RESERVE BANK
OF NEW ZEALAND

DP2000/10

Interest rate smoothing in New Zealand and other dollar bloc countries

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December 2000

Discussion Paper Series

DP2000/10

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Abstract[2,3]

This paper utilises the partial adjustment approach of Judd and Rudebusch (1998) to empirically estimate the degree of short-term interest rate smoothing by central banks in the dollar block countries. All countries appear to smooth short-term interest rates significantly, with New Zealand and Canada smoothing rates by less than what appears to be the case for Australia and the United States. We then examine the macroeconomic implications of interest rate smoothing using the Reserve Bank of New Zealand's macro model. The model is constructed such that the more interest rates are smoothed in the short-term, the larger inflation and output variability will be over the cycle. However, at least over the narrow range of the empirically based smoothing approaches, the results suggest that there may be little cost in smoothing short-term interest rates in New Zealand to the degree seen in Australia or the United States.

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1 Introduction

*"In some circumstances, accepting a bit more short-term variability in inflation **may** mean a bit less variability in interest and exchange rates, and vice versa."*[4]

The Policy Targets Agreement (PTA) that is negotiated between the Governor of the Reserve Bank of New Zealand (the Bank) and the Government specifies the Bank's price stability objective. The current PTA defines this objective as a CPI inflation target band of 0 to 3 per cent. In addition, in pursuit of this objective section 4(c) of the PTA states that the Bank "*shall seek to avoid unnecessary instability in output, interest rates and the exchange rate*".[5]

A broad interpretation of section 4(c) is that the Bank should be concerned with how its policy actions affect the peak-to-trough movements in output, interest rates and the exchange rate over the cycle. That is, it reflects that the Bank recognises there may well be a trade-off between the stability of the economy over the cycle, and keeping inflation tightly tied to the inflation target.

What may also be of some concern, however, is the degree to which policy is adjusted at higher frequencies, for example, over a year or from quarter-to-quarter. The difficulty is that the more a central bank seeks to smooth interest rates at higher frequencies, the greater we might expect the potential 'penalty' to be. For example, if a central bank only adjusts policy quite gradually in the presence of inflation pressures, then over the cycle policy may have to be tighter for longer than might otherwise have been the case. This may imply that output, inflation and the exchange rate experience larger cycles. Overall, there may well also be a trade-off between short-term interest rate smoothing and seeking to avoid instability in output, interest rates and the exchange rate over the cycle.

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[4] From *"The Building Blocks of Economic Growth"*, an address by Dr. Donald T Brash, Governor, Reserve Bank of New Zealand to the Canterbury Employers' Chamber of Commerce Christchurch, 28 January 2000.
http://www.rbnz.govt.nz/speeches/sp000128.htm

[5] See http://www.rbnz.govt.nz/pta.htm for details.

To put the above trade-offs in context with monetary policy research, a common starting-point is to assume that the central bank endeavours to minimise the loss associated with output and inflation variability. The loss is often characterised by a loss function of the form:

$$L_t = \theta(\pi_t - \pi^*)^2 + (1-\theta)(Y_t - Y_t^P)^2 \qquad (1)$$

where π_t is the level of inflation at time t, π^* is the inflation target, Y_t is the level of real GDP at time t, Y_t^P is the level of potential GDP at time t, and θ is the weight placed on the squared deviation of inflation relative to the output gap. To achieve a central bank's preferred trade-off between output and inflation variability, the monetary policy maker(s) adjusts short-term interest rates to balance the costs associated with output and inflation variability.[6]

In general terms, all central banks, whether they have an explicit inflation target or not, adopt a so-called 'flexible' approach.[7] Under a flexible approach, weight is placed upon both inflation and output deviations by the central bank. As suggested by clause 4c of the PTA, this reflects that the policy maker recognises the trade-off between inflation and output variability, and as such is mindful of how its policy actions may affect the economy over the cycle.

In general terms, models that are typically used by researchers to minimise the above loss function normally suggest fairly rapid and aggressive responses of short-term interest rates, even under a flexible approach.[8] However, in reality interest rates are adjusted

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[6] Generally, the trade-off between output and inflation variability is embodied in most models used by central banks [Taylor (1999)], and also exists in the Bank's economic model, the Forecasting and Policy System (FPS). However, there are no long run trade-offs between the level of output and the level of inflation in these models. The trade-off in only exists between the variabilities of the two competing objectives.

[7] See Svensson (1997), Drew and Orr (1999) and Haldane and Batini (1999).

[8] For example, see Drew and Hunt (1998, 1999), Conway, et. al. (1998), Ha (2000), Taylor (1999), and Williams (1999).

considerably less aggressively, and over longer periods of time.[9] Reflecting this fact, a considerable amount of literature has been developed to addresses whether this is desirable.[10] In this literature, many reasons are given for the desirability or causes of short-term interest rate smoothing behaviour of central banks. These reasons include central bank preferences for lower interest rate volatility, dislike of policy reversals, uncertainty about structural parameters in the economic model used, exploiting the forward-looking behaviour of market participants, or measurement error (noise) in economic data.

For simplicity, this paper assumes that the Bank derives some utility or benefit from smoother short-term interest rates, and only briefly discusses the potential benefits of providing the Bank with better control over longer-term rates. In addition, we do not assume that the Bank cares explicitly about exchange rate variability per se, but that it does make use of the exchange rate in forecasting inflation (see Ball (1999) and Svensson (1997) for comparison).

All of the explanations for interest rate smoothing may be partially or wholly valid, but all suggest that the costs and benefits associated with interest rate smoothing should be explored. This paper begins by presenting cross-country evidence on interest rate smoothing using a partial adjustment Taylor rule approach as in Judd and Rudebusch (1998). The results suggest that interest rates in New Zealand and Canada have been smoothed the least, while in contrast, interest rates in Australia and the United States have been smoothed the most over the sample periods examined.[11]

The estimation technique also captures whether there are significant differences between the extent to which policy continues to move in one direction, or in other words, whether there are apparent differences in the degree of policy 'momentum.' If there is a trade-

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[9]   For example, see Judd and Rudebusch (1998) and Sack and Wieland (1999) for evidence in the United States.

[10]   For example, see Barro (1989), Goodfriend (1991), Levin et. al. (1998), Sack (1998b), and Woodford (1999, 1998).

[11]   Note that the sample period for New Zealand does not cover the recent change to the Overnight Cash Rate (OCR) system.

off between interest rate smoothing and the peak-to-trough movements of interest rates over the cycle, then we might expect that greater smoothing implies greater momentum in the direction of policy movements. The empirical estimates largely agree with this hypothesis. New Zealand and Canada appear to have the least amount of policy momentum, while the United States appears to have the most.

These empirical estimates of interest rate smoothing are used to calibrate the policy reaction function of the Bank's macroeconomic model, the Forecasting and Policy System (FPS). Simulations of the model are then conducted to hypothetically gauge how large the costs of the trade-off between interest rate smoothing and movements of macroeconomic variables over the cycle may be. In particular, we discuss the effects of short-term interest rate smoothing when the Bank gradually adjusts its target rate and consequently slows down the adjustment process of the 90-day interest rate. This approach attempts to evaluate the potential costs in terms of increased output and inflation variability versus the benefit of reduced interest rate variability, if the Bank were to smooth rates as much as the United States or Australia.[12]

Over the narrow range of the empirically based rules, the results suggest that there is little apparent cost to increasing, on the margin, the degree of interest rate smoothing to be similar to what appears to occur in the United States or Australia. Moreover, because we perform this evaluation assuming that the 90-day interest rate is the primary interest rate that matters, we tend to view the results as a possible upper bound on the costs of further gradualism. As in Woodford (1999), it is possible that increased gradualism may actually have some potential benefits if it allows the Bank to better control other interest rates further down the yield curve.

The remainder of this paper is as follows. Section 2 outlines the empirical technique used to estimate the degree of interest rate smoothing and presents the results. In section 3, the results of the

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[12] In addition, we show the effects on the variability of interest rates and exchange rates over the cycle.

FPS simulations and impulse responses are provided. Section 4 concludes and discusses areas for future research.

2 Short-term interest rate smoothing across countries

To provide an indication of the empirical differences between the amount of smoothing undertaken by central banks, we adopt an approach employed by two economists at the San Francisco Fed to compare various chairmen of the Federal Reserve (Fed), see Judd and Rudebusch (1998). Under this approach, the time taken for the central banks to reach their 'desired' short-term interest rate position is estimated, as is the degree of policy momentum. The 'desired' interest rate is given by a generalised Taylor rule, that is, the desired interest rate level is a function of the deviation of current output from potential output and current inflation from the target rate of inflation. We freely estimate the degree to which each central bank responds to inflation and output deviations using non-linear least squares, and allow each country to have a different real interest rate intercept.

In particular, the generic specification of the estimated equations are:

$$i_t - i_{t-1} = \alpha(i_t^* - i_{t-1}) + \beta(i_{t-1} - i_{t-2}), \text{ or alternatively as} \quad (2)$$

$$i_t = (1 - \alpha)i_{t-1} + \alpha i_t^* + \beta(i_{t-1} - i_{t-2}) \quad (2')$$

where $i_t^* = r_t^* + \pi_t + \gamma_\pi(\pi_t - \pi_t^*) + \gamma_Y(Y_t - Y_t^*)$ \quad (3),

i_t is the quarterly average of the short-term interest rate at time t; i_t^* is the desired interest rate given by the Taylor rule; π is annualised inflation, π^* is the inflation target of the central bank, Y is the natural log of real GDP, Y^* is the natural log of potential GDP, and $\alpha, \beta, r^*, \gamma_\pi, \gamma_Y$ are estimated parameters.[13]

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[13] Estimation was done in EViews 3.1. In order to identify all parameters, the inflation target in each country must be specified (or assumed constant), and HP filtered output gaps (λ=1600) were used in every country. The EView workfiles are available from the authors on request.

The parameter α serves as a proxy for the degree of interest rate smoothing, and should lie between zero and one because it indicates what percentage of the gap is closed each quarter. A lower value for α implies that short-term interest rates are adjusted less towards the desired interest rate. The parameter β captures policy momentum.[14] A higher value of β indicates that the interest rates are more likely to change (not change) in the current quarter if they changed (did not change) in the previous quarter. The overall adjustment of interest rates in any given quarter is then a function of current conditions (which determines i^*), last period's interest rate, the degree of smoothing, and the degree of interest rate momentum. For ease of presentation and in order to concentrate on policy smoothness, the results on r* and each γ are excluded in the body of the paper. The interested reader can see tables 2 through 4 in the regression appendix for details on other parameters and results.

Separating the adjustment of interest rates into the pieces above is crucial as it affords us, to the extent possible, the ability to control for 'intrinsic' cross-country differences. For example, as New Zealand is relatively small and undiversified to shocks, this could well imply that the estimated 'desired' interest rate is relatively more variable compared to the other countries examined. The estimated adjustment to the desired rate, however, can be thought of as an independent policy choice that reflects central bank preferences, and not factors such as the size (or inherent variability) of the economy. In addition, while we do not allow for feedback between central bank responses and the economy, this approach does sufficiently condition the central bank's desired short-term interest rate on the current state of output and inflation.

In table 1 below the estimated parameters from equation (2') are shown for New Zealand, the United States, Australia, and Canada when the equation is run in the level of the nominal short-term interest rate. The standard errors of the parameter estimates are also

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[14] One should not necessarily view β, policy momentum, as being optimal. Rather, it should be viewed as capturing some of the serial correlation in the estimation of these regressions. Also, policy momentum may capture times when central banks move before actual data on output and inflation begin to change. In the case of the US, the estimated β is rather high and would be destabilising if not for the weight on the desired interest rate in equation (2').

shown in brackets, and these are used to construct the hypothesis tests for α = 0 and β = 0. For comparative purposes, the smoother, α, currently used in the FPS policy rule is also provided.

Table 1:
Smoothing parameters and hypothesis tests

Parameter	New Zealand	United States	Australia	Canada	FPS
Sample period	88:2-99:2	87:3-99:2	90:1-98:4	84:1-98:4	N/A
Smoothing (α)	0.379[a] (0.080)	0.208[a] (0.064)	0.222[a] (0.056)	0.461[a] (0.102)	0.667 N/A
Momentum (β)	0.291[b] (0.114)	0.506[a] (0.100)	0.214 (0.223)	0.109 (0.120)	0 N/A
Fit of estimated equations (R^2)	0.960	0.976	0.980	0.938	N/A

Notes:
[a,b,c]   denotes that the estimated parameters are significantly different from zero at the 1% level, 5% level, and 10% level respectively.
     N/A implies not applicable.

In absolute terms, the degree to which the countries are estimated to smooth interest rates from highest to lowest are: the US (Greenspan period), Australia, New Zealand (Brash period), and Canada. However, all countries still smooth by more than the degree of smoothing contained in the current FPS policy rule.[15] For example, in the case of Canada, if the actual 90-day interest rate is below the 'desired' rate by 100 basis points, then short-term rates are increased by around 50 basis points during the quarter. In contrast, all else equal, under the same conditions the FPS policy rule would suggest

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[15]   Note that the lower degree of smoothing in the model does not necessarily imply that interest rates overall are more volatile in FPS as the policy rule responds to forecasts of inflation, rather than current inflation and the current output gap. In practice, forecasts of inflation tend to be less volatile than a linear combination of current inflation and the output gap for several reasons. First, the forecast will be conditioned upon a wider set of state variables. Second, the forecast will tend to be less influenced by what are judged to be 'transitory' factors influencing both inflation and output. Finally, forecasts tend be more conservative than what is suggested by historical data behavior.

that rates need to be increased by around 70 basis points. Finally, for the United States and Australia, the increase in short-term rates suggested is around 25 basis points.

Without running complicated hypothesis tests across different non-linear regressions, the standard errors of the estimated smoothing parameters, α, seem to indicate that some of the differences in smoothing are statistically significant. In particular, Australia and the United States appear to smooth rates significantly more than Canada and New Zealand. In contrast, the degree of smoothing between New Zealand and Canada does not look to be significantly different, nor is the degree of smoothing between Australia and the United States.

If there is a trade-off between interest rate smoothing and the time interest rates need to be away from 'neutral' over the cycle, then we might expect that greater smoothing implies greater momentum in the direction of policy movements. The empirical estimates are somewhat supportive of this hypothesis. In absolute terms, Canada appears to smooth policy the least, and it also has the least degree of policy momentum. In contrast, while the United States smoothes interest rates the most, it also appears to have the most policy momentum. However, while Australia smoothes interest rates by more than what is apparent in New Zealand, at least over the sample period examined, it appears to have not 'paid for it' as policy momentum is also lower.

3 The effects of smoothing in FPS

Although the empirical differences in smoothing appear statistically significant, they may not necessarily be 'economically' significant. In other terms, if the estimated differences in the smoothing approaches only affect the cycle at the margin, they need not be of any deep concern to the policy maker. We examine this issue by tracing out the adjustment paths the economy may undergo given the differing policy approaches. In particular, we show how macroeconomic variables in FPS evolve given the following types of simulations:

1) A simple deterministic shock; and,
2) stochastic simulations.

The simple deterministic shock is used to demonstrate the effects of the alternative policy approaches in a 'controlled environment', in the sense that the economy starts from a point of equilibrium. In contrast, stochastic simulations show the implications given a barrage of shocks, and as such they give a feel for what the trade-offs involved in interest rate smoothing may look like.

Under each type of simulation, the policy rule in FPS is adjusted to represent the estimated cross-country differences in smoothing and policy momentum only. Therefore, we maintain the current FPS objective of penalising deviations of forecast inflation from the inflation target.

Specifically, equation (3) now becomes equation (3') to reflect the desired short-term interest rate rule in FPS.

$$i_t^* = r_t^* + \pi^* + \sum_{i=6}^{8} \theta_{t+i}(\pi_{t+i} - \pi^*) \qquad (3')$$

where θ_{t+i} is the weight (or penalty) on deviations from the inflation target i quarters out, π_{t+i} is annualised inflation rate i quarters out, and π^* is the inflation target. A key difference here is that (3') uses the inflation target, π^*, in the equilibrium nominal rate while (3) uses actual inflation, π_t, in the equilibrium nominal rate.

Under all cases, interest rates respond to the projected deviation of inflation from the target at a horizon of 6 to 8 quarters ahead and assume that r* reflects New Zealand's r* only. Using this approach allows us to focus primarily on the degree of smoothing that occurs in interest rate setting, rather than on variations of the policy rule in FPS. For the interested reader, Drew and Hunt (1999) explore inflation targeting, Taylor rule variations, and hybrids of the two extensively. Now, we turn to the results for interest rate smoothing.

3.1   Simple disturbance

Figure 1 below shows the outcomes for the nominal 90-day interest rate given a shock that causes inflation to rise by around half a percent over the models policy horizon.[16]   There are five cases shown in the graph, shaded from lightest to darkest, each corresponding to the following policy rules:

1.   No smoothing or momentum
2.   Standard FPS policy rule (smoothing = 0.66, no momentum)
3.   New Zealand estimated policy rule
4.   United States estimated policy rule
5.   Australian estimated policy rule[17]

Cases 1-3 provide a baseline to judge how much smoothing is actually done in the FPS projections relative to the New Zealand empirical estimate. Cases 4 and 5 then give a feel for how these results compare to the Australian and US empirical estimates, respectively.

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[16]   The source of the shock could equally be thought of as a demand shock, or a cost-push inflation shock. The impulse response graphs for output would obviously be different though.

[17]   The Canadian policy response is not shown to avoid clutter on the graph. The outcome for the interest rate path, however, lies between the standard FPS policy rule response and the New Zealand estimated policy rule response.

Figure 1:
Alternative 90-day interest rate adjustment paths
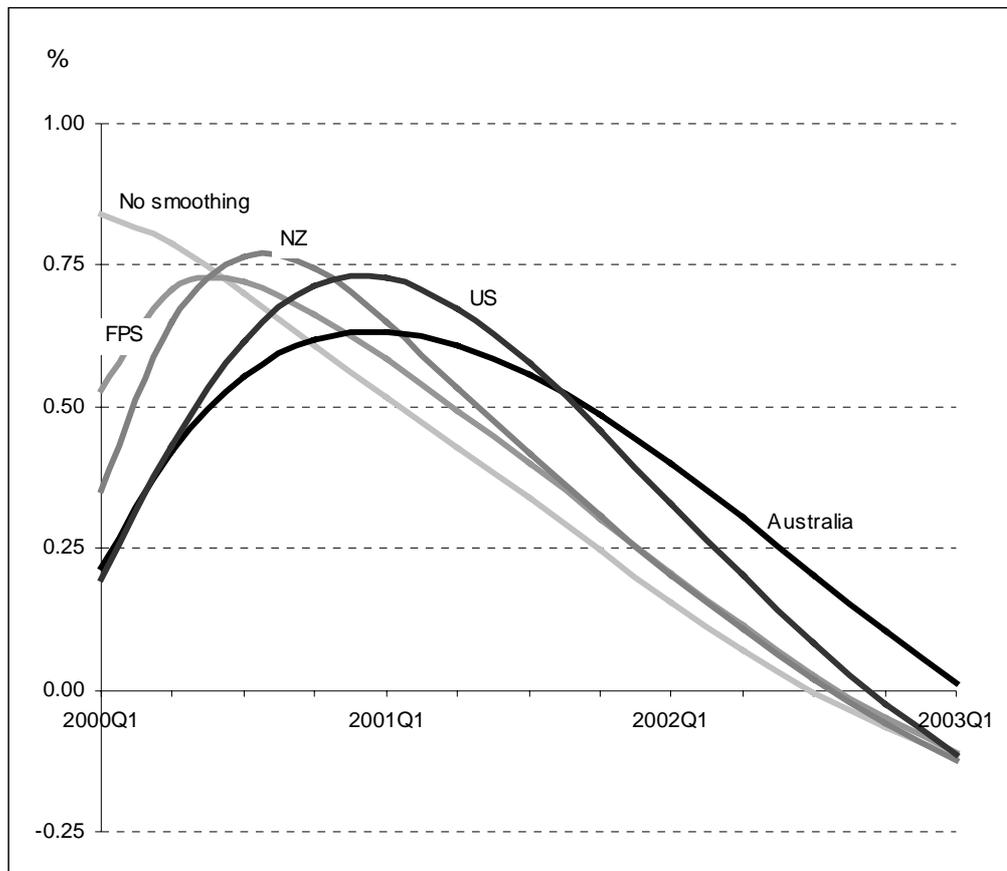
The basic result arising from these simulations is that if policy is adjusted by less initially, it has to be higher further out. In the case of no smoothing, the 90-day interest rate immediately jumps to a relatively high level (around 80 basis points), from which point policy is progressively eased. Under interest rate smoothing, policy is adjusted more gradually upwards, and then more slowly back towards neutral.

The level at which the interest rate peaks for all rules with some smoothing is around 75 basis point above neutral.[18] There are, however, interesting timing differences that qualitatively match what many people would expect. Using the standard FPS rule, policy reaches the level of around 75 basis points after 3 quarters. Under the New Zealand estimated policy rule the timing is a little

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[18] The peak level under the Australian policy rule is slightly lower at around 62.5 basis points.

later at between the 3rd and 4th quarter.[19] For the US (Australian) rule, the timing is later still with interest rates reaching a level of 75 (62.5) basis points at around 5 quarters. If we put these timing differences in the context of our current OCR resets that occur every six weeks, they suggest that on average the RBNZ gets policy to its peak level at least two resets before either the RBA or the Fed.

If we think of policy adjustment in 25 basis points steps, the benefit of adjusting policy more quickly to the peak level appears to be that it does not need to stay at that level for as long. For the New Zealand rule, policy is 50 basis points above zero change for around 4 quarters. For the US rule, policy is around 50 basis points above zero change for 5-6 quarters, and for the Australian rule policy the amount of time is 6-7 quarters.

Regardless of how long policy is kept at high levels, policy returns to zero in about the same time for all rules examined, i.e. they differ by one or two quarters. Furthermore, the outcomes (not shown) for output and inflation are also very similar under the alternative policy rules.[20] This suggests, at least for this simple shock, that the timing differences involved in the alternative interest rate smoothers have little lasting implications for macro variability over the cycle. However, from figure 1 above it can be seen that the smoother policy engenders less variability in the quarter-to quarter movements in the interest rate.

We turn now to see whether these results hold under a more complete accounting of the shocks that New Zealand may face over the business cycle.

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[19] The estimated policy rule for the Brash years has more initial smoothing relative to the FPS policy rule, but 'makes up for it' with greater policy momentum. The overall path of the 90-day interest rate under the NZ estimated rule is quite similar to the path obtained using the FPS rule, at least in comparison to the paths obtained for 90-day rates using the estimated US and Australian policy rules.

[20] The profiles for the real exchange rate largely mirror the profiles for the 90-day interest rate given the UIP relationship in the model.

3.2 Stochastic simulations

In figure 2 below, outcomes of stochastic simulations of FPS are presented for a range of policy rules with alternative degrees of interest rate smoothing, including the alternative estimated interest rate smoothers.[21] Before discussing the results, it is useful to outline how to interpret the graphs.

Each point on the graphs represents the outcomes for one policy rule. In particular, the points labelled 'NZ' and 'AUS' are where the outcomes lie using the New Zealand (Don Brash period) and Australian empirically estimated smoothers respectively. The results are scaled such that the outcomes obtained using the New Zealand rule lie at the center of each graph. As such, all other outcomes are expressed *relative* to the outcome obtained using the estimated New Zealand smoothers. The vertical axis of each graph gives an indication of how the average quarterly change in the interest rate is affected by interest rate smoothing. The horizontal axis of each graph shows how variability over the cycle for various macro variables responds to greater or lesser interest rate smoothing. The variability is measured as the sum of squared deviations from equilibrium over the 25 year horizon that the model is simulated with the stochastic disturbances. Overall, each graph in figure 2 presents a different 'dimension' of the trade-offs involved in short-term interest rate smoothing. In particular, the slopes of the graphs give a feel for how the variability for the various macro variables change as the degree of smoothing is changed.

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[21] See Drew and Hunt (1998) for a discussion on the methodology employed to perform stochastic simulations of FPS.

Figure 2:
Trade-offs in interest rate smoothing
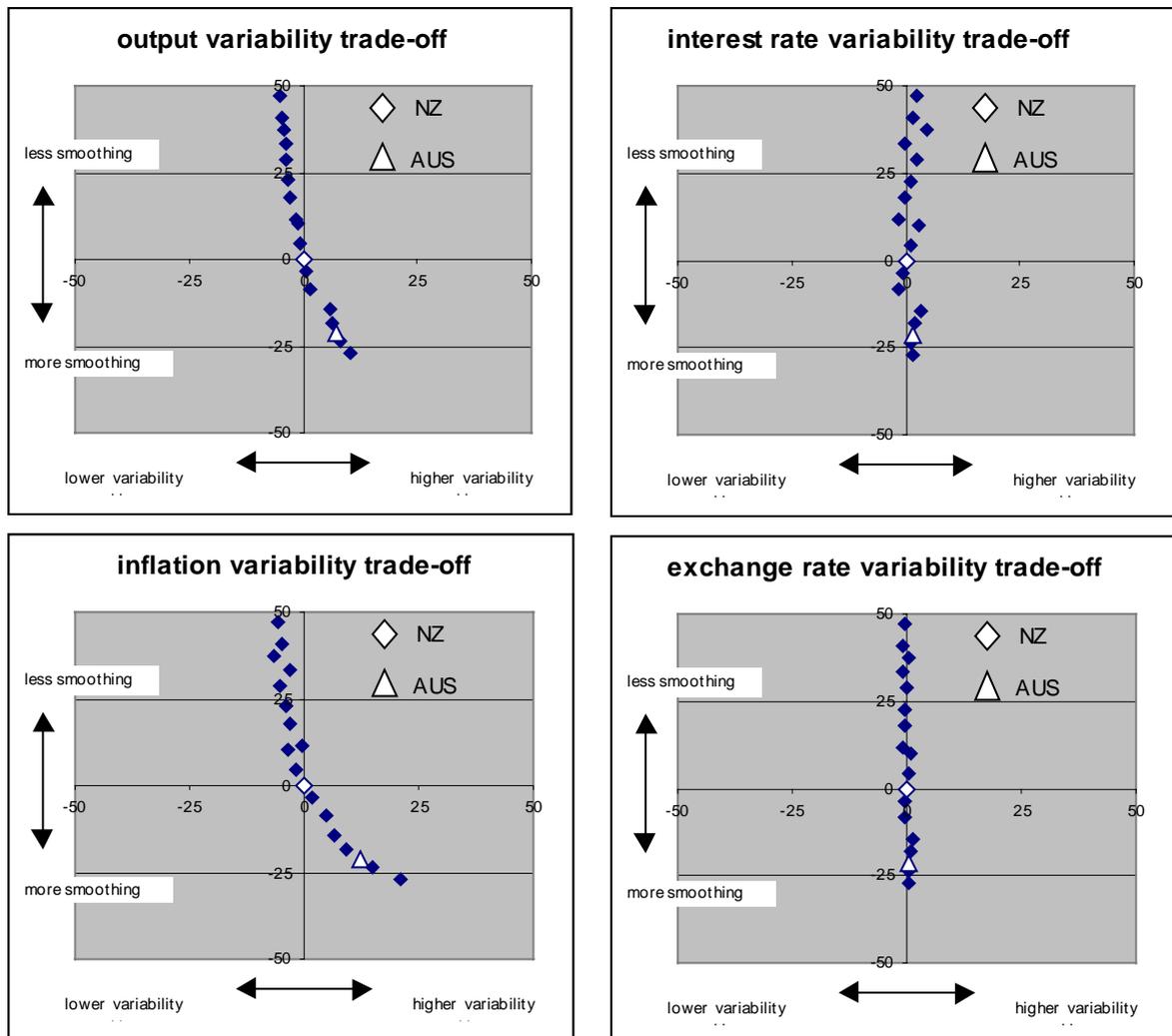
In order to provide an overview, consider what occurs in moving from the point labelled 'NZ' to the point labelled 'AUS' in the first graph of figure 2. As the Australian estimated policy rule entails more smoothing than the New Zealand estimated policy rule, the average quarterly change in the interest rate is, unsurprisingly, reduced. The size of the reduction is estimated to be around 25% of the average quarterly change in the interest rate that occurs using the New Zealand estimated policy rule. The trade-off or cost of the extra smoothing is that output (inflation) variability is around 8% (15%) higher over the cycle than what occurs using the New Zealand policy rule. What must be noted, however, is that this extra variability largely results from the cycle being more prolonged. The peaks and troughs for output are not necessarily larger.

Turning to the results more generally, for inflation and output, there is the expected trade-off between short-term interest rate smoothing and variability over the cycle. However, the slope of the model generated trade-offs are quite steep. This suggests that as long as policy is not 'excessively' smoothed, reducing the quarter-to-quarter volatility in the instrument via interest rate smoothing leads to only a relatively small increase in variability cost. In other words, because the trade-offs are relatively steep it may be worth smoothing interest rates slightly more even if the there is only a relatively small preference for doing so. While these trade-offs are relatively steep in the estimated range of smoothing (interest rate variability falls more than output (inflation) variability rises), they become horizontal rather quickly when policy is smoothed even more than the US or Australian cases. This dramatic change in slope arises because interest rates are adjusted too slowly and inflation and output experience much larger and more persistent swings over the cycle. Figure 3 at the end of paper illustrates the graph of this stylised trade-off for output (inflation) variability versus interest rate variability.

For the real exchange rate there is almost no apparent trade-off between interest rate smoothing and exchange rate variability over the cycle. The reason why this result occurs is that UIP has a relatively strong short run effect, but a much weaker effect in the model over longer horizons. Over the cycle shocks emanating from the rest of the world, such as world demand and commodity price shocks, are far more important. These types of shocks tend to dominate any positive relationship that exists in the short run between the real interest and real exchange rate.

Finally, there is only a relatively small trade-off between short-term interest rate smoothing and the variability of interest rates over the cycle, at least over the narrow range of policy rules presented here. The slope of the trade-off does exist, but it runs in the opposite direction than the trade-off for output and inflation and is a function of the 'momentum' term in the policy rule. Higher momentum appears to result in both slightly higher quarterly changes in interest rates and higher variability in interest rates over the cycle. Hence, the results suggest that too much policy 'momentum' should be avoided.

4   Conclusion

This paper shows that as an empirical issue, New Zealand in the pre-OCR period appears to have smoothed 90-day interest rates less, *on average*, than what occurs in either the United States or Australia. As such, policy is estimated to reach its 'desired' level at least two policy resets earlier than what occurs in Australia or the United States.

Using FPS, we investigate the trade-offs involved in interest rate smoothing over the narrow range of the empirically based rules. For the real exchange rate and for the interest rate, there appears to be almost no trade-off between interest rate smoothing and variability over the cycle. For output and inflation, smoothing the change in quarterly interest rates tends to increase the volatility of output and inflation over the cycle. The amount by which this variability is increased, however, is small relative to the reduction in the quarter-to-quarter volatility of interest rate changes.

Depending on how strong preferences (or perceived benefits) are to smooth short term interest rate changes, the results suggest there may be little cost in adopting a policy approach that, on average, smoothes interest rate changes marginally more than in the past. Adopting such an approach would seem to be consistent with the spirit of the new PTA, but further study is warranted before concluding on the 'optimal' degree of interest rate smoothing for New Zealand.

In particular, Woodford (1999, 1998) stresses that short-term interest rate smoothing gives central banks better control over longer term rates. These longer-term rates are especially important if they significantly affect economic decisions and improve a central bank's overall ability to reduce the variability of output and inflation. This type of policy requires central bankers to change their target interest rates less frequently, but to hold these rates higher (or lower) for longer periods of time.[22]   In this context, central bankers choose to

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[22]   This sort of reasoning and fixed costs to adjusting the target rate may explain why target interest rates in many countries look to be non-stationary in high frequency data [Guthrie and Wright (2000)]. While Guthrie and Wright assume

smooth interest rates because it gives them better control over the economy rather than because they care about short-term interest rate volatility per se.

Woodford uses this rationale to explain short-term interest rate smoothing behaviour in US monetary policy, but it is not clear how well this would work in New Zealand. Firstly, debt contracts in New Zealand at present tend to be of very short duration relative to the US. Secondly, although two year rates are highly correlated with 90-day interest rates, longer-term rates in New Zealand are determined more by interest rates in the US and Australia rather than developments in New Zealand [Eckhold (1998)]. In summary, longer-term rates are not as important in New Zealand and New Zealand monetary policy has less influence over them. On the face of it, this would suggest that there would be little benefit in smoothing interest rates for the reasons Woodford suggests. That said, despite the lack of historical support, a change in the degree of short-term interest rate smoothing in New Zealand may in itself cause these relationships to change.

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a Brownian motion for the preferred rate, a highly persistent preferred rate would likely lead to similar results as well. For example, when these rates are changed, these changes are very unlikely to be quickly reversed.

Figure 3:
Quarterly interest rate variability versus inflation (output) variability over the cycle
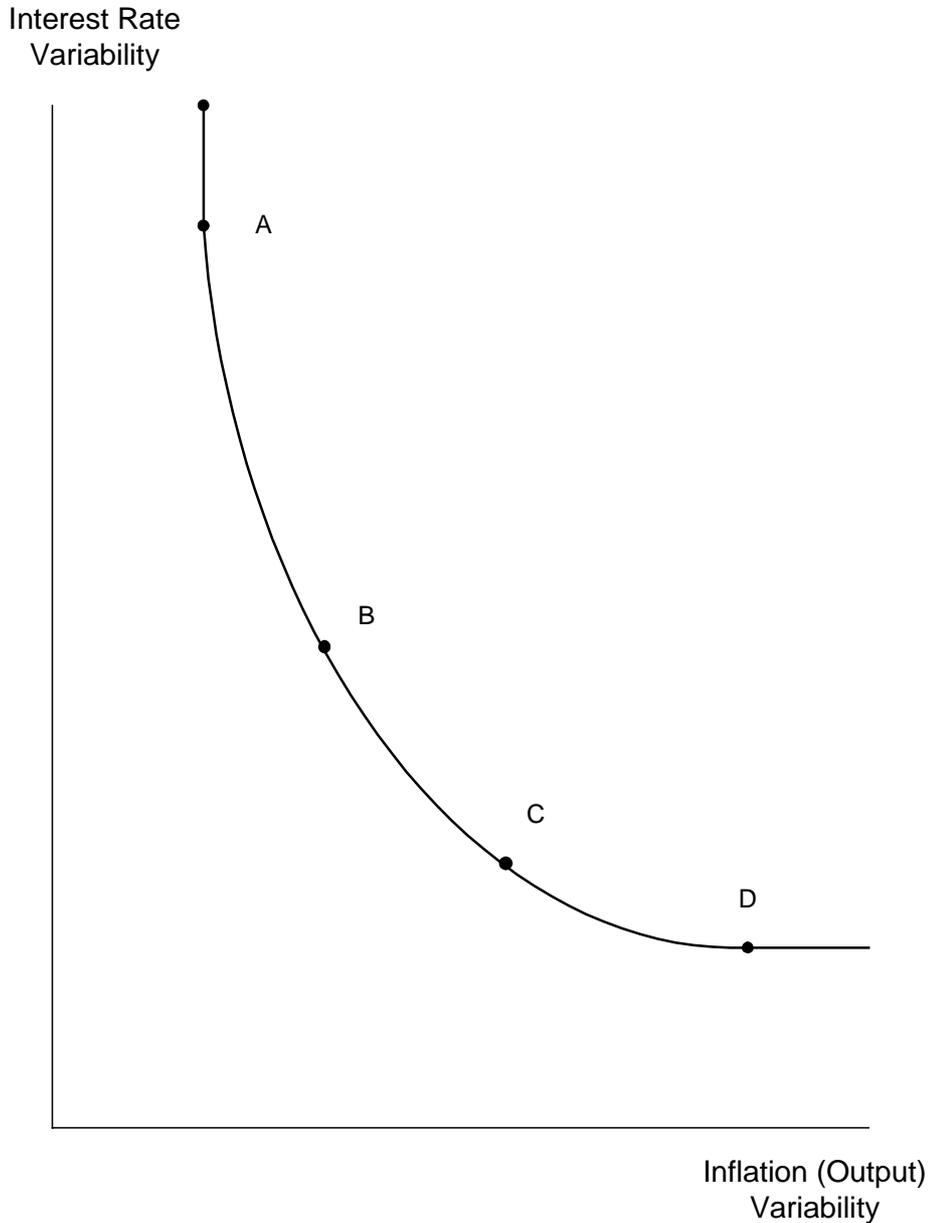
In FPS, **Point A** represents the No Smoothing case, **Point B** represents the degree of smoothing in the pre-OCR period, and **Point C** represents US or Australian smoothing. **Point D** represents the point at which further smoothing does not decrease interest rate volatility, but only increases inflation and output variability.

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FPS Reaction Function Appendix

This appendix puts the FPS reaction function into rn space from its current formulation in terms of the slope of the yield curve, and allows a comparison to the J&R approach. rn is the nominal 90-day bank bill interest rate, rn_eq is the equilibrium nominal 90-day bank bill, rnl is the long term interest rate, rnl_eq is the equilibrium long rate, θ_{t+i} is the weight on inflation deviations i quarters out, $\hat{\pi}_{t+i}$ is the inflation deviation i quarters out, and λ is the penalty on interest rate changes.

Current FPS Reaction Function

$$\frac{1+rn_t}{1+rnl_t} = \frac{rn\_eq_t}{rnl\_eq_t} + \sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i} - \lambda[(1+rn_t)+(1+rn_{t-1})]$$

Since $\dfrac{1+rn_t}{1+rnl_t} \cong rn_t - rnl_t - 1$, then

$$rn_t - rnl_t - 1 = rn\_eq_t - rnl\_eq_t - 1 + \sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i} - \lambda rn_t + \lambda rn_{t-1}$$

$$(1+\lambda)rn_t = rn\_eq_t - rnl\_eq_t - rnl_t + \sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i} + \lambda rn_{t-1}$$

$$rn_t = \frac{(rn\_eq_t + \lambda rn_{t-1})}{(1+\lambda)} + \frac{(rnl_t - rnl\_eq_t)}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)}$$

Add and subtract rn_{t-1} from RHS

$$rn_t = \frac{(rn\_eq_t + \lambda rn_{t-1})}{(1+\lambda)} - rn_{t-1} + rn_{t-1}$$

$$+ \frac{(rnl_t - rnl\_eq_t)}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)} \qquad ,$$

and combine terms

$$rn_t = \frac{(rn\_eq_t - (1+\lambda)rn_{t-1} + \lambda rn_{t-1})}{(1+\lambda)} + rn_{t-1}$$

$$+ \frac{(rnl_t - rnl\_eq_t)}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)} \quad ,$$

and simplify

$$rn_t = \frac{(rn\_eq_t - rn_{t-1})}{(1+\lambda)} + rn_{t-1} + \frac{(rnl_t - rnl\_eq_t)}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)}$$

Making this reaction function equivalent to J&R requires that the long rate is dropped, and adding the momentum term.

$$(\text{FPS}) \quad \Delta rn_t = \frac{(rn\_eq_t - rn_{t-1})}{(1+\lambda)} + \frac{(rnl_t - rnl\_eq_t)}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)}$$

$$(\text{FPS}) \quad \Delta rn_t = \frac{(rn\_eq_t - rn_{t-1})}{(1+\lambda)} + \frac{\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i}}{(1+\lambda)} + \beta(rn_{t-1} - rn_{t-2}) \quad (3)$$

$$(\text{J\&R}) \quad \Delta rn_t = \alpha(rn\_eq_t - rn_{t-1}) + \alpha\sum_{i=6}^{8}\theta_{t+i}\hat{\pi}_{t+i} + \beta(rn_{t-1} - rn_{t-2})$$

$$(4)$$

Notice that equation (3) and (4) are the same except that $\alpha = 1/(1+\lambda)$ in equation (4). In FPS, $\lambda = 0.5$ which means that $\alpha = 2/3$ and that two thirds of any policy error is corrected in the next quarter. Further, recall that (3) uses the inflation target, π^*, in the equilibrium nominal rate and (4) uses actual inflation, π_t, in the equilibrium nominal rate. In order to make them exactly the same for simulations requires that both use the target inflation rate as in FPS.

To summarise the key differences and similarities:
- Both approaches allow for interest rate smoothing
- J&R approach uses short rate, or 90-day bank bill in NZ case
- FPS approach uses slope of the yield curve formulation which includes long rate
- J&R approach allows for policy momentum
- J&R approach uses actual inflation in equilibrium nominal rate
- FPS approach uses inflation target in equilibrium nominal rate
- J&R approach allows response to contemporaneous output and inflation gaps
- FPS approach responds to forecast inflation

Approach used in this paper for regressions: J&R approach

Approach used in this paper for simulations and impulse response exercises:
- Allow for both interest rate smoothing and policy momentum
- Use short rate, 90-day bank bill, formulation for reaction function
- Use NZ inflation target in equilibrium nominal rate

Regression Appendix

Table 2 and 3 present the regression results for AU, CA, NZ, and US and were run in levels of the relevant short-term interest rate for each country. The results for the first difference regression for New Zealand are shown for comparison in table 2. The relevant rates were the 13 week T-bill rate for AU, the 3 Month T-bill rate for CA, 90-day Bank bill rate for NZ, and the Federal Funds rate for the US.[23]

Recall that equation (2) and (3) determine the interest rate adjustment in each country.

$$i_t - i_{t-1} = \alpha(i_t^* - i_{t-1}) + \beta(i_{t-1} - i_{t-2}) \tag{2}$$

The desired rate is determined by equation (3) for a given π_t^* and Y_t^* in each period.

where $i_t^* = r_t^* + \pi_t + \gamma_\pi(\pi_t - \pi_t^*) + \gamma_Y(Y_t - Y_t^*)$ (3)

Equation (2) can be rewritten in the level of the short-term interest rate as

$$i_t = (1-\alpha)i_{t-1} + \alpha i_t^* + \beta(i_{t-1} - i_{t-2}) \tag{2'}$$

Equation (2') states that the level of the short-term interest rate is a weighted average of last period's rate and the desired rate in the current period (the first two terms), and is also determined by whether the interest rate changed last period.

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[23]   IFS short-term interest rate data was used for AU and CA, and the codes are 19360C..ZF... and 15660C..ZF..., respectively. Data for the US was obtained from the St. Louis Fed's website, http://www.stls.frb.org/fred/index.html, and Glenn Rudebusch was kind enough to give us his RATS data file to check our US results. NZ data was obtained from the RBNZ's Aremos database.

Digression on use of dummy variable for disinflationary period

The stability of this regression may be suspect especially when one includes a period where the RBNZ until 1992 was actively trying to bring down inflation and inflationary expectations. In order to check whether this is a problem, a dummy variable for the disinflationary period 1987:1-1991:4 was used.

The dummy variable was included to allow the intercept and the responses to inflation and output to be different in the pre and post 1992 periods. The regressions that appear to work best are the ones that either allow for a higher real interest rate intercept and response to the output gap in the pre 1992 period, or the ones that allow only the response of inflation to vary pre and post 1992. Either a higher real interest rate or a higher response to inflation pre 1992 seems sufficient to capture the increased aversion to inflation during the pre 1992 period.

Obviously, whether one uses 1985:1, 1986:1, or 1987:1 as the start date for the dummy does not matter at all for the regression results that have a start date 1988:2, but would matter for the regressions that begin in 1985:1. The 1988:2 start date for the sample period was used because it represents the beginning of Don Brash's period as governor at the RBNZ. The regressions with 1985:1 as the start date are only for comparison and are therefore sensitive to the dummy variable start date.

Table 2:
New Zealand first difference and level regressions

Equation	(2) Δi_t	(2') i_t	(2') i_t	(2') i_t	(2') i_t
Sample	88:2-99:2	88:2-99:2	88:2-99:2	85:1-99:2	85:1-99:2
α	0.379[a] (.080)	0.379[a] (.080)	0.392[a] (.069)	0.666[a] (.090)	0.703[a] (.116)
r*	5.18[a] (.459)	5.18[a] (.459)	5.35[a] (.412)	5.18[a] (.356)	5.30[a] (.337)
Pre-92 Dum	2.52[a] (.452)	2.52[a] (.452)		3.077[a] (.559)	
γ_π	.469 (.325)	.469 (.325)	0.233 (.312)	0.398[a] (.071)	0.351[a] (.055)
P92dum•γ_π			0.546[a] (.083)		0.551[a] (.100)
γ_Y	0.400[a] (.126)	0.400[a] (.126)	0.434[a] (.135)	0.190 (.151)	0.191 (.124)
P92dum•γ_Y	0.482[b] (.224)	0.482[b] (.224)		0.502[b] (.217)	
β	0.291[b] (.114)	0.291[b] (.114)	0.325[a] (.102)	0.169 (.122)	0.130 (.104)
R^2	0.507	0.960	0.960	0.962	0.964
Adj. R^2	0.429	0.954	0.955	0.958	0.961
DW Statistic	1.927	1.927	1.948	1.938	1.940

Notes:

[a,b,c] denotes that the estimated parameters are significantly different from zero at the 1% level, 5% level, and 10% level respectively.

Pre-92 Dum or P92dum indicates a dummy variable for the disinflationary period, 1987:1 to 1991:4, and equals one during the disinflationary period and zero at all other times. The dummy is used to see if the real rate or responses to inflation and output are different before 1992.

Table 3:
NZ, AU, CA, and US level regressions

Equation	NZ1 (i_t)	NZ2 (i_t)	AU (i_t)	CA (i_t)*	US (i_t)
Sample	88:2-99:2	88:2-99:2	90:1-98:4	84:1-98:4	87:3-99:2
α	0.379[a] (.080)	0.392[a] (.069)	0.222[a] (.056)	0.460[a] (.123)	0.208[a] (.064)
r*	5.18[a] (.459)	5.35[a] (.412)	3.48[a] (.564)	3.71[a] (.238)	2.88[a] (.258)
Pre-92 Dum	2.52[a] (.452)				
γ_π	.469 (.325)	0.233 (.312)	-0.003 (.410)	1.618[a] (.269)	0.566[b] (.257)
P92dum•γ_π		0.546[a] (.083)			
γ_Y	0.400[a] (.126)	0.434[a] (.135)	0.655[b] (.290)	0.954[a] (.268)	0.812[a] (.172)
P92dum•γ_Y	0.482[b] (.224)				
β	0.291[b] (.114)	0.325[a] (.102)	0.214 (.223)	0.109 (.112)	0.506[a] (.100)
R^2	0.960	0.960	0.980	0.938	0.976
Adj. R^2	0.954	0.955	0.977	0.933	0.973
DW Statistic	1.927	1.948	1.805	2.024	1.854

Notes:

[a,b,c] denotes that the estimated parameters are significantly different from zero at the 1% level, 5% level, and 10% level respectively.

*   For CA, it does not matter significantly whether one uses data since 1990 or since 1984.

Table 4:
NZ, AU, CA, and US first difference regressions

Equation	NZ1 (Δi_t)	NZ2 (Δi_t)	AU (Δi_t)	CA (Δi_t)*	US (Δi_t)
Sample	88:2-99:2	88:2-99:2	90:1-98:4	84:1-98:4	87:3-99:2
α	0.379[a] (.080)	0.392[a] (.069)	0.222[a] (.056)	0.460[a] (.123)	0.208[a] (.064)
r*	5.18[a] (.459)	5.35[a] (.412)	3.48[a] (.564)	3.71[a] (.238)	2.88[a] (.258)
Pre-92 Dum	2.52[a] (.452)				
γ_π	.469 (.325)	0.233 (.312)	-0.003 (.410)	1.618[a] (.269)	0.566[b] (.257)
P92dum•γ_π		0.546[a] (.083)			
γ_Y	0.400[a] (.126)	0.434[a] (.135)	0.655[b] (.290)	0.954[a] (.268)	0.812[a] (.172)
P92dum•γ_Y	0.482[b] (.224)				
β	0.291[b] (.114)	0.325[a] (.102)	0.214 (.223)	0.109 (.112)	0.506[a] (.100)
R^2	0.507	0.505	0.614	0.377	0.600
Adj. R^2	0.429	0.442	0.565	0.332	0.563
DW Statistic	1.927	1.948	1.805	2.024	1.854

Notes:

[a,b,c] denotes that the estimated parameters are significantly different from zero at the 1% level, 5% level, and 10% level respectively.

* For CA, it does not matter significantly whether one uses data since 1990 or since 1984.