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Explicit and Implicit Targets in Open Economies

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Abstract

Under a *flexible* inflation targeting regime, should policymakers avoid any reaction to movements in the foreign exchange market? Using data for six advanced open economies explicitly targeting inflation, the paper examines empirically whether real exchange rate disequilibria systematically affect the conduct of monetary policy. Estimates indicate that monetary policy responses in inflation–targeting, open economies have changed significantly, as the institutional framework for the conduct of monetary policy has evolved. In particular, an explicit target for core inflation and a greater use of the expectation channel of monetary policy appear to be key features of the newest policy framework. In this context, central banks are unlikely to react to regular fluctuations in the exchange rate.

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I. INTRODUCTION

In a number of industrial countries, an inflation targeting regime has been instrumental in taming inflation and stabilizing the economy, and appears to have gained considerable credibility over time.[2] Central banks have generally operated a *flexible* inflation targeting regime, smoothing interest rate adjustments over a "reasonable" time horizon, while taking into consideration both variability in output and variability in inflation.[3] In most cases, recent measures have further improved both the flexibility and the transparency of the policy framework, thus enhancing guidance to the markets.[4]

An unsettled issue in inflation–targeting open economies remains, however, whether deviations of the real exchange rate from equilibrium should be taken into account in formulating monetary policy. Under a flexible inflation targeting regime, should policymakers focus solely on domestic variables and avoid any reaction to movements in the foreign exchange market? Or is it correct to claim that "a substantial appreciation of the real exchange rate [...] furnishes a *prima facie* case for relaxing monetary policy," as argued by Obsteld and Rogoff (1995, pp. 93)? The primacy of inflation targeting entails that, as soon as macroeconomic indicators suggest that inflationary pressures begin to surfacing, the monetary authority should start a gradual policy tightening. Indeed, delays in rising interest rates might undermine the credibility of the inflation targeting framework itself. In practice, however, the room for maneuver of open economies' policymakers is likely to be constrained by the need to avoid an exchange rate appreciation that would damage the traded goods sector. Should this prospect make a case against an immediate policy tightening?

Using data for six advanced open economies explicitly targeting inflation (e.g., Australia, Canada, New Zealand, Norway, Sweden, and the United Kingdom), this paper examines empirically whether deviations of the exchange rate from equilibrium systematically affect the conduct of monetary policy. For this purpose, we first assess the role of the exchange rate as information variable into the policy decision–making process, and then test whether it also enters as a separate argument in a forward–looking interest rate reaction function.

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[2] Over the 1990's, Australia, Canada, New Zealand, Sweden, and the United Kingdom, all changed the institutional framework under which monetary policy was conducted, by shifting to an inflation targeting regime. Norway and Iceland followed suit in 2001. The literature on the institutional aspects of inflation targeting in industrial countries is extremely vast. For a recent review, see Bernanke and Woodford (2005) and references therein.

[3] Svensson (2000), for example, analyzes the properties of a *flexible* inflation targeting regime in an open economy context.

[4] On recently introduced measures enhancing the transparency of Norway's monetary framework and related discussion, see IMF (2005a). Analogous discussions for Sweden and the United Kingdom can be found in IMF (2004, 2005b), respectively.

Open economies targeting *core* inflation do not seem to react to regular fluctuations in the exchange rate. Nonetheless, in three out of six cases (Canada, Australia, and New Zealand)—e.g., in those countries where exports of non–oil commodities play a major role in the economy—the real exchange rate emerges as an independent monetary policy target. Tellingly, in all cases considered, exchange rate disequilibria appear to be valuable inputs for monetary policy decisions.

Estimates from rolling regressions also indicate that monetary policy responses in inflation–targeting open economies have varied significantly over time. As the institutional framework for the conduct of monetary policy has evolved over recent years, the parameterization of interest rate reaction functions has changed accordingly. The use of an explicit target for core inflation and a greater use of the expectation channel of monetary policy appear to be key features of the newest policy framework. We interpret this evidence as an indication that central banks' credibility has increased over time and is now well established. At the same time, putting private sector perceptions about the stability of monetary policies at center stage highlights the importance of central bank communication.

The paper is organized as follows. Section II briefly reviews the standard framework of analysis of forward–looking monetary reaction functions. The model is generalized to an interest rate rule explicitly allowing for real exchange rates to act both as information variables and as monetary policy targets. Inter alia, alternative targets for inflation and a range of proxies for the output gap are here examined. Section III reports the main empirical results from estimating standard forward–looking rules as well as augmented forward–looking Taylor rules, which takes into account possible exchange rate targeting. For each country, the actual and the implied value of the policy interest rate under the standard and the augmented monetary reaction function are shown. Finally, changes in central banks' behavior over time are analyzed by presenting results from rolling regressions, in which parameter estimates are reported over successive forty–quarter windows. The results are open to several interpretations, which are discussed in the concluding section.

II. Theoretical Background

Extensive academic work on monetary policy tends to characterize conduct in terms of interest rate rules and consequences in stylized models embedding these rules.[5] According to this framework, short–term money market rates are set to stabilize *domestic* variables—such as price inflation and real output—around their equilibrium path. Several contributions within the so–called New Keynesian synthesis have shown that—under quite general conditions—a simple, inward–looking, interest rate rule can be regarded as an optimal policy response for a *closed* economy.[6] Less attention has been paid to the choice of monetary

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[5] See, among others, Clarida, Galí, and Gertler (1999), Taylor (1993, 2000), and Woodford (2001).

[6] See, for example, Taylor (1999) and references therein.

policy objectives in an *open economy* context, given that an open economy is isomorphic to a closed economy whenever the exchange rate pass–through to import prices is complete.[7] In other words, under *complete exchange rate flexibility*, open economies' policymakers should also be focused uniquely on domestic targets. Unfortunately, there is extensive evidence that—in reality—departures from the law of one price for traded goods prices are large and pervasive.[8] Under these circumstances, policy choices are hardly independent of exchange rate dynamics and monetary conduct is liable to focus on more than just domestic stabilization.[9] Indeed, recent empirical studies provide evidence that exchange rates are statistically significant in interest rate rules depicting the reaction function of major economies.[10]

Following a widespread approach in the literature of flexible inflation targeting, this paper assumes that central banks face a quadratic loss function over inflation and output.[11] Under standard conditions, this implies that in each period the monetary authority has a target for the nominal money market interest rate i_t^*, which is a function of the gaps between expected inflation and output from their respective targets:

$$i_t^* = i^* + \beta\left[E\left(\pi_{t+k^\pi} \middle| \Omega_t\right) - \pi^*\right] + \gamma\left[E\left(y_{t+k^y} \middle| \Omega_t\right)\right], \tag{1}$$

where i^* is the desired nominal rate of interest when both inflation and output are at their target levels; $E\left(\pi_{t+k^\pi} \middle| \Omega_t\right)$ denotes the expectations of inflation at time $t+k^\pi$; and $E\left(y_{t+k^y} \middle| \Omega_t\right)$ denotes corresponding expectations of the output gap at time $t+k^y$. π^* is the level of inflation implicitly or explicitly targeted by the central bank, whereas the output gap, y, is defined as the difference between the level of real output and its efficient level. The coefficients β and γ measure the strength of (long–run) policy responses to deviations from the target variables. A parameter γ=0 suggests a pure inflation target, whereby monetary policy is uniquely concerned about price stability and does not aim at stabilizing business cycle fluctuations. If β<1, policy is attempting to accommodate inflationary shocks, which—

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[7] On this point, see Galí and Monacelli (2002).

[8] See, for instance, Rogoff (1996) and Engel (1993, 1999, 2002).

[9] Corsetti and Pesenti (2001) and Monacelli (2003) show that, with incomplete pass-through, optimal monetary policy is not purely inward looking.

[10] See, for example, Clarida, Galí, and Gertler (1998) and Chadha, Sarno, and Valente (2004).

[11] See, among others, Bernanke and Woodford (1997) and Svensson (1997).

over the long run—will lead to instability as real rates respond perversely to inflationary disturbances.[12]

However, central banks are likely to react gradually to expected deviations from targets, by smoothing their policy rate adjustments over several periods.[13] To account for this behavior, the interest rate rule (1) is modified by allowing for a second–order partial adjustment to the target rate, namely:

$$i_t = \rho(L) i_{t-s} + \left[1 - \rho(L)\right] i_t^* + v_t, \tag{2}$$

where $\rho(L)$ is generalized to a second–order polynomial, L is the lag operator, i_t^* is the target rate whose behavior is described by equation (1), and v_t is a zero–mean interest rate shock. Combining equations (1) and (2) yields an expression for the standard forward–looking Taylor rule, e.g.

$$i_t = \rho(L) i_{t-s} + \left[1 - \rho(L)\right] \left\{ \alpha + \beta \left[E\left(\pi_{t+k^\pi} \middle| \Omega_t \right) \right] + \gamma \left[E\left(y_{t+k^y} \middle| \Omega_t \right) \right] \right\} + v_t, \tag{3}$$

which, in turn, allows direct inference of the policy responses, β and γ, and derivation of the implied (ex–ante) equilibrium real interest rate, $r^* = \alpha - (1-\beta)\pi^*$, if the inflation target is known. So far, the only innovation in this policy rule specification regards the inclusion of two (rather than one) lagged terms in the interest rate. As discussed below, this more flexible dynamic structure provides a better description of some of the changes in monetary responses over time.

It is under debate whether and how exchange rates (and asset prices, in general) should be taken into account in formulating monetary policy.[14] While it is unanimously recognized that exchange rates are useful indicators of inflationary pressures in the economy (because changes in the exchange rate feed through into domestic prices and affect aggregate demand), central bankers have often been explicit about the fact that exchange–rate stabilization is not a direct target of policy. To assess whether this is really how they act, the interest rate rule (3) is further generalized to allow for policymakers' responses to exchange rate disequilibria:

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[12] Christiano and Gust (2000) emphasize that a high inflation expectations trap may arise if policy accommodates inflation.

[13] Sack and Wieland (2000) provide an in depth discussion of interest rate smoothing. On the issue of gradualism as optimal response to uncertainty, see Brainard (1967) as canonical reference on the theory side, Woodford (1999) for a recent application, and Walsh (2003) for an exhaustive review.

[14] See Taylor (2001) and Goodhart (2001).

$$i_t = \rho(L) i_{t-s} + [1-\rho(L)]\left\{\tilde{\alpha} + \tilde{\beta}\left[E\left(\pi_{t+k^{\pi}} | \Omega_t\right)\right] + \tilde{\gamma}\left[E\left(y_{t+k^{y}} | \Omega_t\right)\right] + \delta\left[E\left(e_{t+k^{e}} | \Omega_t\right)\right]\right\} + \varepsilon_t, \quad (4)$$

where e_{t+k^e} denotes the forward–looking real exchange rate. In line with recent empirical literature, purchasing power parity (PPP) is assumed to hold in the long run, so that the real exchange rate follows a persistent, albeit stationary, process. The equilibrium real exchange rate can thus be captured by a constant included in the intercept term $\tilde{\alpha}$ of the "augmented interest rate rule" (4), implying that central banks attempt to correct expected misalignments from PPP. If the real exchange rate is expressed as the domestic price of foreign currency, the resulting monetary rule will stabilize it if $\delta > 0$, as an appreciation of the real exchange rate will require a cut in the short–term interest rate. Under the augmented specification, the implied (ex–ante) equilibrium real interest rate will hence be identified only if both the inflation target *and* the equilibrium real exchange rate are known: $r^* = \tilde{\alpha} - \left(1-\tilde{\beta}\right)\pi^* + \delta e^*$.

Under rational expectations, central banks form their forecasts of future inflation, output gap, and real exchange rate using *all* relevant information available at the time the interest rate is set. Let z_t denote the vector of indicators comprising the central bank's information set at that time (i.e., $\mathbf{z}_t \in \Omega_t$). If the monetary authority adjusts the interest rate according to the augmented interest rate rule (4), while forming expectations of future variables in a fully rational manner, then there must exist a set of parameters $\left\{\hat{\tilde{\rho}}_1, \hat{\tilde{\rho}}_2, \hat{\tilde{\alpha}}, \hat{\tilde{\beta}}, \hat{\tilde{\gamma}}, \hat{\delta}\right\}$ such that the residuals obtained from the estimation of equations (4) are orthogonal to the information set available, z_t. Formally, $E\left[\varepsilon_t | \mathbf{z}_t\right] = 0$. This set of orthogonality conditions forms the basis of the estimates, using the Generalized Method of Moments (GMM). In addition, the validity of the set of instruments used can be tested by means of overidentifying restrictions, provided the number of instruments in z_t is greater than the number of parameters to be estimated.

The dataset comprises quarterly data from January 1984 to June 2004 for six inflation targeting, open economies: Australia, Canada, New Zealand, Norway, Sweden, and the United Kingdom. The baseline inflation measure is the annual core inflation rate (π^{CORE}), as reported by national monetary authorities. Because this measure is generally available only over recent periods, the series were extended backwards using the fourth differences in the log of CPI, as reported by the IFS database. Results are however also described using fourth differences in the log of CPI series (π^{CPI}) throughout the sample. Figure 1 plots the instrument interest rate for each of the six countries against measures of underlying and headline inflation.[15] Standard deviations of the countries' policy rates are estimated in the

[15] In the case of Australia and New Zealand, both inflation measures correct for the large effects of the goods and services taxes (introduced in 2000 in Australia and in 1986 in New Zealand). As a result, headline inflation in these countries tends to resemble more closely core inflation.

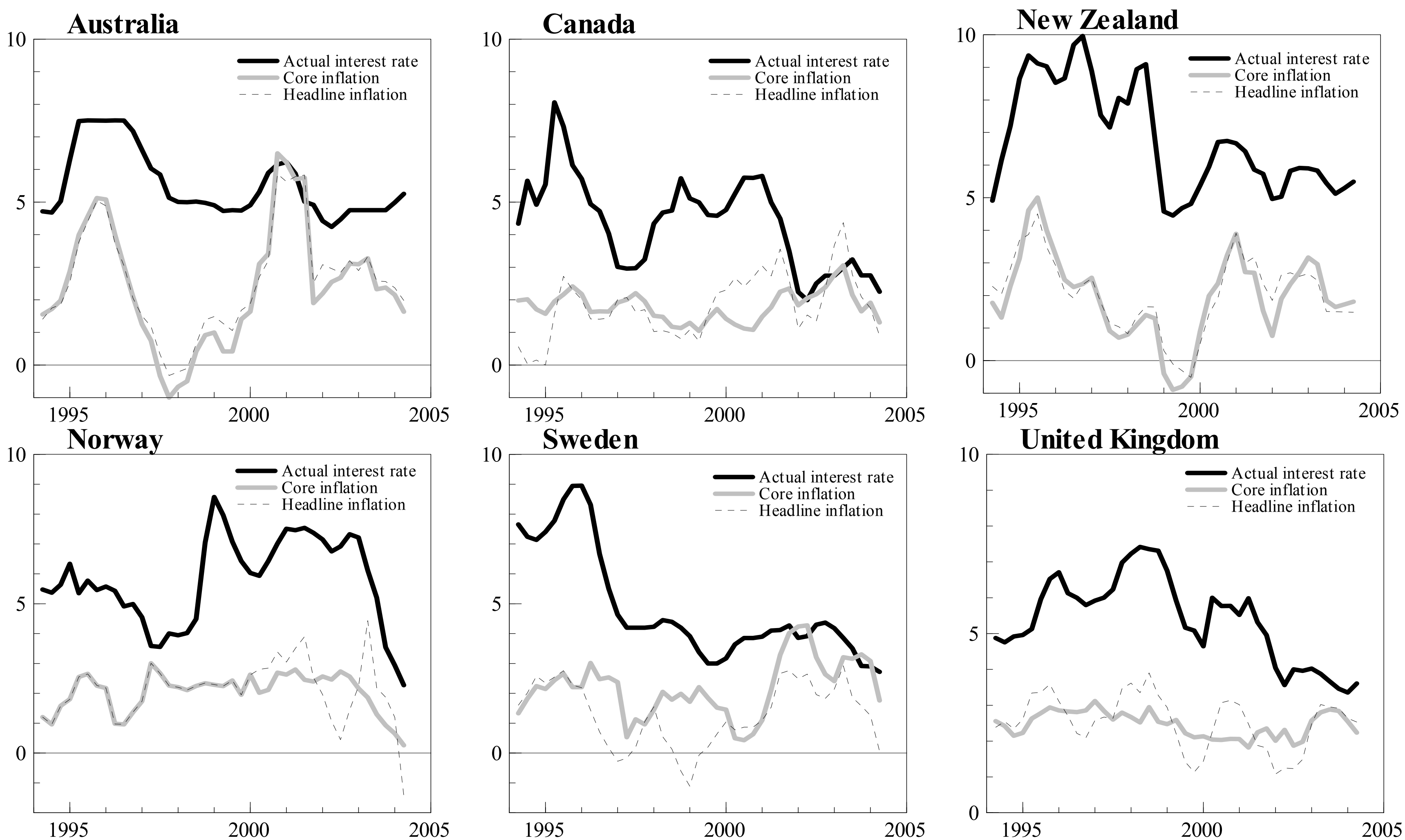
order of 1 percent, with the exception of New Zealand, where the volatility is slightly higher (around 1.3 percent).

As for the output gap, the preferred indicator is the *growth* gap (y^{DGAP}), given recent findings on the optimal policy response to potential output uncertainty (Orphanides and van Norden, 2002). Results are also reported for two alternative measures of the output gap: the Hodrick–Prescott filter for the level of real output (y^{HP}), and the real unit labor cost after adjusting for wage markup (y^{ARMC}), constructed as documented in Galí, Gertler, and López–Salido (2001). Figure 2 seems to confirm that the three output gap series are, overall, positively correlated.[16, 17] Finally, for all countries, misalignments from PPP are proxied by the logs of the real effective exchange rates based on CPI, given that real effective exchange rates series based on unit labor costs were not available for all countries.

[16] Our measures of activity refer to the whole economy. As such, they do not correct for sizable supply-side shocks to the agriculture sector.

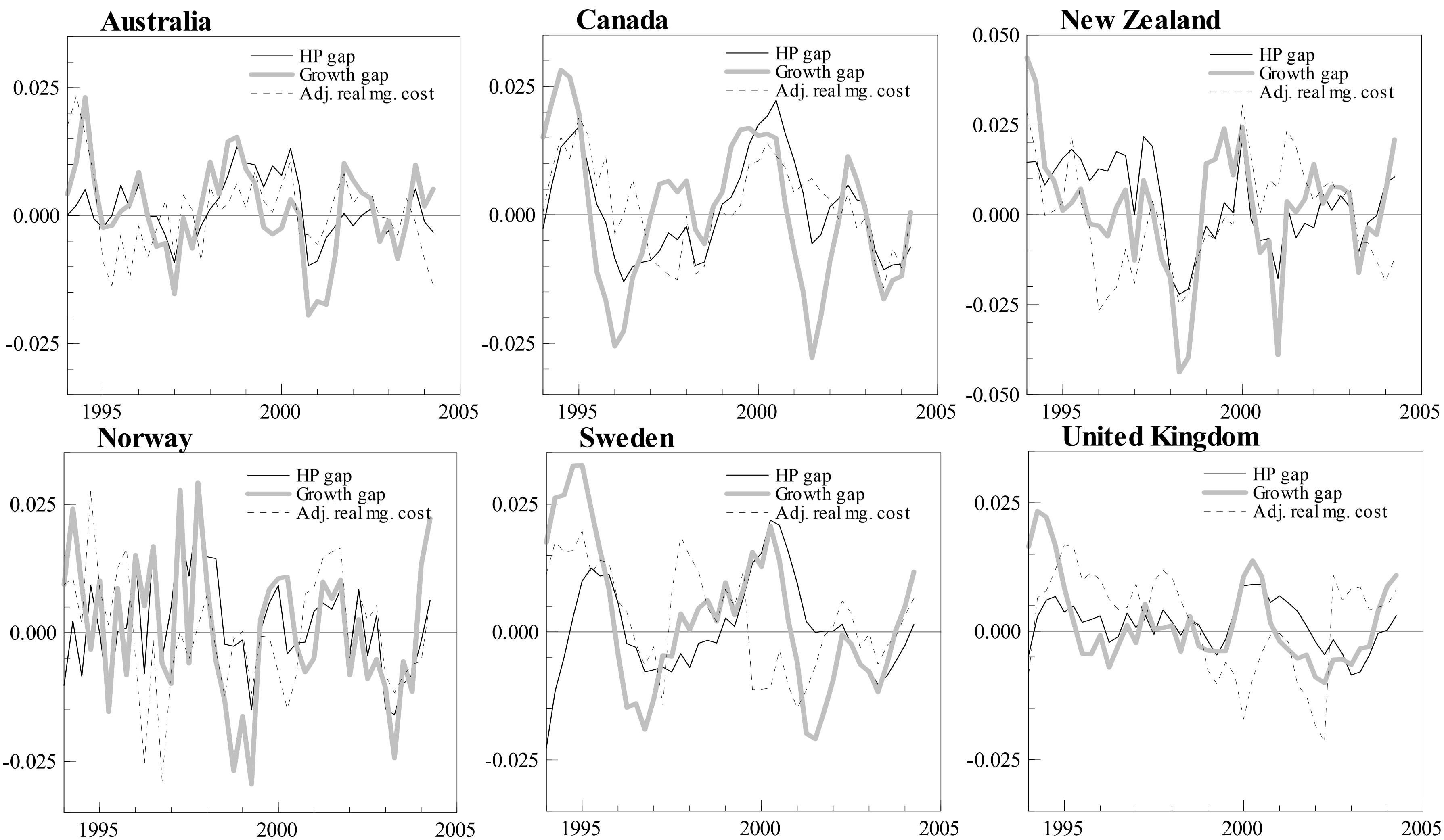
[17] In all cases, pairwise correlations between the Hodrick-Prescott output gap (y^{HP}) and the growth gap measure (y^{DGAP}) are statistically significant, ranging between 0.46 (for the United Kingdom) and 0.65 (for New Zealand). For all countries, the adjusted real unit labor cost (y^{ARMC}) exhibits the least synchronized behavior with the other two gap measures; in the case of Sweden and the United Kingdom, it appears to be uncorrelated with the HP filter, although positively and significantly correlated with the growth gap.

Figure 1. Interest Rate, Core, and Headline Inflation (percent)



Source: *International Financial Statistics,* and IMF staff calculation.

Figure 2. Output Gap Measures



Source: *International Financial Statistics,* and IMF staff calculation.

III. EMPIRICAL RESULTS

Table 1 reports GMM estimates of the parameters $\left\{\hat{\rho}_1, \hat{\rho}_2, \hat{\beta}, \hat{\gamma}\right\}$ in the standard forward–looking Taylor rule (3), where only expected inflation and expected output gap are considered as explanatory variables. The target horizon is assumed to be one quarter for both inflation and the output gap (i.e. $k^{\pi} = k^{y} = 1$), although results look qualitatively unaffected by this choice (not reported). The instrument set, $\mathbf{z}_t$, includes a constant, a world commodity price index, and four lags of the policy rate, inflation, and the output gap. In estimating the model for Norway and Sweden, the 1993Q1 and the 1992Q4 interest rate observations, respectively, are dummied out as extreme and unsystematic monetary tightening episodes dealing with the 1992–1993 Exchange Rate Mechanism crisis.

Estimation results yield parameter values broadly consistent with previous findings reported by the literature for inflation targeting countries. In particular, for Norway, New Zealand, Sweden, and the United Kingdom, for each of the specifications considered, the estimate of β is always correctly signed, strongly significant, and greater than unity, while the estimate of γ is not statistically different from zero at conventional significance levels. This implies that central banks in these countries have responded only to deviations of expected inflation from target, not to the expected output gap, which is consistent with a pure inflation targeting regime.[18] As for Australia, the estimate of β is strongly significant and greater than unity, but there is also some evidence that monetary policy aims to stabilize expected business cycle fluctuations. The evident outlier is Canada, for which monetary policy responses to both inflation and output gap are much stronger than in other countries, though the parameters are estimated with far less precision. Likely, shifts in the behavior of the Canadian monetary authority may not be described accurately by the framework at hand. Indeed, the close link with the United States may have forced the Bank of Canada to have a watchful eye on the U.S. Federal Reserve's behavior, whereas our current interest rate reaction function does not account for any systematic response to the U.S. monetary policy stance.

For all specifications and for each country, the overidentifying restrictions cannot be rejected, with the Hansen test supporting the validity of the information set used. Given that the instrument set used comprises four lags in the log of the real effective exchange rate, the result of this test can be interpreted as follows: under the null hypothesis, the central bank adjusts the interest rate according to the reaction function (3), with the expectations of future inflation and output based on the relevant information available at time *t.* The assumption that inflation and output gap forecasts are *also* based on available information from the foreign exchange market cannot be statistically rejected.

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[18] For the United Kingdom, this holds true in five out of six specifications, while the estimate of γ becomes significant when the output gap is proxied by the HP filter and price changes are measured by core inflation. The same exception remains valid in Table 2, when deviations from PPP are also allowed for.

Table 1. Forward–Looking Taylor Rule [1/]

Norway	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.585	0.062	**1.731**	0.002	0.884	1.010
	(0.111)	(0.058)	**(0.099)**	(0.175)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.555	0.085	**1.788**	0.007	0.904	1.031
	(0.138)	(0.066)	**(0.107)**	(0.291)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.613	0.064	**1.739**	0.504	0.873	1.003
	(0.109)	(0.057)	**(0.188)**	(0.586)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.685	0.042	**1.780**	0.206	0.657	1.051
	(0.116)	(0.073)	**(0.162)**	(0.311)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.699	0.060	**1.738**	0.671	0.614	1.051
	(0.134)	(0.076)	**(0.183)**	(0.669)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.695	0.066	**1.845**	0.974	0.790	1.111
	(0.115)	(0.073)	**(0.259)**	(0.740)		

Sweden	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.824	**–0.055**	**1.951**	0.321	0.573	0.974
	(0.054)	**(0.014)**	**(0.178)**	(0.344)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.901	**–0.063**	**1.900**	0.917	0.704	0.925
	(0.080)	**(0.025)**	**(0.223)**	(0.618)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.823	**–0.064**	**1.916**	–0.394	0.580	1.003
	(0.054)	**(0.014)**	**(0.167)**	(0.448)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.936	**–0.094**	**1.458**	0.285	0.657	1.051
	(0.045)	**(0.014)**	**(0.157)**	(0.414)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.960	**–0.081**	**1.406**	**1.594**	0.614	1.051
	(0.053)	**(0.025)**	**(0.196)**	**(0.804)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.949	**–0.105**	**1.518**	–0.830	0.790	1.111
	(0.049)	**(0.013)**	**(0.190)**	(0.659)		

(continued)

Table 1. Forward–Looking Taylor Rule *(continued)*

United Kingdom	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.771	0.013	**1.838**	0.732	0.570	0.980
	(0.127)	(0.082)	**(0.327)**	(0.773)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.591	**0.124**	**1.900**	**1.416**	0.665	0.968
	(0.108)	**(0.067)**	**(0.243)**	**(0.470)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.777	0.029	**1.799**	0.667	0.585	0.987
	(0.125)	(0.087)	**(0.361)**	(0.982)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.604	0.166	**1.724**	0.144	0.763	0.872
	(0.080)	(0.064)	**(0.203)**	(0.391)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.642	**0.181**	**1.522**	0.872	0.838	0.899
	(0.085)	**(0.061)**	**(0.320)**	(0.901)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.611	0.163	**1.759**	0.294	0.743	0.872
	(0.084)	(0.069)	**(0.217)**	(0.377)		

Canada	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.835	0.129	5.755	9.318	0.732	1.006
	(0.094)	(0.072)	(6.372)	(15.161)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.717	**0.150**	**2.427**	**2.762**	0.800	0.998
	(0.071)	**(0.050)**	**(0.548)**	**(0.940)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.788	0.051	**3.165**	**3.942**	0.757	1.072
	(0.094)	(0.057)	**(0.790)**	**(1.641)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.786	0.153	**3.328**	6.563	0.669	0.988
	(0.106)	(0.075)	**(1.710)**	(5.222)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.779	**0.148**	0.190	**5.379**	0.562	0.934
	(0.082)	**(0.061)**	(0.946)	**(2.806)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.831	0.084	**1.980**	8.500	0.508	1.047
	(0.111)	(0.081)	**(0.920)**	(5.261)		

(continued)

Table 1. Forward–Looking Taylor Rule *(concluded)*

Australia	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	1.031	–0.104	**1.524**	**3.723**	0.767	1.018
	(0.083)	(0.080)	**(0.341)**	**(1.018)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	1.062	–0.141	**0.715**	**3.046**	0.865	1.060
	(0.083)	(0.081)	**(0.360)**	**(1.454)**		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	1.118	**–0.191**	**1.083**	2.705	0.818	1.079
	(0.099)	**(0.090)**	**(0.490)**	(1.772)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	1.012	–0.093	**1.771**	**3.441**	0.723	0.991
	(0.081)	(0.079)	**(0.355)**	**(0.970)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	1.048	–0.136	**0.936**	2.573	0.837	1.037
	(0.081)	(0.080)	**(0.335)**	(1.461)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	1.094	**–0.181**	**1.331**	1.959	0.809	1.049
	(0.101)	**(0.089)**	**(0.420)**	(1.647)		

New Zealand	ρ_1	ρ_2	β	γ	*j–test*	*see*
$y=y^{DGAP}$; $\pi=\pi^{CORE}$						
	0.746	–0.100	**1.341**	–0.520	0.680	1.388
	(0.120)	(0.099)	**(0.066)**	(0.211)		
$y=y^{HP}$; $\pi=\pi^{CORE}$						
	0.876	**–0.196**	**1.349**	–0.081	0.490	1.214
	(0.082)	**(0.069)**	**(0.072)**	(0.267)		
$y=y^{ARMC}$; $\pi=\pi^{CORE}$						
	0.860	**–0.192**	**1.353**	–0.117	0.479	1.230
	(0.089)	**(0.074)**	**(0.095)**	(0.304)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$						
	0.751	–0.107	**1.328**	–0.517	0.725	1.417
	(0.124)	(0.104)	**(0.059)**	(0.210)		
$y=y^{HP}$; $\pi=\pi^{CPI}$						
	0.864	**–0.196**	**1.336**	–0.078	0.540	1.228
	(0.079)	**(0.067)**	**(0.061)**	(0.273)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$						
	0.873	**–0.198**	**1.369**	0.060	0.530	1.345
	(0.088)	**(0.074)**	**(0.098)**	(0.410)		

1/ The estimated parameters refer to equation (3). Estimates are obtained by GMM with Heteroskedastic and Autocorrelation Consistent covariance matrix, obtained by nonlinear three–stage least squares. The Bartlett kernel is used to weight the covariances in order to ensure the covariance matrix to be positive semidefinite. The Newey–West fixed bandwidth is used, so that the weights given by the kernel do not change with the autocorrelation in the data. The sample period is 1984Q1 to 2004Q2. The instruments set includes a constant, the log–difference of a world commodity price index, plus 4 lags of output gap, fourth differences in prices, interest rate, and log real effective exchange rate. The forward–looking horizon is one quarter for each target variable. J–test is the test for overidentifying restrictions (Hansen, 1982), which is distributed as a χ^2 under the null. For this test, only p–values are reported. HAC–consistent standard errors are given in parentheses.

Next, the parameters $\left\{\hat{\bar{\rho}}_1, \hat{\bar{\rho}}_2, \hat{\bar{\beta}}, \hat{\bar{\gamma}}, \hat{\delta}\right\}$ for the six countries in our sample are estimated using an augmented interest rate rule such as (4). The target horizon for the three forward–looking variables—inflation, output gap, and real exchange rate—is still assumed to be one (i.e., $k^{\pi} = k^{y} = k^{e} = 1$). The results of the GMM estimation are reported in Table 2, using alternative measures of inflation and output gap. In all countries except the United Kingdom, there is some evidence that—over the sample—real exchange rate movements have direct explanatory power in characterizing interest rate changes. In Norway and in Sweden, deviations from PPP play a role in explaining interest rate movements *only if* the monetary authority is believed to target *headline* rather than core inflation. Only in those economies that are commonly lumped together as the "commodity currencies" (e.g., Canada, Australia, and New Zealand), the real exchange rate yields significant (and correctly signed) parameter estimates, even when the central bank is assumed to stabilize core inflation. However, it is worth noticing that in countries where exports of non–oil commodities play a major role, exchange rate fluctuations are likely to reflect changes in the *equilibrium* exchange rate due to commodity prices shocks rather than deviations of the REER from equilibrium (Chen and Rogoff, 2003). Under these circumstances, monetary authorities are unlikely to smooth exchange rate volatility through changes in the interest rate (Clinton, 2001). Unfortunately, our empirical framework cannot distinguish between different sources of exchange rate fluctuations, as it implicitly assumes a time–invariant REER equilibrium.

Overall, the inclusion of exchange rate disequlibria do not seem to affect appreciably the model's interest rate predictions. To aid interpretation of the results, Figure 3 shows, for each country, the actual interest rate and its estimated value implied by the baseline standard forward–looking Taylor rule (Table 1) and by the preferred augmented interest rule specification allowing also for exchange rate responses (Table 2). The interest rates implied by the estimated rules characterize well the behavior of the actual rates. Indeed, both specifications of the reaction function satisfactorily trace the dynamics of the interest rates. The simple visual inspection of the models' predictions suggests that the contribution of real exchange rate disequilibria is not sufficient to distinguish between the two models. Interestingly, even for Australia and New Zealand—where deviations from PPP play a slightly greater role in explaining interest rate movement, given our preferences for measuring inflation and output gap—it is the standard Taylor rule to provide better fit over the latest quarters of the sample. This suggests that central banks have been recently inclined to ignore real exchange rate misalignments.

A more flexible approach to inflation targeting implies that central banks can decide to apply a somewhat longer period for bringing inflation back to target. The horizon for achieving the inflation target implicitly provides some indication of how much weight the central bank gives to stability in the real economy. Considerable emphasis on stability in the real economy—at the expenses of somewhat greater and more persistent deviations from the inflation target—implies a relatively longer horizon. A precondition for a longer monetary policy horizon is that financial market participants are confident that inflation will be low and stable over time. Indeed, financial market confidence in the inflation target provides central banks with greater scope for promoting stability in the real economy.

Table 2. Augmented Forward–Looking Taylor Rule

Norway	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.608	0.061	**1.760**	0.643	0.006	0.917	1.051
	(0.120)	(0.055)	**(0.205)**	(0.514)	(0.119)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.571	0.051	**1.718**	0.198	0.060	0.874	1.028
	(0.147)	(0.063)	**(0.266)**	(0.339)	(0.109)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.577	0.040	**1.716**	0.100	0.050	0.848	1.018
	(0.122)	(0.055)	**(0.214)**	(0.184)	(0.098)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.658	0.080	**1.714**	0.895	0.067	0.715	1.101
	(0.116)	(0.072)	**(0.250)**	(0.645)	(0.114)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.667	0.050	**1.435**	0.919	0.219	0.517	1.048
	(0.139)	(0.069)	**(0.301)**	(0.644)	(0.125)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.655	0.031	**1.533**	0.228	**0.173**	0.574	1.035
	(0.119)	(0.069)	**(0.202)**	(0.279)	**(0.084)**		

Sweden	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.839	**–0.067**	**1.668**	0.076	0.075	0.538	0.952
	(0.067)	**(0.019)**	**(0.267)**	(0.656)	(0.070)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.923	**–0.065**	**2.086**	1.371	–0.063	0.638	0.937
	(0.094)	**(0.025)**	**(0.564)**	(1.475)	(0.171)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.847	**–0.058**	**1.721**	0.412	0.075	0.591	0.945
	(0.064)	**(0.020)**	**(0.229)**	(0.391)	(0.053)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.914	**–0.097**	**1.202**	–0.018	0.117	0.663	0.926
	(0.050)	**(0.013)**	**(0.226)**	(0.729)	(0.076)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.962	**–0.081**	**1.424**	1.668	–0.009	0.705	0.914
	(0.061)	**(0.025)**	**(0.343)**	(1.417)	(0.134)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.892	**–0.082**	**1.165**	0.313	**0.109**	0.609	0.914
	(0.043)	**(0.015)**	**(0.159)**	(0.357)	**(0.045)**		

(continued)

Table 2. Augmented Forward–Looking Taylor Rule *(continued)*

United Kingdom	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.778	0.031	**1.760**	0.470	–0.016	0.489	0.989
	(0.121)	(0.083)	**(0.403)**	(1.315)	(0.072)		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.615	0.123	**1.829**	**1.502**	–0.015	0.561	0.966
	(0.108)	(0.067)	**(0.271)**	**(0.567)**	(0.035)		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.801	0.008	**1.740**	0.689	–0.010	0.515	0.993
	(0.128)	(0.083)	**(0.383)**	(0.974)	(0.062)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.608	**0.165**	**1.657**	–0.174	–0.033	0.630	0.874
	(0.094)	**(0.062)**	**(0.217)**	(0.682)	(0.044)		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.657	**0.180**	**1.443**	1.142	–0.032	0.791	0.908
	(0.097)	**(0.061)**	**(0.346)**	(1.118)	(0.037)		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.650	**0.140**	**1.655**	0.092	–0.022	0.634	0.886
	(0.117)	**(0.070)**	**(0.213)**	(0.737)	(0.045)		

Canada	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.730	0.012	**1.223**	**3.459**	**0.178**	0.805	1.121
	(0.104)	(0.074)	**(0.491)**	**(0.868)**	**(0.071)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.640	**0.133**	0.681	**2.141**	**0.180**	0.845	1.018
	(0.087)	**(0.053)**	(0.373)	**(0.502)**	**(0.040)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.835	0.126	5.339	8.744	0.023	0.648	1.013
	(0.094)	(0.074)	(6.752)	(13.724)	(0.390)		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.709	0.029	0.427	**3.825**	**0.254**	0.958	1.175
	(0.120)	(0.100)	(0.415)	**(1.076)**	**(0.065)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.666	0.118	–0.292	**2.257**	**0.251**	0.772	0.944
	(0.096)	(0.063)	(0.407)	**(0.422)**	**(0.047)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.785	0.145	2.835	5.621	0.049	0.579	0.993
	(0.106)	(0.077)	(1.600)	(4.212)	(0.134)		

(continued)

Table 2. Augmented Forward–Looking Taylor Rule *(concluded)*

Australia	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.902	**–0.149**	**1.054**	–0.381	**0.269**	0.570	0.948
	(0.069)	**(0.066)**	**(0.135)**	(0.322)	**(0.035)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.911	–0.120	**1.082**	0.307	**0.277**	0.485	0.902
	(0.072)	(0.072)	**(0.158)**	(0.381)	**(0.039)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.996	**–0.169**	**1.108**	0.980	**0.251**	0.749	0.913
	(0.083)	**(0.075)**	**(0.182)**	(0.545)	**(0.043)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.827	–0.099	**1.171**	–0.596	**0.242**	0.517	0.923
	(0.072)	(0.060)	**(0.129)**	(0.369)	**(0.032)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.880	–0.104	**1.231**	0.305	**0.261**	0.454	0.865
	(0.069)	(0.067)	**(0.157)**	(0.372)	**(0.036)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.951	**–0.142**	**1.287**	0.786	**0.245**	0.607	0.868
	(0.080)	**(0.070)**	**(0.173)**	(0.465)	**(0.038)**		
New Zealand	$\tilde{\rho}_1$	$\tilde{\rho}_2$	$\tilde{\beta}$	$\tilde{\gamma}$	δ	*j–test*	*see*
$y=y^{ARMC}$; $\pi=\pi^{CORE}$							
	0.855	**–0.214**	**1.434**	0.552	**0.150**	0.468	1.301
	(0.077)	**(0.078)**	**(0.100)**	(0.336)	**(0.047)**		
$y=y^{HP}$; $\pi=\pi^{CORE}$							
	0.819	**–0.219**	**1.341**	–0.187	**0.123**	0.430	1.265
	(0.086)	**(0.078)**	**(0.058)**	(0.242)	**(0.044)**		
$y=y^{DGAP}$; $\pi=\pi^{CORE}$							
	0.748	–0.149	**1.355**	–0.369	**0.102**	0.581	1.359
	(0.106)	(0.098)	**(0.060)**	(0.215)	**(0.046)**		
$y=y^{ARMC}$; $\pi=\pi^{CPI}$							
	0.902	**–0.224**	**1.475**	0.929	**0.158**	0.600	1.474
	(0.084)	**(0.078)**	**(0.110)**	(0.500)	**(0.054)**		
$y=y^{HP}$; $\pi=\pi^{CPI}$							
	0.833	**–0.225**	**1.343**	–0.124	**0.113**	0.390	1.251
	(0.091)	**(0.082)**	**(0.062)**	(0.274)	**(0.044)**		
$y=y^{DGAP}$; $\pi=\pi^{CPI}$							
	0.743	–0.142	**1.356**	–0.375	**0.097**	0.545	1.335
	(0.121)	(0.108)	**(0.063)**	(0.212)	**(0.044)**		

1/ The estimated parameters refer to equation (4). Estimates are obtained by GMM with Heteroskedastic and Autocorrelation Consistent covariance matrix, obtained by nonlinear three–stage least squares. The Bartlett kernel is used to weight the covariances in order to ensure the covariance matrix to be positive semidefinite. The Newey–West fixed bandwidth is used, so that the weights given by the kernel do not change with the autocorrelation in the data. The sample period is 1984Q1 to 2004Q2. The instruments set includes a constant, the log–difference of a world commodity price index, plus 4 lags of output gap, fourth differences in prices, interest rate, and log real effective exchange rate. The forward–looking horizon is one quarter for each target variable. J–test is the test for overidentifying restrictions (Hansen, 1982), which is distributed as a χ^2 under the null. For this test, only p–values are reported. HAC–consistent standard errors are given in parentheses.

Monetary authority's scope of maneuver tends to increase as the inflation target succeeds in providing an anchor for the formation of inflation expectations and, in particular, for the wage bargaining process. This creates a role for regular central bank communication to help markets filter macroeconomic news. However, in situations where there is a risk that inflation may deviate considerably from the target over a lengthy periods, or confidence in monetary policy is in jeopardy, a rapid and pronounced change in the interest rate may remain appropriate.

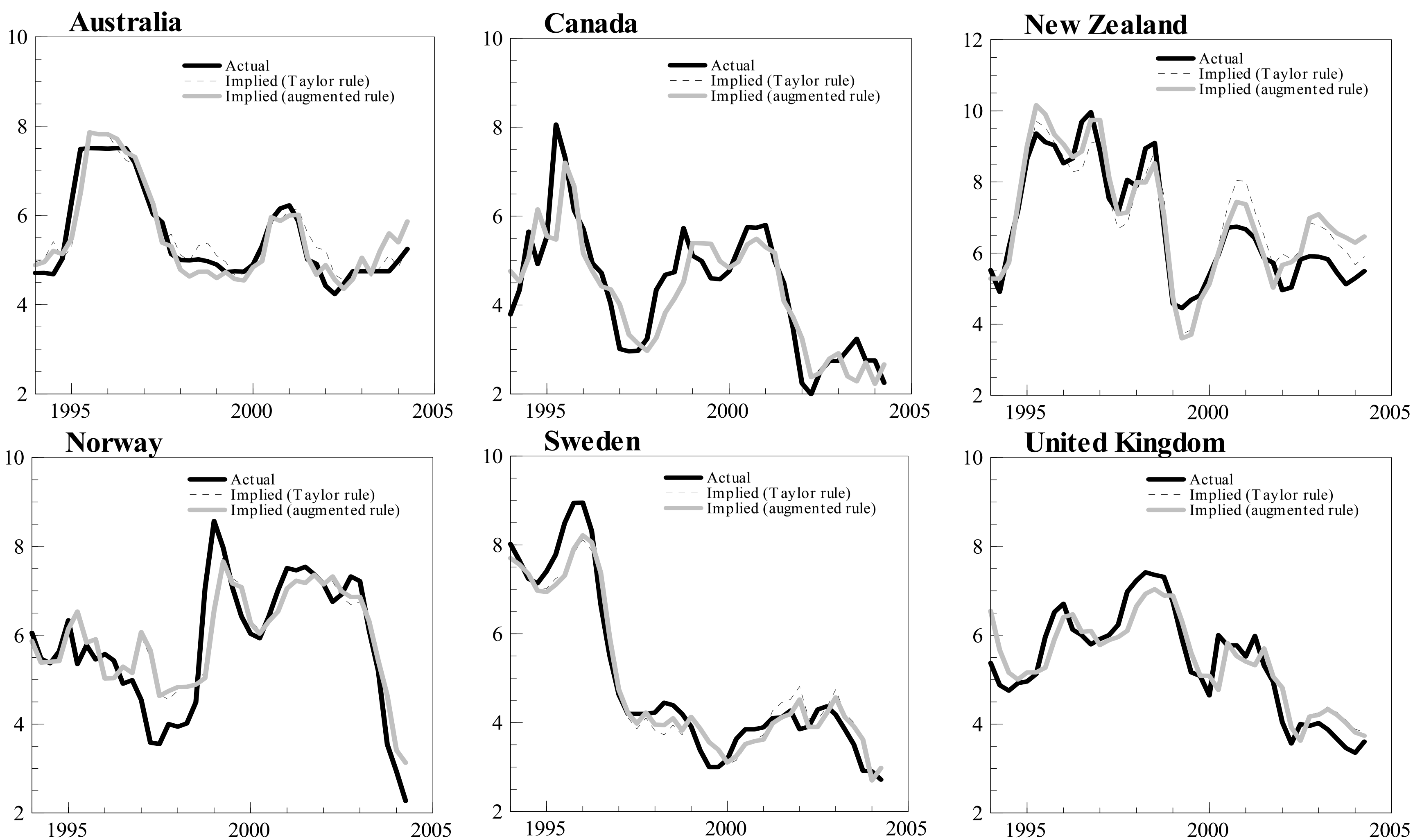
The results confirm the view that central banks tend to smooth the adjustment of interest rates over several quarters, thereby increasing the predictability of monetary policy conduct. However, the extent to which central banks rely on smoothing appears to differ across countries and over time. In particular, for Australia, Norway, and Sweden, the coefficient on the first lag appears to be close to one, while the second lag displays a significant corrective behavior, signaling more elongated and predictable interest rate movements in response to changes in the macroeconomic environment and, hence, a greater use of the expectation channel of monetary policy. Previous work in this area indicates that the strength of the expectation channel relates to the degree of forward–looking behavior in the rest of the economy, which—in turn—can be seen as the policymaker's reward for ensuring monetary stability.[19] Figure 4—plotting parameter estimates from rolling regressions over successive forty–quarter windows—shows that, in this respect, Norges Bank (and, to a lesser extent, the Swedish Riksbank) has enjoyed the greatest confidence gains over recent times, possibly in connection with its latest switch to a longer adjustment horizon. At the other end of the spectrum is New Zealand (and, to a lesser extent, Canada), for which the degree of smoothing seems to be lower.

Central banks' response to real exchange rate misalignments have varied over time. Indeed, the sample period 1984Q1–2004Q2 transcends several different monetary regimes for almost all countries in the sample. Rolling–window estimates of the exchange rate responses (Figure 5) suggest that, even if the level of the implied instrument rate is very similar to the one implied by the standard forward–looking Taylor rule, central banks in each of the six countries have effectively targeted the exchange rate at some point over the sample. Norway and Sweden, for example, have been concerned about exchange rate misalignments until the first half of the 1990s. Over the last decade, however, interest rate responses to deviations of exchange rates from target have become statistically insignificant. Conversely, for the United Kingdom, exchange rate disequilibria have been important in determining the interest rate target around the sterling devaluation of 1992 and during the protracted sterling appreciation of the mid– to late 1990s. As suggested below, the statistical significance of the central bank's reaction to exchange rate disequilibria may in fact reflect the *size* of the disequilibria themselves, rather than the formal monetary regime actually in place.[20]

[19] On this point, see also Bayoumi and Sgherri (2004a, 2004b).

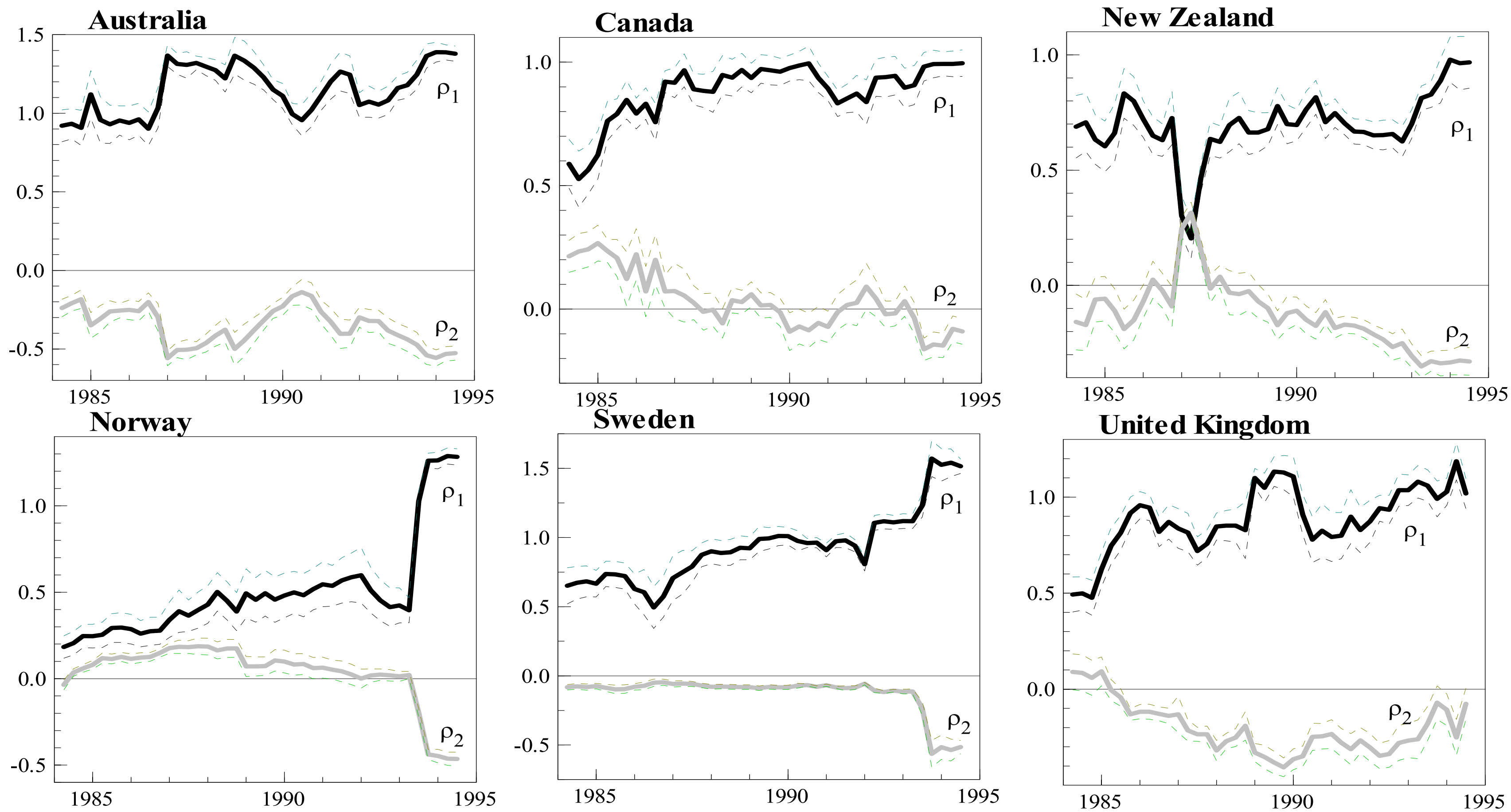
[20] A similar argument is suggested by Chadha, Sarno, and Valente (2004).

Figure 3. Interest Rate: Actual versus Implied (percent)



Source: *International Financial Statistics,* and IMF staff calculation.

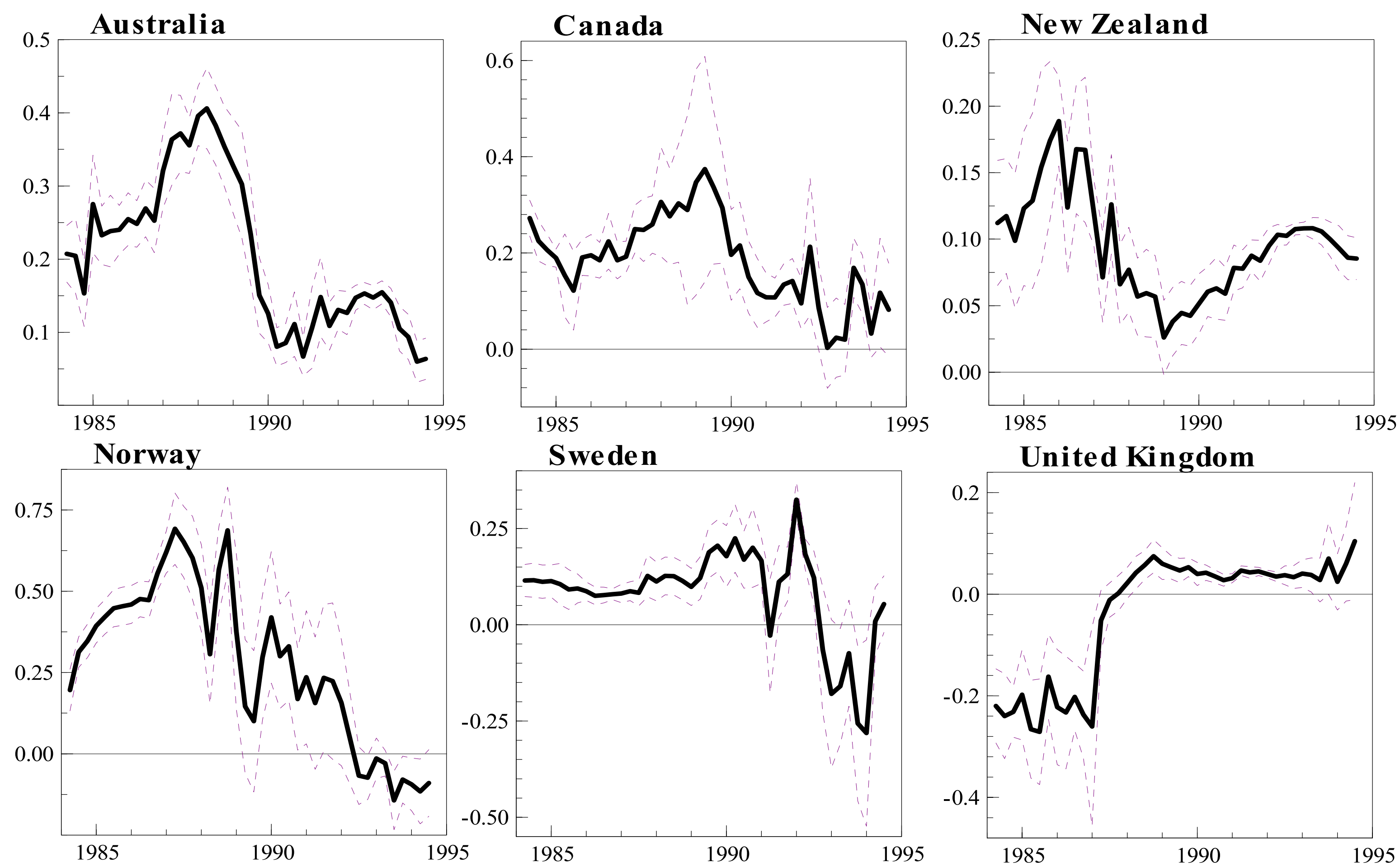
Figure 4. Interest Rate Smoothing[1]



Source: *International Financial Statistics,* and IMF staff calculation.

[1] Rolling GMM estimates over successive forty–quarter periods. Dates displayed on the horizontal axes indicate the initial period of the 10–year window.

Figure 5. Long–term Response to the Real Exchange Rate[1]



Source: *International Financial Statistics,* and IMF staff calculation

[1] Rolling GMM estimates over successive forty–quarter periods. Dates displayed on the horizontal axes indicate the initial period of the 10–year window.

IV. DISCUSSION

Inflation targeting is now a well established framework for the conduct of monetary policy. The experience of advanced open economies has been that the period of inflation targeting has delivered favorable economic outcomes. According to surveys, medium–term inflationary expectations in these countries remain well anchored, thereby contributing to stabilizing inflation around the target and amplifying the effects of monetary policy itself. Expectations concerning inflation and economic stability are indeed of crucial importance for both wage–price formation and the stability of the foreign exchange market.

Inflation targeting has evolved over time across a number of dimensions, notably the degree of flexibility and the approach to communication. The evidence seems to confirm that, across advanced open economies, the regime has recently become more flexible, allowing greater scope for inflation to vary around the target and, as a result, for broader macroeconomic goals to be taken into account. As central banks have started to smooth the adjustment of interest rates over a longer horizon, the predictability of monetary policy conduct has also increased. In addition, monetary authorities have gradually become more and more transparent, improving the scope of their communication and delivering it in more varied forms.

Although with some significant differences across countries, the paper finds that exchange rates are generally *not* key for systematic monetary responses in inflation–targeting, open economies. More precisely, if a country attempts to target core (rather than headline) inflation, the exchange rate does not seem to enter as a separate argument in interest rate rule. At the same time, however, exchange rates are found to be valuable inputs into the monetary policy decision–making process, as information variables.

As stressed by Taylor (2001), there may be two reasons why central banks' actions in open economies are better described by interest rate rules not entailing a direct response to the exchange rate. First, if the policy rule is based on (rational) expectations of future inflation and output, a short–run appreciation of the exchange rate at time t will be expected to translate into lower output and inflation in the future. As such, a policy rule like equation (3) will entail a decline in interest rates today, even though the exchange rate does not appear directly in the rule. Second, in some situations, changes in the real exchange rate might reflect changes in productivity that should not be offset by the monetary policy. As such, while fluctuations in the exchange rate may not have much consequences on inflation expectations—and thus have little impact on the interest rate through this channel—these movements may result in dangerous swings in interest rates if there were a strong direct reaction to them.

Finally, our findings may be consistent with the view that, while committed to a flexible inflation targeting regime, central banks may still act in response to exchange rates *on occasions* when there is a need to smooth out high volatility in foreign exchange markets that could destabilize domestic inflation. Indeed, to detect *unsystematic* interest rate responses to abrupt corrections in the exchange rate (or in any other asset price), a nonlinear framework of analysis could be more helpful than a standard linear framework like the one used in this paper.

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