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Is There an Exchange Rate Channel in the Forward-Looking Phillips Curve? A Theoretical and Empirical Investigation

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Abstract

This paper shows how the exchange rate affects the price-setting behavior of monopolistically competitive firms in the sticky price framework that gives rise to a forward-looking Phillips Curve at the aggregate level. The open economy Phillips Curve differs from its closed economy counterpart in that the real exchange rate exerts a direct effect on domestic inflation. The exchange rate channel in the Phillips Curve is pivotal in determining the optimal policy setting in an open economy. On balance, we find only scant empirical evidence for the existence of a direct exchange rate channel in the Phillips Curve in a sample of six OECD countries. Indeed, the forward-looking Phillips Curve does not receive much backing from the data. The use of highly aggregated data may account for the poor fit.

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1. Introduction

The existence of a direct exchange rate channel in the Phillips Curve or the aggregate supply curve has far-reaching implications for the conduct of monetary policy in the open-economy. Several recent contributions underscore the importance of this direct exchange rate effect in the design of optimal policy and in the performance of targeting strategies such as nominal income targeting or price-level targeting.

In a backward-looking model for an open economy, Ball (1999) shows that the direct exchange rate channel in the Phillips Curve matters in the setting of optimal policy. Guender (2005) compares and contrasts the setting of optimal policy under domestic inflation targeting and CPI inflation targeting in a forward-looking open-economy model. His findings suggest that the existence of a direct exchange rate channel prevents the policymaker from perfectly offsetting demand-side disturbances when the policymaker targets domestic inflation. In addition, the conduct of optimal policy under domestic inflation targeting depends on both demand-side and Phillips Curve parameters (as well as the policymaker's preference for output vis-à-vis inflation variability) provided that there is a direct exchange rate channel in the Phillips Curve. In the absence of the direct exchange rate effect, optimal policy is only a function of the policymaker's preference parameter and the parameter on the output gap in the Phillips Curve.

In an open economy AS-AD framework that features an imported intermediate input, Froyen and Guender (2000) show that the existence of a direct exchange rate channel in the AS relation impairs the perfect stabilizing property of nominal income targeting or price-level targeting in the face of demand-side disturbances. Irrespective of the underlying model, all of these contributions come to the conclusion that the conduct of monetary policy in an open economy differs substantially from the conduct of policy in a closed economy if the direct exchange rate channel is operative on the supply side of the economy.

The role of a direct exchange rate effect has been investigated mainly from a theoretical perspective in the literature. This paper examines whether there is empirical evidence for the existence of a direct exchange rate effect in the Phillips Curve in a forward-looking open-economy framework. While the central focus of the paper rests on the verification of a direct exchange rate channel in the Phillips Curve, our empirical analysis also considers other issues such as the empirical relevance of the output gap in determining inflation and the extent to which past as opposed to future inflation drives current inflation. We present econometric estimates of the open-economy Phillips Curve for a number of OECD countries. They are: Australia, Canada, Korea, New Zealand, Sweden, and the United Kingdom. These countries share a number of distinctive characteristics. To begin with, they are small open economies where international trade plays an important role in the exchange of goods. In addition, these countries have maintained their independence in the conduct of monetary policy. Specifically, they have resisted the urge to adopt a common currency (Sweden, the United Kingdom, Australia, and New Zealand), and all of them engage in inflation targeting under a flexible exchange rate regime.[1]

Empirical support for the relevance of the real exchange rate in the determination of domestic inflation would be an interesting finding all by itself. However, just as important would be the implication of this finding for the conduct of monetary policy in an open economy. Empirical evidence in favor of the direct exchange rate channel in the forward-looking Phillips Curve would buttress the notion that the conduct of monetary policy in an open economy is not isomorphic to the conduct of monetary policy in a closed economy. The isomorphism result is due to Clarida, Gali, and Gertler (2001). They employ a forward-looking Phillips Curve that does not feature the real exchange rate to show that the conduct of optimal policy in an open economy is virtually identical to policy in a closed economy.

Our empirical investigation produces two noteworthy findings. Firstly, the results bring forth only scant evidence for the existence of an exchange rate channel in the forward-looking Phillips Curve in the sample of OECD countries. For all countries but Korea the hypothesized link between the real exchange rate and the rate of inflation in the Phillips Curve is not supported by the data. A likely explanation for the absence of the link is that the pricing decisions of domestic producers are not affected by movements in the *nominal* exchange rate. Second, in all but one case a simple specification of the Phillips Curve featuring lagged and forward-looking inflation rates does not receive any support from the data. Our empirical investigation fails to detect a statistically significant positive relationship between the measures of the output gap employed in this paper and the rate of inflation. The fact that we estimate the Phillips Curve using highly aggregated data may account for the lack of general support in the data for the hypothesized link between the output gap and the rate of inflation.

The organization of the paper is as follows. Section II takes the standard representation of a closed-economy forward-looking Phillips Curve and extends it to an open economy framework. We show that the sticky-price framework due to Rotemberg (1982) can be augmented to give rise to a forward-looking open-economy Phillips Curve where the real exchange rate has a direct effect on domestic inflation. Section III traces the implications of the existence of a direct exchange rate channel for the conduct of monetary policy in an open economy. Section IV initially reviews the empirical literature from a closed-economy perspective. This is followed by the presentation of the econometric estimates of the open-economy Phillips Curve for the chosen countries. Section V offers a summary of our findings.

II. The Derivation of the Open-Economy Phillips Curve

Monopolistically competitive firms aim to minimize menu costs weighed against the cost of being away from the optimal price they would charge in the absence of those menu costs. This optimal price is denoted p^*. The objective function faced by the typical firm is:

$$\min_{P} \Omega_t = E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \left[\left(p_\tau - p_\tau^* \right)^2 + c\left(p_\tau - p_{\tau-1} \right)^2 \right] \tag{1}$$

where:[2]

Ω_t = the total cost at time t

p_t = the price of the domestic good at time t

p_t^* = the optimal price a firm charges.

β = the constant discount factor

c = the parameter that measures the ratio of the costs of changing prices to the costs of deviating from the optimal price

E_t = the expectations operator conditional on information available at time t.

After taking and rearranging the first-order condition for the above cost-minimization problem (where we have assumed β to equal one for simplicity), we can characterize the relationship between past, current, and future price levels as:

$$p_t - p_{t-1} = E_t\left(p_{t+1} - p_t\right) - \frac{1}{c}\left(p_t - p_t^*\right) \tag{2}$$

The optimal price p^* is:

$$p_t^* = \hat{p}_t + \kappa y_t + \varsigma_t \qquad \kappa > 0 \tag{3}$$

where all variables are as previously defined. In addition:

$\hat{p}_t$ = the price charged by foreign firms at time *t*

y_t = the output gap at time *t* (the difference between the level of real output and potential output)

ς_t = a stochastic disturbance.

The optimal price is set as a mark-up over marginal cost. But marginal cost and the output gap are positively related.[3] Hence it is innocuous to replace marginal cost with the output gap in (3). So far our analysis of price-setting behavior has been very much in the spirit of the closed economy "New Keynesian Framework". In a small open economy, however, the price-setting behavior of domestic firms also takes into consideration developments abroad. Being a small player in world markets, the typical firm is guided in its pricing decision by the prevailing conditions in world markets.[4] More specifically, there exists a benchmark price $\hat{p}_t$ that the firm faces in world markets. This benchmark price affects the optimal price charged by the firm. Indeed, the firm adjusts its optimal price in line with the domestic currency price of the final goods charged by its foreign competitors. Thus $\hat{p}_t$ becomes:

$$\hat{p}_t = p_t^f + s_t \tag{4}$$

where

p_t^f = the price of the foreign good in foreign currency at time *t*

s_t = the nominal exchange rate at time *t* (units of domestic currency per unit of foreign currency).

From equation (4) it is evident that there is a one-for-one "pass-through" effect of the nominal exchange rate on the optimal price.

Using this specification for p_t^*, we can rewrite equation (3) as:

$$p_t - p_{t-1} - E_t\left(p_{t+1} - p_t\right) = -\frac{1}{c}\left(p_t - p_t^f - s_t - \varsigma_t\right) + \frac{\kappa}{c} y_t \tag{5}$$

The real exchange rate, defined as $q_t = p_t^f + s_t - p_t$, appears on the right-hand side of equation (5). After aggregating over all firms, equation (5) represents a Phillips Curve relation for an open economy. The same equation can also be expressed as:

$$\pi_t = E_t \pi_{t+1} + a y_t + b q_t + u_t \tag{6}$$

where

$\pi_t = p_t - p_{t-1}$

$E_t \pi_{t+1} = E_t p_{t+1} - p_t$

$q_t = p_t^f + s_t - p_t$

$a = \frac{\kappa}{c}$

$b = \frac{1}{c}$

$u_t = \frac{1}{c}\varsigma_t$.

Equation (6) differs from the standard forward-looking Phillips Curve by allowing the real exchange rate to affect domestic inflation directly. In the wake of a depreciation of the domestic currency, domestically produced goods become cheaper in world markets. Hence domestic production is stepped up. In addition, the domestic currency price of the imported foreign consumption good rises. Both the rise in domestic production and in the price of the import-competing good cause the optimal price to increase. Facing an increase in the optimal price, firms raise the price of their output so as to minimize the deviation between the actual price charged and the optimal price. At the aggregate level, the increase in the domestic price level causes the rate of domestic inflation to rise. Thus we observe the positive link between the real exchange rate and the rate of domestic inflation.[5]

III. The Relevance of the Direct Exchange Rate Channel in the Conduct of Optimal Monetary Policy in an Open Economy

In this section we present a simple forward-looking model of a small open economy. The model consists of three equations. All variables with the exception of the nominal interest rate are expressed in logarithms. All parameters are positive.

$$\pi_t = E_t \pi_{t+1} + a y_t + b q_t + u_t \tag{6}$$

$$y_t = E_t y_{t+1} - a_1 \left(R_t - E_t \pi_{t+1}\right) + a_2 q_t + v_t \tag{7}$$

$$R_t - E_t\pi_{t+1} = R_t^f - E_t\pi_{t+1}^f + E_t q_{t+1} - q_t + \varepsilon_t \qquad (8)$$

where all variables are defined as previously. In addition:

$E_t\pi_{t+1}$ = the expectation of π_{t+1} formed at time t.

$E_t\pi_{t+1}^f$ = the expectation formed at time t of the foreign rate of inflation for period t+1

R_t = the domestic nominal interest rate at time t.

R_t^f = the foreign nominal interest rate at time t.

$E_t q_{t+1}$ = the expectation dated t of the real exchange rate for period t+1.

v_t , and ε_t are stochastic disturbances.

The first two relations incorporate the forward-looking behavior typical of the New Keynesian framework. Equation (6) represents the forward-looking Phillips curve relation for the open economy derived in the previous section. Equation (7) defines an open economy IS relation – the output gap depends on the expected real interest rate and the real exchange rate.[6] Equation (8) is the uncovered interest rate parity condition (UIP), expressed in real terms. This equation embodies the assumption of perfect capital mobility, reflecting the high level of integration of a small open economy's financial sector with the rest of the world. The disturbance term ε_t can be interpreted as a time-varying risk premium.

The Preferences of the Policymaker

The policymaker's preferences extend over the variance of the output gap $V(y_t)$ and the domestic rate of inflation $V(\pi_t)$, respectively. The expected loss function that he attempts to minimize is given by:

$$E(L_t) = V(y_t) + \mu V(\pi_t) \qquad (9)$$

Solving the Model

The policymaker sets policy on the basis of the two variables that he cares about: the output gap y_t and the rate of domestic inflation π_t:

$$(\theta y_t + \pi_t) = 0 \tag{10}$$

The policy parameter θ indicates the weight the policymaker attaches to the output gap relative to the rate of inflation in setting policy. To solve the model, we first solve the UIP condition for q_t and substitute the resulting expression into the Phillips Curve and the IS relation. These two expressions are in turn substituted in turn into the policy rule, equation (10). Solving this equation for R_t yields the policymaker's reaction function:

$$R_t = \Delta\left[(\theta + a)(E_t y_{t+1} + v_t) + ((\theta + a)(a_1 + a_2) + b + 1)E_t \pi_{t+1} + ((\theta + a)a_2 + b)\Omega + u_t\right] \tag{11}$$

where $\Delta = \dfrac{1}{(\theta + a)(a_1 + a_2) + b}$; $\qquad \Omega = (R_t^f - E_t \pi_{t+1}^f + E_t q_{t+1} + \varepsilon_t)$

To obtain a reduced form solution for y_t, we substitute the reaction function into the IS function (after replacing the real exchange rate with the remaining variables of the UIP condition). This equation takes the following form:

$$y_t = \Delta\left[b(E_t y_{t+1} + v_t) - (a_1 + a_2)E_t \pi_{t+1} - a_1 b(R_t^f - E_t \pi_{t+1}^f + E_t q_{t+1} + \varepsilon_t) - (a_1 + a_2)u_t\right] \tag{12}$$

Optimal Monetary Policy under Simple Commitment [7]

Under the assumption of white noise disturbances, the conditional expectations of the endogenous variables are straightforward:[8]

$$E_t y_{t+1} = 0 \tag{13}$$

$$E_t \pi_{t+1} = 0$$

$$E_t q_{t+1} = 0$$

The expectation of the foreign rate of inflation, $E_t \pi^f_{t+1}$, is likewise zero. Substituting these expectations into equation (12) yields the following final form equation for real output:

$$y_t = \frac{1}{(a_1 + a_2)(\theta + a) + b}\left[bv_t - a_1 b(R^f_t + \varepsilon_t) - (a_1 + a_2)u_t\right] \qquad (14)$$

The solution for the domestic rate of inflation is given by

$$\pi_t = \frac{\theta}{(a_1 + a_2)(\theta + a) + b}\left[-bv_t + a_1 b(R^f_t + \varepsilon_t) + (a_1 + a_2)u_t\right] \qquad (15)$$

Calculation of the variances of inflation and the real output gap is straightforward. After inserting both variances into equation (9), we can express the objective of the policymaker in the following way:

$$\underset{\theta}{Min}\left[\frac{1}{(a_1 + a_2)(\theta + a) + b}\right]^2 \begin{Bmatrix} \left[b^2\sigma^2_v + (a_1 b)^2(\sigma^2_{Rf} + \sigma^2_\varepsilon) + (a_1 + a_2)^2\sigma^2_u\right] + \\ \mu\theta^2\left[b^2\sigma^2_v + (a_1 b)^2(\sigma^2_{Rf} + \sigma^2_\varepsilon) + (a_1 + a_2)^2\sigma^2_u\right] \end{Bmatrix} \qquad (16)$$

The policymaker chooses θ, the weight on the output gap in the policy rule, so as to minimize fluctuations in the output gap and the domestic rate of inflation. The resulting optimal value for the policy parameter is:

$$\theta^* = \frac{1}{\mu\left[a + \dfrac{b}{a_1 + a_2}\right]} \qquad (17)$$

Equation (17) shows that in the forward-looking open economy model the weight on the output gap in the policy rule is a function of the parameters of *both* the IS relation and the Phillips curve.[9] This is a consequence of the fact that a change in the policy setting has an immediate impact on the nominal exchange rate that in turn has a direct effect on the rate of inflation through the real exchange rate in the Phillips curve. This effect complements the indirect effect on the rate of inflation brought about by a change in the output gap through changes in the expected real rate of interest and the real exchange rate.

Notice the pivotal role played by the direct exchange rate channel in the Phillips Curve. In its absence $b=0$. Hence for an open economy where the direct exchange rate channel is not operative in the Phillips Curve, the optimal policy parameter reduces to

$$\theta^* = \frac{1}{\mu a}. \tag{18}$$

This is the same setting for the optimal policy parameter in a closed economy. Demand-side parameters such as the sensitivity of the output gap to the expected real rate of interest (a_1) and the real exchange rate (a_2) do not figure in the optimal setting of θ in the open economy framework because in the absence of a direct exchange rate channel in the Phillips Curve the policymaker can perfectly offset demand-side shocks by simply varying the interest rate.

IV. Empirical Specifications of Closed and Open-Economy Forward-Looking Phillips Curves

A few papers take the theoretical specification of the forward-looking Phillips Curve to the data. Fuhrer (1997), Gali and Gertler (1999), Roberts (1997, 2005), Rotemberg and Woodford (1997), Rudebusch (2001), and Sbordone (1998), to name but a few, dwell on theoretical and empirical aspects of modeling the Phillips Curve. These existing contributions share three characteristics. First, they estimate a closed-economy version of the Phillips Curve. Second, the importance of expected future inflation relative to past inflation in predicting current inflation is assessed. Third, the empirical investigations are based on US data. Still, there is at least one important unresolved issue. The point of contention concerns the choice of a suitable proxy variable for marginal cost in the estimation stage.

Most economists now acknowledge that the strict version of the forward-looking model – which includes expected future inflation but excludes lags of the rate of inflation - does not fit the data very well. As a consequence, attention has focused largely on motivating the addition of lagged inflation to the Phillips curve specification. Roberts (2005) describes three ways in which lagged inflation enters the Phillips Curve specification. One way to introduce lagged inflation is to do away with the assumption of complete rationality. In this scenario, a fraction of agents do not exhibit optimizing behavior in setting prices but instead follow a rule of thumb such as basing their forecast of inflation on lagged inflation. The two remaining ways of introducing lagged inflation into the forward-looking Phillips Curve retain the assumption of complete rationality but draw on structural features of the economy or change the specification of the error process. If wage bargains are conditioned on the change in the real wage (Fuhrer and Moore (1995)), then both forward-looking expectations of inflation and lagged inflation enter the Phillips Curve. The occurrence of serial correlation in the error results from potential shortcomings in calculating the trend component of output. This possibility was first pointed out by Rotemberg and Woodford (1997).

There is an ongoing debate on the most suitable proxy variable for marginal cost. As pointed out in Section II, the theoretical specification of the forward-looking model includes marginal cost as a right-hand side variable of the Phillips Curve equation. The last step of the derivation of the forward-looking Phillips Curve links marginal cost to aggregate economic activity with a view towards establishing the connection between the rate of inflation and aggregate economic activity as in earlier renditions of the Phillips Curve. Sbordone (1998) and Gali and Gertler (1999) do not take this last step. Instead they argue that the cost of labor is a good proxy for marginal cost. In their empirical test of the goodness of fit of the forward-looking model, they use the labor share of income as a proxy to show that it exerts a statistically significant positive effect on inflation as predicted by the model. These results are questioned by Roberts (2005) who attributes the positive link between the cost of labor and inflation to the pro-cyclical behavior of average productivity that underlies the calculations of Sbordone and Gali and Gertler. As a result, Roberts sticks with more conventional ways of estimating the level of economic activity relative to potential such as capacity output, the output gap (based on Hodrick-Prescott filter) or the rate of unemployment.

Our investigation of the empirical relevance of the open-economy forward-looking Phillips Curve begins with a brief overview of a few modeling issues that concern data selection and estimation technique. Our preferred measure of the rate of inflation is based on the GDP deflator. This is in line with the spirit of the model which suggests that domestic inflation should enter the specification of the Phillips Curve. However, we also report our findings for the case where the CPI-based rate of inflation is employed to estimate the Phillips Curve. Although the CPI is narrower in scope than the GDP deflator, it has the advantage of measuring market prices. In marked contrast, the GDP deflator is based in no small measure on imputed prices. We also employ two widely-used measures of the output gap. The first measure is derived from a simple detrending procedure. We regress the level of real output on a quadratic trend and use the resulting residuals as our measure of the output gap. The second measure is based on the Hodrick-Prescott filter.[10] For New Zealand, we actually try a third measure of the output gap. The multivariate filter is an augmented version of the Hodrick-Prescott filter and employed by the Reserve Bank of New Zealand in its assessment of current and future economic conditions.[11]

The bilateral nominal exchange rate of the domestic currency vis-à-vis the US Dollar, the US GDP deflator, and the domestic GDP deflator are employed in the calculation of the real exchange rate.

The rate of expected inflation next period is replaced with its actual value. Imposing rational expectations on the model is standard practice.[12] As prices typically remain fixed for a year or longer, single leads or lags of the rate of inflation do not capture the true nature of the inflation dynamics in quarterly data. Because of this, three- or four-period averages of the leads and lags of inflation are employed in the estimation of the Phillips Curve.

Due to the endogeneity of future inflation, the output gap, and the real exchange rate, we use the instrumental variables approach in the estimation stage.[13] This limited information estimation procedure proves to be more robust to potential misspecification than full-information maximum likelihood.[14] Lags of the rate of inflation, the output gap, the real exchange rate, and if applicable, lags of the dummy variables serve as instruments.

As a check on the presence of serial correlation in the residuals, we run Godfrey's (1994) test for serial correlation in dynamic models estimated by instrumental variables. This procedure adds lagged residuals to the set of instruments and produces asymptotically valid Wald, Lagrange Multiplier or Likelihood Ratio tests for serial correlation. We test for both first-order and fourth-order serial correlation using the Lagrange Multiplier test.

Taken altogether, our investigation of the empirical validity of the forward-looking Phillips Curve in small open economies attempts to shed light on three separate modeling issues. They concern:

1. the extent to which a direct exchange rate channel is operative in the Phillips Curve. If the data confirm its existence, then the setting of the optimal policy parameter θ in an open economy is indeed a function of all parameters of the model and does not depend merely on the sensitivity of the rate of inflation to the output gap in the Phillips Curve.
2. the importance of future inflation relative to past inflation in determining current inflation.
3. the contemporaneous effect of the output gap on the rate of inflation.

The specification of the forward-looking Phillips Curve that we estimate takes the following form:[15]

$$\pi_t = \gamma_0 + \gamma_1 \pi_{t-1} + \gamma_2 E_t \pi_{t+1} + \gamma_3 \Delta q_t + \gamma_4 y_t + u_t \tag{19}$$

All variables are as previously defined.

The sample period extends from the early 1980s to 2002 for the two European countries and Canada. For Korea and the Antipodean countries the sample period is somewhat shorter.[16] The empirical analysis is based on quarterly data. The data were retrieved from the *OECD Main Economic Indicators* database.

Our empirical findings are summarized in Tables *1* through *5*. Tables *1* and *2* present the findings for the case where inflation is defined in terms of changes in the log of the GDP deflator. When a deterministic trend is employed to derive the output gap, we find that past inflation is more important than future inflation in predicting current inflation. According to Table *1*, for the UK, Korea, and Canada the effect on current inflation of the three-quarter average of past inflation is positive and significant at the one or five percent level. For Canada, there is also a statistically significant positive link between future inflation and current inflation. The same positive link exists in Australia but it is only marginally significant at the ten percent level. There is only scant evidence for the hypothesized positive effect of the real exchange rate and the output gap on current inflation. For Korea positive changes in the real exchange rate (i.e. devaluation or depreciation) appear to have exerted upward pressure on domestic inflation. For Canada there is a weak relation between domestic inflation and (the second difference of) the real exchange rate but it bears the wrong sign. The only country where domestic inflation reacts to the output gap is the United Kingdom. The positive effect of the output gap on domestic inflation is significant at the one percent level.

Table *2* presents the findings when the output gap is calculated by means of the Hodrick-Prescott filter. All in all, the findings based on the Hodrick-Prescott filter are equally supportive of the existence of a backward linkage of inflation in the United Kingdom, Korea, and Canada, confirm positive link between future and current inflation in Canada but offer only weak evidence that points to the existence of a potent direct exchange rate channel in Korea. There is no discernible effect of the output gap on inflation.

Tables *3* and *4* contain the results for the case where the rate of inflation is calculated as the log difference of the Consumer Price Index. The coefficient on lagged inflation is statistically significant in three of the six countries, and the size of the coefficient ranges from a high of *0.4494* in Australia to a low of *0.2737* in Canada. Notice that in Canada future inflation is not only statistically significant but it has also a greater positive effect on current inflation than past inflation. The CPI inflation results for Canada mimic the inflation linkages reported in Table *1*. The potency of the direct exchange rate channel in Korea is again apparent in the results reported in Table *3* although its economic significance is somewhat weaker compared to Table *1*. For the UK the coefficient on the real exchange rate bears the wrong sign.[17] The output gap based on the deterministic trend does not exert a significant effect on CPI inflation in any one of the six countries.

When the Hodrick-Prescott filter generates the output gap, the results do not change dramatically. But there are a few notable changes. As shown in Table *4*, past inflation is no longer a significant factor for current inflation in Canada while for the UK past inflation is now marginally significant and the marginal effect of the direct exchange rate channel on CPI inflation disappears. In New Zealand the output gap now exerts a marginally significant effect on CPI inflation.

Owing to the prominent role of the output gap in policy deliberations, central banks use sophisticated techniques to construct alternative, more accurate measures of the output gap. For instance, the Reserve Bank of New Zealand uses a multivariate filter to generate the output gap. The multivariate filter is the standard Hodrick-Prescott Filter supplemented by three additional gaps: an inflation gap derived from an expectations-augmented Phillips Curve, an unemployment gap, and a capacity utilization gap. Because it incorporates more information about the state of the economy, the multivariate filter should be a better indicator of the existing or impending inflationary pressure than other more conventional measures.[18] Table *5* shows that the output gap generated with the help of the multivariate filter bears no statistically significant positive relationship to either rate of inflation in New Zealand. Thus, even a more sophisticated technique for determining the output gap fails to establish the positive co-movement between the output gap and the rate of inflation in New Zealand data.

V. Summary and Conclusion

This paper highlights the important role that the exchange rate plays on the supply side of an open economy. Specifically, the paper shows how the exchange rate affects the price-setting behavior of monopolistically competitive firms in a microeconomic framework that gives rise to a forward-looking Phillips Curve at the aggregate level. The open economy Phillips Curve differs from its closed economy counterpart in that the real exchange rate exerts a direct effect on domestic inflation. The existence of this direct exchange rate channel implies that *both* IS and Phillips Curve parameters are instrumental in determining the conduct of optimal monetary policy.

Drawing on data from six small open economies, the empirical part of the paper seeks to verify the existence of a direct exchange rate channel in the Phillips Curve. A general specification of the forward-looking Phillips Curve model is set up with a view towards examining the hypothesized link between the real exchange rate and the rate of inflation. In addition, we assess the extent to which past inflation as opposed to future inflation explains current inflation. The effect of the output gap on inflation is also examined. On balance, we find only scant evidence for the existence of a direct exchange rate channel in the Phillips Curve. Substantial evidence in favor of this channel exists only for Korea. Thus the important role of a direct exchange rate channel in the determination of optimal monetary policy is confirmed only for Korea. But even this conclusion is tempered somewhat by the existence of fourth-order serial correlation in the residuals when CPI inflation is used. The absence of a strong link between the real exchange rate and the rate of inflation may be due to the fact that the "pass-through" effect of the nominal exchange rate on the optimal domestic price is non-existent.

The empirical results attest to the importance of past inflation in explaining the current rate of inflation. In all countries but Sweden there exists a strong link between past and current domestic or CPI inflation. The link between future inflation and current inflation is more tenuous, especially for domestic, i.e. GDP deflator-based inflation. Future domestic inflation is far less relevant than past domestic inflation in explaining current domestic inflation.

Econometric inference is hampered by the existence of serial correlation in a few cases. For instance, the LM test for fourth-order serial correlation uncovers a systematic pattern in the regression residuals for Canada. This may be indicative of a misspecification problem. At the very least, the existence of fourth-order serial correlation in the residuals suggests that the results reported for Canada and the results based on the CPI for Korea are to be interpreted with care.

In our cross-country analysis neither measure of the output gap measure exerts a significant positive effect on the rate of inflation. This result is somewhat surprising in view of the central role played by the output gap in policy discussions. At the same time it underscores the urgent need to construct accurate statistical measures of the output gap. Simple detrending procedures or filters such as the ones employed in this paper may not do the trick. A promising alternative would be to devise improved measures of the proxy for marginal cost.[19]

The use of highly aggregated data may also account for the poor performance of the Phillips Curve specification employed in this paper. Future research ought to focus on the extent of price stickiness at the industry level. It is conceivable that the specification of the New Keynesian Phillips Curve receives stronger empirical support at a more disaggregate level, i.e. at the industry level. After all, price stickiness is more ingrained in service-oriented and certain manufacturing sectors (apparel, machinery, general manufacturing) of the economy than in others. The forward-looking Phillips Curve may also fare better in an empirical analysis that distinguishes between the rate of inflation for tradable and non-tradable goods.[20]

Taken altogether, we are led to the conclusion that the model of the forward-looking Phillips Curve derived in this paper does not receive much backing from aggregate data.

References

Ball, Laurence, 1999, "Policy Rules for Open Economies", in John B. Taylor, ed. *Monetary Policy Rules*, Chicago, IL: University of Chicago Press, 127-144.

Bergin, P. and Feenstra, R., 2000, "Staggered Price Setting and Endogenous Persistence", *Journal of Monetary Economics*, 45, 657-80.

Blanchard, O. and Kiyotaki, N., 1987, "Monopolistic Competition and the Effects of Aggregate Demand", *American Economic Review*, 77, 647-66.

Calvo, G., 1983, "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics*, 12, 393-398.

Clarida, R., Jordi, G. and Gertler, M., 1999, "The Science of Monetary Policy: a New Keynesian Perspective", *Journal of Economic Literature*, 37, 1661-1707.

------, Jordi, G. and Gertler, M., 2001, "Optimal Monetary Policy in Open vs. Closed Economies: An Integrated Approach", *American Economic Review*, 91, 248-252.

------, Jordi, G. and Gertler, M., 2002, "A Simple Framework for International Monetary Policy Analysis", *Journal of Monetary Economics*, 49, 879-904.

Froyen, Richard and Guender, A., 2000, "Alternative Monetary Policy Rules for Small Open Economies", *Review of International Economic*s, 8, 721-740.

------- 2007, *Elements of Monetary Policy under Uncertainty*, Edward Elgar, Northampton, MA (in press).

Fuhrer, Jeffrey, 1997, "The (Un)Importance of Forward-Looking Behavior in Price Specifications", *Journal of Money, Credit, and Banking*, 29 (August), 338-350.

-------- and Moore G., 1995, "Inflation Persistence", *Quarterly Journal of Economics*, 110, 127-159.

Gali, Jordi and Gertler M., 1999, "Inflation Dynamics: A Structural Econometric Analysis", *Journal of Monetary Economics*, 44, 195-222.

-------- and Tommaso Monacelli, 2005, "Optimal Monetary Policy and Exchange Rate Volatility in a Small Open Economy", *Review of Economic Studies,* 72, 707-734.

Godfrey, L. G., 1994, "Testing for Serial Correlation by Variable Addition in Dynamic Models Estimated by Instrumental Variables", *Review of Economic and Statistics*, 76, 550-559.

Graff, Michael, 2004, "Estimates of the Output Gap in Real Time: How Well Have We Been Doing?" DP/2004/04, Reserve Bank of New Zealand.

Guender, Alfred V., 2006, "Stabilizing Properties of Discretionary Monetary Policies in a Small Open Economy: Domestic vs. CPI Inflation Targets", *Economic Journal*, 116, 309-326.

Gwin, Carl and VanHoose David, 2005, "Disaggregate Evidence on U.S. Price Stickiness and Implications for Sticky-Price Macro Models", unpublished manuscript, Baylor University.

King, R., 2000, "The New IS-LM Model: Language, Logic, and Limits", Federal Reserve Bank of Richmond *Economic Quarterly,* 86, 45-103.

McCallum, Bennett T. and Nelson, E., 1999, "An Optimizing IS-LM Specification for Monetary Policy and Business Cycle Analysis", *Journal of Money, Credit, and Banking*, 31, 296-316.

-------- 2004, "Timeless Perspective vs. Discretionary Monetary Policy in Forward-Looking Models", *Federal Reserve Bank of St. Louis Review,* 86, 43-56.

Matheson, Troy, 2006, "Phillips Curve Forecasting in a Small Open Economy," DP2006/01, Reserve Bank of New Zealand, Wellington.

Monacelli, Tommaso, 2005, "Monetary Policy in a Low Pass-Through Environment", *Journal of Money, Credit, and Banking*, 37, 1047-1066.

Orphanides, Athanasios, 2001, "Monetary Policy Rules Based on Real-Time Data," *American Economic Review*, 91, 964-985.

Roberts, J. M., 1995, "New Keynesian Economics and the Phillips Curve", *Journal of Money, Credit, and Banking*, 27, 975-984.

-------- 1998, "Is Inflation Sticky?" *Journal of Monetary Economics*, 9, 173-196.

------- 2005, “How Well Does the New Keynesian Sticky Price Model Fit the Data?” *Contributions to Macroeconomics*, 5, 1-37.

Rotemberg, Julio, 1982, “Sticky Prices in the United States”, *Journal of Political Economy*, 90, 187-211.

-------- and Woodford, M., 1997, “An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy”, in Ben. Bernanke and Julio Rotemberg, eds., *NBER Macroeconomics Annual 1997*, MIT Press.

Rudebusch, Glenn D., 2002, “Assessing Nominal Income Rules for Monetary Policy With Model and Data Uncertainty”, *Economic Journal*, 112, 402-432.

Sbordone, Argia, 1998, “Prices and Unit Labor Costs: A New Test of Price Stickiness”, Working Paper, Rutgers University (October).

Svensson, L., 2000, “Open Economy Inflation Targeting”, *Journal of International Economics*, 50, 117-153.

Taylor J. B., 2000, “Low Inflation, Pass-Through, and the Pricing Power of Firms”, *European Economic Review*, 44, 1389-1408.

Walsh, C., 1999, “Monetary Policy Trade-Offs in the Open Economy”, mimeo, University of California, Santa Cruz.

Woodford, Michael, 2003, *Interest and Prices*, Princeton, Princeton University Press.

Table 1: GDP-Inflation: Output Gap Based on Deterministic Time Trend

Country	*BPi*	*FPi*	Δq	*y*	*X*	*X2*	*IVLM AR(1)/AR(4)*	*Std Error*
NZ	0.1815	0.0919	0.1543	-0.0073	-0.0044		1.75/1.98	0.0116
88:3-02:4	(0.3634)	(0.9054)	(0.2398)	(0.0860)	(0.0203)			
Australia	0.5053	0.7187#	-0.0702	-0.0478	0.0048		5.45*/4.98**	0.0051
90:4-02:4	(0.3239)	(0.4284)	(0.0666)	(0.0771)	(0.0058)			
Korea	0.3156*	0.4051	0.1078*	0.0364	-0.0060		0.023/1.55	0.0126
91:2-02:4	(0.1143)	(0.4488)	(0.0547)	(0.0778)	(0.0045)			
Sweden	0.3442	0.3800	-0.0718	0.0049	0.0353		2.82/2.07	0.0122
82:1-02:4	(0.4994)	(0.6447)	(0.0476)	(0.0406)	(0.0424)			
UK	0.9606**	-0.7864	0.0078	0.1589**	-0.0105	0.0367**	1.56/1.51	0.0063
82:2-02:4	(0.2943)	(0.4999)	(0.0193)	(0.0684)	(0.0262)	(0.0140)		
Canada	0.4009**	0.8389*	-0.0650#	0.0028			1.07/9.08**	0.0051
82:2-02:4	(0.1247)	(0.4273)	(0.0392)	(0.0249)				

Notes:

1. Standard errors are in parentheses (calculation based on Newey-West HAC in *EVIEWS).* # significant at the 10 percent level * significant at the 5 percent level ** significant at the 1 percent level
2. Lagged and future inflation are defined as follows:

   $$Bpi = (\pi_{t-1} + \pi_{t-2} + \pi_{t-3})/3 \qquad Fpi = (\pi_{t+1} + \pi_{t+2} + \pi_{t+3})/3$$

   The definition of lagged and future inflation for the UK is based on 4 lags and 4 leads, respectively.
3. Four lags of the rate of inflation (π_{t-j}, *j=1…4*), the real exchange rate, the output gap and the dummy variable(s) appear in the set of instruments.
4. X is a dummy variable. For New Zealand, Australia, and Korea it is meant to capture the effect of the Asian Currency Crisis. X = 1 for 1997:2 – 1998:4, X =0 otherwise. For Sweden and the United Kingdom the dummy variable is meant to capture the European Exchange Rate Crisis of September 1992. X=1 for 1992:3, X= 0 otherwise.
5. X2 captures the effect of the miner"s strike in the UK in 1984.
6. Godfrey"s LM test for serial correlation, reported in column 8, consists of computing $IVLM = ESS(e_0;W)/s_0^2 - ESS(e_g;W)/s_0^2$. After multiplying *IVLM* by $1/g$, we compare the test statistic to a right-hand tail critical value of the $F(g, N-k-g)$ distribution. In the paper, we test for first and fourth-order serial correlation. Hence *g=1,4*. *N*= number of observations, *k* = number of regressors, and s_0^2 = the sum of squared residuals divided by *N-k*. *ESS* = Explained sum of squares. *W*=set of instruments. e_0=*IV* residuals from restricted equation. e_g=*IV* residuals from unrestricted equation.

Table 2: GDP-Inflation: Output Gap Based on Hodrick Prescott Filter (HPy)

Country	*BPi*	*FPi*	*Δq*	*HPy*	*X*	*X2*	*IVLM AR(1)/AR(4)*	*Std Error*
NZ	0.1781	-0.0307	0.1767	-0.0140	-0.0056		1.57/0.99	0.0117
88:3-02:4	(0.3719)	(1.0093)	(0.2657)	(0.1305)	(0.0202)			
Australia	0.7464	0.7548	-0.1288	-0.1785	0.0115		3.54/4.37**	0.0060
90:4-02:4	(0.4854)	(0.6399)	(0.1125)	(0.1919)	(0.0120)			
Korea	0.2932*	0.4999	0.1232#	-0.0142	-0.0127		0.01/2.23	0.0129
91:2-02:4	(0.1345)	(0.3988)	(0.0668)	(0.1201)	(0.0081)			
Sweden	0.5102	0.0764	-0.0876	-0.0509	0.0140		1.78/9.26**	0.0121
82:1-02:4	(0.8493)	(1.4938)	(0.0738)	(0.0932)	(0.0583)			
UK	0.7931**	-0.2572	-0.0079	0.1500	-0.0175	0.0288#	0.02/0.91	0.0068
82:2-02:4	(0.2692)	(0.3976)	(0.0200)	(0.1171)	(0.0208)	(0.0169)		
Canada	0.4291**	0.7571*	-0.0605	0.0389	-0.0143		0.90/8.96**	0.0056
82:2-02:4	(0.1291)	(0.3295)	(0.0417)	(0.0287)	(0.0326)			

Notes:

7. BPi and FPi for Sweden and UK include 4 lags and 4 leads. BPi and FPi for NZ, Australia, Korea and Canada include 3 lags and 3 leads.

Table 3: CPI-Inflation: Output Gap Based on Deterministic Time Trend

Country	*BCPI*	*FCPI*	Δq	*y*	*IVLM AR(1)/AR(4)*	*Std Error*
NZ	0.4271**	0.2319	-0.0421	0.0517	0.18/1.33	0.0061
88:3-02:4	(0.1672)	(0.5061)	(0.0483)	(0.0319)		
Australia	0.4494**	-0.1056	-0.0184	0.1008	0.42/0.38	0.0067
90:4-02:4	(0.1611)	(0.6356)	(0.0343)	(0.1359)		
Korea	0.4036	0.7875	0.0478*	-0.0218	0.008/4.48**	0.0065
91:2-02:4	(0.3126)	(0.8205)	(0.0238)	(0.0630)		
Sweden	0.8212	-0.0899	0.0275	0.0630	1.18/1.10	0.0105
82:1-02:4	(0.5335)	(0.6779)	(0.0293)	(0.0553)		
UK	0.3791	0.6964	-0.1141#	-0.0423	0.17/2.46	0.0093
82:2-02:4	(0.3362)	(0.9361)	(0.0688)	(0.1268)		
Canada	0.2737*	0.7490**	0.0084	-0.0046	3.34/3.84**	0.0039
82:2-02:4	(0.1209)	(0.2531)	(0.0248)	(0.0220)		

Notes:

8. *BCPI* and *FCPI* for all countries are based on *4* lags and *4* leads

$$BCPI = (\pi_{t-1}^{CPI} + \pi_{t-2}^{CPI} + \pi_{t-3}^{CPI} + \pi_{t-4}^{CPI})/4 \qquad FCPI = (\pi_{t+1}^{CPI} + \pi_{t+2}^{CPI} + \pi_{t+3}^{CPI} + \pi_{t+4}^{CPI})/4$$

9. The dummy variables have been dropped from the specification in a number of countries as they do not exercise any meaningful effect on CPI inflation but cause problems applying the instrumental variables procedure. The coefficients of the dummy variables are not significant in any one of the countries.

Table 4: CPI-Inflation: Output Gap Based on Hodrick-Prescott Filter (HPy)

Country	*BCPI*	*FCPI*	Δq	*HPy*	*IVLM AR(1)/AR(4)*	*Std Error*
NZ	0.3755**	0.1386	-0.0111	0.1209#	0.03/0.84	0.0057
88:3-02:4	(0.1251)	(0.3333)	(0.0411)	(0.0701)		
Australia	0.4390**	-0.0145	-0.0144	0.2734	0.06/0.20	0.0064
90:4-02:4	(0.1371)	(0.7445)	(0.0235)	(0.3316)		
Korea	0.2195	1.2708**	0.0524**	-0.0597	0.81/4.45**	0.0069
91:2-02:4	(0.2195)	(0.4998)	(0.0205)	(0.0667)		
Sweden	0.6304	0.2109	0.0190	0.0637	2.87/1.57	0.0096
82:1-02:4	(0.5693)	(0.7279)	(0.0263)	(0.0938)		
UK	0.6667#	-0.1818	-0.0958	0.1433	0.003/1.52	0.0091
82:2-02:4	(0.3879)	(0.9005)	(0.0602)	(0.1862)		
Canada	0.1271	0.9531**	0.0247	-0.0343	1.67/4.20**	0.0044
82:2-02:4	(0.1349)	(0.2669)	(0.0280)	(0.0373)		

Notes:

10. *BCPI* and *FCPI* for all countries are based on *4* lags and *4* leads
11. The dummy variables have been dropped from the specification in a number of countries as they do not exercise any meaningful effect on CPI inflation but cause problems in interpreting the results produced by the instrumental variables procedure. In any event, the coefficient(s) on the dummy variable(s) is (are) not statistically significant in any one of the six countries.

Table 5: Output Gap for New Zealand Based on Multivariate Filter:

A. Inflation Based on CPI:

Sample Period 88:3-02:4	*BCPI*	*FCPI*	Δq	*RBNZy*	*IVLM AR(1)/AR(4)*	*Std Error*
	0.4649**	0.0592	-0.0124	0.0009	0.53/1.10	0.0056
	(0.1871)	(0.4117)	(0.0677)	(0.0006)		
B. Inflation Based on GDP Deflator:						
Sample Period 88:3-02:4	*BPI*	*FPI*	Δq	*RBNZy*	*IVLM AR(1)/AR(4)*	*Std Error*
	0.2588	0.5356	0.0433	-0.0008	0.02/2.96*	0.0114
	(0.2942)	(0.6959)	(0.2069)	(0.0016)		

Notes:

13. *RBNZy*= output gap based on multivariate filter. A unit root test for this series over the 1983Q1-2006Q2 period rejects the null hypothesis of a unit root in the output gap at the 1 percent level.
14. The regression equation where inflation is measured as the log change in the GDP Deflator also contains a dummy variable (X). See 5. for further details.

ENDNOTES

[1.] The Bank of Korea began to target the rate of inflation in 1998 in the wake of the Asian Currency Crisis. The other countries adopted inflation targeting in the late 1980s or the early 1990s.
[2] Lower case letters denote the logarithms of variables.
[3] Within a general equilibrium framework, the comovement between marginal cost and economic activity can be established by combining the labor supply and demand relations with the market clearing condition in the goods market. On this point see Clarida, Gali, and Gertler (2001, 2002) or Gali and Monacelli (2005) who derive a similar relation that stresses the positive relation between real marginal cost and domestic consumption. The positive link between real output and marginal cost is also characteristic of earlier models of monopolistic competition such as Blanchard and Kiyotaki (1987).
[4] For the pricing decision of domestic firms to be sensitive to the prevailing price charged by foreign competitors, it is necessary to drop the assumption of constant elasticity of substitution in the utility function of households. Bergin and Feenstra (2000) and Taylor (2000) show how a *translog* specification for preferences or a *linear* demand relation yields an optimal pricing rule that responds to competitors' prices *in addition* to marginal cost. Equation (3) embodies this idea.
[5] An open-economy Phillips Curve can also be derived from the Calvo (1983) model that emphasizes stochastic price adjustment. This approach emphasizes that nominal marginal cost and the domestic currency price of the foreign consumption good are the factors that govern the determination of the price of the domestic consumption good. As firms are uncertain about the next available opportunity to change their prices, they look at the future evolution of both factors. The resulting Phillips Curve also features a real exchange rate channel in the Phillips Curve. See Guender (2006) for how the closed-economy Calvo model can be extended to an open economy.
[6] This is a simplified version of McCallum and Nelson's (1999) IS relation for an open economy. Clarida, Gali, and Gertler (2001,2002), Gali and Monacelli (2005), and Monacelli (2005) model aggregate demand in similar fashion. For an explicit derivation of an IS relation in an open economy framework, see Guender (2006). For the purpose at hand, the simplified version of the IS relation is entirely satisfactory as the degree of openness of the model economy, which affects the size of the parameters of the IS relation, is assumed constant. Moreover, the effect of a foreign output shock is similar to the effect of an IS shock. Hence the foreign output shock does not appear in the simplified version of the IS relation.
[7] The timeless perspective of monetary policy is stronger form of commitment that introduces inertia into the behaviour of real output and inflation. Froyen and Guender (2007), McCallum and Nelson (2004), Woodford (2003) discuss the timeless perspective in greater detail.
[8] As the stochastic disturbances follow a white noise process, there is no difference between optimal policy under discretion and simple commitment. For the case of autocorrelated disturbances, the setting of optimal policy under simple commitment depends also on the degree of persistence in the disturbances. See Froyen and Guender (2007) for a detailed analysis of this case.
[9] The expression in equation (17) is also the solution to the case of monetary policy being carried out under discretion. Under discretion, the policymaker minimizes the loss function, treating all expectations as fixed. As seen above, under commitment, all expectations of the endogenous variables are fixed at zero due to the assumption of all shocks following white noise processes. Hence the optimal weight on real output is the same for both discretion and commitment.
[10] The smoothing parameter is set to 1600.
[11] In our empirical analysis, we sidestep an issue concerning the measurement of the output gap that has received wide attention in policy circles. The issue focuses on the availability of only imprecise measures of the output gap when monetary policy decisions are taken. See Orphanides (2001) for a detailed account of the use of 'real time" data in the implementation of monetary policy in the United States.
[12] See Roberts (1995, 2005), Gali and Gertler (1999). The alternative would be to use surveys of inflationary expectations as is done by Roberts (1995, 1998) or Rudebusch (2002).
[13] Augmented Dickey-Fuller tests are carried out to test for the non-stationarity of the variables. These tests prove helpful in avoiding specifying an unbalanced regression model. The tests reveal that the rate of inflation and the output gap in each country are not non-stationary. However, the real exchange rate in all countries but Canada contains a unit root. In the case of Canada the null hypothesis of a unit root in the change of the real exchange rate cannot be rejected. As a consequence, the second difference of the real exchange rate appears in the model of the Phillips Curve estimated for Canada while the first difference of the real exchange rate appears in the specification of the Phillips Curve for the other countries.
[14] Roberts (2005) emphasizes this point.
[15] The condition $\gamma_1 + \gamma_2 = 1$ is not imposed on the specification. This is sometimes done to gauge the empirical relevance of the backward relative to the forward-looking element.
[16] The different sample periods for the countries are due to the limited availability of quarterly data for Australia, Korea, and New Zealand in the OECD database. Extending the empirical analysis to the early or mid-1980s would

complicate matters for the case of New Zealand due to shifts in regimes (switch to a pure float in 1985) and the deregulation of the financial sector.

[17] The negative effect may capture exchange rate pass-through. Suppose nominal exchange rate changes are passed through completely. Then $\pi_t^{CPI} = \pi_t + \alpha \Delta q_t$ where α represents the share of foreign goods in the CPI. An appreciation of the real exchange rate ($\Delta q_t < 0$) thus exerts downward pressure on CPI inflation.

[18] See Graff (2004) for further details.

[19] As pointed out earlier, existing proxies for marginal cost such as the labour income share (used by Gali and Gertler (1999)) have also been found wanting. For more on the choice of a suitable proxy for marginal cost, the reader is referred to Roberts (2005) and Gwin and VanHoose (2005). The latter investigate the extent of price stickiness at the industry level in the United States and employ the percentage change in average variable cost as the proxy for marginal cost.

[20] Matheson (2006) presents empirical evidence for New Zealand and Australia according to which sectoral Phillips Curves fit the data much better than an aggregate Phillips Curve.