*)	0.10	Gamma	0.103
β_4 (coefficient on *zgap* in *ygap*)	0.10	Beta	0.093
β_5 (coefficient on *ygap** in *ygap*)	0.15	Beta	0.170
δ_1 (coefficient on own lead in π)	0.20	Gamma	0.198
δ_2 (coefficient on *ygap* in π)	0.26	Gamma	0.234
δ_3 (coefficient on Δz in π)	0.30	Gamma	0.294
φ (coefficient on own lead in *z*)	0.50	Beta	0.254
α_1 (coefficient on own lag in *rs*)	0.50	Gamma	0.633
α_2 (coefficient on inflation *gap* in *rs*)	1.50	Gamma	1.391
α_3 (coefficient on *ygap* in *rs*)	0.50	Beta	0.474
Foreign			
β^*_1 (coefficient on own lag in *ygap**)	0.85	Gamma	0.699
β^*_2 (coefficient on own lead in *ygap**)	0.10	Beta	0.104
β^*_3 (coefficient on *rrgap** in *ygap**)	0.10	Gamma	0.103
δ^*_1 (coefficient on own lead in π^*)	0.20	Beta	0.181
δ^*_2 (coefficient on *ygap** in π^*)	0.30	Gamma	0.225
α^*_1 (coefficient on own lag in *rs**)	0.50	Beta	0.587
α^*_2 (coefficient on inflation *gap* in *rs**)	1.50	Gamma	1.415
α^*_3 (coefficient on *ygap** in *rs**)	0.50	Beta	0.479

Table 2. Iceland: Estimation Results for the Error Processes and Measurement Errors
Sample period 1992Q2 to 2005Q2

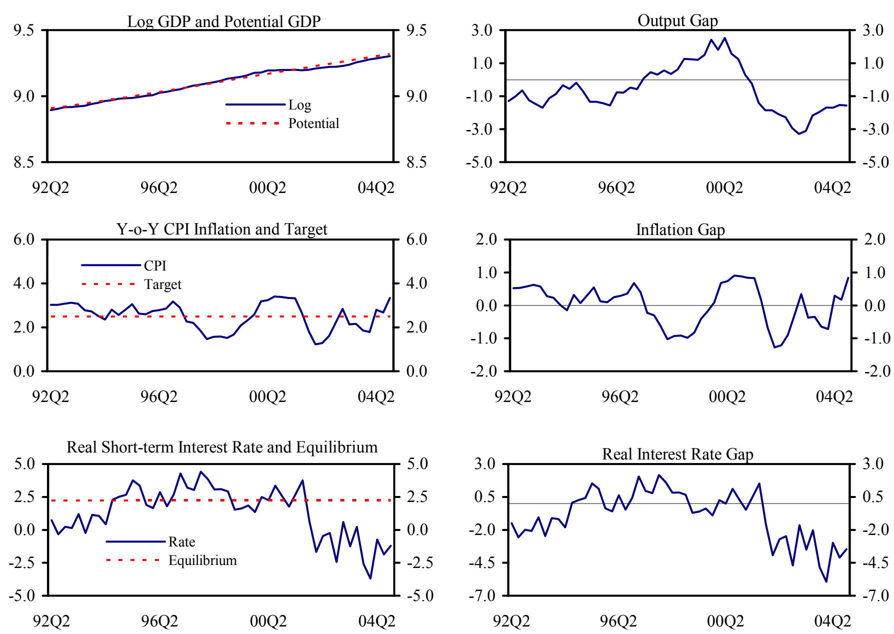
Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
ρ^{ygap}	0.75	Beta	0.731
standard deviation ξ^{ygap}	0.75	inverse gamma	0.510
standard deviation measurement error *ygap*	0.20	inverse gamma	1.238
ρ^{π}	0.50	Beta	0.579
standard deviation ξ^{π}	0.75	inverse gamma	0.707
standard deviation measurement error π	0.20	inverse gamma	2.339
ρ^{rs}	0.750	Beta	0.787
standard deviation ξ^{rs}	0.25	inverse gamma	0.325
standard deviation measurement error *rs*	0.20	inverse gamma	0.158
standard deviation ε^{z}	6.00	inverse gamma	8.254
Foreign			
ρ^{ygap*}	0.75	Beta	0.690
standard deviation ξ^{ygap*}	0.25	inverse gamma	0.209
standard deviation measurement error *ygap*	0.20	inverse gamma	0.171
$\rho^{\pi*}$	0.50	Beta	0.483
standard deviation $\xi^{\pi*}$	0.25	inverse gamma	0.241
standard deviation measurement error π	0.20	inverse gamma	0.976
ρ^{rs*}	0.750	Beta	0.825
standard deviation ξ^{rs*}	0.25	inverse gamma	0.158
standard deviation measurement error *rs*	0.20	inverse gamma	0.102

Figure 2. Data Used for Estimation: Canada and United States.

Canada



The United States



Sources: Haver Analytics; Statistics Canada; United States Bureau of Economic Analysis; and staff estimates.

Table 3. Canada: Model Parameter Estimation Results
Sample Period 1992Q2 to 2004Q4

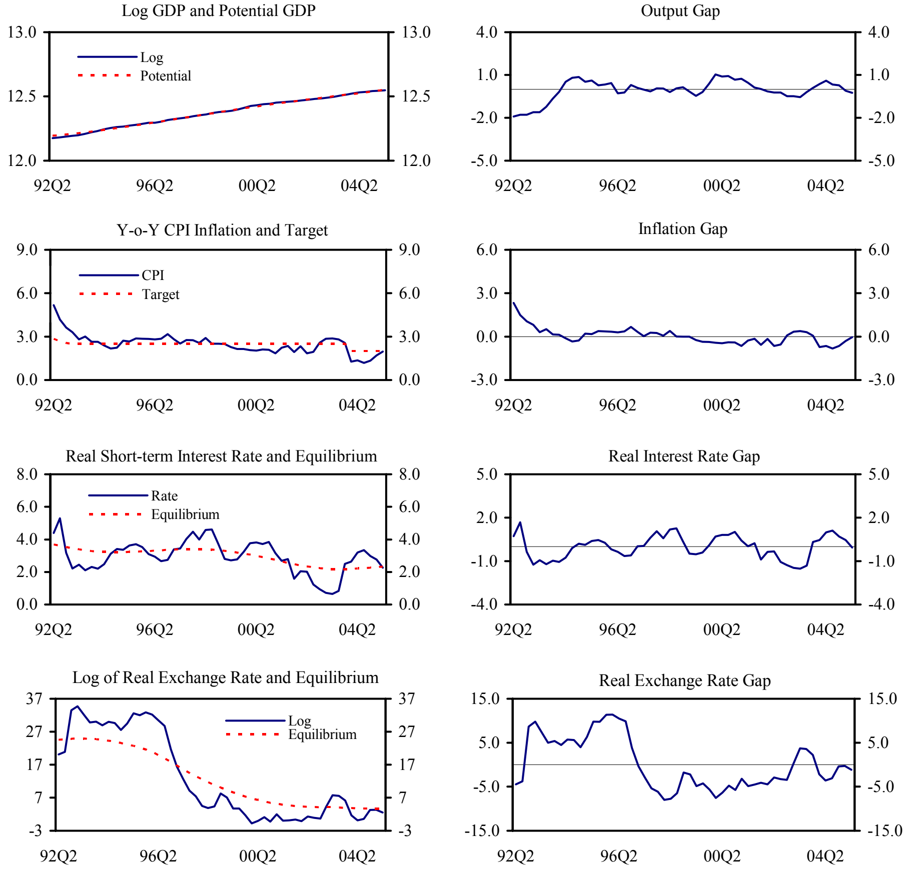
Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
β_1 (coefficient on own lag in *ygap*)	0.85	Gamma	0.703
β_2 (coefficient on own lead in *ygap*)	0.10	Beta	0.102
β_3 (coefficient on *rrgap* in *ygap*)	0.10	Gamma	0.104
β_4 (coefficient on *zgap* in *ygap*)	0.05	Beta	0.054
β_5 (coefficient on *ygap** in *ygap*)	0.25	Beta	0.25
δ_1 (coefficient on own lead in π)	0.20	Gamma	0.189
δ_2 (coefficient on *ygap* in π)	0.30	Gamma	0.258
δ_3 (coefficient on Δz in π)	0.10	Gamma	0.099
φ (coefficient on own lead in *z*)	0.50	Beta	0.314
α_1 (coefficient on own lag in *rs*)	0.50	Beta	0.443
α_2 (coefficient on inflation *gap* in *rs*)	2.00	Gamma	2.025
α_3 (coefficient on *ygap* in *rs*)	0.50	Beta	0.462
Foreign (United States)			
β^*_1 (coefficient on own lag in *ygap**)	0.85	Gamma	0.706
β^*_2 (coefficient on own lead in *ygap**)	0.10	Beta	0.108
β^*_3 (coefficient on *rrgap** in *ygap**)	0.10	Gamma	0.106
δ^*_1 (coefficient on own lead in π*)	0.20	Beta	0.176
δ^*_2 (coefficient on *ygap** in π*)	0.30	Gamma	0.226
α^*_1 (coefficient on own lag in *rs**)			
α^*_2 (coefficient on inflation *gap* in *rs**)	2.00	Gamma	1.713
α^*_3 (coefficient on *ygap** in *rs**)	0.50	Beta	0.489

Table 4. Canada: Estimation Results for the Error Processes and Measurement Errors
Sample Period 1992Q2 to 2004Q4

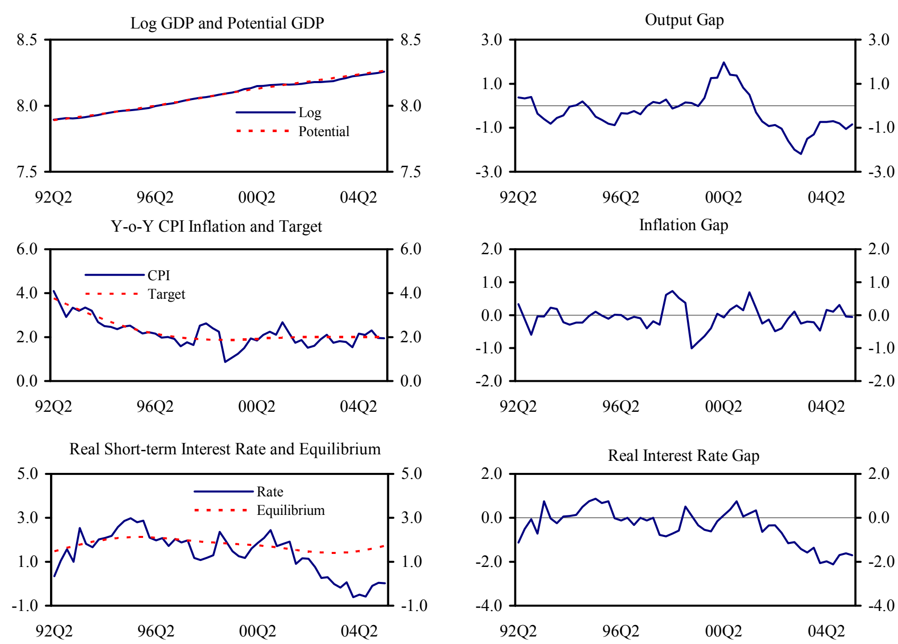
Parameter	**Prior Mean**	**Distribution**	**Posterior Mean**
Domestic			
ρ^{ygap}	0.75	Beta	0.864
standard deviation ξ^{ygap}	0.25	inverse gamma	0.158
standard deviation measurement error *ygap*	0.20	inverse gamma	0.139
ρ^{π}	0.50	Beta	0.493
standard deviation ξ^{π}	0.25	inverse gamma	0.138
standard deviation measurement error π	0.20	inverse gamma	1.344
ρ^{rs}	0.75	Beta	0.722
standard deviation ξ^{rs}	0.25	inverse gamma	0.487
standard deviation measurement error *rs*	0.20	inverse gamma	0.130
standard deviation ε^{z}	4.00	inverse gamma	5.000
Foreign (United States)			
ρ^{ygap*}	0.75	Beta	0.717
standard deviation ξ^{ygap*}	0.25	inverse gamma	0.227
standard deviation measurement error *ygap*	0.20	inverse gamma	0.139
$\rho^{\pi*}$	0.50	Beta	0.519
standard deviation $\xi^{\pi*}$	0.25	inverse gamma	0.245
standard deviation measurement error π	0.20	inverse gamma	0.639
ρ^{rs*}	0.750	Beta	0.824
standard deviation ξ^{rs*}	0.25	inverse gamma	0.184
standard deviation measurement error *rs*	0.20	inverse gamma	0.117

Figure 3. Data Used for Estimation: The United Kingdom and Rest of World

The United Kingdom



Rest of World



Sources: Bank of England; United Kingom Office of National Statistics; and staff estimates.

Table 5. The United Kingdom: Model Parameter Estimation Results
Sample period 1992Q4 to 2005Q3

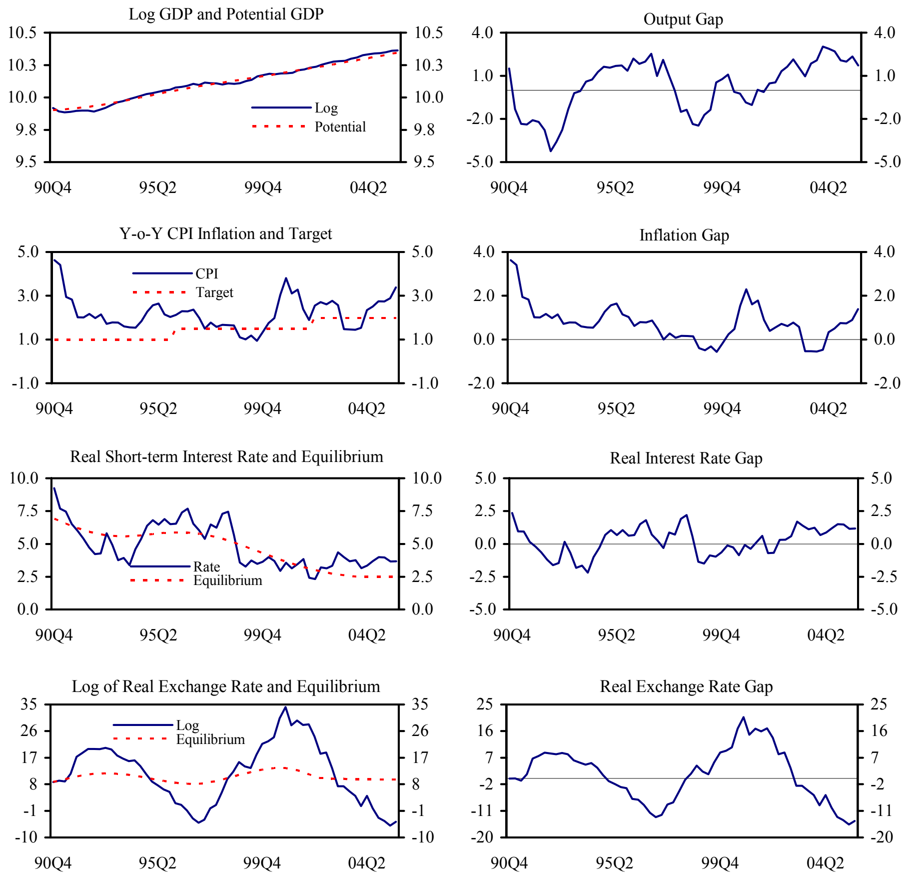
Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
β_1 (coefficient on own lag in *ygap*)	0.85	Gamma	0.718
β_2 (coefficient on own lead in *ygap*)	0.10	Beta	1.003
β_3 (coefficient on *rrgap* in *ygap*)	0.10	Gamma	0.108
β_4 (coefficient on *zgap* in *ygap*)	0.05	Beta	0.033
β_5 (coefficient on *ygap** in *ygap*)	0.15	Beta	0.160
δ_1 (coefficient on own lead in π)	0.20	Gamma	0.198
δ_2 (coefficient on *ygap* in π)	0.30	Gamma	0.285
δ_3 (coefficient on Δz in π)	0.10	Gamma	0.078
φ (coefficient on own lead in z)	0.50	Beta	0.353
α_1 (coefficient on own lag in *rs*)	0.50	Beta	0.549
α_2 (coefficient on inflation *gap* in *rs*)	2.00	Gamma	1.897
α_3 (coefficient on *ygap* in *rs*)	0.50	Beta	0.521
Foreign			
β^*_1 (coefficient on own lag in *ygap**)	0.85	Gamma	0.711
β^*_2 (coefficient on own lead in *ygap**)	0.10	Beta	0.105
β^*_3 (coefficient on *rrgap** in *ygap**)	0.10	Gamma	0.104
δ^*_1 (coefficient on own lead in π^*)	0.20	Beta	0.182
δ^*_2 (coefficient on *ygap** in π^*)	0.30	Gamma	0.223
α^*_1 (coefficient on own lag in *rs**)	0.50	Beta	0.596
α^*_2 (coefficient on inflation *gap* in *rs**)	2.00	Gamma	1.745
α^*_3 (coefficient on *ygap** in *rs**)	0.50	Beta	0.456

Table 6. The U.K Estimation Results for the Error Processes and Measurement Errors
Sample period 1992Q4 to 2005Q3

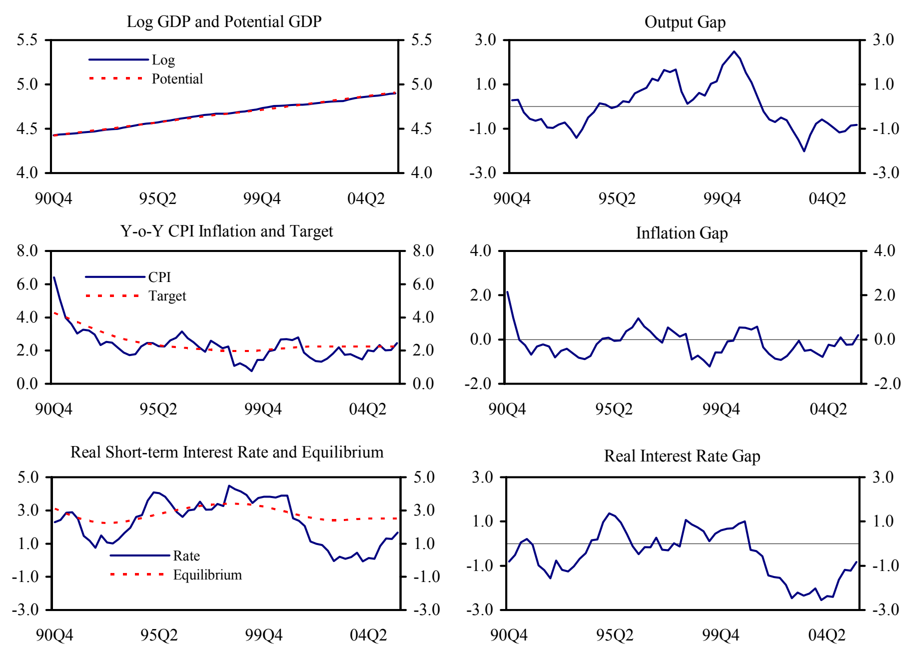
Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
ρ^{ygap}	0.75	Beta	0.818
standard deviation ξ^{ygap}	0.25	inverse gamma	0.170
standard deviation measurement error *ygap*	0.20	inverse gamma	0.139
ρ^{π}	0.50	Beta	0.514
standard deviation ξ^{π}	0.25	inverse gamma	0.256
standard deviation measurement error π	0.20	inverse gamma	1.486
ρ^{rs}	0.750	Beta	0.777
standard deviation ξ^{rs}	0.25	inverse gamma	0.192
standard deviation measurement error *rs*	0.20	inverse gamma	0.123
standard deviation ε^{z}	4.00	inverse gamma	5.903
Foreign			
ρ^{ygap*}	0.75	Beta	0.733
standard deviation ξ^{ygap*}	0.25	inverse gamma	0.196
standard deviation measurement error *ygap*	0.20	inverse gamma	0.152
$\rho^{\pi*}$	0.50	Beta	0.505
standard deviation $\xi^{\pi*}$	0.25	inverse gamma	0.277
standard deviation measurement error π	0.20	inverse gamma	1.080
ρ^{rs*}	0.750	Beta	0.720
standard deviation ξ^{rs*}	0.25	inverse gamma	0.134
standard deviation measurement error *rs*	0.20	inverse gamma	0.143

Figure 4. Data Used for Estimation: New Zealand and Rest of World.

New Zealand



Rest of World



Sources: Reserve Bank of New Zealand; and staff estimates.

Table 7. New Zealand: Model Parameter Estimation Results
Sample period 1990Q4 to 2005Q3

Parameter	**Prior Mean**	**Distribution**	**Posterior Mean**
Domestic			
β_1 (coefficient on own lag in *ygap*)	0.90	Gamma	0.670
β_2 (coefficient on own lead in *ygap*)	0.10	Beta	0.094
β_3 (coefficient on *rrgap* in *ygap*)	0.15	Gamma	0.147
β_4 (coefficient on *zgap* in *ygap*)	0.10	Beta	0.089
β_5 (coefficient on *ygap** in *ygap*)	0.15	Beta	0.141
δ_1 (coefficient on own lead in π)	0.25	Gamma	0.264
δ_2 (coefficient on *ygap* in π)	0.30	Gamma	0.208
δ_3 (coefficient on Δz in π)	0.10	Gamma	0.103
φ (coefficient on own lead in *z*)	0.50	Beta	0.283
α_1 (coefficient on own lag in *rs*)	0.70	Beta	0.646
α_2 (coefficient on inflation *gap* in *rs*)	1.23	Gamma	1.755
α_3 (coefficient on *ygap* in *rs*)	0.30	Beta	0.309
Foreign			
β^*_1 (coefficient on own lag in *ygap**)	0.85	Gamma	0.756
β^*_2 (coefficient on own lead in *ygap**)	0.10	Beta	0.099
β^*_3 (coefficient on *rrgap** in *ygap**)	0.10	Gamma	0.093
δ^*_1 (coefficient on own lead in π^*)	0.20	Beta	0.181
δ^*_2 (coefficient on *ygap** in π^*)	0.30	Gamma	0.218
α^*_1 (coefficient on own lag in *rs**)	0.50	Beta	0.541
α^*_2 (coefficient on inflation *gap* in *rs**)	1.50	Gamma	1.052
α^*_3 (coefficient on *ygap** in *rs**)	0.50	Beta	0.495

Table 8. New Zealand: Estimation Results for the Error Processes and Measurement Errors
Sample period 1990Q4 to 2005Q3

Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
ρ^{ygap}	0.75	Beta	0.829
standard deviation ξ^{ygap}	0.50	inverse gamma	0.611
standard deviation measurement error *ygap*	0.20	inverse gamma	0.310
ρ^{π}	0.50	Beta	0.491
standard deviation ξ^{π}	0.50	inverse gamma	0.374
standard deviation measurement error π	0.20	inverse gamma	1.029
ρ^{rs}	0.750	Beta	0.738
standard deviation ξ^{rs}	0.25	inverse gamma	0.657
standard deviation measurement error *rs*	0.20	inverse gamma	0.162
standard deviation ε^{z}	4.00	inverse gamma	5.903
Foreign			
ρ^{ygap*}	0.75	Beta	0.771
standard deviation ξ^{ygap*}	0.25	inverse gamma	0.215
standard deviation measurement error *ygap*	0.20	inverse gamma	0.148
$\rho^{\pi*}$	0.50	Beta	0.607
standard deviation $\xi^{\pi*}$	0.25	inverse gamma	0.346
standard deviation measurement error π	0.20	inverse gamma	1.051
ρ^{rs*}	0.750	Beta	0.765
standard deviation ξ^{rs*}	0.25	inverse gamma	0.167
standard deviation measurement error *rs*	0.20	inverse gamma	0.130

APPENDIX III. ESTIMATION RESULTS FOR ICELAND MODEL WITH FISCAL POLICY

Table 1. Iceland: Extended Model Parameter Estimation Results
Sample period 1992Q2 to 2005Q2

Parameter	Prior Mean	Distribution	Posterior Mean
Domestic			
β_1 (coefficient on own lag in *ygap*)	0.85	Gamma	0.706
β_2 (coefficient on own lead in *ygap*)	0.10	Beta	0.095
β_3 (coefficient on *rrgap* in *ygap*)	0.10	Gamma	0.101
β_4 (coefficient on *zgap* in *ygap*)	0.10	Beta	0.092
β_5 (coefficient on *ygap** in *ygap*)	0.15	Beta	0.170
B_6 (coefficient on fb*gap* in *ygap*)	**0.15**	**Beta**	**0.150**
δ_1 (coefficient on own lead in π)	0.20	Gamma	0.198
δ_2 (coefficient on *ygap* in π)	0.26	Gamma	0.234
δ_3 (coefficient on Δz in π)	0.30	Gamma	0.294
φ (coefficient on own lead in *z*)	0.50	Beta	0.254
α_1 (coefficient on own lag in *rs*)	0.50	Gamma	0.633
α_2 (coefficient on inflation *gap* in *rs*)	1.50	Gamma	1.391
α_3 (coefficient on *ygap* in *rs*)	0.50	Beta	0.474
θ_1 (coefficient on y*gap* in *fbgap*)	**0.17**	**Beta**	**0.179**
θ_2 (coefficient on d*gap* in *fbgap*)	**0.10**	**Beta**	**0.093**
Foreign			
β^*_1 (coefficient on own lag in *ygap**)	0.85	Gamma	0.699
β^*_2 (coefficient on own lead in *ygap**)	0.10	Beta	0.104
β^*_3 (coefficient on *rrgap** in *ygap**)	0.10	Gamma	0.103
δ^*_1 (coefficient on own lead in π^*)	0.20	Beta	0.181
δ^*_2 (coefficient on *ygap** in π^*)	0.30	Gamma	0.225
α^*_1 (coefficient on own lag in *rs**)	0.50	Beta	0.587
α^*_2 (coefficient on inflation *gap* in *rs**)	1.50	Gamma	1.415
α^*_3 (coefficient on *ygap** in *rs**)	0.50	Beta	0.479

Table 2. Iceland: Estimation Results for the Error Processes and Measurement Errors
Sample period 1992Q2 to 2005Q2

Parameter	**Prior Mean**	**Distribution**	**Posterior Mean**
Domestic			
ρ^{ygap}	0.75	Beta	0.788
standard deviation ξ^{ygap}	0.75	inverse gamma	0.405
standard deviation measurement error *ygap*	0.20	inverse gamma	1.749
ρ^{π}	0.50	Beta	0.571
standard deviation ξ^{π}	0.75	inverse gamma	0.653
standard deviation measurement error π	0.20	inverse gamma	2.293
ρ^{rs}	0.750	Beta	0.779
standard deviation ξ^{rs}	0.25	inverse gamma	0.235
standard deviation measurement error *rs*	0.20	inverse gamma	0.162
standard deviation ε^{z}	6.00	inverse gamma	8.257
standard deviation ε^{fbgap}	**0.25**	**inverse gamma**	**0.110**
Foreign			
ρ^{ygap*}	0.75	Beta	0.697
standard deviation ξ^{ygap*}	0.25	inverse gamma	0.221
standard deviation measurement error *ygap*	0.20	inverse gamma	0.168
$\rho^{\pi*}$	0.50	Beta	0.503
standard deviation $\xi^{\pi*}$	0.25	inverse gamma	0.221
standard deviation measurement error π	0.20	inverse gamma	0.960
ρ^{rs*}	0.750	Beta	0.845
standard deviation ξ^{rs*}	0.25	inverse gamma	0.169
standard deviation measurement error *rs*	0.20	inverse gamma	0.142

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