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**The Inflation-Output
Trade-Off:
Is The Phillips Curve
Symmetric?
A Policy Lesson from New Zealand**

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Non-technical summary

New Zealand data show that the inflation-output relationship is asymmetric. This asymmetry implies that positive demand shocks tend to increase inflation by more than negative demand shocks of similar magnitudes reduce it. An important implication of this asymmetry is that a monetary authority with the objective of maintaining the inflation rate within a narrow band needs to react more promptly to demand shocks than otherwise be necessary. Alternatively, policy that is slow to respond to demand disturbances will result in higher inflation, and greater losses of output than would be the case with a linear Phillips curve.

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Abstract

Quarterly data spanning the period 1982Q3 to 1996Q1 for New Zealand are used to test the hypotheses that the relationship between inflation and output is symmetric. A single-equation expectations-augmented Phillips-curve is estimated by the *Generalised Method of Moments* (GMM). The hypothesis is rejected by the data. A small open-economy model with an asymmetric Phillips curve, rational expectations, persistent inflation and a monetary policy reaction function that is known by the public is then calibrated using the parameter estimates from GMM. It is shown that an important implication of this asymmetry is that a monetary authority with the objective of maintaining the inflation rate within a narrow band needs to react promptly to positive demand shocks. Alternatively, policy that is slow to respond to positive demand disturbances will result in higher inflation, and greater losses of output than would be the case in an economy with a model of similar features, but with a linear Phillips curve.

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1 Introduction

A range of models suggest that the relationship between inflation (or wage-inflation) and output (or unemployment) is asymmetric. For example, Summers' (1988) efficiency wage model; Greenwald and Stiglitz (1988) who provide an explanation relating cyclical fluctuations to credit shocks; Hall (1988) who uses the notion of "the thick-market externalities" of multiple equilibria; and Ball and Mankiw (1994), who present a "menu costs" explanation for asymmetric adjustment of prices. Empirical evidence, however, is mixed. Gordon (1994), for example, finds no evidence of asymmetry in the US data. In contrast, Clark, Laxton and Rose (1995) show evidence of asymmetry in OECD data.

Positive demand shocks increase inflation. In the short run, the increase in inflation depends, among other things, on the size and the duration of the shock, and on the slopes of aggregate demand and aggregate supply curves. This paper has two general objectives. First, with respect to the slope of the short-run aggregate supply curve, we test the hypothesis that the relationship between inflation and output is symmetric in New Zealand. Second, we study some policy implications of an asymmetric Phillips curve. Examination of the causes of asymmetry, however, is beyond the scope of this paper. Asymmetry means that positive demand shocks tend to increase inflation by more than negative demand shocks of similar magnitudes reduce it.¹ The symmetry hypothesis is tested by estimating a single-equation expectations-augmented Phillips curve via GMM (Hansen and Singleton, 1982). The hypothesis is rejected by the data.

The objective of the monetary authority in New Zealand is to keep annual CPI inflation within a narrow band (0-2 percent). Implications of the policy response to demand shocks in an economy with an asymmetric Phillips curve are important. We are interested in two types of policy response, prompt and slow responses. Precisely, we are interested in the effect of

¹ Laxton, Meredith and Rose (1995) show that if monetary policy is conducted symmetrically (ie, responding in an equal measure to excess demand and excess supply) under the assumption that the Phillips curve is symmetric while in fact it is not then, on average, output losses will tend to be higher and (or) inflation higher than if policy is conducted in an asymmetric fashion. This policy implication may not hold, however, if the effects of adjustments in the stance of monetary policy are themselves asymmetric. Therefore, the asymmetry in the inflation-output relationship is a necessary but not sufficient condition for conducting policy asymmetrically. I thank Glenn Rudebusch for drawing this point to my attention.

positive demand shocks on inflation, interest rates and output under these policy scenarios with an asymmetric Phillips curve.

To examine the implication of different policy reactions to demand shocks, we introduce a simple model that has the following features:

- it is a small-open economy model;
- information is symmetric, and expectations are model-consistent;
- the Phillips curve is asymmetric in the short run, and vertical in the long run;
- inflation is assumed to be persistent, but not a unit root process;
- the policy instrument is the short-term nominal interest rate; and
- the monetary policy reaction function, *known by the public*, is based on the deviations of expected annual inflation from a 1 percent target rate.

We calibrate the model and examine the effects of fully unanticipated demand shock on inflation, the interest rate and output when (a) the monetary authority reacts promptly; (b) the monetary authority reacts slowly; and (c) the monetary authority reacts slowly, but the Phillips curve is linear. Model simulation shows that:

- (a) If the Phillips curve is asymmetric, *ceteris paribus*, slower policy reactions to demand shocks lead to greater variations in output and inflation than prompt policy reactions. In addition, cumulative output loss is greater when policy reactions are slow.
- (b) The cumulative loss in output in a model with an asymmetric Phillips curve depends on the degree of persistence in inflation. Cumulative output loss is minimal if inflation is not persistent.
- (c) Cumulative output loss resulting from slow disinflationary policies is approximately zero when the Phillips curve is linear. This is true regardless of the degree of persistence in inflation.

We conclude that a slow policy response to positive demand disturbances is costly if the Phillips curve is asymmetric.

The rest of the paper is organised as follows: testing the null hypothesis that the Phillips curve is symmetric is presented in the next section. A model for

a small open-economy is calibrated in section 3. Simulation results are reported in section 4. Section 5 provides a summary.

2 Testing the symmetry hypothesis

The expectation-augmented Phillips curve is modelled as a kinked function with two linear segments:²

$$p_t - P_{t-1} = \delta E_t(P_{t+1} - P_t) + \sum_{i=0}^j \beta(Y_{t-i} - Y^P_{t-i}) + \sum_{i=0}^j \gamma_i \left[\frac{(Y_{t-i} - Y^P_{t-i}) + |Y_{t-i} - Y^P_{t-i}|}{2} \right] + e_t \quad (1)$$

$$\delta = 1, \quad \beta > 0, \quad \gamma \geq 0,$$

where: P_t is the price level, Y_t is real GDP, Y^P_t is potential output, and e_t is a white-noise error term. Both the price level and output are expressed in natural logarithms. The parameters β and γ are interpreted as elasticities and assumed to be constant.³ The term in squared brackets is the positive output gap. Potential output is estimated by a simple k -quarter two-sided centred moving average of actual real GDP:⁴

$$Y_t^P = \frac{1}{2k+1} \left[Y_t + \sum_{i=1}^k Y_{t+i} + Y_{t-i} \right]. \quad (2)$$

Testing the null hypothesis that the Phillips curve is symmetric requires testing the null hypothesis that $\gamma=0$. If γ is zero; the Phillips curve is symmetric.

² There are many different ways and functional forms to test for symmetry and linearity such as fitting a quadratic function or using the Box-Cox transformation method.

³ The parameter β is a function of the relative variances of general demand shocks to those shocks that are market-specific in the Lucas-Barro type models.

⁴ We use data from 1977Q2 for GDP to compute potential output. The parameter k is set equal to 8.

Estimating a single-equation Phillips curve by Least Squares methods is problematic (Santomero and Seater, 1978).⁵ New Zealand time series are short. Also, inflation expectations and potential output have measurement problems.⁶ Even then, there are structural breaks in the data. Clearly, estimating a system of equations with all these problems is difficult. We use GMM to estimate equation (1). GMM allows us to use some *strictly exogenous* and *relevant* instruments, which can remedy parameter inconsistency, and produce more efficient estimators (Hall, Rudebusch and Wilcox, (1994) and Hall (1993)). Because New Zealand is an open economy, foreign variables can be regarded as both strictly exogenous, relevant, and therefore, appropriate to use as instruments.⁷ Unbiasedness is not guaranteed.

Equation (1) is estimated for the period 1983Q2 to 1994Q2.⁸ Results of the estimation are reported in tables 1 to 3. Three different inflation rates are used in the estimation of equation (1), namely, the CPI excluding interest

⁵ Watanabe (1966) provides evidence that parameter estimates differ significantly if the model is estimated in a system of equations rather than in a single equation. Klein and Ball (1959) and Kuh (1967) show that causality runs from wage inflation to unemployment. Similarly, in the current context, causality may also run from inflation to output. The single-equation model is subject to the Lucas Critique.

⁶ Typically, the difference between Y_t and Y_{pt} , which is the output gap, integrates to zero. Laxton, Rose, and Tetlow (1993) show that the use of such a measure to estimate potential output will generally result in a non-rejection of the null hypothesis of symmetry in the inflation-output relationship. They argue that not accounting for the convexity in the Phillips curve creates two problems. First, the estimated degree of convexity (slope) will be biased downward. Second, statistical tests will be biased toward non-rejection of the null hypothesis of a linear Phillips curve. They estimate the Phillips curve with a constant term that should account for the bias. Errors in measurement of the RHS in equation (1) lead to biased and inconsistent parameter estimates. Results will depend ultimately on the measurement of potential output.

⁷ The instruments used in GMM are the contemporaneous first difference of the natural logarithm of trade-weighted real GDP for New Zealand's major trading partners, and its three lags, the contemporaneous trade-weighted foreign CPI inflation rate and three lagged values, and the trade-weighted foreign interest rates as measured by the 90-day lending rates. The rest of the instruments are the lags of the explanatory variables, a constant, and a trend.

⁸ We start from 1983Q2 because the survey of expectation data are only available from that date. We lost eight observations from the end of the sample when we estimated potential output.

and GST, the CPI excluding interest, GST, fresh food and fuel prices, and the median CPI excluding interest and GST.⁹ We use a market survey of inflation expectations for expected inflation.¹⁰ The data are described in the appendix. The parameter estimates, their standard errors, t-tests, and χ^2 tests are reported.

The null hypothesis that $\delta=1$ is rejected by data in all three regressions. Testing for the symmetry requires testing the null hypothesis that $\gamma=0$. This hypothesis is rejected (tables 1 and 3).

Three tests for serial correlations are reported. Most tests indicate that the null hypothesis that the errors are not serially correlated cannot be rejected.¹¹

Finally, a quick check for the stability of the Phillips curve. I run the regressions over two samples, the first is from 1983Q2 to 1989Q1 and the second is from 1989Q2 to the end of the sample. I then compare the J statistics for overidentifying restrictions. I found that changes in the J statistics over the two subsamples are not significant.¹²

We use the parameter estimates β and γ from table (1) to plot the linear and the non-linear Phillips curves. We superimpose these plots on scatter plots of actual inflation and the output gap. Figure (1) shows that the non-linear Phillips curve maybe a more reasonable approximation of the true relationship between inflation and output than the linear curve.

⁹ GST means the Goods and Services Tax, which was introduced at a 10% rate in 1986Q4 and raised to 12.5% in 1989Q3.

¹⁰ We cannot use the Reserve Bank's own forecasts because the time series is very short (1990 onward).

¹¹ We also estimate the model with supply shocks as an additional explanatory variable. The difference between actual inflation and median inflation is used as a proxy for supply shocks or relative price shocks. The estimated coefficient is found to be statistically not different from zero.

¹² It might be worth noting that at the American Economic Meeting in New Orleans 1997, Alastair Hall and Amit Sen presented a test for structural stability in models estimated by GMM. They use the ratio of J statistics.

We also estimated equation (1) with excess demand measured by two other measures. First is the deviations of output from the trend, where the trend is estimated by the HP filter. Second by using the first difference of capacity utilization survey data. The null hypothesis that $\gamma=0$ is rejected, and the magnitudes of γ are 0.29 and 0.20 respectively. The residuals however, are serially correlated.¹³

¹³ Meltzer (1995) argues that even in a world with expectations formed rationally, sluggish prices and costly information, and misperception of the nature of the shock (ie, whether it is transitory or permanent) will lead to a gradual adjustment toward steady state. Both agents and the monetary authority can misinterpret the shocks and take time to correct their decisions.

3 The model

Next, a simple open-economy model with an asymmetric Phillips curve is calibrated using GMM estimates of δ , β , and γ from table 1. The objective of this exercise is to examine the responses of inflation, the interest rate and output responses to an unanticipated demand shock with model-consistent expectations and an inflation targeting regime. Consider the following model for an open economy, where asterisks denote foreign variables that are assumed exogenous.¹⁴ All variables are expressed in natural logarithms except for the interest rates. The asymmetric expectations-augmented Phillips curve is given by:

$$P_t - P_{t-1} = \delta E_t(P_{t+1} - P_t) + (1 - \delta)(P_{t-1} - P_{t-2}) + \beta(Y_{t-3} - Y_{t-3}^P) + \gamma \left[\frac{(Y_t - Y_t^P) + |Y_t - Y_t^P|}{2} \right] + e_{1,t} \quad (3)$$

where, P_t is the price level, Y_t is output, and Y_t^P is potential output. A lagged inflation term is added to reflect persistence in inflation.¹⁵ Because δ is estimated to be less than unity (see tables 1-3), the restriction $(1-\delta)$ ensures that the Phillips curve is vertical in the long run.

The real interest rate parity condition is:

$$q_t = E_t q_{t+1} + \eta(r_t - r_t^*) + e_{2,t} \quad (4)$$

where r and r^* are the real domestic and foreign interest rates respectively. The real exchange rate q_t is defined as:

¹⁴ McCallum (1995) provides a similar model for New Zealand.

¹⁵ There is no general agreement among economists as to why inflation is persistent. Fuhrer (1995) shows that different sources of inflation persistence lead to different implications of monetary policy. Razzak (1994a) uses an SVAR, where identifying restrictions are derived from a neo-classical growth model of the Solow-Swan type. He shows that demand shocks increase inflation in the short-run, and inflation takes about six quarters to return to the mid-point of the target zone (ie, 1%). Razzak (1994b) estimates an ARIMA(P,d,q) model for CPI inflation in New Zealand, and estimates d from the data by estimating the negative of the slope of the spectral density function. He provides evidence that inflation is not a unit root, but highly persistent.

$$q_t = S_t + P_t - P_t^*,$$

where S_t is the nominal foreign currency price of the New Zealand dollar. Thus, an increase in S_t and q_t implies a real appreciation of the NZ dollar.

A Fisher equation is given by:

$$r_t = i_t - E_t(P_{t+1} - P_t) + e_{3,t} \quad (5)$$

where i_t is the domestic short-term nominal interest rate. A similar equation is defined for foreign real interest rate r_t^* .

The open economy IS curve is given by:

$$Y_t = a_0 + \theta Y_{t-1} + \phi Y_t^* - \rho_1 r_{t-1} - \rho_2 r_{t-2} - \xi_1 q_{t-1} - \xi_2 q_{t-2} + e_{4,t} \quad (6)$$

Equation (6) says that the effects of real interest rate and the real exchange rate changes on output are not instantaneous. In the calibration, we abstract from steady-state growth. The log-level of potential output is normalized to zero.

Finally, we assume the following policy reaction function for the central bank:¹⁶

$$\begin{aligned} i_t &= i_{t-1} + \lambda(E_t \hat{\Pi} - c), \\ \lambda &\geq 0 \end{aligned} \quad (7)$$

where E_t is expected inflation over a one year horizon (i.e., $\Pi_{t+1} + \Pi_{t+2} + \Pi_{t+3} + \Pi_{t+4}$), and c is the mid-point of the inflation target zone for New Zealand (ie, 1 percent). We assume that the Reserve Bank forecasts one year-ahead inflation based on the information set Ω_t . We also assume that

¹⁶ McCallum (1995) and Nadal-De Simone (1996) models for the New Zealand economy have reaction functions similar to this but the LHS variable is the exchange rate instead of the interest rate. Svensson (1996) uses a reaction function similar to this, but with actual inflation and the output gap as additional explanatory variables. The results of this model are robust to Svensson's specification.

the information set includes, among other variables, surveys of inflation expectations. The Bank then determines the stance of monetary policy based on the deviations of expectations from the mid-point of the target zone. The forcefulness of the policy response is measured by λ . For simplicity, λ is assumed to be constant in this model. Expectations are assumed to be rational, where E_t is the expectations operator dated at time t . To solve the model, I assume that Y_t^* , i_t^* , $e_{1,t}$ and $e_{4,t}$ follow an AR1 processes with white-noise errors. And the disturbances $e_{2,t}$ and $e_{3,t}$ are assumed to be white-noise.

We attempt to calibrate the model to match actual CPI inflation and the Reserve Bank of New Zealand projections of inflation.¹⁷ All the parameters in the model except those of the Phillips curve are chosen on this basis. The parameters of the Phillips curve are taken from table 1. Parameters other than δ , β , and γ are based on various unpublished empirical research by the Reserve Bank of New Zealand. The parameter ϕ is set equal to 1.5 assuming that New Zealand is a small open economy that is strongly affected by the growth rate of foreign output. The ratio of ρ/ξ is assumed to be 2. We calibrate ρ_1 to 0.1, ρ_2 to 0.1, ξ_1 to 0.05 and ξ_2 to 0.05. The parameter λ is set equal to 0.75.¹⁸

¹⁷ Annual CPI inflation during 1995 exceeded the 2 percent upper bound of the target range. The Reserve Bank's published CPI inflation projection for 1996 exceeds 2 percent. The projection shows that quarterly CPI inflation over the year 1996 varies between 0.8 percent and 0.4 percent.

¹⁸ Sensitivity analysis is also conducted. For the ratio ρ/ξ , we take values 1/1, 1/2, 2/1 along with different values of λ ranging from 2 to 0.5.

4 Simulation results

At time t we introduce an unanticipated demand shock to the system. The size of the shock is 0.25 percent per quarter. The duration of the shock is one calendar year. Because we are calibrating the model to match actual inflation, a shock of that magnitude delivers an inflation rate that is consistent with realized inflation rates. The shock increases Y_t such that $Y_t > Y_t^p$. We then examine the effect of the shock on inflation, the interest rate, and output. The same exercise is repeated under the assumption that the monetary authority does not respond to the shock promptly, but with a two-quarter lag.¹⁹ A policy reaction to a positive demand shock is slow in the sense that the monetary authority recognizes the shock, but delays its response. This delay implies time-inconsistency if the central bank "cheats" for some political gain (see Barro and Gordon, 1983). The delay may not be time-inconsistent if the policy maker misinterprets the shock without any intention of cheating. Brunner, Cukierman and Meltzer (1983) and Meltzer (1995) argue that the recognition-lag of the policy depends on the relative variances of permanent to transitory shocks.²⁰

For this exercise, it does not matter whether this delay is a time-inconsistent policy or it is just a misinterpretation of the shock. In both cases, a delay will cause inflation and output to increase in the short run. We compare the inflation, the policy instrument, and output behaviours under the alternative policy reactions.

First, we want to show the implication of the asymmetry of the Phillips curve. Figure 2 plots quarterly inflation deviations from control when the shock is positive. Figure 3 plots the deviation of the inflation rate from

¹⁹ A prompt policy reaction implies that the monetary authority affects the short-term nominal interest rate first, then the real interest rate and the real exchange rate are affected. Effects on real output take two quarters (the IS curve). The slow policy reaction is two quarters after the shock. Given the lag structure in the IS equation, it will take a year before policy affects the real economy.

²⁰ Razzak (1994a) and Razzak and Dennis (1995) show that the variances of various supply shocks to the New Zealand economy have increased significantly after the reforms in 1984. Also, the variance of demand shock has increased. This might explain the confusion of the central bank about the nature of the shocks, which produced delays in the policy maker's response to demand shocks.

control when the shock is negative. Clearly, positive demand shocks increase inflation by more than negative demand shocks of the same magnitude reduce it.

Second, we compare the effects of positive demand shocks on inflation, the interest rate and output under the two policy scenarios discussed earlier. In figure 4, under the first scenario (prompt policy response), inflation peaks at 0.5 percent per quarter after one quarter. The monetary policy reaction brings inflation back to control within six quarters. In figure 5, under the second scenario (slow policy response), however, quarterly inflation peaks at almost 1 percent three quarters after the shock. The monetary authority brings inflation back to control in about the same time as with the prompt policy response, but at a different cost. We also plot the inflation rate resulting from the same shock under a slow policy reaction, but with a linear Phillips curve. Figure 6 shows that the increase in inflation is lower than that in figure 5, it is about .75 percent. For a monetary authority that cares about controlling inflation, the difference between inflation under the asymmetric Phillips curve and the linear one is .25 percent per quarter. Inflation is significantly higher when the Phillips curve is asymmetric.

To reduce inflation, the interest rate must rise. The interest rate rises by 125 basis points under a prompt reaction policy as compared with a 175 basis point under a slow policy reaction (figures 7 and 8). Figure 9 plots the interest rate under the assumption of a linear Phillips curve. Again, less tightening is required to disinflate when the Phillips curve is linear than if it is asymmetric. Eventually, the rise in the interest rate exerts more pressure on the real economy, and produces much larger losses in output under a slow policy reaction than with the prompt policy reaction.

Figures 10 and 11 plot the deviation of output from control. Under a slow policy reaction by the monetary authority, the short-run cumulative loss in output resulting from disinflation is much larger than that arising from a prompt policy response. Under the assumption of a linear Phillips curve, cumulative output loss is approximately zero (figure 12). This is true regardless of the degree of persistence in inflation, or the quickness of the policy response, as long as expectations are assumed to be model-consistent. Here we compute the cumulative loss in output from the point in time when the monetary authority starts disinflating.

These results indicate that a monetary authority whose objective is to keep inflation within a narrow band should react promptly to demand shocks. This is particularly true if the Phillips curve is asymmetric. It is also true, if the monetary authority is concerned about the cost of its policy in terms of short-run output loss. However, the size of the output loss also depends on the degree of persistence in inflation.

5 Summary

Although there are theories that attempt to explain asymmetry in the inflation-output relationship or in the price movements, empirical evidence is rare in the literature. If the inflation-output relationship is asymmetric, positive demand shocks have larger effects on inflation than negative demand shocks. New Zealand data lead to the rejection of the null hypothesis that the expectations-augmented Phillips curve is symmetric.

Parameter estimates for the asymmetric Phillips curve are used to calibrate a small model for the New Zealand economy. It is a small open-economy model, where expectations are model-consistent, and the monetary authority targets a 1 percent annual inflation rate. Delays in monetary policy responses to positive demand shocks lead to an increase in the inflation rate, and larger output losses in bringing inflation down. This is attributable to the asymmetry of the Phillips curve, and the persistence of inflation, and occurs despite the fact that expectations are rational. A monetary authority with the objective of maintaining the inflation rate within a narrow band needs to react more promptly to positive demand than to negative demand shocks. An alternative implication is that if policy does not respond to demand disturbances promptly, inflation and output variations can be higher than they would be in an economy with a linear Phillips curve.

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Table 1
GMM Single Equation Estimation of the Phillips Curve
Dependent Variable: CPI excluding Interest and GST

$$P_t P_{t-1} = \delta E_t(P_{t+1} - P_t) + \beta(Y_{t-3} - Y_{t-3}^P) + \gamma \left[\frac{Y_t - Y_t^P + |Y_t - Y_t^P|}{2} \right] + e_t$$

Effective Sample 1983Q2 to 1994Q2

Parameters	Coefficient	St. Error	t-test	χ^2_1
δ	0.54	0.044	12.27*	150.25*
β	0.08	0.045	1.77#	3.10#
γ	0.46	0.088	5.23*	27.23*
R ²	0.74			
DW	1.61			
Wald Test				
H ₀ : $\delta=1$ χ^2_2	105.39*			
	(0.0001)			
Box-Pierce Q Stat ~ χ^2_6	7.30			
Bartlett's Kolmogrov Smirnov ^a	0.2166			
Fisher-Kappa ^b	5.4185			
J test ^c ~ χ^2_{12}	12.466			
J test (1983Q2-1989Q1)	18.388			
J test (1989Q2-1994Q2)	13.989			

Seventeen instruments are contemporaneous foreign inflation, foreign interest rates, and foreign output growth, and their three lags plus three lags of positive output gap, a constant and trend.

a: H₀ - White-noise and the 95% level critical value is 0.320 with n=30.

b: H₀ - White-noise and the 95% level critical value is 5.935 with n=30.

c: Testing for over-identifying restrictions.

*: Significant at the 95% level.

#: Significant at the 90% level.

P-values in parentheses.

The number of lags is determined by fitting four lags first. Second, we test backward using a χ^2 test. Only the third lag is found to be significant.

Table 2
GMM Single Equation Estimation of the Phillips Curve
Dependent Variable: CPI excluding Interest, GST, Fresh Food and Fuel Prices

$$P_t - P_{t-1} = \delta E_t(P_{t+1} - P_t) + \beta(Y_{t-3} - Y_{t-3}^P) + \gamma \left[\frac{(Y_t - Y_t^P) + |Y_t - Y_t^P|}{2} \right] + e_t$$

Effective Sample 1983Q2 to 1994Q2

Parameters	Coefficient	St. Error	t-test	χ^2_1
δ	0.48	0.05	9.60*	99.45*
β	0.10	0.05	2.00*	3.35#
γ	0.57	0.12	4.75*	19.97*
R ²	0.73			
DW	1.62			
Wald Test				
H ₀ : $\delta=1$ χ^2_2	108.87*			
	(0.0001)			
Box-Pierce Q Stat $\sim \chi^2_6$	2.77			
Bartlett's Kolmogorov	0.2222			
Smirnov ^a				
Fisher-Kappa ^b	3.7855			
J test ^c $\sim \chi^2_{12}$	11.57			
J test (1983Q2-1989Q1)	8.183			
J test (1989Q2-1994Q2)	10.591			

Seventeen instruments are contemporaneous foreign inflation, foreign interest rates, and foreign output growth, and their three lags plus three lags of positive output gap, a constant and trend.

a: H₀ - White-noise and the 95% level critical value is 0.320 with n=30.

b: H₀ - White-noise and the 95% level critical value is 5.935 with n=30.

c: Testing for over-identifying restrictions.

*: Significant at the 95% level.

#: Significant at the 90% level.

P-values in parentheses.

The number of lags is determined by fitting four lags first. Second, we test backward using a χ^2 test. Only the third lag is found to be significant.

Table 3

GMM Single Equation Estimation of the Phillips Curve
Dependent Variable: Median CPI Inflation

$$P_t - P_{t-1} = \delta E_t(P_{t+1} - P_t) + \beta(Y_{t-3} - Y_{t-3}^P) + \gamma \left[\frac{(Y_t - Y_t^P) + |Y_t - Y_t^P|}{2} \right] + e_t$$

Effective Sample 1983Q2 to 1994Q2

Parameters	Coefficient	St. Error	t-test	χ^2_1
δ	0.41	0.04	10.25*	96.07*
β	0.11	0.03	3.66*	15.56*
γ	0.30	0.09	3.33*	10.95*
R^2	0.77			
DW	1.28			
Wald Test				
$H_0: \delta=1 \chi^2_2$	188.57*			
	(0.0001)			
Box-Pierce Q Stat $\sim \chi^2_6$	11.37			
Bartlett's Kolmogorov	0.3706			
Smirnov ^a				
Fisher-Kappa ^b	5.0422			
J test ^c $\sim \chi^2_{12}$	17.21			
J test (1983Q2-1989Q1)	15.719			
J test (1989Q2-1994Q2)	19.129			

Seventeen instruments are contemporaneous foreign inflation, foreign interest rates, and foreign output growth, and their three lags plus three lags of positive output gap, a constant and trend.

a: H_0 - White-noise and the 95% level critical value is 0.320 with n=30.

b: H_0 - White-noise and the 95% level critical value is 5.935 with n=30.

c: Testing for over-identifying restrictions.

*: Significant at the 95% level.

P-values in parentheses.

The number of lags is determined by fitting four lags first. Second, we test backward using a χ^2 test. Only the third lag is found to be significant.

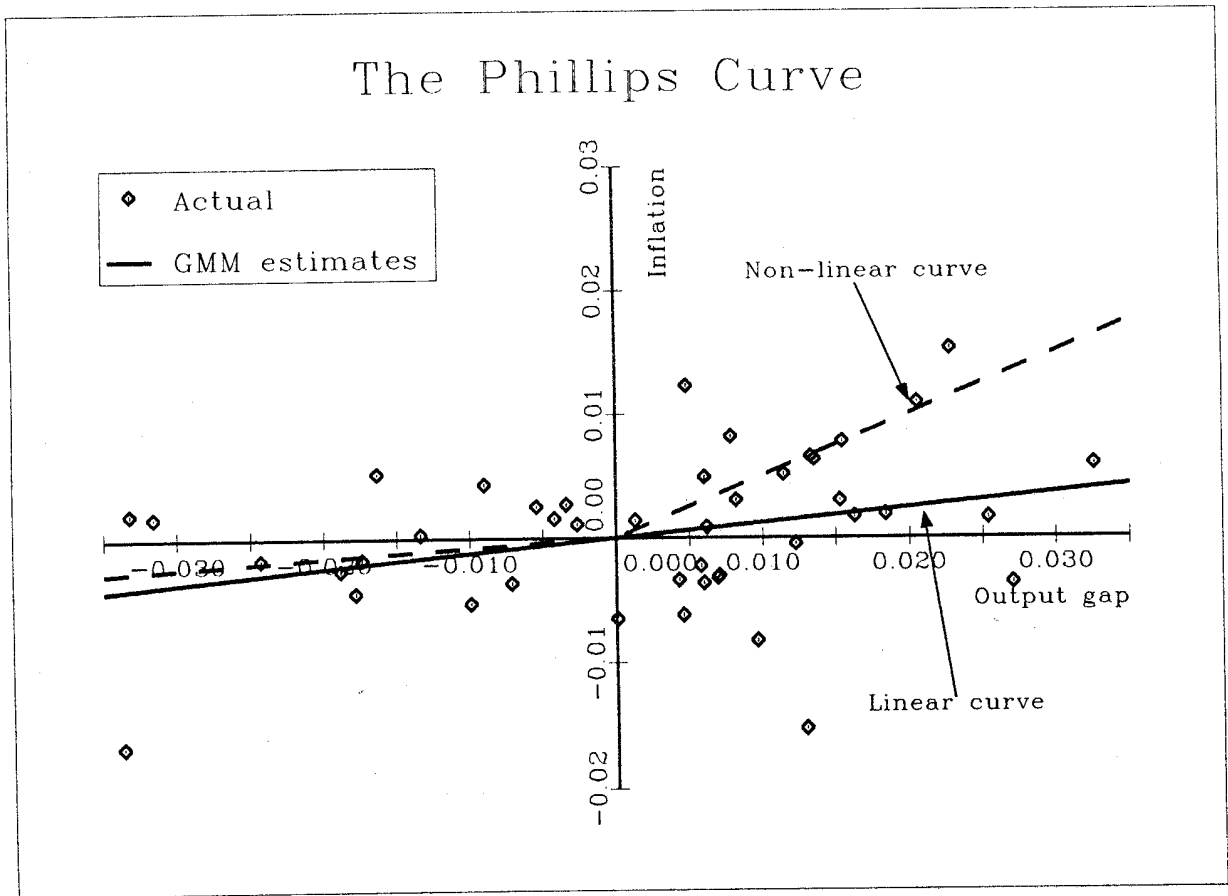


Figure 1

Positive Demand Shock

Asymmetric PC

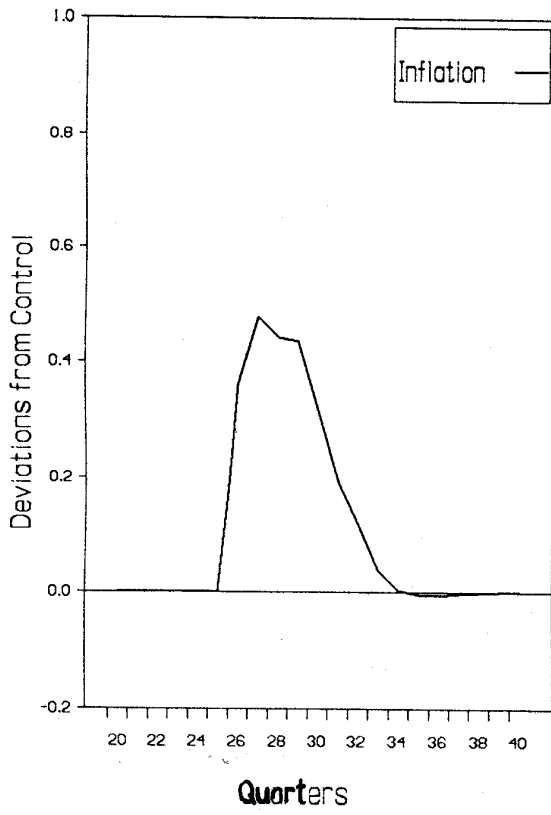


Figure 2

Negative Demand Shock

Asymmetric PC

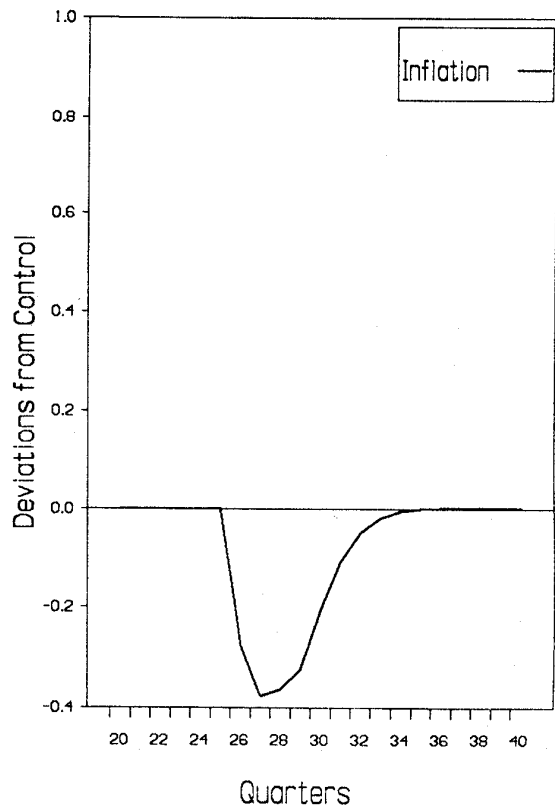


Figure 3

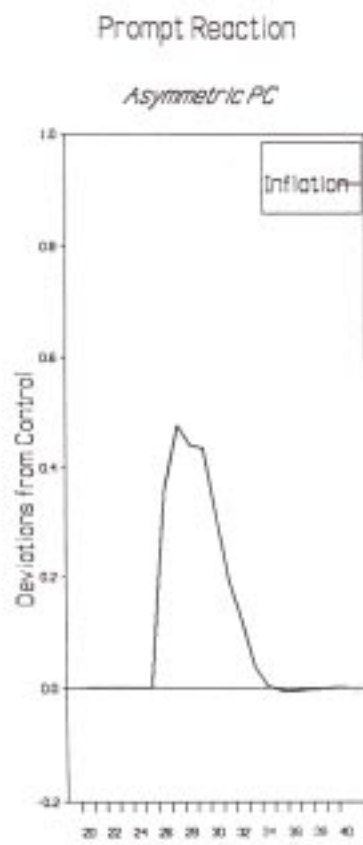


Figure 4

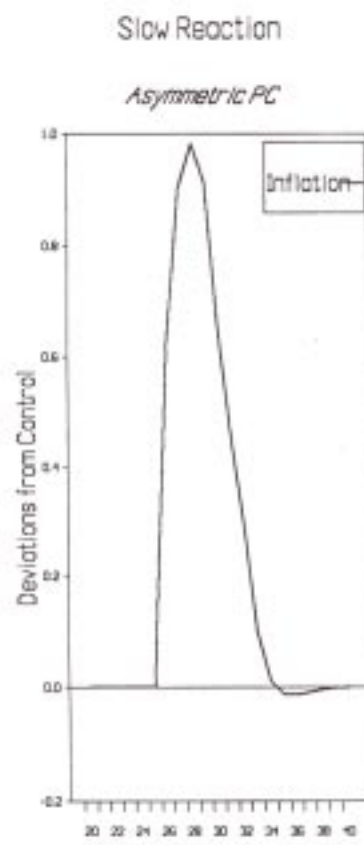


Figure 5

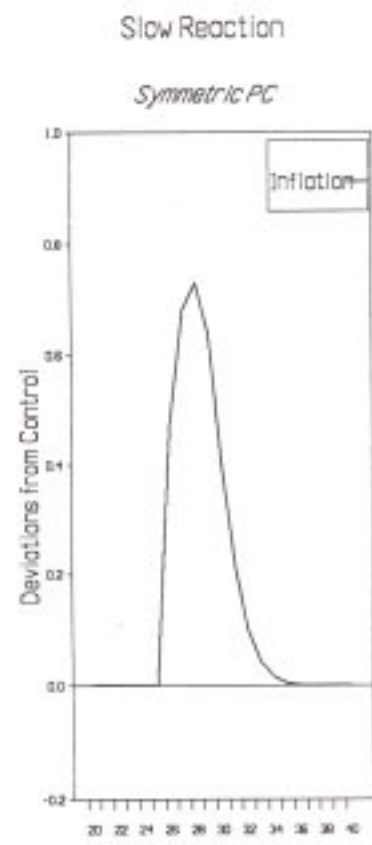
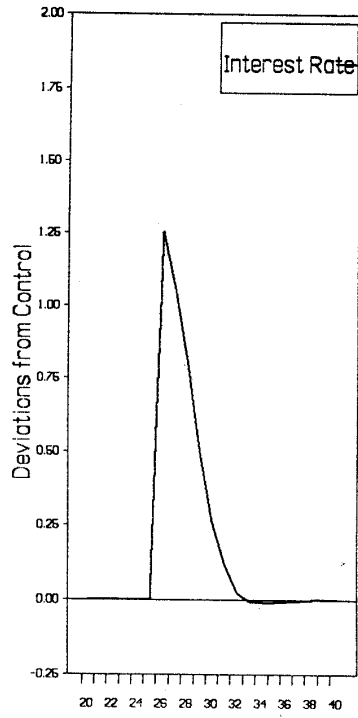


Figure 6

Prompt Policy

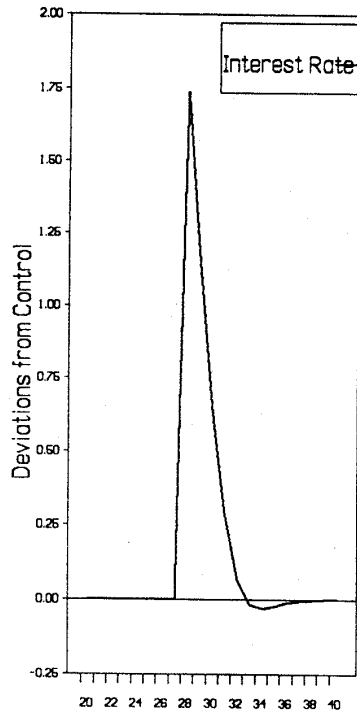
Asymmetric PC



Quarters
Figure 7

Slow Policy

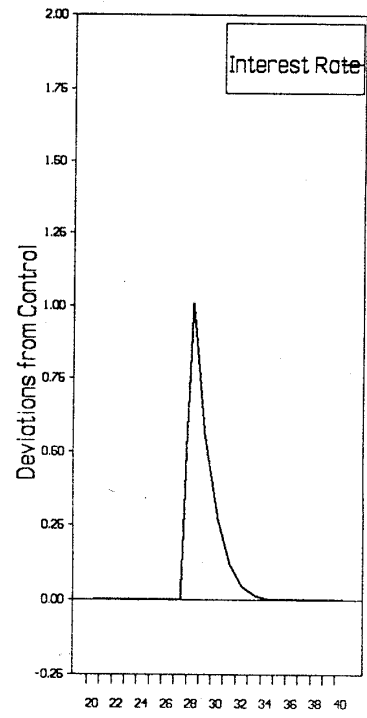
Asymmetric PC



Quarters
Figure 8

Slow Policy

Symmetric PC



Quarters
Figure 9

Prompt Reaction

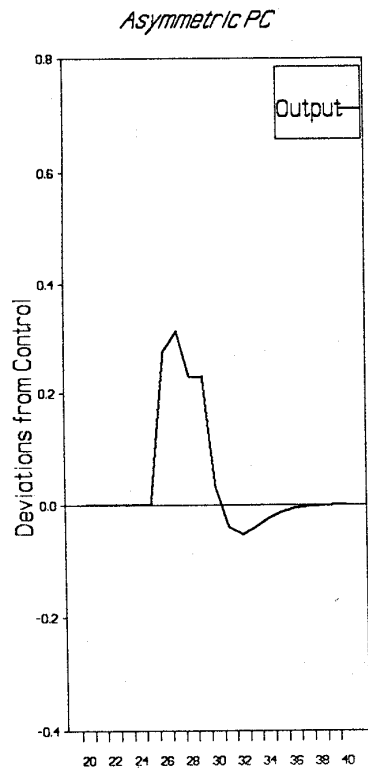


Figure 10

Slow Reaction

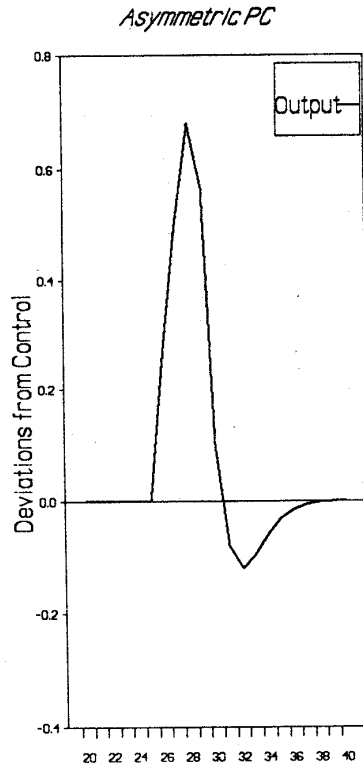


Figure 11

Slow Reaction

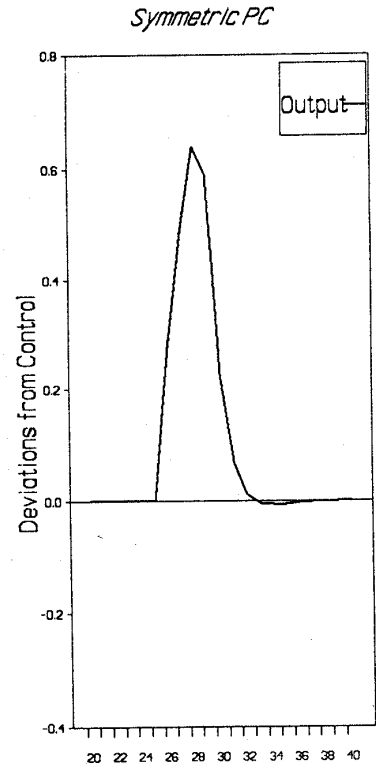


Figure 12

Data Appendix

Data that are used in estimation of the Phillips curve are:

CPI: Three different series for CPI are used. First is the CPI excluding interest and GST, second is the CPI excluding interest, GST, fresh food and fuel prices, third, is median CPI excluding interest and GST.

GDP: Real production Gross Domestic Product.

Inflation

Expectations: Inflation expectations are the National Bank Survey of expectations, which measures public expectations of the 12 months-ahead CPI inflation. The data are converted into quarterly observations to match actual quarterly inflation in equation 1. At the beginning of each month, participants were asked about their expectations of CPI annual inflation rate. The data are published at the end of each month.

Foreign variables: The foreign price is a trade-weighted index of New Zealand's major trading partners (The UK, the US, Germany, Japan, and Australia). The foreign real GDP and the 90-day lending rates are constructed similarly.

All data are seasonally adjusted.