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Abstract

In this report, we evaluate several simple monetary policy rules in twelve private and public sector models of the Canadian economy. Our results indicate that none of the simple policy rules we examined is robust to model uncertainty, in that no single rule performs well in all models. In fact, our results show that the performance of some of the simple rules, particularly interest-rate-smoothing rules and rules that have a high coefficient on the inflation gap, can substantially deviate from the optimal rule and can even be unstable in some models. Our results are thus very different from those of Levin, Wieland, and Williams (1999), who argue that simple policy rules are not only robust but also generate essentially the same policy frontier as more complicated rules or rules that respond to a large number of variables. Furthermore, we find that open-economy rules do not perform well in many models. In fact, we find that adding an exchange rate term to a simple policy rule often increases the loss-function value. This result is thus very different from that of Ball (1999), who argues in favour of a rule that includes the exchange rate. Although it is not robust, we find that a simple nominal Taylor-type rule that has a coefficient of 2 on the inflation gap and 0.5 on the output gap outperforms the other simple rules in a certain class of models. But even in those models the loss-function value of this simple rule can substantially deviate from the optimal or base-case rule.

JEL classification: E52, E58
Bank classification: Uncertainty and monetary policy

Résumé

Les auteurs du rapport évaluent plusieurs règles de politique monétaire simples à l'aide de douze modèles différents de l'économie canadienne utilisés dans les secteurs privé et public. Ils constatent qu'aucune des règles étudiées n'est robuste face à l'incertitude de la modélisation, c'est-à-dire qu'aucune ne donne de bons résultats dans la totalité des modèles. Certaines d'entre elles, en particulier les règles de lissage des taux d'intérêt et les règles où le coefficient de l'écart d'inflation est élevé, sont beaucoup moins efficaces que la règle optimale et peuvent même se révéler instables dans des modèles particuliers. Ainsi, les résultats obtenus par les auteurs sont très différents de ceux de Levin, Wieland et Williams (1999), qui soutiennent que les règles de politique monétaire simples non seulement sont robustes, mais qu'elles créent essentiellement la même frontière efficace que les règles plus complexes ou que celles qui comportent un grand nombre de variables. En outre, les auteurs observent que les règles qui incluent le taux de change produisent de piètres résultats dans de nombreux modèles. D'après eux, le fait d'ajouter le taux de change à une règle de politique monétaire simple accroît souvent la valeur de la fonction de perte. Ce résultat est donc à l'opposé de celui de Ball (1999), qui se déclare en faveur d'une règle incluant le taux de change. Les auteurs constatent également que, même si elle n'est pas robuste, une règle nominale simple à la Taylor dans laquelle les écarts d'inflation et de production sont assortis de coefficients égaux à 2 et 0,5 respectivement se comporte mieux que les autres règles simples dans un groupe précis de modèles. Toutefois, même dans ces modèles, la valeur de la fonction de perte associée à cette règle simple peut fortement s'écarter de celle de la règle optimale ou de la règle de base propre à chacun des modèles.

Classification JEL : E52, E58
Classification de la Banque : Incertitude et politique monétaire

1. Introduction

When conducting monetary policy, monetary authorities face several sources of uncertainty. Among the most important is the uncertainty surrounding the channels through which monetary policy affects the economy and the types of shocks hitting the economy. One way to address these problems is to use many different models in the decision-making process. It is expensive, however, to build and maintain several models. Moreover, forecasts generated by different models may lead to contradictory recommendations, in which case decision-makers must decide how much weight to assign to each model. That is not an easy task. Another strategy, recommended and pursued by several researchers, is to search for a simple monetary policy rule that performs well across a wide range of models and is thus robust to model uncertainty.[1]

We define a simple rule as one that is linear and contains a small number of state variables. One advantage of simple rules is that they are relatively easy to build and communicate. Moreover, they are less model-dependent, because they use available information and hence do not depend on the forecasts of specific models. An example of a simple rule is the now-famous Taylor rule that John Taylor (1993) proposed to describe the behaviour of the U.S. Federal Reserve between 1987 and 1992.

Numerous studies have shown that simple rules not only perform well but are more robust to model uncertainty than complicated rules. Levin, Wieland, and Williams (1999) find that simple policy rules—particularly rules that have a high degree of interest rate smoothing and that respond to the deviation of inflation from its target and the contemporaneous output gap—perform nearly as well as more complicated rules in four models of the U.S. economy. Moreover, they find that complicated rules, although optimal in some models, are not very robust, because they lead to substantial deterioration in the loss-function value when they are tested in different models.[2]

Most studies on simple monetary policy rules have involved models of the U.S. economy; few studies have evaluated these types of rules in models of the Canadian economy.[3] This report partially fills that gap by investigating the performance and robustness of several simple monetary policy rules in twelve private and public sector models of the Canadian economy (see Appendix A

1. For example, Levin, Wieland, and Williams (1999) and McCallum (1999).
2. This result is rather intuitive, because complex rules are usually fine-tuned to account for the specific dynamics of a given model. When tested outside that model, they often perform poorly.
3. Exceptions are Amano (1998), Armour, Fung, and Maclean (2002), Côté and Lam (2001), and Srour (Forthcoming). These authors study the performance of simple rules using a given model. Consequently, they cannot say much about the robustness of simple policy rules in various models. Note, however, that Amano and Srour study the performance of simple rules in different versions of the same model.

for a list of the participating organizations and their models, plus definitions of abbreviations used for model names).[4] Our work differs from the previous studies on simple rules in several ways. First, we use a very large number of models to evaluate simple policy rules. Moreover, the models used are very diverse and are used to forecast key variables of the Canadian economy and/or for policy analysis. As a result, we pay careful attention to how they fit the data.[5] By using a wide variety of models, we are able to address some of the criticisms, notably those of Hetzel (2000) and Svensson (2002), that the models used in the past to evaluate simple monetary policy rules were too similar in structure and did not really test the robustness of the rules. Second, we pay close attention not only to model uncertainty but also to shock uncertainty. Research on policy rules to date has mainly emphasized the robustness of simple rules with respect to model uncertainty. We thus investigate whether simple policy rules are robust to shock uncertainty.

All participants in the study evaluated a common set of simple rules that were chosen according to specific criteria. We proceeded in two steps:

(i) Participants who could perform stochastic simulations or solve their model analytically were first asked to identify the "best" simple rule in their models.[6] Those simple rules were evaluated according to a simple loss function consisting of the unconditional variance of the deviations of inflation from its target and of the variance of the output gap. The "best" simple rule was assumed to be the one that minimized the loss function. Because only five participants were able to run stochastic simulations, five "best" simple rules were identified.[7]

(ii) The five "best" simple rules, in addition to the original Taylor rule and an open-economy rule (which included an exchange rate term), were then submitted to the seven participants who were not able to perform stochastic but only deterministic simulations. These rules are shown in Table 1.[8] Because the unconditional variances for inflation and the output gap could not be generated in this case, we took a different but complementary approach to compute the loss-function value of each rule. Participants who were unable to perform stochastic simulations

4. Participating organizations performed most of the simulations on which this study is based. They also provided information on the properties of their models to facilitate our interpretation of the simulations.

5. Sims (2001) argues that existing studies that use models to evaluate policy rules have not paid enough attention to how those models fit the data.

6. These are QPM, MULTIMOD, NAOMI, the M1-VECM, and the LPM. Because we restrict our attention to simple rules, the "best" simple rule, in most cases, is not the optimal rule for the model.

7. Apart from testing virtually thousands of rules, we ensured that the participants evaluated each other's "best" simple rule. Note that MULTIMOD is the only model that does not evaluate open-economy rules.

8. The coefficients for the open-economy rule are essentially those of Taylor (1999).

were asked to simulate five deterministic shocks in their model. To calculate "variance" statistics, we used the mean squared deviation of the "shock-minus-control" response of inflation and output from equilibrium. These two "variance" statistics were assumed to be equivalent to the unconditional variances of inflation and the output gap. Using the same loss function as in step (i), we then computed the loss-function value for each rule in these seven remaining models. The rules were then ranked according to their ability to minimize the loss function.

Table 1: The Seven Simple Rules

Rule	ρ	α_π	α_y	α_ε
Original Taylor rule	0	1.5	0.5	0
Simple rule from LPM	0.9	1.0058	0	0
Simple rule from M1-VECM	0.9	1.5	0.5	0
Simple rule from MULTIMOD	0	4	2	0
Simple rule from NAOMI	0	2	0.5	0
Simple rule from QPM	0	3	0.5	0
Open-economy rule	0	2	0.5	0.2

Note: The simple rules have the following form:

$$i_t = \rho i_{t-1} + (1-\rho)[i_t^* + \alpha_\pi(\pi_t - \pi_t^*) + \alpha_y(y_t - y_t^*) + \alpha_\varepsilon(e_t - e_{t-1})],$$

where i_t is the short-term nominal interest rate, i_t^* is the equilibrium value of that interest rate, ρ represents the degree of smoothing, $(\pi_t - \pi_t^*)$ is the inflation gap, $(y_t - y_t^*)$ is the output gap, and e_t is the nominal bilateral Can$/US$ exchange rate.

Our results indicate that none of the seven simple rules is robust to model uncertainty. In fact, we find that only four rules are stable in all models.[9] Moreover, unlike Levin, Wieland, and Williams (1999), we find that simple rules can lead to substantial deterioration in the loss-function value

9. The simple rules from NAOMI, QPM, the original Taylor rule, and the open-economy rule are the only rules that are stable in all models. Each of these four rules has the same coefficient on the output gap, with the simple rule from QPM, NAOMI, and the open-economy rule having higher coefficients on the inflation gap compared with that of the original Taylor rule.

when compared with the base-case or optimal rule of each model. We also find that rules with interest rate smoothing perform poorly or are often unstable, particularly in models that fall under the "conventional" paradigm.[10] Rules with interest rate smoothing perform relatively well, however, in the M1-VECM and the LPM—models that fall under the "money matters" paradigm.[11] In the LPM, a rule with interest rate smoothing works well because agents are completely forward looking and because such rules decrease the likelihood that inflationary expectations will become self-fulfilling. On the other hand, a rule with interest rate smoothing outperforms the other simple rules in the M1-VECM, since it is optimal in this model for policy-makers to keep interest rates high for a long period of time once inflation increases, because the money gap (which causes inflation) is persistent.

Our results thus differ from those of Levin, Wieland, and Williams (1999), who find that rules with a high degree of smoothing work well in four models of the U.S. economy. They argue that these rules perform well because they offer policy-makers greater influence over long-term rates. As argued by Goodfriend (1991) and discussed in Levin, Wieland, and Williams (1999), a rule with interest rate smoothing, by moving short rates in a smooth but persistent manner, will induce persistent movements in long-term rates and hence allow policy-makers to have greater influence over output and inflation. This argument relies on the assumption that long-term interest rates have an important role in the transmission mechanism and that smooth and persistent changes in short-term rates can influence the long-term rate via the term structure. Because the long-term rate on its own probably does not play as vital a role in the transmission mechanism in Canada as in the United States, there may be fewer reasons to adopt an interest-rate-smoothing rule in models of the Canadian economy.[12]

We also find that rules that contain an exchange rate term do not improve but rather often lead to a deterioration in the loss function. Our findings are thus similar to those of Taylor (1999) and Leitemo and Söderstrom (2001), but differ from those of Ball (1999). Working with a backward-looking, small open-economy model, Ball (1999) concludes that incorporating the exchange rate in a policy rule leads to a significant improvement in the volatility of output and inflation.[13] On the other hand, Taylor (1999), after simulating his multi-country model, finds that the rule proposed by Ball often creates more instability than the basic Taylor rule.

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10. The models that fall under this category are mostly backward-looking models. Our results are thus similar to those of Ball (1999) and Rudebusch and Svensson (1999).
11. These two paradigms are described in section 2.
12. This may be because the monetary authority has less influence on long-term rates in Canada (and in models of the Canadian economy), as they are mostly determined by global markets.
13. Ball (1999) argues that his "open-economy" rule, when compared with Taylor-type rules, reduces output variability by around 17 per cent without inducing an increase in inflation volatility.

There are several reasons why rules that contain an exchange rate term do not perform well even in open-economy models. If movements in the exchange rate mostly reflect changes in fundamentals rather than portfolio shocks, then an attempt by the monetary authorities to smooth fluctuations in the exchange rate will undermine the ability of the exchange rate to act as a shock absorber, hence causing output and inflation to be more volatile.[14] Moreover, uncertainty associated with the determination of the equilibrium exchange rate may also partly explain why such types of rules do not perform very well. In addition, since the exchange rate is a highly endogenous variable, movements in it may already be reflected in inflation and the output gap. In that case, including an exchange rate term in a policy rule that already contains inflation and the output gap could be redundant (see Taylor 2001).

This paper is organized as follows. In section 2 we describe the models involved in this study. Section 3 analyzes the performance of simple monetary policy rules in models that were used to perform stochastic simulations and in models that were used to perform deterministic simulations. Section 4 concludes.

2. Comparison and Description of the Models

The models considered in this study (listed in Appendix A) differ in several ways.[15,16] We start our analysis by examining and comparing the basic features of the different models with respect to their paradigm, structure, and dynamic properties. We then describe two examples of how the models respond following a short-term interest rate shock and an exchange rate shock.

The twelve models used in this study can be classified under two economic paradigms. The first one is the “conventional” paradigm and the second is the “money matters” paradigm. Under the conventional paradigm, monetary policy actions affect inflation mainly through their effects on aggregate demand and the output gap. While most models fall under the conventional paradigm, there are nevertheless important differences within it, such as structure, parameterization, size, and estimation techniques. For example, NAOMI is a small estimated model but QPM is a large-scale calibrated model. MTFM is a fairly disaggregated model compared with most of the others.

Under the “money matters” paradigm, monetary policy actions affect inflation mostly through movements in monetary aggregates. Only two models fall under this category: the M1-VECM, in

14. This is consistent with the conclusions reached by Djoudad, Murray, Chan, and Daw (2001) and Djoudad, Gauthier, and St-Amant (2001), who use different methodologies.
15. For a more thorough analysis, see Côté et al. (2002).
16. The frequency of all models is quarterly, except MULTIMOD, which is an annual model, and INTERLINK, which is semi-annual.

which the money gap—the disequilibrium between money supply and estimated long-term money demand—influences inflation, while still allowing a role for the output gap, and the LPM, in which rigidities in adjusting money balances are the main source of the short-run non-neutrality of monetary policy.

The models can also be differentiated based on the channels through which monetary policy actions affect the economy. In most of the models, monetary policy actions affect the economy through the level of short-term interest rates. This is the case for CEFM, DRI, FOCUS, FOCUS-CE, INTERLINK, MTFM, WEFA, LPM, and MULTIMOD. In other models, such as the M1-VECM, NAOMI, and QPM, the monetary policy transmission mechanism works through the slope of the yield curve.

Inflation is determined by a linear Phillips curve in most participating models: CEFM, DRI, FOCUS, INTERLINK, WEFA, and NAOMI. While the M1-VECM falls under the "money matters" paradigm, the disequilibrium in the product market also plays a role in the adjustment of prices. Asymmetries in the inflation process are introduced in the models of FOCUS-CE, MULTIMOD, and QPM. On the other hand, the MTFM uses a very disaggregated approach to determining price adjustment.

Eight out of twelve models (CEFM, DRI, FOCUS, INTERLINK, MTFM, WEFA, M1-VECM, and NAOMI) assume purely backward-looking inflation expectations, while three models (FOCUS-CE, MULTIMOD, and QPM) include both backward-looking and model-consistent inflation expectations. In QPM and MULTIMOD, in particular, the hybrid Phillips curve assigns more weight to backward-looking inflation expectations than to model-consistent inflation expectations.[17] The LPM is the only model that incorporates purely model-consistent behaviour and is optimally derived from microfoundations.

To further understand the structure and properties of the different models (i.e., the way the various models respond to different macroeconomic shocks), we perform several deterministic simulations. Because output and inflation dynamics depend in part on the specification of monetary policy, to compare the different models we specify a common policy reaction function. The original Taylor rule is thus imposed as the baseline reaction function in each model. Eight deterministic shocks (seven temporary and one permanent) are then simulated in eleven of the twelve models.[18] The seven temporary shocks are as follows: a domestic demand shock, an external shock, a shock

17. In QPM, the weight on lagged inflation is 0.7, whereas it is 0.75 in MULTIMOD.
18. Except for the LPM, which was not able to simulate any of the shocks described in Appendix B.

to commodity prices, a price shock, a wage growth shock, a shock to short-term interest rates, and a shock to the exchange rate. The permanent shock is a shock to long-term interest rates.[19]

Tables 2 and 3, respectively, present the peak response in the first four quarters of real gross domestic product (GDP), consumer price index (CPI) inflation, and the exchange rate following a transitory increase in short-term interest rates and a transitory depreciation in the exchange rate.[20] For comparison, the models are grouped into three categories: "Least sensitive," "Moderately sensitive," and "Most sensitive," according to the sensitivity of real GDP, CPI inflation, and the exchange rate with respect to the interest rate shock. Using our definition of sensitivity, the peak response of real GDP and CPI inflation in most models does not appear to be very sensitive to changes in interest rates. When the sensitivity of the exchange rate is considered, however, several models appear to be very responsive to changes in interest rates. When the exchange rate shock is considered, it does not have a big impact on real GDP and CPI inflation in most models (except for QPM and, to a lesser extent, the M1-VECM, which are highly responsive to this shock). There are two reasons why this might be the case. First, some models do not have a well-developed external sector; hence the linkages between the exchange rate, output, and inflation may be weak. Second, if most models are interpreting this shock not as a portfolio shock but as a fundamental shock, the response of output and inflation will be muted.

19. These deterministic shocks are described in Appendix B. Several of them require explanation. The price shock, for example, is interpreted as a temporary change to firms' profit margins. The temporary shock to short-term interest rates is interpreted as a modification of the inflation target, while the permanent shock to long-term interest rates represents a permanent change in the term premium. Finally, the transitory shock to the exchange rate is interpreted as a temporary loss of confidence by investors in the Canadian economy.

20. Detailed results of the eight deterministic shocks are not described here. They are, however, available from the authors upon request or from the Bank of Canada Web site at http://www.bankofcanada.ca/workshop2001/.

Table 2: Peak Response to a Transitory Change in Short-Term Interest Rates

	Least sensitive (Peak response in the first four quarters is less than 0.25%)	**Moderately sensitive** (Peak response in the first four quarters is between 0.25% and 0.5%)	**Most sensitive** (Peak response in the first four quarters is more than 0.5%)
Real GDP	CEFM, WEFA, FOCUS-CE	INTERLINK, NAOMI, MULTIMOD, QPM, M1-VECM, DRI	FOCUS, MTFM
CPI inflation	CEFM, DRI, QPM, INTERLINK, MTFM, MULTIMOD, WEFA	FOCUS, FOCUS-CE, NAOMI	M1-VECM
Exchange rate	CEFM, DRI	QPM, WEFA	FOCUS, FOCUS-CE, INTERLINK, MTFM, MULTIMOD, NAOMI, M1-VECM

Note: Short-term interest rates are increased by 100 basis points, 75 basis points, 50 basis points, and 25 basis points, respectively, during the first four quarters. Results for the LPM were not available.

Table 3: Peak Response to a Transitory Change in the Exchange Rate

	Least sensitive (Peak response in the first four quarters is less than 0.25%)	**Moderately sensitive** (Peak response in the first four quarters is between 0.25% and 0.5%)	**Most sensitive** (Peak response in the first four quarters is more than 0.5%)
Real GDP	CEFM, DRI, FOCUS, INTERLINK, WEFA, MULTIMOD, NAOMI, FOCUS-CE	MTFM	QPM, M1-VECM
CPI inflation	DRI, FOCUS, INTERLINK, MTFM, MULTIMOD, NAOMI, M1-VECM	CEFM, FOCUS-CE, WEFA	QPM

Note: The Canadian currency relative to that of the United States depreciates by 1 per cent in the first quarter, by 0.75 per cent in the second, 0.50 per cent in the third, and 0.25 per cent in the fourth. Results for the LPM were not available.

3. Comparison of Rules

Table 1 lists the common set of rules that we evaluate. As the table shows, the simple rules from the M1-VECM and LPM have a high coefficient on the lagged interest rate, with the simple rule from the LPM having a zero weight on the output gap and the simple rule from the M1-VECM having a small weight on both the inflation and output gaps. The simple rules from MULTIMOD, NAOMI, and QPM, on the other hand, are all variants of the rule proposed by Taylor (1993). All three simple rules have a higher coefficient on the inflation gap than Taylor's original specification, with the simple rule from MULTIMOD also having a higher coefficient on the output gap.

All of the models that were used to perform stochastic simulations showed that rules containing an exchange rate term were dominated by closed-economy rules. We have already offered an intuition for this finding. Despite the finding, we have included an open-economy rule in our exercise, because Canada is a small open economy and it has been argued that open-economy rules can perform well in small open-economy models.

3.1 Results of stochastic simulations

The performance of the seven simple rules is first analyzed in models that are able to derive efficiency frontiers either analytically or through stochastic simulations. These models are the LPM, M1-VECM, MULTIMOD, NAOMI, and QPM. Except for NAOMI, which is solved analytically, stochastic simulations are implemented by drawing from a random process that reflects the historical distribution of shocks. In MULTIMOD, for example, the shock processes are obtained from the estimated residuals of the model and 100 random draws, each lasting 100 years, are generated. The simulation results are then summarized by calculating the unconditional variances of inflation, the output gap, and nominal interest rates. A similar type of exercise is performed in QPM, the M1-VECM, and the LPM. On the other hand, in NAOMI, because this model is solved analytically, the variances of inflation, the output gap, and nominal interest rates are calculated simply as a function of the model's residual variance and covariance and coefficient matrix. Since we do not assume a common distribution of shocks in all of these models, to avoid a scaling problem resulting from this lack of uniformity we rank the seven simple rules using an ordinal rather than a cardinal approach.

In each model, all simple rules are evaluated according to an explicit loss function consisting of the unconditional variance of the deviation of inflation from its target and the variance of the output gap. This loss function is given by:

$$Loss = Var(\tilde{\pi}) + 0.25Var(\tilde{y}) . \tag{1}$$

Our specification of the loss function is similar to those commonly found in the literature (see, for example, Levin, Wieland, and Williams 1999, Rotemberg and Woodford 1999, and Svensson 2000).[21] The smaller weight on the variability of the output gap assumes that policy-makers have a stronger preference for minimizing the variability of inflation than the variability of output.[22]

We first evaluate the seven simple rules in these five models by comparing their performance with that of the base-case or optimal rule for each model.[23] Our results, shown in Tables 4 to 8, indicate that none of the seven rules tested is very robust to model uncertainty, in the sense of performing well in all models and being able to generate policy frontiers that are essentially similar to the base-case or optimal rule. In fact, our findings indicate that the results of some of the simple rules, particularly rules with interest rate smoothing, can substantially deviate from those of the optimal or base-case rule in some models.

For example, as Table 4 shows, when the seven rules are tested in QPM, except for the simple rule from MULTIMOD, QPM, and NAOMI, the other rules perform very poorly compared with an inflation-forecast-based (IFB) rule, which is the base-case rule of the model, indicating that replacing the base-case rule by a simple rule can lead to substantial deterioration in the loss function.[24] Table 4 shows that if the IFB rule is replaced by the original Taylor rule, the loss-function value in QPM increases by 128 per cent. On the other hand, if the simple rule from the M1-VECM replaces the IFB rule, the loss-function value increases by 750 per cent.

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21. Woodford (1999) has shown that such a loss function can be derived as a second-order approximation of a representative agent's utility function.
22. Because a large number of models are involved in this study, for practical reasons we have decided not to include the volatility of interest rates in the base-case loss function. We have performed several sensitivity tests, however, by including a non-zero weight on interest rate volatility in our loss function. These sensitivity tests did not alter our basic results.
23. In most cases, the optimal rule was not derived. We instead use the base-case rule for comparison.
24. The choice of the "best" simple rule in QPM deserves some explanation. Although the simple rule from MULTIMOD has a lower loss-function value than the simple rule from QPM in the QPM, the latter was chosen as the "best" simple rule, because the former generates too much volatility in interest rates and frequently violates the lower zero bound of nominal interest rates.

Table 4: Performance of the Simple Rules in QPM

Rule	Value of loss function	Deviation from base-case rule (per cent)
Base-case rule—IFB rule	2.32	0
Simple rule from LPM	7.16	209
Simple rule from M1-VECM	19.71	750
Simple rule from MULTIMOD	2.74	18
Simple rule from NAOMI	3.84	66
Simple rule from QPM	2.96	28
Original Taylor rule	5.28	128
Open-economy rule	6.45	178

Table 5: Performance of the Simple Rules in LPM

Rule	Value of loss function	Deviation from optimal rule (per cent)
Optimal rule	0.92	0
Simple rule from LPM	1.43	50
Simple rule from M1-VECM	2.42	162
Simple rule from MULTIMOD	unstable	unstable
Simple rule from NAOMI	2.96	220
Simple rule from QPM	2.60	181
Original Taylor rule	4.54	390
Open-economy rule	4.05	340

Table 6: Performance of the Simple Rules in NAOMI

Rule	Value of loss function	Deviation from base-case rule (per cent)
Base-case rule—IFB rule	1.1	0
Simple rule from LPM	unstable	unstable
Simple rule from M1-VECM	unstable	unstable
Simple rule from MULTIMOD	unstable	unstable
Simple rule from NAOMI	1.22	11
Simple rule from QPM	11.39	935
Original Taylor rule	1.51	37
Open-economy rule	1.48	35

Table 7: Performance of the Simple Rules in MULTIMOD

Rule	Value of loss function	Deviation from base-case rule (per cent)
Base-case rule—IFB rule	1.80	0
Simple rule from LPM	6.20	244.4
Simple rule from M1-VECM	unstable	n/a
Simple rule from MULTIMOD	2.11	17.2
Simple rule from NAOMI	3.42	90
Simple rule from QPM	2.64	46.7
Original Taylor rule	4.84	168.9
Open-economy rule	n/a	n/a

Table 8: Performance of the Simple Rules in M1-VECM

Rule	Value of loss function	Deviation from base-case rule (per cent)
Base-case rule	1.85	0
Simple rule from LPM	2.08	12.2
Simple rule from M1-VECM	1.98	7.1
Simple rule from MULTIMOD	2.64	42.7
Simple rule from NAOMI	2.03	9.7
Simple rule from QPM	2.12	14.7
Original Taylor rule	2.01	8.5
Open-economy rule	3.05	64.9

Simple rules, particularly rules that are not very aggressive, do not work well in QPM because they do not bring inflation back to target quickly enough. On the other hand, rules that are fairly aggressive and bring inflation back to target quickly work well in this model, for two main reasons. First, in QPM, current inflation depends partly on expected future inflation and on lagged inflation, but also indirectly on the credibility of the central bank to bring inflation back to target within a given horizon. A rule that is fairly aggressive and returns inflation to target within the desired horizon will send the right signal to agents and influence their expectations of future inflation in a favourable manner. Since current inflation depends, at least partially, on expected future inflation, an aggressive monetary policy helps to keep current inflation close to target by keeping expected future inflation close to target. Second, a policy rule that returns inflation to its target within the desired horizon will enhance the credibility of the central bank, and this in turn will help reduce current inflation. Because MULTIMOD shares these features with QPM, the same type of argument can be applied to MULTIMOD.

We also find that our common set of simple rules is not very robust in the other models. For example, as Table 5 shows, in the LPM, except for the simple rule from LPM, the other simple rules perform poorly compared with the optimal rule of that model.[25] For instance, the simple rules from QPM and NAOMI have loss-function values that are, respectively, 181 per cent and 220 per cent higher than the optimal rule in the LPM. A similar result is obtained in this model when the other simple rules (except for the simple rule from LPM, for which it was designed to work well) are used.

Rules that have a high coefficient on inflation and interest rates and a zero (or negative) coefficient on the output gap work well in the LPM, for two main reasons. First, rules that respond aggressively to inflation and that respond with a negative or zero weight on the output gap decrease the likelihood of inflation expectations from becoming self-fulfilling in this model. The argument is best illustrated by the following example.

Higher anticipated inflation in the LPM will make agents reallocate their portfolios, decreasing the amount of funds flowing to the financial sector, thereby putting pressure on nominal interest rates to increase. If the weight on inflation in the policy-makers' rule is small, to prevent a large increase in nominal interest rates a large amount of liquidity must be injected into the economy. This increase in liquidity will produce a further increase in expected inflation. As a result, agents' inflation expectations become self-fulfilling and the economy can remain trapped in such an equilibria.[26] This causation chain from expected inflation to actual inflation can be eliminated if the policy rule places a high weight on inflation and a zero or negative weight on the output gap.

The second reason why such types of rules work well in the LPM is that most of the shocks built in the LPM can be interpreted as supply shocks (the contemporaneous correlation between output and inflation is negative for most shocks). A rule that responds strongly to inflation and/or weakly or even negatively to the output gap is generally recommended in this case.

In NAOMI, the results are even more dramatic. Of the seven rules, only four are stable: the simple rule from NAOMI, QPM, the original Taylor rule, and the open-economy rule. As Table 6 shows, however, the simple rule from QPM led to a very large deterioration in the loss-function value compared with the base-case rule of NAOMI (935 per cent), which is an IFB rule. Timing is one

25. The optimal rule in this model responds to all of the model's state variables and thus is not in the class of simple rules.

26. A high weight on the output gap is bad in this model for similar reasons. If higher anticipated inflation causes interest rates to rise for the reasons explained above, this in turn will produce a fall in output. This fall in output will put downward pressure on interest rates. The bigger the coefficient on the output gap in the policy-makers' reaction function, the bigger the decrease in interest rates. As a result of this downward pressure on interest rates, inflation will increase. Hence, in this case also, expectations can become self-fulfilling. A similar argument can be used to explain why a rule with a high degree of smoothing works well in this model. See Christiano and Gust (1999) for more details.

of the reasons why fairly aggressive rules and rules with interest rate smoothing do not work well or are unstable in this model. Because monetary policy operates with a lag in this model, the central bank benefits from "avoiding doing too little too late." If the central bank is too aggressive, however, large secondary cyclings can result, which can be reversed only at the cost of large swings in output and inflation. Hence, a "good" rule in this model is one that is relatively preemptive but not too aggressive.

In the M1-VECM, a rule with a high degree of interest rate smoothing works well because it helps to mitigate the negative impact that the money gap—the disequilibrium between the money supply and long-run money demand—has on inflation. Since the money gap is persistent and influences inflation in the model, the central bank benefits from keeping interest rates high for a long period of time. Note that the simple rules from NAOMI, QPM, and the original Taylor rule also perform relatively well in this model.

Overall, our results indicate that the seven simple rules are not very robust in these five models, especially the simple rules from the M1-VECM, LPM, and MULTIMOD. These three rules are unstable in at least one of the five models and their performance often deviates substantially from the base-case or optimal policy rule. On the other hand, the simple rules from NAOMI, QPM, the original Taylor rule, and the open-economy rule are stable in all five models. These four rules have the same coefficient on the output gap but different coefficients on the inflation gap. Even if these four rules are stable, however, their performance, particularly that of the original Taylor rule, can substantially deviate from the optimal or base-case rule.

Table 9 shows the ordinal ranking of each rule in each model. We choose an ordinal rather than a cardinal ranking to avoid the scaling problem that results from the fact that we do not assume a common distribution of shocks in all of these models. In case a rule is unstable in a model, it is penalized by a score of 10.[27] On average, the simple rules from QPM and NAOMI outperform the other simple rules, particularly rules with interest rate smoothing and the open-economy rule. Although the average ranking of the simple rule from QPM is lower, as Table 9 shows, the simple rule from NAOMI seems to be more robust, in the sense that, on average, it deviates less from the optimal or base-case rule than QPM. This result is shown in Table 10. The simple rule from QPM does very poorly in the model of NAOMI. It generates a loss function that is 935 per cent higher than the base-case rule of NAOMI in that model. This difference is particularly important if policy-makers believe that NAOMI might be the correct representation of the economy. In that case, the simple rule from NAOMI clearly dominates the simple rule from QPM.

27. We have experimented with a rank of six, but this made no difference to our results. A weight of 10 penalizes rules that are unstable in one or more models. We have also experimented with different weights on the inflation and output gap in the loss function. These sensitivity tests did not affect our baseline results.

Table 9: Summarized Performance of the Seven Simple Rules in LPM, M1-VECM, MULTIMOD, NAOMI, and QPM

Rule	LPM	M1-VECM	MULTI-MOD	NAOMI	QPM	Average	Standard deviation
Original Taylor rule	6	2	4	3	4	3.4	1.2
NAOMI rule	4	4	3	1	3	3	1.09
QPM rule	3	2	2	4	2	2.4	0.49
MULTIMOD rule	10	6	1	10	1	5.6	4.02
M1-VECM rule	2	1	10	10	7	5.8	3.81
LPM rule	1	5	5	10	6	5.2	2.86
Open-economy rule	5	7	n/a	2	5	4.75	1.79

Table 10: Average Loss-Function Value in LPM, M1-VECM, MULTIMOD, NAOMI, and QPM

Rule	LPM	M1-VECM	MULTI-MOD	NAOMI	QPM	Average[a]
Original Taylor rule	4.54	2.01	4.84	1.51	5.28	3.64
NAOMI rule	2.96	2.03	3.42	1.22	3.84	2.69
QPM rule	2.60	2.12	2.64	11.39	2.96	5.43
MULTIMOD rule	unstable	2.64	2.11	unstable	2.74	n/a
M1-VECM rule	2.42	1.98	unstable	unstable	19.71	n/a
LPM rule	1.43	2.08	6.20	unstable	7.16	n/a
Open-economy rule	4.05	3.05	n/a	1.48	6.45	3.76

a. The average is calculated for rules that are stable in all models.

Our findings are thus very different from those of many other studies (mostly for U.S. models), which have shown that rules with interest rate smoothing not only perform well but are fairly robust. In particular, our results differ from those of Levin, Wieland, and Williams (1999), who conclude that "for a given model, complicated rules perform only slightly better than simple ones . . . and . . . simple rules are robust to model uncertainty." This indicates that policy rules cannot only be model-specific but also country-specific. In general, we find that simple rules can lead to a substantial deterioration in the loss-function value compared with more complex rules in some models, and that they are not very robust to model uncertainty. If we restrict ourselves to a certain class of models, however, the simple rule from NAOMI seems to perform reasonably well compared with the other rules, although in this case, also, there can be substantial deviation from the optimal rule.

3.2 Results of deterministic simulations

This section discusses the simulation results obtained from the seven models that were used to perform deterministic simulations only.[28] The performance of the seven simple rules is analyzed by simulating five deterministic shocks that we believe are important for the Canadian economy: domestic demand, external demand, commodity prices, consumer prices, and exchange rate. Because the unconditional variances for inflation and the output gap cannot be generated in this case, we take a different but complementary approach to compute the variance of the deviations of inflation from its target and of the output gap for each rule. To calculate these "variance" statistics, we use the mean squared deviation of the "shock minus control" response of inflation and output from equilibrium. These two "variance" statistics are assumed to be the equivalent of the unconditional variances of inflation and the output gap, and are used to calculate the loss function associated with each rule in each of the seven models. The "variance" statistic is given by the following equation:

$$S = \frac{\sum_{n=1}^{24} x^2}{24} \,. \tag{2}$$

To evaluate the performance of each simple rule in each model, we again use a simple loss function given by equation (3)[29]:

28. The seven models are CEFM, DRI, FOCUS, FOCUS-CE, INTERLINK, MTFM, and WEFA.

29. By inspecting the impulse-response function (IRF), we can also check whether the responses of output and inflation—which are simulated for 24 quarters—are unstable (a response is assumed to be unstable if, at the end of the simulation horizon, the IRF significantly diverges from the control solution or equilibrium) or have excessive secondary cyclings. Unstable responses or excessive secondary cyclings will be reflected in a bigger (or infinite) loss-function value.

$$Loss = S_{INF} + 0.25 S_{GDP}, \tag{3}$$

where S_{INF} is the mean squared deviation of the shock minus control for inflation and S_{GDP} is the same statistic, but for output.[30] Equation (3) is assumed to be similar to the loss function that we used earlier. Moreover, because we do not have any information on the optimal rule in these seven models, we compare the performance of each simple rule with the simple rule that ranks first in that model and not to the optimal rule itself.[31]

As in section 3.1, we rank the seven rules using an ordinal rather than a cardinal approach, to avoid the scaling problem that results from the lack of uniformity in the design of the shocks. Although each model simulates the same shocks, the distribution between the different shocks—for the economy—can be quite different. For example, the price shock that we impose may be at the extreme end of the distribution of price shocks, while the demand shock may be closer to the middle of the distribution of demand shocks. Comparing the values of the loss function from these events may not be representative of the expected value of the loss function for all of the realization of the shock in a particular model. We thus focus on the ordinal ranking of the rules to correct the scaling problem introduced by the difficulty of designing representative shocks.[32] We further assume that each shock can occur with equal probability and thus assign equal weights to each of the five shocks.

As stated in the introduction, the deterministic simulations enable us not only to measure the robustness of a given rule with respect to model uncertainty but also to shock uncertainty. The latter, to our knowledge, has not received much attention in the literature. This information may be useful if we know the nature of the shock hitting the economy.[33] We start by comparing the average performance of the rules in these seven models when the five shocks are simulated. We then take an average of the loss-function value of each rule in each model for all five shocks, and on the basis of this information rank the rules using an ordinal approach. For example, in Table 11, the simple rule from MULTIMOD has the lowest average loss-function value across the five shocks in CEFM, and is thus ranked first in that model.

30. As in section 3.1, we perform several sensitivity tests on equation (3) by varying the weight on the inflation and output gap. We also include the volatility of interest rates. As in section 3.1, our results remain unchanged.
31. In many models, the simple rules outperformed their base-case reaction function.
32. We also used a cardinal ranking as a robustness check.
33. Finding a rule that is robust to shock uncertainty may not necessarily be useful for policy-makers. If current and future shocks are unknown, one has to choose a rule that will perform well given the expected distribution of shocks and not with respect to a specific shock.

Table 11: Summarized Performance of the Seven Simple Rules in CEFM, DRI, FOCUS, FOCUS-CE, INTERLINK, MTFM, and WEFA—Base-Case Loss Function

Rule	CEFM	DRI	FOCUS	FOCUS-CE	INTERLINK	MTFM	WEFA	Average	Std. dev.
Original Taylor rule	3	1	2	6	1	1	6	2.9	2.1
NAOMI rule	4	3	3	3	2	2	3	2.9	0.6
QPM rule	5	6	5	2	3	4	2	3.7	1.7
MULTIMOD rule	1	2	1	1	10	10	1	3.9	3.9
M1-VECM rule	6	4	10	7	4	5	7	6.1	2.0
LPM rule	10	10	10	5	10	6	5	8.0	2.3
Open-economy rule	2	5	4	4	5	3	4	3.9	1.0

Overall, our results are very similar to those obtained in the context of stochastic simulations. There is no robust rule, in the sense that no single rule performs well in all models. Our results also indicate that some of the rules, particularly the simple rule from MULTIMOD, the LPM, and the M1-VECM, are highly model-dependent and are even unstable in some models. For example, the simple rule from MULTIMOD ranks first in four out of the seven models, but is unstable in two. On the other hand, the two rules with smoothing (the LPM and M1-VECM) perform poorly in all seven models. This result is thus similar to that of Ball (1999) and Rudebusch and Svensson (1999), who also find that rules with interest rate smoothing perform poorly or can be unstable in backward-looking models.[34]

As in the models that were used to perform stochastic simulations, our results from these seven models show that only four simple rules are stable in all models: the original Taylor rule, the

34. This argument can also be illustrated by looking at the performance of the two rules with smoothing in the two versions of the FOCUS model. The two rules with smoothing are unstable in FOCUS, a completely backward- looking model but not unstable in its more forward-looking version, although their performance remains poor.

open-economy rule, and the simple rules from NAOMI and QPM. But there is one important difference between the results from the two sets of models. The original Taylor rule, which was outperformed by the simple rules from NAOMI and QPM in the previous set of models, does reasonably well in this set of models. In many cases, the original Taylor rule is ranked first or second and does not perform well in only two out of the seven models. The simple rule from NAOMI also does reasonably well compared with the other rules, indicating that this rule may be among the most robust ones in our set of simple policy rules.

Taking a closer look at the results, we find that less-aggressive rules tend to work relatively well in models where output and inflation are relatively sensitive to changes in interest rates. For example, in MTFM, the original Taylor rule and the simple rule from NAOMI, which are not very aggressive, outperform the other simple rules, whereas the simple rule from MULTIMOD, which is a fairly aggressive rule, is unstable in this model. On the other hand, models with low interest rate sensitivity tend to favour more aggressive rules (see Table 2). This is clearly the case for the models of WEFA and FOCUS-CE. Those two models have a low interest rate sensitivity and prefer aggressive rules—in our case, the simple rule from MULTIMOD or QPM. This result is fairly intuitive. If output and inflation respond aggressively to changes in interest rates, the monetary authority is not required to move interest rates a lot to get a significant effect on these two variables.

Interest rate sensitivity alone cannot explain why some models prefer less or more aggressive rules. For example, both the original Taylor rule (the least aggressive) and the simple rule from MULTIMOD (the most aggressive) work well in the models of CEFM, DRI, and FOCUS, which have various degrees of interest rate sensitivity. An important similarity between the two rules, however, is that their ratios between the coefficients on the inflation gap and the output gap are relatively low compared with the other rules.[35] Therefore, it may be that the relative and not the absolute weight on the inflation- and output-gap terms plays a more important role in determining a “good” policy rule in these three models.

Table 12 shows the percentage deviation of the loss-function value of each rule with respect to the best simple rule in a particular model. It also shows that the performance of a given rule can deviate substantially from the “best” simple rule in a given model, indicating that these simple rules are not very robust. For example, the original Taylor rule and the simple rule from NAOMI can lead to substantial deviation when compared with the “best” simple rule in many of these models (as in DRI, FOCUS, FOCUS-CE, CEFM, and INTERLINK). This result reinforces our findings reported in section 3.1.

35. This ratio is two for the simple rule from MULTIMOD, three for the original Taylor rule, four for the simple rule from NAOMI and the open-economy rule, and six for the simple rule from QPM.

Table 12: Average Percentage Deviation from the Best Simple Rule for all Shocks

Rule	CEFM	DRI	FOCUS	FOCUS|CE	INTERLINK	MTFM	WEFA	Average	Std. dev.
Original Taylor rule	38.5	49.4	50.9	86.1	53.5	4.6	19.7	43.2	24.2
NAOMI rule	41.1	297.8	65.1	67.8	60.9	4.9	14.6	78.9	92.3
QPM rule	45.6	395.1	102.0	37.9	100.6	6.8	6.7	99.2	126.1
MULTIMOD rule	0.0	240.8	13.3	4.9	n/a	n/a	0.4	n/a	n/a
M1-VECM rule	94.5	236.5	n/a	187.8	192.3	33.7	33.2	n/a	n/a
LPM rule	n/a	n/a	n/a	95.8	n/a	62.1	25.7	n/a	n/a
Open-economy rule	37.7	314.0	54.8	64.4	243.0	2.7	14.6	104.4	113.4

Table 13 shows the average ranking of the simple rules for a given shock. This information would be useful to policy-makers if they were confident about the nature of the shocks affecting the economy but uncertain about which model is the true representation of the economy (paradigm and parameter uncertainties). We do not find a robust rule across shocks, in that none of the rules performs well under all shocks. The standard deviations of these rankings, however, show that the performance of the rules varies more across models than across shocks, implying that the performance of rules is more model-dependent than shock-dependent.

Table 13: Ranking Across all Models for a Given Shock

Rule	Demand shock	External shock	Commodity price shock	Price shock	Exchange rate shock	Average	Standard deviation
Original Taylor rule	1	2	1	3	3	2.0	0.9
NAOMI rule	2	1	2	1	4	2.0	1.0
QPM rule	3	3	3	2	2	2.6	0.5
MULTIMOD rule	10	10	10	10	10	10	0
M1-VECM rule	10	10	10	10	10	10	0
LPM rule	10	10	10	10	10	10	0
Open-economy rule	4	3	3	4	1	3.0	1.1

While the original Taylor rule performs well in the face of demand and commodity price shocks, the simple rule from NAOMI outperforms the other rules in the face of the external and price shocks. The simple rule from MULTIMOD is probably the least robust rule across shocks. This rule yields unstable responses in MTFM for all shocks simulated and for the external and commodity price shocks in INTERLINK. Nevertheless, it dominates the other simple rules in the CEFM model in all five shocks.

Table 14 shows the results when the rankings from the stochastic and deterministic simulations are combined. It also shows the average ranking of each rule in all twelve models (an equal weight is assigned to each model).[36] Three conclusions can be made. First, only four out of seven simple rules are stable in all twelve models: the original Taylor rule, the open-economy rule, and the simple rules from NAOMI and QPM. Second, although none of these four rules performs very well or is robust in the sense of performing as well as the base-case rule in each of the twelve models, the simple rule from NAOMI has a lower average ranking across models and outperforms the other simple rules, particularly in some models. Third, rules with interest rate smoothing (the simple rules from the LPM and M1-VECM) and rules that are fairly aggressive (the simple rule from MULTIMOD) are the least robust rules, because they are either unstable or perform poorly in

36. We also check for the robustness of these results by assigning different weights to the different models. We rank each model according to its ability to match certain features of a simple vector autoregressive (VAR) model of the Canadian economy. We then assign weights to each model according to its ability to match certain features of our benchmark VAR (the best model receives a weight of 1 and the worst receives a weight of 1/12). For more information and details, see Côté et al. (2002).

many models. As with Ball (1999) and Svensson (1999), we find that rules with interest rate smoothing do not perform well in backward-looking models.

Table 14: Overall Rankings

Rule	CEFM	DRI	FOCUS	FOCUS|CE	INTERLINK	MTFM	WEFA	LPM	M1|VECM	MULTIMOD	NAOMI	QPM	Average	Std. dev.
Original Taylor rule	3	1	2	6	1	1	6	6	2	4	3	4	3.3	1.9
NAOMI rule	4	3	3	3	2	2	3	4	4	3	1	3	2.9	0.9
QPM rule	5	6	5	2	3	4	2	3	2	2	4	2	3.3	1.4
MULTIMOD rule	1	2	1	1	10	10	1	10	6	1	10	1	4.5	4.1
M1-VECM rule	6	4	10	7	4	5	7	2	1	10	10	7	6.1	2.9
LPM rule	10	10	10	5	10	6	5	1	5	5	10	6	6.9	2.9
Open-economy rule	2	5	4	4	5	3	4	5	7	n/a	2	5	4.2	1.4

Overall, our results are thus very different from those of Levin, Wieland, and Williams (1999), who claim that simple rules, particularly rules with interest rate smoothing, not only perform well but are very robust to model uncertainty. Their study may have considered models that are too similar to each other.[37] As a result, it is not surprising that they concluded that simple rules were robust. Our findings reveal that when a more diverse set of models is considered, simple rules do not pass this robustness check.

4. Conclusions

One of the primary objectives of this report was to identify a simple monetary policy rule that is robust in a very large number of models of the Canadian economy. Our analysis includes models that use both the “conventional” and the “money matters” paradigm. Because of the diverse array of models used in this report, our robustness test is more rigorous than that of other studies that

37. All four of their models would fall under the “conventional” paradigm.

have used many similar models to evaluate rules. Unlike Levin, Wieland, and Williams (1999), we find that simple policy rules are not particularly robust to model uncertainty. Of the seven simple rules we tested, only four are stable in all models: the original Taylor rule, the simple rule from NAOMI and QPM, and the open-economy rule. These rules, however, are not very robust to model uncertainty, since they do not perform well compared with the base-case or optimal rule in several models.

These rules are not robust to shock uncertainty, in that a rule performs differently in many models for a given shock. Nonetheless, some rules perform better than others in certain models. For example, the simple rule from NAOMI performs quite well in a certain class of models, particularly NAOMI, QPM, and some similar types of models. Compared with the base-case or optimal rule, however, even this rule can lead to a significant deterioration of the loss function in these models.

Rules with interest rate smoothing perform poorly in most models, particularly in backward-looking models. In those models, rules with smoothing are either unstable or are ranked last. On the other hand, rules with smoothing perform better in models that fall under the “money matters” paradigm (the LPM and M1-VECM). This result is explained by the fact that one of these models (the LPM) incorporates purely model-consistent behaviour, while the other (the M1-VECM) includes an important variable, the money gap, that is persistent.

Adding the exchange rate to a simple Taylor-type rule leads to a deterioration in the loss-function value in most models, mainly because the exchange rate is a built-in stabilizer in those models and helps the economy return to equilibrium after a shock. As a result, any attempt by the monetary authority to smooth fluctuations in the exchange rate interferes with that adjustment process.

Although we did not find a robust simple rule for Canada, our results do not necessarily imply that simple rules do not have a role to play in the conduct of monetary policy. Our results indicate that a certain class of rules, particularly the simple rule from NAOMI, can be useful for the conduct of monetary policy, especially if policy-makers believe that a certain class of models portrays economic features well. Moreover, although we did not test for this result, this simple rule is likely to be more robust than using complex rules in different models (see Levin, Wieland, and Williams 1999). In addition, simple rules like NAOMI remain relatively easy to develop and communicate, and do not depend on specific models, because they use only the available information. Our results do not enable us to quantify the value of this contribution nor the weight that the monetary authorities should assign to these rules. That is left for future research.

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Appendix A: Participating Organizations and Their Models

This study considers twelve private and public sector models of the Canadian economy. Five of them are maintained by private sector organizations. The models are

- CEFM: Canadian Economic and Fiscal Model, Department of Finance Canada
- DRI: Data Resources Inc. of Canada[1]
- FOCUS: Policy and Economic Analysis Program (PEAP), Institute for Policy Analysis, University of Toronto
- FOCUS-CE: a version of FOCUS that incorporates forward-looking expectations
- INTERLINK: Organisation for Economic Co-operation and Development
- LPM: Limited-Participation Model, Monetary and Financial Analysis Department, Bank of Canada
- M1-VECM: Vector-Error-Correction Model, based on the M1 aggregate, Monetary and Financial Analysis Department, Bank of Canada
- MTFM: Medium-Term Forecasting Model, Conference Board of Canada
- MULTIMOD: International Monetary Fund
- NAOMI: North American Open-Economy Macroeconometric Integrated Model, Department of Finance Canada
- QPM: Quarterly Projection Model, Research Department, Bank of Canada
- WEFA: Wharton Economic Forecasting Associates

1. Data Resources Inc. of Canada and Wharton Economic Forecasting Associates merged in 2001 under the name DRI-WEFA.

Appendix B: Model Shocks

Shock	Description	Details
1. Domestic demand	A 4-quarter transitory increase in the levels of consumption and investment at the same time.	Shock to consumption and investment: Q1: 1.00%, Q2: 0.75%, Q3: 0.50%, Q4: 0.25%; i.e., the levels of consumption and investment increase by 1 per cent at the 1-quarter horizon and then progressively come back to control (there is no permanent increase in the level of output).
2. External demand	A 4-quarter transitory increase in the level of real U.S. output with endogenous responses of U.S. inflation and interest rate, and world commodity prices.	Shock to U.S. GDP: Q1: 1.00%, Q2: 0.75%, Q3: 0.50%, Q4: 0.25%. Endogenous response of U.S. inflation. Endogenous response of U.S. short-term interest rate. Endogenous response of world commodity prices.
3. Commodity prices	An 8-quarter transitory increase in the level of real commodity prices with endogenous responses of U.S. output, inflation and interest rate.	Shock to commodity prices: Q1: 4.00%, Q2: 3.50%, Q3: 3.00%, Q4: 2.50%, Q5: 2.00%, Q6: 1.50%, Q7: 1.00%, Q8: 0.50%. Endogenous response of U.S. output. Endogenous response of U.S. inflation. Endogenous response of U.S. short-term interest rate.
4. Consumer price	A 4-quarter transitory increase in the level of CPI excluding food, energy, and indirect taxes.	Shock to CPI: Q1: 1.00%, Q2: 0.75%, Q3: 0.50%, Q4: 0.25%.
5. Wage growth	A 4-quarter transitory increase in nominal-wage growth.	Shock to wage growth: Q1: 1.00 percentage point, Q2: 0.75 of a percentage point, Q3: 0.50 of a percentage point, Q4: 0.25 of a percentage point.
6. Short-term interest rate	A 4-quarter transitory increase in the short-term interest rate.	Shock to short-term interest rate: Q1: 100 basis points, Q2: 75 basis points, Q3: 50 basis points, Q4: 25 basis points.
7. Long-term interest rate	A permanent change in the term premium.	Shock to long-term interest rate: Permanent increase of 100 basis points.
8. Nominal exchange rate depreciation	A 4-quarter temporary increase in the risk premium on the exchange rate (a depreciation).	Shock to exchange rate: Q1: 1.00%, Q2: 0.75%, Q3: 0.50%, Q4: 0.25%.

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