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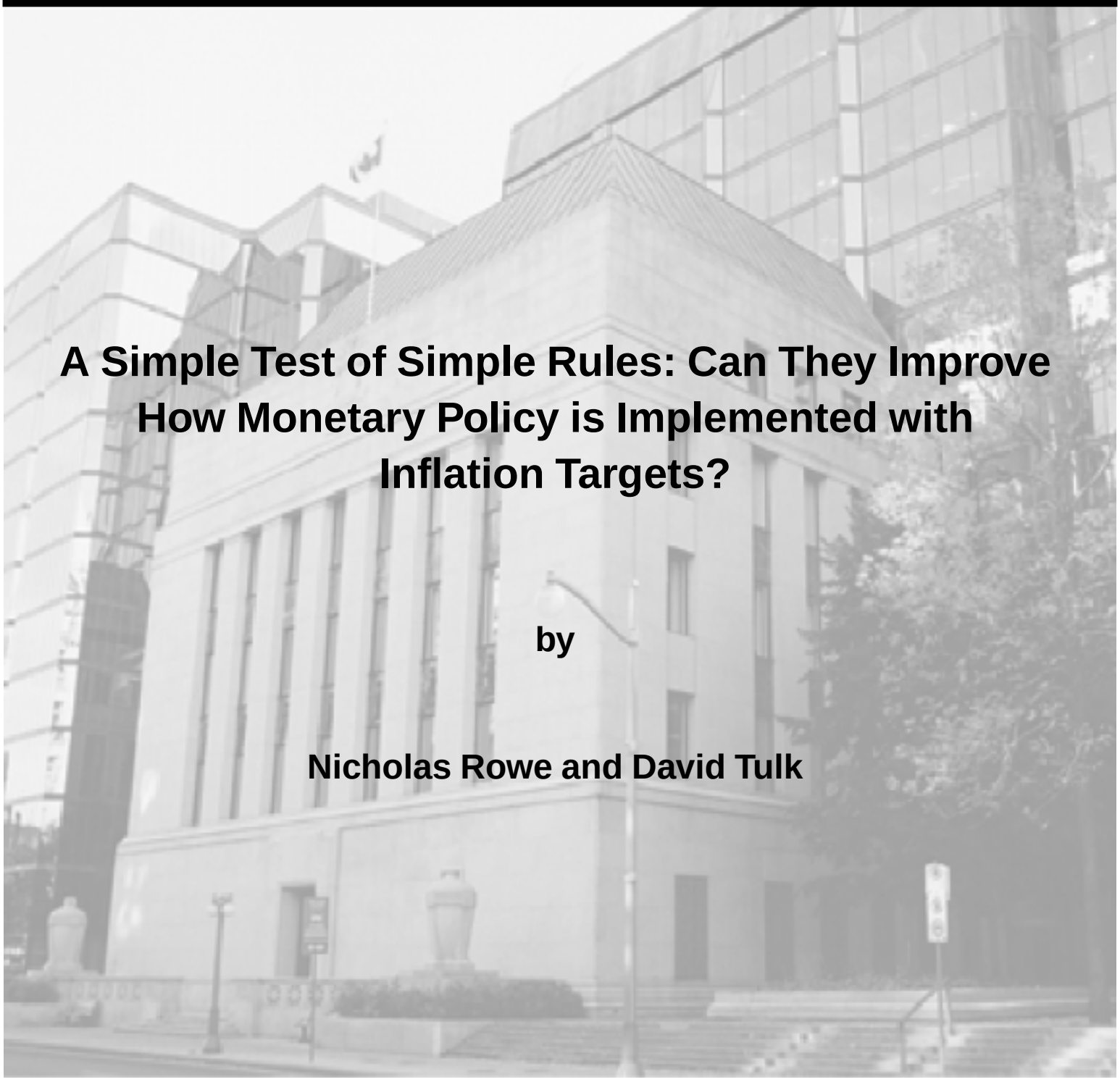

A Simple Test of Simple Rules: Can They Improve How Monetary Policy is Implemented with Inflation Targets?

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Nicholas Rowe and David Tulk

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by

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Contents

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Abstract

The authors evaluate whether an assortment of simple rules could improve how the Bank of Canada implements its inflation-targeting monetary policy. They focus on measuring the correlation between the deviations of inflation from the target and the lagged deviations of rule recommendations from the actual policy interest rate. This empirical procedure evaluates the rules in a model-free environment and uses historical data over the Bank's inflation-targeting regime. The authors find that the Bank would not improve its policy of targeting inflation by paying more attention to the advice provided by these rules.

JEL classification: E5
Bank classification: Inflation targets; Monetary policy implementation

Résumé

Les auteurs évaluent si un assortiment de règles simples pourrait aider la Banque du Canada à mettre en œuvre plus efficacement sa politique monétaire, axée sur la poursuite d'une cible d'inflation. Ils se concentrent sur la corrélation entre les écarts de l'inflation par rapport à sa cible et les écarts retardés des taux directeurs recommandés (c'est-à-dire obtenus à partir des règles) par rapport aux taux pratiqués. Privilégiant cette méthode empirique plutôt que le recours à des modèles, les auteurs fondent leur évaluation sur les données chronologiques couvrant la période d'application du régime de cibles d'inflation au Canada. Ils concluent que la Banque n'atteindrait pas plus facilement sa cible d'inflation si elle accordait plus de poids à ces règles qu'elle ne le fait déjà.

Classification JEL : E5
Classification de la Banque : Cibles en matière d'inflation; Mise en œuvre de la politique monétaire

1. Introduction

A simple rule for monetary policy, as we define it, is one in which the Bank of Canada sets the policy rate of interest as a positive linear function of two variables: the rate of inflation and the output gap. The most widely recognized simple rule was proposed by John Taylor in 1993 and has become known simply as the Taylor rule. Originally used to describe the behaviour of the U.S. Federal Reserve between 1987 and 1992, the Taylor rule has spawned a voluminous literature on monetary policy rules, including a host of alternative specifications and parameterizations. Slightly more complex versions of the original Taylor rule have included a lagged policy interest rate and, for an open economy, the rate of exchange rate depreciation.

The advantage of simple rules over more complex alternatives has been widely documented in the literature. Participants at a 1998 NBER conference on monetary policy rules concluded that not only are complex rules not very robust over different models, but a simple rule performs almost as well as complex rules within a given model (Levin, Wieland, and Williams 1999). Extending this kind of evaluation to various simple rules, the key question becomes: For a given rule, with specified coefficients on inflation and the output gap, and within a given model, what would be the variances of output and inflation, and the utility of the representative agent (if the model includes agents' preferences), compared with other simple rules, or compared with the optimal monetary policy rule?

Previous research answering this question is certainly useful and instructive, but it is open to two criticisms. First, if we want to know whether adopting a simple rule could improve the implementation of monetary policy, then comparing a simple rule with the implementation of *optimal* monetary policy may be of less practical relevance than comparing a simple rule with the implementation of *actual* monetary policy. Second, the evaluation of a simple rule within a given economic model is valid only if the economic model itself is valid as a representation of the actual economy. This point is of major practical relevance, since Côté et al. (2002) show that a simple rule that performs well in one economic model may perform very poorly in another.

This paper complements previous research on testing simple rules by addressing the above two criticisms. Rather than testing simple rules against an optimal implementation of monetary policy, we test simple rules against the actual, historical implementation of monetary policy. And rather than testing simple rules within an economic model, we test simple rules against the actual data. A potential weakness of our method, compared with previous research, is that we must assume that the Bank's objective is solely to target inflation, rather than to maximize agents' welfare, or to minimize a weighted sum of variances of output and inflation.

2. Methodology

Our method for testing simple rules against actual policy is very simple. For any given rule, we calculate its recommended policy interest rate given the existing inflation rate and output gap. Next, we compare this recommendation with the actual policy interest rate set by the Bank. If the rule recommends a higher policy interest rate than was actually implemented, then the rule is saying, in effect, that the stance of actual monetary policy was too loose for that period, and that future inflation will rise above target. Conversely, if the recommendation is below the actual policy interest rate, then the rule is saying that the stance of actual monetary policy is too tight, and that future inflation will fall below target. These implicit predictions of the rule can easily be tested empirically.

Our method for testing simple rules is an application of Rowe (2002), which shows that, if deviations of inflation from target are positively (negatively) correlated with a given indicator of inflation, then the Bank should react more strongly (less strongly) to that indicator when setting the policy interest rate. The Bank is responding optimally to an indicator if the correlation is zero. The recommendations of a simple rule can be seen as analogous to an indicator.

Suppose the Bank has a control, or targeting horizon, of 8 quarters and a pure inflation target at that horizon. This means the Bank's objective is to set the current policy interest rate so that 8-quarter-ahead inflation will equal the target. We estimate a simple regression of deviations of inflation from target on 8-quarter lagged deviations of rule recommendations from the actual policy interest rate, with no constant term in the regression.[1] The testing equation is as follows:

$$\pi - \pi^* = \alpha_1(\hat{i} - i)_{t-8}\,, \qquad (1)$$

where $\pi - \pi^*$ is the deviation of inflation from target, $\hat{i}$ is the calculated policy interest rate as specified by the rule, and i is the actual policy interest rate set by the Bank. If the estimated coefficient (α_1) is positive and statistically significant, it means that when the rule says that the stance of actual policy is too loose, it does indeed turn out on average to have been too loose, and when the rule says that the stance of actual policy is too tight, it does indeed on average turn out to have been too tight.

An estimated coefficient with a positive sign does not necessarily mean that the simple rule would have been better at targeting inflation than actual policy, but it does mean that putting more weight on the advice of such a rule would, on average, move policy in the right direction. It might also

1. For a discussion of why no constant term was included, see section 3.3.

mean that following the rule's recommendation exactly could move policy too far in the right direction, so that a policy that was too loose would become too tight, and consequently be worse than the old policy. But a positive estimated coefficient does mean that the implementation of policy would be improved by listening to, and putting more weight on, the advice of the simple rule.

An estimated negative coefficient, on the other hand, means that when the simple rule says the stance of policy is too loose, it is on average too tight, and vice versa. It also means that the implementation of policy would be improved if the Bank put less weight on the advice of the rule.

An estimated coefficient of zero implies that the Bank is already putting the optimal weight on the advice of a given simple rule. If the historical weight was also zero, meaning that the Bank was ignoring simple rules, then it should continue to do so.

3. Technical Details

3.1 Simple monetary policy rules

Côté et al. (2002) is our main source for the simple monetary policy rules.[2] We compare each of the seven rules listed in their paper against the actual policy of the Bank. In addition to Taylor's original rule, Côté et al.'s (2002) paper examines rules from a range of macroeconomic models, from both the public and private sectors. Three of the six remaining rules are reparameterizations of Taylor's original rule and come from a rule used with the Bank's Quarterly Projection Model (QPM),[3] Murchison's (2001) NAOMI model, and the MULTIMOD model from the International Monetary Fund (IMF). The QPM is a large-scale calibrated model in which monetary policy affects inflation through the aggregate demand relationship and the output gap (referred to as the "conventional paradigm" in Côté et al. 2002 and hereafter). Inflation in the QPM is subject to asymmetries and it employs both backward and model-consistent expectations. MULTIMOD also falls under the conventional paradigm and shares both asymmetric inflation and the dual-expectation mechanism with the QPM. In contrast to the previous two, NAOMI (which is still within the conventional paradigm) is a small estimated model with a linear Phillips curve with only backward-looking expectations.

2. Appendix A gives the functional form of all the rules we test.
3. The base-case projections from the QPM are developed using an inflation-forecast-based rule, rather than a Taylor rule.

Côté et al.'s (2002) paper also examines two models that have a lagged policy interest rate term in the rule: the Limited-Participation Model (LPM) and the Bank's M1-VECM model. Neither of these models fits under the conventional paradigm—monetary policy affects inflation directly through monetary aggregates rather than via aggregate demand and the output gap. M1-VECM uses the money gap to influence inflation, whereas LPM uses rigidities in the adjustment of short-run money balances to create the non-neutrality of monetary policy. In terms of expectations, M1-VECM uses pure backward-looking expectations and LPM uses pure forward-looking expectations that are derived from micro foundations.

Whereas Côté et al. (2002) consider a generic open-economy rule developed in Taylor (1999), we consider two variations on the open-economy rule: the "Ball rule" and the "Change rule," which are evaluated in the context of the QPM in Armour, Fung, and Maclean (2002). Both of these rules include the exchange rate as an extra variable. Where the Ball rule uses an exchange rate gap,[4] the Change rule uses the rate of change in the exchange rate series. And whereas the Ball rule is derived from a macroeconomic model, the Change rule does not have a theoretical basis. It does, however, deal effectively with the measurement and estimation problems associated with an equilibrium exchange rate. Armour, Fung, and Maclean (2002) conclude that, because of these drawbacks,[5] these models are inappropriate for the QPM. It is still of interest, however, to test them in a model-free environment and against other model based-rules.

3.2 The data

As noted earlier, one potential weakness of our technique is the assumption that the Bank's sole objective is to target inflation. To mitigate such a weakness, we focus on the period in which the Bank was an inflation-targeting institution. The Bank adopted inflation targets in February 1991; they were designed to set out a desired path for reducing consumer price index (CPI) inflation from 3 per cent at the end of 1992 to 2 per cent by the end of 1995. Since that time, the 2 per cent target has been extended several times and the current target agreement extends until the end of 2006. Whereas the inflation target is formally defined in terms of total CPI, the Bank uses a

4. This presents a minor complication in the estimation of the rule-recommended overnight rate, because its calculation is dependent on a long-run equilibrium exchange rate. Given the difficulties of estimating such a rate, and following Armour, Fung, and Maclean (2002), we left this as a constant, which for the purpose of our study does not need to be uniquely specified, because it is folded into the constant term of the rule (see section 3.3).

5. One additional complication with these rules involves the calculation of a core-core inflation rate in which all exchange rate pass-through effects are controlled for. Ball uses the following formula linking core and core-core consumer price inflation in logs, which is subsequently converted into year-over-year growth: $lcpi_{core\text{-}core} = lcpi_{cpix} - 0.2*lexch_{t-1}$, where 0.2 is an estimate of the pass-through coefficient and *lexch* is the log of the exchange rate. Ball's value of 0.2 implies a far more rapid pass-through than does the empirical literature. To mitigate this issue, a lagged 8-quarter moving average of the exchange rate was tried, but it did not alter the results. The target inflation rate remains at 2 per cent.

measure of core inflation as an operational guide. Originally, core inflation was defined using the CPI excluding food, energy, and the effect of changes in indirect taxes. Since May of 2001, however, core inflation has been measured using CPI excluding the eight most volatile components and the effect of changes in indirect taxes. We use the old definition of core CPI as our measure, since it is the measure used throughout most of the inflation-targeting regime, and we target inflation at 2 per cent.[6]

All of the data used in this study are recorded at a quarterly frequency. Consistent with the targeting regime, our sample period runs from the first quarter of 1991 to the second quarter of 2003. The effect of the 8-quarter lag in equation (1) restricts the date range of the deviations of the rule-recommended overnight rate from the actual one to be between 1991Q1 and 2001Q2, whereas the deviation of inflation from the target ranges from 1993Q1 to 2003Q2. This ensures that the last date to which the test can be applied matches the 2001Q2 recommended and actual overnight rate to the deviation of inflation from the target observed in 2003Q2.

Figure 6 shows a graphical representation of the deviations of inflation from 2 per cent from 1992Q2 to 2003Q2 (which is the largest sample in this study, corresponding to a transmission lag of 6 quarters[7]). The sample mean of this series is -0.29 percentage points, which suggests that the Bank was reasonably successful in ensuring that core inflation remained close to target over this period.

Our measure of a policy interest rate is the target overnight rate as set by the Bank. Our measure of the output gap is (almost)[8] a real-time measure; it is the same as was measured by the Bank's QPM.[9] In the rules that have a lagged policy interest rate, we use the lagged actual overnight rate instead of the lagged rule-recommended policy rate. This approach ensures that the overnight rate will be treated solely as another indicator, thereby preserving the historical empirical relationship between the variables in the rule. For the open-economy rules, we include the exchange rate depreciation, relative to the U.S. dollar, measured as a monthly average at close, converted to a quarterly frequency.

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6. As a more realistic alternative, we adjust our target to reflect the early period of inflation targeting, in which the target began at 3 per cent and decreased uniformly to 2 per cent by the end of 1995. This alternative does not significantly alter our results.
7. As a robustness check, we test over multiple targeting horizons, ranging from 6 to 10 quarters.
8. Since estimates of the historical output gap are continually revised, a real-time output gap is constructed using projections back to 1993Q3. The output gap prior to this date is taken as is from the September 1993 projection. Sample cross correlations between the historical estimates available in June 2003 and the aforementioned real-time output gap show a correlation of 0.922 over the entire sample. Figure 5 shows a graphical comparison of the real-time output gap and the historical estimates available in June 2003. Since each projection is run at the end of each quarter, our real-time measure of the output gap is lagged one quarter. Other specifications of the output gap do not significantly change our results.
9. See Butler (1996) for a description of the QPM's estimate of potential output.

3.3 The constant term in the simple rule

A simple monetary rule will normally contain a constant term, as well as two (or more) slope coefficients. This constant term can normally be interpreted as the equilibrium level of the policy interest rate, when inflation is equal to target and the output gap is zero.[10] The simple rules that we test lack a pre-specified constant term, so we need to give them one. We set the constant term so that the rule's average recommendation for the overnight rate, using the average values of inflation and the output gap, is exactly the same as the average actual overnight rate over the matching time periods implied by the lag length in equation (1) and discussed in section 3.2.

Table 1: Rule Constants

Model	Rule constant
Original Taylor rule	5.77
QPM	6.07
NAOMI	5.87
MULTIMOD	6.20
M1-VECM	0.44
LPM	0.42
Ball rule	7.92
Change rule	6.98

Table 1 details the values of the constant for the rules tested assuming a transmission lag of 8 quarters. A consequence of our procedure is that we ignore whether the implementation of monetary policy is too contractionary or too expansionary on average when compared with the recommendations of the simple rule. We are concerned only with whether the rule's recommendations or actual policy responds better to *changing* economic conditions. Our procedure also removes any systemic bias that arises from inaccurate estimates of the equilibrium exchange rate, thereby giving the simple rules the best possible chance to improve on the Bank's implementation of monetary policy.

10. For rules containing the lagged overnight rate (M1-VECM and LPM), the constant term is the change in the policy rate required to keep the policy rate in "equilibrium."

4. Results

The first rule we test is the original Taylor rule, which places a coefficient of 0.5 on the output gap and 1.5 on the inflation gap. Figure 1 plots the difference between the actual overnight rate as set by the Bank, as well as the rule-recommended overnight rate. It appears that the original Taylor rule tracks the actual overnight rate fairly well over the sample period. For a transmission lag of 8 quarters, the results from the testing equation (1) are as follows (with the standard error in parentheses[11]):

$$\pi - \pi^* = 0.015(\hat{i} - i)_{t-8} \qquad (2)$$

$$(0.045).$$

To show that a simple rule represents an improvement on the Bank's policy, the testing equation should return a coefficient that is both positive and statistically significant on the deviation of the rule-recommended overnight rate from the actual overnight rate. The overall result from equation (2) shows that the Bank would not improve its policy decisions by following this rule. As a robustness check, the same test is run using transmission lags ranging from 6 to 10 quarters. The results are shown in Table 2. Clearly, none of the parameter estimates is statistically significant.

Table 2: Original Taylor Rule

Lag	Coeff.	Std. error	*p*-value
6	0.048	0.053	0.368
7	0.042	0.051	0.409
8	0.015	0.045	0.733
9	-0.020	0.043	0.642
10	-0.054	0.042	0.194

Moving to the reparameterized Taylor rules, Figure 2 plots the difference between the rule-recommended overnight rate and the actual overnight rate for the three relevant models. Apart from the MULTIMOD rule, the reparamaterized rules closely follow the actual overnight rate.[12]

11. All reported standard errors are calculated with a consistent covariance matrix.
12. In fact, the QPM rule tracks the actual overnight rate best (having a correlation coefficient of 0.69, compared with 0.59 for NAOMI and 0.22 for MULTIMOD).

None of these models, however, improves on the result from the original Taylor rule as reported in Table 3, which uses a transmission lag of 8 quarters.[13]

Table 3: Various Reparameterizations of the Original Taylor Rule

Model	Coeff.	Std. error	*p*-value
QPM	0.037	0.054	0.493
NAOMI	0.024	0.052	0.639
MULTIMOD	0.027	0.021	0.208

So far, the Bank could not use any of these rules to improve its policy of targeting inflation. Our next task is to test the two lagged-overnight rate rules tested by Côté et al. (2002). Again, it should be made clear that the actual overnight rate is used as the lagged variable in place of the lagged rule-recommended policy rate. Figure 3 shows the standard comparison deviations of the rule-recommended overnight rate from actual for the lagged-overnight rate rules. Apart from major turning points in the actual overnight rate series, these rules follow the actual overnight rate closely over the sample (as would be expected by their construction). The results of the testing equation are shown in Table 4, using a transmission lag of 8 quarters. As with the original Taylor rule, none of the parameter estimates on the testing equation is statistically significant.

Table 4: Lagged Overnight Rate Rules

Model	Coeff.	Std. error	*p*-value
M1-VECM	0.059	0.076	0.443
LPM	0.042	0.077	0.582

Figure 4 plots the deviation of the open-economy rule-recommended overnight rates from the actual overnight rate. It is apparent that the inclusion of the exchange rate in the rule makes the rule-recommended overnight rate extremely volatile over the sample period. The results of the testing equation (shown in Table 5, using a transmission lag of 8 quarters) confirm that including

13. Tests ranging from 6 to 10 lags do not significantly alter the results.

the exchange rate does not add useful information to improve the implementation of monetary policy at the Bank.

Table 5: Open-Economy Rules (pass-through = 0.20)

Model	Coeff.	Std. error	*p*-value
Ball rule	-0.002	0.017	0.923
Change rule	-0.002	0.018	0.905

One assumption embedded in the data used for the open-economy rules is a pass-through coefficient of 0.2, which appears in the calculation of the core-core inflation rate discussed in footnote 5. For Canada, Kichian (2001) shows that pass-through is much lower than 0.2 and, in some cases, the exchange rate is shown to have no effect on domestic inflation. To explore this scenario, the open-economy rules are recalculated with a pass-through coefficient of 0.05.[14] Figure 7 shows the two measures of core-core inflation and Figure 8 repeats Figure 4 with the new pass-through coefficient embedded in the rule-recommended overnight rate.

A comparison of Figures 4 and 8 shows that lowering the effect of exchange rate pass-through smooths out some of the fluctuations around the actual overnight rate of the rule-recommended rate from the two open-economy rules. This result is expected, since any reduction of the influence of the exchange rate, which is the most volatile variable in the open-economy rule specification, would smooth out the rule-recommended interest rate. These rules, however, continue to do a poor job of replicating the actual overnight rate over the sample period. The results from the testing equation are reported in Table 6. Although the *p*-values are less than the open-economy rules under the original parameterization, the coefficients are still clearly statistically insignificant, which again suggests that the Bank would not improve its policy by paying more attention to the recommendations of these rules.

Table 6: Open-Economy Rules (pass-through = 0.05)

Model	Coeff.	Std. error	*p*-value
Ball rule	-0.017	0.027	0.532
Change rule	-0.018	0.028	0.513

14. The choice of 0.05 is somewhat arbitrary. Sensitivity analysis around this number does not alter the results.

The consistent pattern of statistical insignificance shown in all of the tables so far implies that we cannot say with confidence that any of the rules tested would improve the Bank's actual policy. In addition to looking at levels of statistical significance, there is some value in examining the "economic significance" of the estimates of the alpha parameter in equation (1). The values of alpha reported throughout the results tend to be very small in magnitude, which suggests that even if a rule-recommended overnight rate were to significantly differ from the actual rate, the effect on deviations of inflation from target would be small. For example, if the estimated alpha was 0.010 and the deviation of the rule-recommended rate to the actual overnight rate was 5 percentage points, the resulting deviation of inflation from target would be only 0.050 percentage points. In a sense, this gives a notion of the penalty (assuming that the estimate of alpha was statistically significant) the Bank would pay if it ignored a rule that would provide them with superior policy advice. Again, it is important to place this notion of "economic significance" within the realm of conventional statistics. We have very little confidence that inflation targeting could be improved by putting more weight on simple rules, and we believe that, even if it could be improved, the gain would probably be very small.

5. Searching for a Simple Rule

All of the rules that have been tested to this point are derived and specified by economic models. It is possible, however, to derive a simple rule that is independent of any existing model by evaluating a set of linear combinations of the deviations of inflation from target and the output gap. Testing these rules by the same procedure as described above would provide a complete picture of how all possible simple rules would fare compared with actual policy.

To facilitate this kind of analysis, we perform a grid search over an extensive choice of weights[15] on the output gap and the rate of inflation. Using the rule-determined optimal overnight rate, the same testing procedure as described in section 2 is applied. As with the model-based rules, none of the arbitrarily created linear-combination rules produce a statistically significant test result. Following the theoretical underpinnings of the lagged dependent models, a grid search is also performed over a wide selection of lagged variable rules,[16] but, as with the model-based rules, the results are deemed insignificant by conventional statistical-significance tests. This procedure provides a clear finality to our approach, because it rules out a large swath of potential rules that could be employed in improving the implementation of monetary policy.

15. The output-gap values range from 0.50 to 1.5 (increments of 0.10) and the inflation coefficient ranges from 0.50 to 5.5 (increments of 0.10).
16. The output and inflation weights are the same as the original grid search and the lagged short-run dependent variable ranges from 0.1 to 0.9 (increments of 0.10). The lagged dependent variable (as with the theory-based rules) is the actual overnight rate instead of the rule-determined lagged short-run interest rate.

Two possible conclusions can be made from the results of the grid search. First, perhaps the output gap is a weak indicator that prevents the simple rule from working well. There have been many critiques of the output gap, mainly centring around the problems involved in estimating potential GDP. An alternative measure of capacity is the unemployment rate gap, defined as the difference between the actual and the equilibrium rate of unemployment. To test this alternative, a grid search is performed using the unemployment rate in place of the output gap.[17] Not only does this procedure return an extensive list of statistically insignificant results, but they are almost all negative in sign, which suggests that the Bank would do worse by following such a rule. The second possible conclusion, which also feeds from the disappointing results of the unemployment-augmented rule, is that a simple rule is just that, too simple to single-handedly improve the policy of the Bank. In this case, we find that we cannot put any more weight on rules of this class as a way of improving inflation targeting.

6. Conclusions

This paper has used a very simple testing procedure to evaluate the usefulness of simple rules in the policy decisions of the Bank of Canada. The central result is that the Bank would not improve on the implementation of monetary policy by putting more weight on the advice of simple rules. What needs to be stressed is that this paper does not say that simple rules are useless in setting policy, but rather that all of the information contained in those rules has already been fully utilized by the Bank. On the margin, these rules cannot contribute any more than they already have to monetary policy. This conclusion holds true for a wide range of rules, including those that allow for persistence in the overnight rate and those that are modified to include the effects of the exchange rate. This result is a pretty intuitive conclusion when we consider the wealth of information available to the Bank,[18] compared with the relatively small amount of information contained in a linear combination of two or three indicators. An implicit conclusion of this paper is that, moving forward, more sophisticated techniques will need to be employed to improve the Bank's ability to target inflation.

17. As with the open-economy rules, the equilibrium unemployment rate is assumed to be constant and therefore can be rolled into the constant term of the simple rule during the estimation procedure.
18. Macklem (2002) outlines the breadth of information available to monetary policy decision-makers.

References

Armour, J., B. Fung, and D. Maclean. 2002. "Taylor Rules in the Quarterly Projection Model." Bank of Canada Working Paper No. 2002–1.

Ball, L. 1998. "Policy Rules for Open Economies." NBER Working Paper No. 6760.

Butler, L. 1996. *A Semi-Structural Method to Estimate Potential Output: Combining Economic Theory with a Time-Series Filter.* Technical Report No. 77. Ottawa: Bank of Canada.

Côté, D., J. Kuszczak, J.-P. Lam, Y. Liu, and P. St-Amant. 2002. *The Performance and Robustness of Simple Monetary Policy Rules in Models of the Canadian Economy.* Technical Report No. 92. Ottawa: Bank of Canada.

Kichian, M. 2001. "On the Nature and the Stability of the Canadian Phillips Curve." Bank of Canada Working Paper No. 2001–4.

Levin, A., V. Wieland, and J. Williams. 1999. "Robustness of Simple Monetary Policy Rules Under Model Uncertainty." In *Monetary Policy Rules,* edited by J.B. Taylor. Chicago: University of Chicago Press.

Macklem, T. 2002. "Information and Analysis for Monetary Policy: Coming to a Decision." *Bank of Canada Review* (Summer 2002): 11–18.

Murchison, S. 2001. "NAOMI: A New Quarterly Forecasting Model Part II: A Guide to Canadian NAOMI." Department of Finance Working Paper No. 2001–25.

Rowe, N. 2002. "How to Improve Inflation Targeting at the Bank of Canada." Bank of Canada Working Paper No. 2002–23.

Taylor, J.B. 1999. "The Robustness and Efficiency of Monetary Policy Rules as Guidelines for Interest Rate Setting by the European Central Bank." *Journal of Monetary Economics* 43(3): 655–79.

Figure 1: Original Taylor Rule

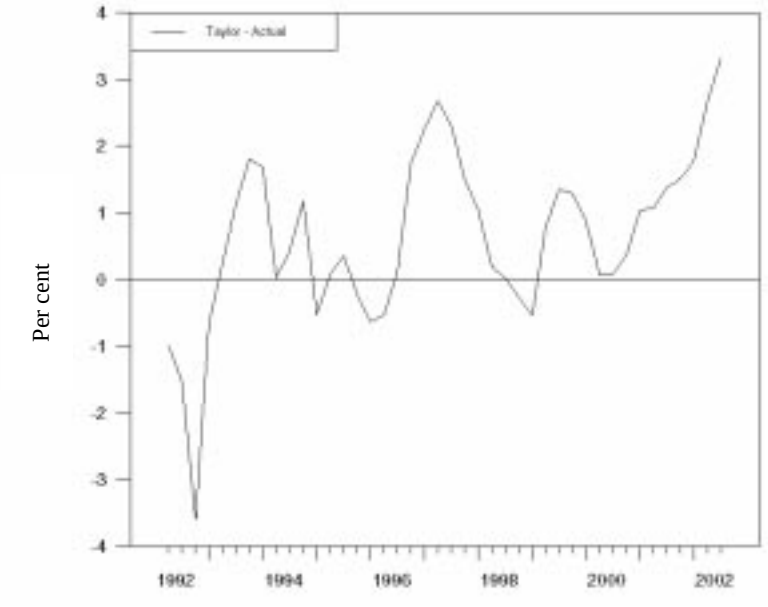

Figure 2: Reparameterized Taylor Rules

Figure 3: Lagged Dependent-Variable Rules

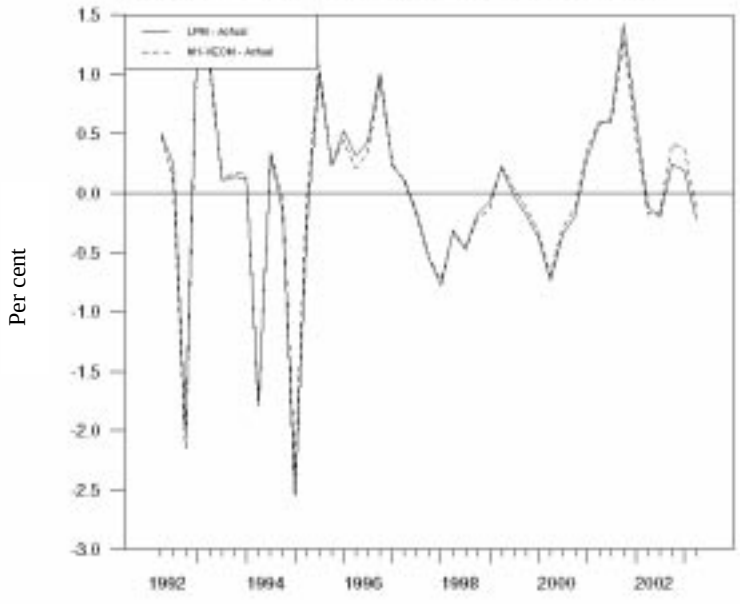

Figure 4: Open-Economy Rules

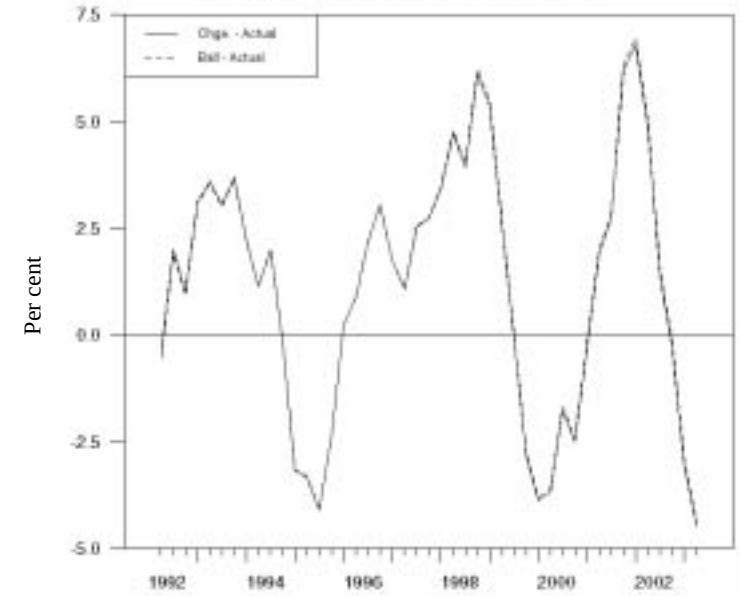

Figure 5: Measures of the Output Gap

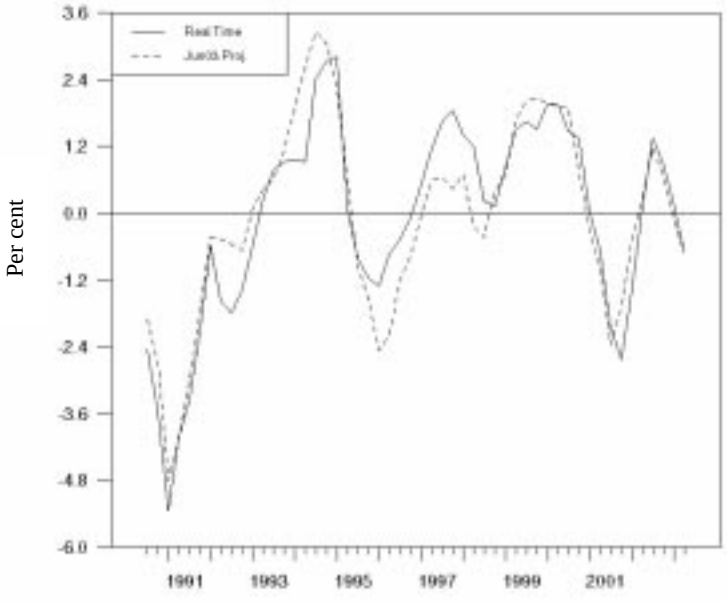

Figure 6: Deviation of Inflation from 2 Per Cent

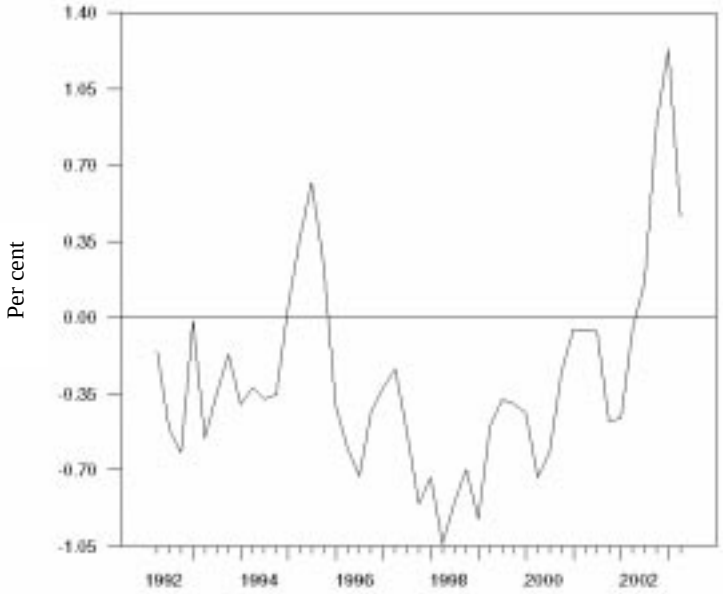

Figure 7: Measures of the Core-Core Inflation Rate

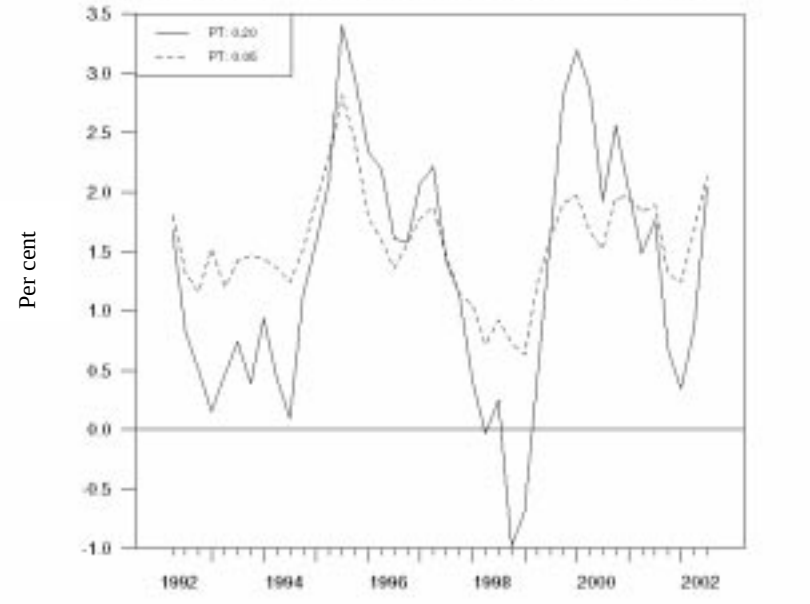

Figure 8: Open-Economy Rules with Alternative Pass-Through Specification

Appendix A: Functional Form of the Rules Tested

Most of the rules tested in this paper have the following form:[1]

$$i_t = \rho i_{t-1} + (1-\rho)(\alpha_y \tilde{\gamma}_t + \alpha_\pi(\pi_t - \bar{\pi}_t)), \quad \text{(A.1)}$$

where i_t is the nominal policy interest rate, $\hat{\gamma}_t$ is the output gap, and $(\pi_t - \bar{\pi}_t)$ is the deviation of inflation from the target.

The coefficients of the rules plotted in Figures 1 through 3 and tested in Tables 1 through 3 are summarized in Table A1.

The two open-economy rules have the following form:

$$i_t = \alpha_y \tilde{\gamma}_t + \alpha_\pi(\Pi c_t - \bar{\Pi} c_t) + \eta(e_t - e^*), \quad \text{(A.2)}$$

where Πc_t and $\bar{\Pi} c_t$ refer to the actual and target core-core measures of inflation discussed in footnote 5. In the Ball rule, e^* is the equilibrium exchange rate; in the Change rule, it is equal to e_{t-1}. Ball (1998) calculates η to be equal to 0.3 for Canada, and Armour, Fung, and Maclean (2002) run deterministic simulations to confirm this choice. The coefficients on the open-economy rules are the same as the original Taylor rules, but are scaled to account for the exchange rate term by (η - (1-η)θ). Following Ball (1998) and Armour, Fung, and Maclean (2002),we assume that θ is roughly equal to 2.

Table A1: Simple Rule Specification

Model	ρ	α_y	α_π
Original Taylor rule	0	0.5	1.5
Simple rule from QPM	0	0.5	3
Simple rule from NAOMI	0	0.5	2
Simple rule from MULTIMOD	0	2	4
Simple rule from M1-VECM	0.9	0.5	1.5
Simple rule from LPM	0.9	0	1.0058

1. As documented in section 3.3, a constant term that approximates, for the rules where $\rho = 0$, the "equilibrium" overnight rate is added empirically. For rules with a lagged dependent variable ($\rho \neq 0$), see footnote 10 for the interpretation of the constant term.

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