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Inflation Targeting and Price-Level-Path Targeting in the Global Economy Model: Some Open Economy Considerations

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This paper compares the capability of simple inflation targeting (IT) and price-level-path targeting (PLPT) rules to minimize inflation and output gap variability in a two-country, two-sector version of the Global Economy Model calibrated for Canada and the United States. We find that simple PLPT rules are slightly better than simple IT rules at macroeconomic stabilization and that the presence of terms-of-trade shocks tends to bolster the case for PLPT. Lastly, we demonstrate that the choice of monetary policy framework in the United States does not affect the relative merits of IT vs. PLPT in Canada. [JEL C51, C52, E17, E31, E52]

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One way of implementing a strong nominal anchor for the economy that has become particularly popular in recent years is the adoption

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of formal inflation targets. The basic principles of inflation targeting (IT) are straightforward. In the advent of a shock that pushes inflation away from target, the central bank adjusts policy interest rates to affect both the level of spending in the economy and inflation expectations, thereby pulling inflation back to target.

IT in Canada and in many other countries has proved to be quite successful, as inflation expectations have become better anchored leading to a reduction in inflation volatility and persistence, with no increase in output volatility (Mishkin and Schmidt-Hebbel, 2001). Despite these notable achievements, it is also clear that IT may have some important limitations. In particular, owing primarily to the fear of hitting the lower zero bound on nominal interest rates, inflation targets worldwide typically remain at about 2 percent, despite a consensus in the economics community that there would be benefits associated with moving to a lower target. In addition, price-level movements are not completely reversed under IT, leading to price-level drift and leaving uncertainty about future price levels higher than it needs to be. This is problematic for agents who are risk averse and who enter into long-term, nominal contracts (for example, home mortgages).

An alternative way to achieve a strong nominal anchor for the economy that may help alleviate these problems is price-level-path targeting (PLPT). PLPT differs from IT because, under PLPT, a shock that pushes the price level above its target path would require the monetary authority to fully reverse the initial positive shock, by creating a period in which prices must rise by less than the growth rate of the target path. With price-level-path targets, there is good reason to believe that they could serve to anchor inflation expectations, even when there is significant downward pressure on nominal interest rates, thus reducing the likelihood of encountering the zero bound on nominal interest rates (Eggertsson and Woodford, 2003; and Laxton, N'Diaye, and Pesenti, 2006). If this is true, everything else being equal, the relative benefits of PLPT vs. IT rise, as the underlying trend increase in prices falls. PLPT also caps the variance of expected future prices, thus leading to a fall in price-level uncertainty. PLPT, however, may not offer a panacea. Many authors have argued that PLPT has the potential to increase the volatility of inflation and/or output relative to IT (see, for example, Lebow, Roberts, and Stockton, 1992; and Fillion and Tetlow, 1994).

This paper focuses on the argument that PLPT generates increased macroeconomic instability relative to IT. We compare the capability of simple IT and PLPT interest rate feedback rules to minimize inflation and output gap variability in a simplified, two-country, two-sector (tradable and nontradable goods) version of the global economy model (GEM), calibrated for Canada and the United States.[1]

[1]For a description of the full GEM, see Pesenti (2008). For the purposes of our work, the risk-adjusted uncovered interest rate parity (UIRP) condition in the GEM was modified to

Our results suggest that simple PLPT rules perform slightly better than simple IT rules, and that this finding is reinforced by the presence of terms-of-trade shocks. In addition, we demonstrate that our results are sensitive to the interaction between how forward-looking price formation is and the incidence of different types of shocks. Lastly, we demonstrate that the relative merits of PLPT and IT are independent of the monetary policy framework followed in the United States.

I. Calibration and Model Properties

Calibration Methodology

The calibration of the model reflects our desire to broadly match a number of selected unconditional moments in the historical data (temporal cross-correlations, autocorrelations, and relative variances), as well as impulse responses to specific domestic shocks (for example, technology, demand, monetary policy) from the Bank of Canada's model of Canada, the terms-of-trade economic model (ToTEM) (see Murchison and Rennison, 2006), and to the Bank of Canada's model of the U.S. economy, the Model of the United States Economy (MUSE) (see Gosselin and Lalonde, 2005).[2] The parameterization process involves selecting a set of candidate model parameters and then using the historical data to "back out" a historical path for the model's shock terms that allows us to exactly replicate history.[3] Using the variance of the historical shocks, we then conduct stochastic simulations, calculate key moments, and compare them to those from the historical data.[4]

Impulse responses from the model are also simulated and compared with those from ToTEM and MUSE. The simulation process is repeated until the model is able to broadly match both the unconditional moments in the historical data and the impulse responses suggested by the other models.

The model has 23 behavioral shocks. We group the shocks into five categories. Domestic demand shocks (consumption, investment, imports,

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address the forward premium puzzle, as in Adolfson and others (2005). For a nontechnical description of the version of the GEM used in this analysis, see Coletti, Lalonde, and Muir (forthcoming).

[2]An alternative approach is to use Bayesian techniques to estimate the model. Bayesian techniques allow modelers to incorporate priors on the structural parameters. However, we agree with the views expressed in Murchison and Rennison (2006) that the priors (especially those of policymakers) are actually more closely related to the behavior of the model rather than the structural parameters themselves. As a result, we pay attention to matching our priors on the impulse responses (gleaned from the other models) rather than the values of the structural parameters.

[3]Over history monetary policy is characterized by simple Taylor-type rules. See Coletti, Lalonde, and Muir (2008) for more details.

[4]Each shock, z, is modeled as a first-order autoregressive stochastic process with standard error of the random disturbance, σ_ε, and persistence, λ: $z_t = \lambda z_{t-1} + \varepsilon_t$.

government spending, and interest rates) share the common feature that they occur in the home country and generate a positive covariance between domestic output (as well as the domestic output gap) and inflation.[5] The second broad class of shocks consists of domestic supply shocks, where output and inflation covary negatively. Domestic supply shocks are further disaggregated, depending on the behavior of the domestic output gap. More specifically, in domestic productivity shocks (technology shocks to the production of tradable and nontradable goods), the domestic output gap covaries positively with inflation, while in the remaining supply shocks—the three domestic mark-up shocks (prices in the tradable goods sector; prices in nontradable goods sector; and the real wage) and a domestic labor supply shock—there is a negative covariance between domestic inflation and the output gap. The final two shocks—those originating in the foreign country and the exchange rate shock—have a stronger open economy flavor. These types of shocks lead to a positive correlation in Canadian inflation and the output gap.

To identify the shocks empirically we use 21 historical data series and an assumption regarding the disaggregation of wage shocks and labor supply shocks in both countries based on previous empirical work (Juillard and others, 2006).[6] The historical series that we use are real consumption, real investment, real government spending, real imports, the price of consumption goods (core CPI for Canada and core personal consumption expenditure, or PCE, for the United States), the price of nontradable consumption goods, wages, total employment in the nontradable-goods sector, total employment in the tradable-goods sector, the real Canadian-U.S. exchange rate (deflated by the prices of consumption goods), and the 90-day commercial paper rate.[7] Real data are detrended using a Hodrick-Prescott filter with a stiffness parameter of 10,000. All Canadian nominal variables are detrended using the inflation target, post-1991, and an implied inflation target over the 1983 to 1990 period (Amano and Murchison, 2005), while all U.S. nominal variables are detrended using an estimated inflation target (Lalonde, 2006). The historical sample studied covers 1983:Q1 to 2004:Q2.

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[5]The output gap is defined as the difference between the economy's actual output and its potential output. We use a measure of potential output that is consistent with the conventional measure usually used at central banks. This measure is calculated based on a production function approach where output is evaluated with actual total factor productivity, actual capital stock, and steady-state labor supply.

[6]Our results are robust to alternative decompositions of the labor supply and wage mark-up shocks.

[7]For Canada, consumer price data is the consumer price index excluding eight volatile components and the effects of indirect taxes (CPIX). Nontradable goods prices are proxied by the prices of services excluding financial services in the core Canadian CPI. Similar price series are used for the United States based on the U.S. PCE deflator. Total employment in the nontradable goods sector is set equal to employment in services excluding financial services from the Canadian Labor Force Surveys. Similar data for the United States are provided by the U.S. Bureau of Economic Activity.

Table 1. Variance Decomposition Using Model-Generated Data
(In percent)

	Standard Deviation	Demand	Productivity	Mark-up and Labor	Exchange Rate	Foreign Shocks
Canada						
CPI inflation	0.7	9.9	2.8	39.2	12.7	35.4
Output gap	2.1	22.3	7.0	7.9	4.7	58.1
Interest rate (change)	0.4	36.9	2.0	32.8	4.7	23.6
Exports	3.0	3.9	1.8	12.9	6.9	74.5
Imports	3.1	43.7	4.0	11.1	13.6	27.6
Real exchange rate	2.9	8.7	2.5	17.7	19.6	48.6
Terms of trade	1.7	8.6	2.4	22.3	21.5	45.2
United States						
CPI inflation	0.6	38.9	17.5	42.9	0.1	0.6
Output gap	1.2	39.8	35.0	15.1	0.1	1.0
Interest rate (change)	0.7	50.1	30.4	18.8	0.0	0.7

Note: CPI = consumer price index.

Matching Unconditional Moments

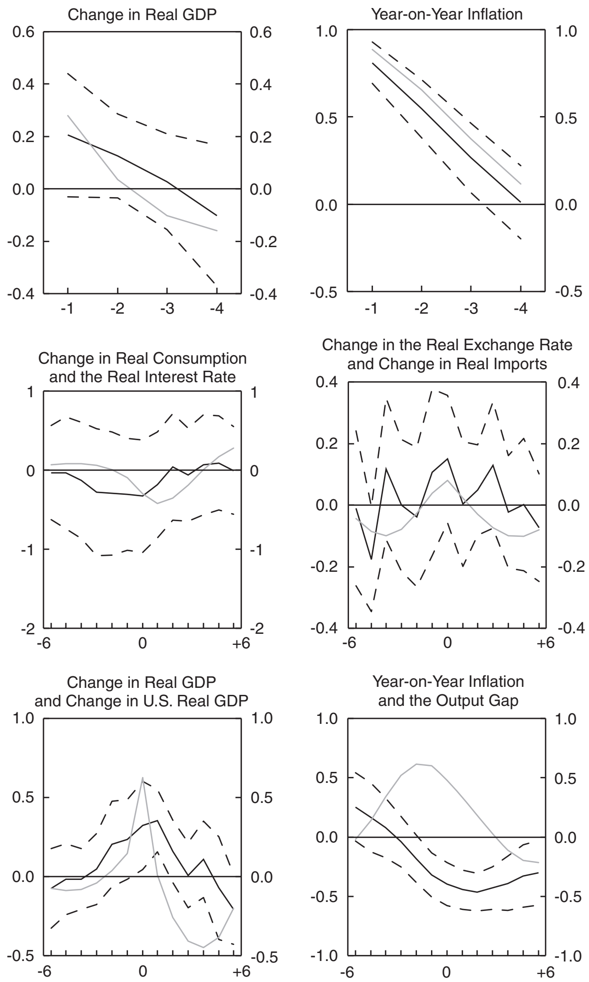
In this section, we demonstrate the ability of the Canadian-U.S. version of the GEM to reproduce some key unconditional moments from history.[8] Table 1 shows the decomposition of the long-run variance of consumer price inflation, the output gap, the short-term nominal interest rate, exports, imports, the real exchange rate, and the terms of trade. Foreign shocks are extremely important for explaining economic developments in Canada, accounting for about 60 percent of the variance in the output gap, and about 35 percent of the variation in consumer price inflation. Domestic demand shocks, on the other hand, are less important, explaining about 20 percent of the variability in the output gap and about 10 percent of inflation variability. Mark-up and labor supply shocks account for little of the variation in the output gap (about 10 percent), but explain a significant proportion (40 percent) of the variation in consumer price inflation in Canada.[9]

Our calibration of the GEM also does a good job at replicating the persistence of GDP growth and year-over-year core inflation in Canada, as

[8] See Coletti, Lalonde, and Muir (2008) for further evidence.

[9] The model structure assumes that the shocks are independent. However, we find that one in five covariances are statistically significant at conventional levels, although most are relatively small. Almost all of the covariances are limited to shocks that are within the same major grouping. Our main results, at least qualitatively, are not sensitive to allowing for these covariances.

Figure 1. Auto- and Cross-Correlation Functions: The Global Economy Model (GEM) Against Historical Data



Note: Grey line is the stochastic simulation of the GEM; black solid line is the historical data; dashed lines are the historical 95 percent confidence intervals

shown in Figure 1.[10] The persistence of price and wage inflation in both countries is matched by calibrating the adjustment cost technology, so that the weight on lagged inflation in the linearized Phillips curves is equal to about 0.41, and the weight on forward-looking expectations of inflation in the next period is 0.58. Furthermore, from Figure 1, we can see that the model captures the broad pattern of the correlations between the real interest

[10]The solid grey lines represent the average correlations based on the GEM data, the solid black lines are the historical correlations and the dashed lines represent the 95 percent confidence intervals around the historical correlations.

Table 2. Relative Standard Deviations

Variable	History		Global Economic Model	
	Canada	United States	Canada	United States
	5th–95th percentile	5th–95th percentile		
Inflation	0.2–0.4	0.2–0.4	0.3	0.5
Interest rate	0.6–1.0	0.6–1.2	0.6	1.4
Real exchange rate	1.1–3.7	—	1.4	—

rate and consumption growth, the growth in real imports, and the change in the real exchange rate, and Canadian and U.S. GDP growth.[11] On the downside, our version of the GEM tends to introduce a four-quarter phase shift in the peak positive correlation in lags of the output gap and inflation, relative to the historical data. Although the model tends to overpredict the degree of volatility in most of the key macro series, we find that when normalized for the volatility in the output gap, the model generates relative variability that is much closer to the empirical estimates for inflation, nominal interest rates, and the real exchange rate (see Table 2).[12]

II. Inflation Targeting vs. Price-Level-Path Targeting

Methodology

In order to assess the relative merits of the alternative monetary policy frameworks, we assume that the central bank seeks to minimize the quadratic loss function:

$$L = \lambda_\pi \sigma_\pi^2 + \lambda_y \sigma_y^2 + \lambda_i \sigma_{\Delta i}^2, \tag{1}$$

where σ_π^2, σ_y^2, and $\sigma_{\Delta i}^2$ are the unconditional variances of the deviations of year-over-year inflation from its targeted level, the output gap, and the first difference of the nominal interest rate. λ_π, λ_y, and λ_i are the respective weights on the deviations. We feel that this characterization of central bank objectives has the benefit of being quite transparent and consistent with central banks' often stated desire to control inflation, while stabilizing the business cycle.[13]

[11]Each figure plots the correlation between the first variable identified in the figure title on the vertical axis and the six lags and leads of the second variable identified on the horizontal axis. So the number −6 along the horizontal axis represents a lag of six periods for the second variable.

[12]To better replicate the absolute variability of the key macro variables, we scale the variance of the shocks used in the stochastic simulations by a common factor.

[13]One weakness of using an ad hoc loss function to evaluate the relative merits of IT and PLPT is that relative weights on the output gap and inflation are also arbitrary in nature. An alternative approach is to assess policies in terms of their relative abilities to maximize the welfare of the model's representative agent.

In our baseline, we assume that the central bank cares equally about both inflation and output gap volatility, so we set $\lambda_\pi = \lambda_y = 1$. Also, a small weight ($\lambda_i = 0.1$) is placed on the change in the nominal interest rate, in order to penalize policy rules in which the nominal short-term interest rate hits the zero lower bound more than 5 percent of the time.[14]

We limit our analysis to simple monetary policy rules. Simple rules differ from fully optimal rules in that they only consider a subset of the variables that are included in the fully optimal rules. Our choice to focus on simple rules is motivated by the belief that they are more likely to be robust across plausible models, than are fully optimal rules (Levin, Wieland, and Williams, 2003), and because central banks find them easier to communicate to the public. We use the following generic form from Batini and Yates (2003):

$$\begin{aligned} i_t = {} & \omega_i i_{t-1} + (1 - \omega_i) i^* \\ & + \omega_p (E_t p_{t+k} - \eta E_t p_{t+k-1} - p_{t+k}^{TAR} + \eta p_{t+k-1}^{TAR}) + \omega_y y_t, \end{aligned} \tag{2}$$

where i is the nominal interest rate, i^* is the equilibrium nominal interest rate, E denotes the expectations operator, p is the logarithmic level of consumer prices, and TAR denotes a targeted value. The central bank attempts to minimize the loss function (1), by choosing the degree of interest rate smoothing, ω_i; the short-run elasticity of the nominal interest rates to expected deviations of prices (inflation) from target, ω_p; the short-run elasticity of the nominal interest rates to expected deviations of real GDP from potential output, ω_y; and the feedback horizon over which policy is conducted, k. For IT, η is assumed to be unity; for PLPT, it is zero.

We minimize the central bank loss function by searching over all of the coefficients and the feedback horizon, using stochastic simulations conducted with numerical perturbation methods. As we are searching over four different parameters, the process is extremely computationally intensive.

Results

Macroeconomic stabilization

The first question that we focus on is the relative ability of IT and PLPT to minimize the variability in inflation and the output gap. Table 3 reports the value of the loss function and the standard deviations of key macroeconomic variables in Canada and the United States under the optimized IT and PLPT rules. For the United States, there are only two rules: IT and PLPT. For Canada, there are four rules: IT and PLPT conditional upon the United States following either IT or PLPT.

The first part of our discussion concentrates on the case of Canada, assuming that the United States chooses IT. From Table 3 we see that PLPT

[14]This calculation is based on a real interest rate of 3 percent and an inflation target of 2 percent (or, alternatively, a price-level-path target that grows by 2 percent per year).

Table 3. Standard Deviations of Key Variables under the Optimized Rules

	United States		Canada (U.S. IT)		Canada (U.S. PLPT)	
	IT	PLPT	IT	PLPT	IT	PLPT
Loss function	0.962	0.903	2.148	2.134	2.167	2.154
CPI inflation	0.350	0.363	0.499	0.407	0.498	0.405
Output gap	0.800	0.750	1.335	1.366	1.343	1.373
Interest rate (change)	1.410	1.440	1.087	1.020	1.079	1.017

Note: IT = inflation targeting; PLPT = price-level-path targeting; CPI = consumer price index.

is preferred to IT in terms of the loss function. The overall gain is, however, quite small, as the incremental benefit of moving from the optimized IT rule to the optimized PLPT rule is only 0.5 percent of the gain of moving from the historical Taylor rule to the optimized IT rule. It is interesting to note that, under PLPT, lower inflation and nominal interest rate variability come at the expense of higher output gap variability. We conclude that PLPT rules can deliver a reduction in price-level uncertainty, while simultaneously reducing inflation and interest rate variability. This could all be achieved at the cost of a small increase in output gap variability.

Table 4 shows that the simple PLPT rule is more forward looking than the simple IT rule. The PLPT rule has a target feedback horizon of three quarters, longer than two quarters in the case of the IT rule. Central banks choose a longer horizon for PLPT relative to IT because it allows them to trade off less output gap volatility for higher inflation variability (Smets, 2003). Note the very high value for the interest rate smoothing term ($\omega_i = 0.97$) in the IT rule. Everything else being equal, as $\omega_i \to 1$, the degree of price-level drift under IT falls, and IT looks to be increasing like PLPT. Optimal IT in the model implies a much higher degree of interest rate smoothing than is suggested by estimates of historical policy rules.

To assess the robustness of our results, we conduct a number of sensitivity analyses. First, we confirm results previously seen in the literature, which suggest that increasing the degree to which price and wage determination is forward looking tends to enhance the merits of PLPT relative to IT. Second, we vary the relative weights on inflation and output gap variability in the loss function. Increasing the relative weight on inflation variability tends to reinforce the attractiveness of PLPT. However, as PLPT does not dominate IT in terms of both output gap and inflation stabilization, it is possible to choose a large enough weight on output gap variability that results in IT being preferred to PLPT.

Our most interesting finding concerns the robustness of our results to the distribution of the shocks. To address this issue, we recalculate optimized PLPT and IT rules for each of the major categories of domestic shocks in Canada—first under the baseline calibration, and then under the alternative

Table 4. Results for Simple Optimized Rules

	United States		Canada (U.S. IT)		Canada (U.S. PLPT)	
	IT	PLPT	IT	PLPT	IT	PLPT
k	1.00	2.00	2.00	3.00	2.00	3.00
ω_i	0.86	0.88	0.97	0.85	0.98	0.86
ω_p	2.95	2.20	2.44	3.74	2.45	3.84
ω_y	1.22	1.83	0.70	0.85	0.70	0.85

Note: IT = inflation targeting; PLPT = price-level-path targeting.

assumption that price and wage determination are completely forward looking. Under the baseline model calibration, we find that IT is preferred in the mark-up and labor supply shocks, but that PLPT is favored in all other shocks. Alternatively, in the model with perfectly forward-looking price and wage determination, PLPT is preferred in all shocks, including the mark-up and labor supply shocks. These simulations lead us to conclude that the relative merits of IT and PLPT are sensitive to an important interaction between the degree to which price and wage determination is forward looking, and the importance of mark-up and labor supply shocks relative to demand and productivity shocks.

Why is it that the source of the shock matters when inflation is partially indexed to lagged inflation? To gain some insight, we first consider a price mark-up shock in the model with fully forward-looking inflation. PLPT offers disadvantages and advantages relative to IT. On the downside, the simple idea of having to return the price level to its target path, everything else being equal, means that the variance of inflation under PLPT must be larger than under IT. On the plus side, PLPT offers a powerful expectations channel. The commitment to a lower future inflation rate under PLPT than what would be implied under IT means that current period inflation will be lower under PLPT than under IT. To generate this result, the central bank must create more cumulative excess supply under PLPT (that is, as long as the price level is above the target, PLPT requires excess supply). Everything else being equal, a PLPT central bank will find it optimal to create less initial excess supply that lasts longer. Taken together, this means that although the cumulative output gap is larger under PLPT, the PLPT output gap has a smaller variance than that generated under IT.

Now consider a positive demand shock. As in the case of the price mark-up shock, the commitment of the central bank to the price-level-path target implies that future inflation rates must be lower under PLPT than under IT. This leads to inflation that is initially lower than under IT. To support this outcome, the central bank needs to create excess supply at some time in the future under PLPT, but not under IT. In addition, the initial jump in the output gap, under PLPT, is smaller than under IT. As a result, both the cumulative output gap and the variance of the output gap, under PLPT, are smaller than under IT.

We can conclude, in the perfectly forward-looking model, that the relative benefits from PLPT vs. IT are larger in demand shocks than in mark-up shocks. If we gradually increase the weight on lagged inflation in the Phillips curve, the monetary control problem becomes more difficult, and the relative advantage of PLPT begins to disappear. Our calibration of the model lies in the zone for which PLPT is still favored in demand shocks, but the degree of indexation in inflation is high enough to tilt the results toward IT in mark-up shocks.

Does the presence of terms-of-trade shocks matter?

In the second part of our analysis, we focus on the role played by terms-of-trade shocks. Our interest in this question is motivated, in part, by arguments that suggest that stabilizing the aggregate price level in face of relative price shocks could introduce increased variability in output, that would outweigh the benefits associated with reduced price-level uncertainty (Bank of Canada, 2006).

The first question that we consider is the definition of a terms-of-trade shock. Based on the long-run historical variance decomposition suggested by the model, we conclude that the shocks that have had the most important influence on Canada's terms of trade are (1) the U.S. consumption shock, (2) the U.S. import demand shock, (3) the exchange rate shock, and (4) the Canadian tradable price mark-up shock, as they account for 60 percent of the total variation in the terms of trade. Then, we re-optimize the simple PLPT and IT rules for this basket of shocks only, and find that PLPT is favored over IT. This result comes about because Canadian terms-of-trade movements have been principally associated with shocks that generate a positive covariance between the output gap and inflation (for example, variations in the demand for Canadian goods).

Does the choice of monetary policy framework in the United States matter for Canada?

Finally, we consider another open economy element of our analysis. Srour (2001) suggests that if alternative monetary policy regimes in the large foreign country lead to significantly different behavior of real variables in the foreign economy, then it is possible that exchange rate adjustment will not completely insulate the small home country from the consequences of the foreign regime choice.

Table 4 shows, however, that the choice of PLPT or IT in the United States has no influence on the relative merits of IT and PLPT in Canada. This result comes through because the choice of PLPT or IT in the United States has little influence on the real factors important for Canada, such as U.S. demand variability, or the variability of U.S. interest rates (see Table 3). Moreover, we find that the choice of IT vs. PLPT in the United States has negligible implications for the parameterization of the monetary policy rule in Canada.

III. Conclusions and Future Extensions

We find that simple PLPT rules are slightly better than simple IT rules, in terms of minimizing inflation and output-gap variability. Our analysis highlights the important interaction between the degree to which price determination is forward looking and the distribution of the shocks to the economy.

Also, our work addresses two important open economy considerations. First, we isolate the contribution of terms-of-trade shocks on the relative merits of PLPT and IT. We find that most shocks that have important implications for explaining the Canadian terms of trade over history also imply a positive covariance between inflation and the output gap in Canada. Consequently, our analysis suggests that macroeconomic stabilization is best achieved by following a simple PLPT rule. Lastly, we find that the choice of monetary policy framework in the United States does not affect the relative merits of IT vs. PLPT in Canada.

There are many possible extensions to our work. In particular, given the importance of fluctuations in commodity prices to the terms of trade for Canada and the United States, we think that it would be prudent to incorporate commodities into the model, as in Lalonde and Muir (2007). Second, we would like to add a distribution sector to the model, to better address the issue of exchange rate pass-through from measured border prices to consumer prices. Third, we would like to consider other model modifications that would help us better match the unconditional moments of the historical data. Finally, we are interested in extending the analysis by performing a full welfare analysis of the two monetary policy frameworks.

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