The Stabilizing Properties of Floating Exchange Rates: Some International Evidence*

Anders Bergvall**

August 18, 2002

Abstract

This paper analyzes the stabilizing properties of alternative monetary policy regimes. In practice there is a choice between two broad types of monetary policy regimes: a fixed exchange rate regime or a floating exchange rate regime. In this paper I compare exchange rate targeting with different floating exchange rate regimes: strict price level targeting, flexible price level targeting and output gap targeting. The paper also evaluates the actual choice of monetary policy regime for seven countries with a pure floating exchange rate regime. In most cases the actual regime can be described as flexible price level targeting. The results suggest that flexible and strict price level targeting gives lower real and nominal variability than both exchange rate targeting and output gap targeting.

Keywords: Monetary policy, exchange rates, macroeconomic stability.

JEL Classification: E52, F31, F41.

---

*I am grateful to Annika Alexius, Nils Gottfries and seminar participants at Uppsala University for helpful discussions and useful comments. Financial support from the Jan Wallander and Tom Hedelius foundation is gratefully acknowledged.

**Department of Economic, Uppsala University Box 513, S-751 20 Uppsala, Sweden; email: Anders.Bergvall@nek.uu.se.

1. Introduction

In the last years, several countries have abandoned a fixed or managed exchange rate regime and instead shifted to a new monetary policy regime with a pure floating exchange rate. For most countries, this new regime is associated with the central bank's discretionary use of the interest rate in order to steer the economy directly toward price stability, in the sense of low and stable inflation. Such a framework, often referred to as inflation targeting, has been formally introduced in several countries. It was pioneered by New Zealand in 1990 and then followed by Canada in 1991, the United Kingdom, Sweden and Australia in 1993, Brazil in 1998, Chile and the Czech Republic in 1999, Poland, South Africa and Switzerland in 2000 and Norway and Iceland in 2001. In practice, it is generally accepted that these regimes are characterized by a flexible inflation target: the central bank tries to stabilize inflation, but also puts some weight on stabilizing other variables, such as output.

This leads to several interesting questions: What are the stabilizing properties of alternative monetary policy regimes? Would another monetary policy regime (e.g. exchange rate targeting or a strict price level targeting) imply a more or less stable macroeconomic environment? What type of monetary policy did countries with floating exchange rates choose; output stability, price stability or some type of intermediate target? Did countries like Canada and New Zealand put more weight on price stability after adopting an explicit inflation target?

In recent years, a growing literature has considered New Keynesian open-economy models of monetary policy (e.g. Ball (1999), Svensson (2000), Batini and Haldane (1999), Clarida, Gali and Gertler (1998), (2001)). However, most of these papers consider monetary policy under a floating exchange rate regime, and only a few compare exchange rate targeting with inflation targeting. A recent exception is Gali and Monacelli (2002), who present a small open economy model version of a model with staggered price-setting, and use this as a framework to study the properties of three alternative regimes: an optimal monetary policy, a Taylor rule and exchange rate targeting.

In this paper, I will analyze the stabilizing properties of alternative monetary policy regimes using a small, estimated open-economy model with forward-looking aggregate demand and supply, and with stylized realistic lags in the different

Table 1: Description of the countries

Country	Floating exchange rate since
Australia	1984
Canada	1970
Japan	1974
New Zealand	1985
Sweden	1993
Switzerland	1974
United Kingdom	1993

transmission channels for monetary policy. In practice, there is a choice between two broad types of monetary policy regimes: a fixed exchange rate regime and a floating exchange rate regime. This paper studies how output, prices and exchange rates would have evolved for seven countries (the countries I will consider are reported in Table 1) with a pure floating exchange rate regime, if the central bank had had a different target.[1] I will consider four alternative targets for the central bank: (1) exchange rate peg, (2) strict price level targeting, (3) flexible price level targeting and (4) output gap targeting. In contrast to most of the existing literature – which compares stability properties under different hypothetical monetary policy regimes – these counterfactual experiments allow us also to evaluate the actual monetary policy regime and not just to compare stability properties under different hypothetical monetary policy regimes.[2]

The results indicate that flexible price level targeting, or strict price level targeting, gives the most stable macroeconomic environment in terms of price, output and exchange rate variability. An output gap target regime gives a more volatile price level but also a more volatile nominal exchange rate, because there is a strong monetary policy response to different shocks. The results also indicate that a strict exchange rate target would have implied a more volatile output and higher price volatility for most

---

[1]For a detailed survey of the monetary policy and macroeconomic development for these countries (all except Japan) during their period of a floating exchange rate regime, see Bernanke, Laubach, Mishkin and Posen (1999).
[2]Similar types of counterfactual experiments in the case of a closed economy are discussed in Rotemberg and Woodford (1999) and Söderlind (2001).

countries. Somewhat surprisingly, a fixed exchange rate does not provide a more stable real exchange rate than a floating exchange rate regime. The reason is that a central bank that targets the nominal exchange rate responds less vigorously to domestic disturbances than it does under a floating exchange rate regime. The actual monetary policy seems to be best characterized as flexible price level targeting, but there seem to be quite substantial differences in the choice of monetary policy regimes between different countries. For example, Japan and Canada seem to put much less weight on stabilizing the price level than Sweden.

The paper proceeds as follows: In the next section, I will present a theoretical open-economy model. The empirical analysis begins in section 3, where I describe the data and estimate the model. In section 4, I describe the alternative monetary policy regimes and their performance is evaluated in section 5 by considering the effect of various regimes on the stability of output, prices, the real exchange rate and the nominal exchange rate. In section 6, I consider how the performance of the regimes may change with a more active fiscal policy and when monetary policy becomes more effective in affecting output. Finally, section 7 provides the conclusions.

2. Theoretical framework

I consider a small open economy model, similar to those of Batini and Haldane (1999) and Svensson (2000). The model is quarterly and all variables (except the interest rate) are measured in logs as deviations from the steady state. Aggregate demand for domestically produced goods in period t is given by:

$$y_t = \hat{b} q_{t-s} + t y_{t|t-s} - g \sum_{t=0}^{\infty} (r_{t+t-s|t-s} - \bar{r}) + \hbar_t . \tag{1}$$

Here, for any variable x, $x_{t|t-s}$ denotes the rational expectation of x_t, conditional on all information available at time t-s.[3] r_t is the short real interest rate and $\bar{r}$ the natural

[3]Equation (1) is derived with some micro foundations in appendix A

(long-run mean) short interest rate. Thus, the aggregate demand depends on the sum of current and expected future deviations of the real interest rate from its mean. There is a decision/planning horizon of s periods, so that the interest rate affects the economy with a lag of s periods. The variable q_t is the real exchange rate, defined as

$$q_t = e_t + p_t^* - p_t , \tag{2}$$

where e_t is the exchange rate, p_t^* the foreign price level and p_t the domestic CPI price level. The real exchange rate affects the economy with a lag of s periods, because the market shares in the international market adjust slowly to changes in relative prices (see e.g. Gottfries (2002)). $\hat{b}$ is a measure of how sensitive real output is to changes in the real exchange rate.

Parameter t captures the effect of fiscal policy stabilization. If fiscal policy were fully flexible, one could minimize a loss function and find the optimal fiscal policy rule. However, such flexibility in fiscal policy seems unrealistic, given fiscal policy decision lags, political negotiations etc. (see e.g. Alesina and Perotti (1995), Ohlsson and Vredin (1996)). I therefore adopt the following reaction function for government expenditure:

$$g_t = \hat{t} y_{t|t-s} + \hat{h}_t^g , \tag{3}$$

where g_t is government expenditure (measured as deviations from the steady state), and $\hat{h}_t^g$ is a vector of other variables influencing fiscal policy (e.g. elections and government ideology) that are assumed to be independent of the monetary policy regime. Parameter $\hat{t}$ is a measure of how sensitive government expenditure is to changes in the output gap. Fiscal policy is assumed to be the same under different monetary policy regimes. Equation (3) may be considered as an active fiscal policy, where fiscal policy responds to the level of activity (represented by the output gap). Alternatively, equation (3) may be considered as a representation of a passive fiscal policy with automatic stabilization, where $\hat{t}$ is the degree of automatic stabilization. t in equation (1) is equal to $n_2 \hat{t}$, where n_2 is the share of public demand in total aggregate demand.

The term $\hat{h}_t$ is a vector of exogenous variables, for example, changes in foreign output, fiscal policy and domestic preference shocks that are independent of the domestic monetary policy regime. Thus, $\hat{h}_t$ captures everything affecting the output gap, except influences from monetary policy and fiscal policy stabilization.

I assume that the uncovered interest parity condition (UIP) holds, which implies that the real interest parity condition

$$r_t - r_t^* = q_{t+1|t} - q_t \tag{4}$$

holds, where r_t^* is the foreign short real interest rate and $q_{t+1|t} - q_t$ the expected relative change in the real exchange rate. Note that q_t and the sum of the current and expected future deviations of the real interest rate are closely related. By equation (4), we have (assuming $\lim_{t\to\infty} q_{t+t|t} = 0$),

$$\sum_{t=0}^{\infty}(r_{t+t|t} - \bar{r}) = \left(\sum_{t=0}^{\infty}\left(r_{t+t|t}^* + q_{t+t+1|t} - q_{t+t|t} - \bar{r}\right)\right)$$

$$= \sum_{t=0}^{\infty}(r_{t+t|t}^* - \bar{r}) - q_t \,. \tag{5}$$

Hence, the only reason for the domestic sum of the current and expected future real interest rates to deviate from the foreign sum of the current and expected future real interest rates is that the real exchange rate deviates from the equilibrium level. Substituting in the new expression for the interest term (equation (5)) into the output equation, we get:

$$y_t = b(e_{t-s} + p_{t-s}^* - p_{t-s}) + t y_{t|t-s} + h_t \,, \tag{6}$$

where $h_t = \hat{h}_t - g\sum_{t=0}^{\infty}(r_{t+t-s|t-s}^* - \bar{r})$ and $b = \hat{b} + g$. Parameter b is a measure of how sensitive real output is to changes in the real exchange rate. Thus, the output gap consists of three parts: the real exchange rate q, government fiscal policy and the exogenous variable h_t, that is assumed to be independent of the monetary policy regime (due to the assumption of a "small open" economy, the foreign interest rate can be treated as exogenous to the domestic economy). h_t is assumed to follow a stationary autoregressive process

$$h_t = r_1 h_{t-1} + r_2 h_{t-2} + J_t \, , \tag{7}$$

where J_t is white noise. This specification of the exogenous variables is chosen for simplicity; obviously we would get the same results if the different exogenous variables were explicitly introduced. h_t is derived and discussed in further detail in appendix A.

Wages are set according to a standard wage equation (e.g. Blanchard and Katz (1999)), where the wage setters in sector j set the wage according to the following equation:

$$w_{jt} = dp_{t|t-k} + (1-d)w_{t|t-k} + \hat{b}y_{t+s|t-k} \, . \tag{8}$$

Here, for any variable x, $x_{t|t-k}$ denotes the wage setter's rational expectation of x_t, conditional on the information available when the wage (w_t) is set. p_t denotes the CPI price level and w_t the aggregate wage level. Wages in period t also depend on the expected output gap, thereby capturing tightness in the labor market. Wages in period t depend on the expected output gap in period t+s, since wages affect output with a lag of s periods, i.e. the wage level in period t affects output (unemployment) in period t+s. Hence, wage setters have a tradeoff between high wages in period t and low output (unemployment) in period t+s. All wage setters have the same information, so that aggregating over all wage setters implies that they set the wage (w_t) such that:

$$w_t = p_{t|t-k} + by_{t+s|t-k} + e_t \, , \tag{9}$$

where $b = \hat{b}/d$ and a zero-mean supply shock (cost-push shock), e_t, has been added. Assuming monopolistic competition in the domestic economy, domestic prices are set as a mark-up on wages (i.e. $P_t^d = W_t$ where P_t^d is the price of domestically produced goods). Then we get that the CPI price level is given by a weighted average the prices of imported goods and the wage level:

$$p_t = a \quad w_t + (1-a \quad)(p_t^* + e_t)\,, \tag{10}$$

where a is the elasticity of the CPI price level with respect to the domestic wage level[4]. That is, I assume that there is no lag in the pass-through of imported costs to domestic prices of imported goods. Substituting the wage equation into the CPI equation, the aggregated supply equation (Phillips curve) can be expressed in terms of CPI inflation:

$$p_t = p_{t|t-k} + b y_{t+s|t-k} + \left(\frac{1-a}{a}\right) q_t + \hat{e}_t\,, \tag{11}$$

where the CPI inflation is defined as $p_t = p_t - p_{t-1}$.[5] Thus, the CPI inflation depends on the expected CPI inflation, the future output gap, the real exchange rate (q_t) and the cost-push shock (e_t). According to equation (11), higher expected inflation, increased aggregated demand or a real exchange rate depreciation will imply higher inflation.

In this model, monetary policy affects the economy through several transmission channels. First, there is a conventional real interest rate channel, working through the output gap and then onto wages and prices. Second, a change in the interest rate also affects the exchange rate, which influences aggregate demand through the price of domestic goods in terms of foreign goods, thereby affecting wages and prices. A change in the exchange rate also has a direct effect on CPI inflation through the prices of imported goods and this is the fastest and most direct channel through which monetary policy affects inflation.

---

[4]The share of imported goods (1-a) in the CPI is exactly constant if the utility function over domestic and imported goods has a constant elasticity of substitution equal to unity (Cobb-Douglas utility function), as assumed in appendix A.

[5]$\hat{e}_t = e_t - (p_{t-1} - p_{t-1|t-k})$.

3. Estimation

In this section, I proceed by estimating the CPI price equation (10), the wage equation (9), the government demand equation (3) and the output equation (6) to get values of a, b, t and b. Before making these estimations, I need to assign the length of the wage setters' wage contract (k) and the consumers' decision lag (s). Wage contracts are typically valid for 1 to 3 years. In the baseline case, I assume that wage setters set the wage one year ahead and that the consumers' decision lag is two quarters, i.e. k = 4 and s = 2. Thus, wage setters can affect the price level with a four-quarter lag and output with a six-quarter lag. All variables in the estimated equations are treated as stationary variables, because before estimating equations (3),(6), (9) and (10), they are detrended with an HP-filter.

Quarterly data on the effective exchange rate (e), real GDP (y), domestic CPI prices (p), foreign CPI prices (p*), wages (hourly rates in manufacturing) and government expenditure (g) are collected from the OECD database Main Economic Indicators. For each country, the exchange rate index is constructed as a competition weighted sum of exchange rate series for ten OECD countries.[6] The foreign price index is constructed using the same methodology and trade weights as in the exchange rate index. All variables are log transformed and detrended using a Hodrick-Prescott filter with a standard smoothing coefficient of 1600. Appendix B provides more details on data sources and definitions for all variables.

The CPI price equation is estimated individually by an ordinary least square for each country to get a measure of the elasticity of the CPI price level, with respect to the domestic wage level (the value of a). Table 2 shows the estimated parameter values. As expected, small countries such as Canada, Sweden and Switzerland have a smaller a value than larger countries such as Japan, because the domestically produced share of GDP is much smaller for these countries. Australia and New Zealand have quite a high a value compared to the "European " countries, since the share of their GDP that consists of imports is quite small (around 20 percent).[7]

[6]For a survey of different definitions of the exchange rate index, see e.g. Lafrance, Osakwe and St-Amant (1998) and Nilsson (1999).

Table 2: Model estimates (t-values in parentheses)

Country	a	b	b	f
Australia	0.92 (40.59)	−0.07 (0.97)	0.11 (2.98)	−0.42 (2.28)
Canada	0.83 (34.39)	0.32 (2.83)	0.46 (3.32)	−0.78 (3.05)
Japan	0.96 (49.99)	0.70 (3.66)	0.22 (2.66)	−0.81 (2.91)
New Zealand	0.95 (33.42)	0.41 (2.09)	0.16 (1.44)	−0.16 (0.60)
Sweden	0.82 (20.71)	0.38 (2.95)	0.37 (3.21)	−0.35 (2.96)
Switzerland	0.72 (22.96)	0.37 (2.61)	0.50 (1.11)	−0.54 (2.92)
United Kingdom	0.97 (34.53)	0.60 (5.49)	0.15 (2.26)	−0.40 (2.44)

Note: The CPI price equation (equation (10)) is estimated with OLS to get a measure of a, the wage equation is estimated with GMM to get a measure of b and the output equation (equation (6)) and the government reaction function (equation (3)) are estimated as a system using GMM to get a value of f and b .

The econometric procedure for estimating the wage equation is relatively straightforward (see e.g. Clarida, Gali and Gertler (1998) for a more detailed description of this procedure). Let Ω_{t-k} denote a vector of variables observed at time t-k. Then, under rational expectations, equation (9) defines the set of orthogonality conditions

$$E[w_t - p_t - by_{t+s} \mid \Omega_{t-k}] = 0. \tag{12}$$

Given these conditions, we can estimate the model using the generalized method of moments (GMM). In this case, the GMM estimator can be seen as a generalization of 2SLS/3SLS that takes account of moving average errors and heteroscedasticity, conditional on the instruments. For each country, the vector of instruments, Ω_{t-k}, includes lagged values of output, domestic and foreign prices, exchange rates and wages. Table 2 shows the estimated parameter values. Overall, the empirical model works reasonably well in most cases. The slope coefficients on the output gap are positive, as implied by the theory for all countries except Australia.

[7]The share of imports of GDP: Australia 0.21, Canada 0.38, Japan 0.08, New Zealand 0.23, Sweden 0.35, Switzerland 0.35 and the United Kingdom 0.29.

The output equation (equation (6)) and the government reaction function (equation (3)) are estimated as a system using generalized method of moments (GMM) to get a measure of how sensitive government expenditure is to changes in the output gap (the value of f) and how sensitive real output is to changes in the real exchange rate (the value of b). Equations (3) and (6) are estimated as a system because the parameter f enters both equations. As discussed in section 2, the system will contain autoregressive (AR (2)) error specifications. I use instruments of output, domestic and foreign prices, exchange rates and wages, dated t-s or earlier. For each country, n_2 is calculated as the average share of public demand in total aggregate demand. According to table 2, the empirical model works reasonably well for all countries. Government expenditure is negatively correlated with aggregated demand and a real deprecation stimulates aggregate demand. The t-values suggest some imprecision in the point estimate of b , but coefficients are within the realm of reason and, as expected, small countries such as Canada, Sweden and Switzerland have a higher b value than larger countries such as Japan and the United Kingdom.

Using the detrended time series for domestic real GDP, the domestic CPI price level, the foreign price level and the exchange rate index, I calculate the actual path for h using equation (6) as:

$$h_t = y_t - b(e_{t-s} + p^*_{t-s} - p_{t-s}) - t y_{t|t-s} . \tag{13}$$

Thus, h is defined as the output gap purged from the effects of variations in the real exchange rate and fiscal policy stabilization. This implies that h captures everything affecting the output gap, except influences from monetary policy and systematic fiscal policy. The supply shock (cost-push shock) is analogously calculated as the residual from the wage equation:

$$e_t = w_t - (p_{t|t-k} + b y_{t+s|t-k}) . \tag{14}$$

Alternatively, I could have proceeded by assigning some values of the structural shocks (assigning variances in the disturbance terms in equations (6) and (9)). However, one advantage of using the residuals from the regression equation as a measure of structural shocks is that we can make counterfactual experiments and not just compare stability properties under different hypothetical regimes. Thus, this paper studies how the economies in Australia, Canada, Japan, New Zealand, Sweden, Switzerland and the UK would have performed if they had been subject to structural disturbances (h and e), whose properties are the same as those affecting them in the past while, at the same time, the monetary policy conducted by the central bank had been different.

Table 3 reports the standard deviations of the output gap, the real exchange rate, the exogenous variable h and the supply shock (e). Comparing the volatility of the output gap and the exogenous variable h, we note that the volatility of the output gap is smaller than that of h for all counties. Hence, the real exchange rate and the government's fiscal policy have had a stabilizing effect on the economy. Comparing the stability properties between different countries indicates that the volatility of the output gap seems to be quite similar across countries, ranging between 1.44 and 2.18, but there are quite substantial differences in the volatility of the real exchange rate.

Table 3: Volatility measures. Standard deviations in percent.

Country	y	h	e	q	*Sample*
Australia	1.44	1.73	1.58	6.34	1984:1-2000:2
Canada	1.51	1.81	1.43	3.33	1970:1-2000:2
Japan	1.52	3.85	2.13	8.57	1974:1-2000:2
New Zealand	2.18	2.52	2.09	6.39	1985:1-2000:2
Sweden	1.82	2.38	2.24	4.44	1993:1-2000:2
Switzerland	1.77	3.02	1.50	4.09	1974:1-2000:2
United Kingdom	1.63	3.83	1.94	5.53	1993:1-2000:2

4. Monetary policy regimes

The short nominal interest rate (i) is the instrument of the central bank. When the central bank sets the interest rate, it directly affects the exchange rate, due to the interest parity condition. Therefore, we can treat the exchange rate as the control variable of the central bank. I assume that the central bank sets i_t to minimize the following intertemporal loss function:

$$\sum_{t=0}^{\infty} d^{t} L_{t|t-m} , \qquad (15)$$

where d is the discount factor and L_t (the period t loss) is a function of the target variables.[8] The central bank minimizes the loss function, given its information in period t-m, where the size of m depends on the central bank's information/implementation lag. I set the information lag to two quarters, i.e. m = 2. This implies that the central bank can affect output with a one-year lag, and the CPI price level with a two-quarter lag. Usually, its main goal is to maintain price stability and without prejudice, this goal the central bank should try to support the general economic policy to reach goals such as high sustainable growth and full employment. For this purpose, the central bank usually has targets (operational goals) such as an inflation/price level target, a zero output gap target or a fixed exchange rate target. To describe the behavior of the central bank, I consider the following loss function:

$$L_t = \frac{l_y}{2}(y_t)^2 + \frac{l_p}{2}(p_t - p_t^n)^2 + \frac{l_e}{2}(e_t - e_t^*)^2 , \qquad (16)$$

where p^n is the CPI price level target and e^* is the nominal exchange rate target (e.g. a basket of foreign exchange rates).[9] In practice, there is a choice between two broad types of monetary policy regimes: a fixed or a floating exchange rate regime. In the first case, there is a continuum of variants, ranging from a strict exchange rate target (adopting the currency of another country or groups of countries) to more flexible variants of exchange rate targeting. In the second case of monetary policy regimes, there is also a continuum of variants, ranging from a strict price level target/strict inflation target to a strict output gap target.

In this paper, I consider one fixed and three floating exchange rate regimes. I evaluate the performance under a strict exchange rate target regime, where the domestic currency is fixed in terms of a competition-weighted basket of currencies.[10] I also

---

[8] I set the discount factor d equal to 0.99

[9] Since the central bank's output target is equal to natural output, there will be no average price level bias. Hence, the average price level will coincide with the price level target.

evaluate the performance under the following three floating exchange rate regimes: strict price level targeting (inflation nutter), strict output gap targeting and flexible price level targeting (intermediate targeting). More precisely, I consider the following four regimes:

- Strict exchange rate targeting: $l_y = 0,\ l_p = 0,\ l_e = 1$
- Output gap targeting: $l_y = 1,\ l_p = 0,\ l_e = 0$
- Flexible price level targeting: $l_y = 1,\ l_p = 1,\ l_e = 0$
- Strict price level targeting: $l_y = 0,\ l_p = 1,\ l_e = 0$

Under the floating exchange rate regimes, the central bank sets the interest rate so as to reach price or output stability (a combination of these two under the intermediate target). Substituting equations for output, CPI prices and the wage equation into the loss function and solving the central bank's problem, we get the following optimal reaction function (under a floating exchange rate regime) for the nominal exchange rate:

$$e_t = p_t^n - p_{t|t-m}^* - a_1 h_{t+s|t-m} - a_2 h_{t+s|t-k} - a_3 h_{t+s|t-s} - a_4 e_t\ , \qquad (17)$$

where a_1, a_2, a_3 and a_4 are complicated functions of $l_y, l_p, a\ , b, b, t$ and d.[11] A formal treatment of the optimization procedure is given in appendix C. According to equation (17), it is optimal to respond to the expected determinants of the targets, rather than the targets themselves.[12] The coefficients in the reaction function (the numerical values of a_1, a_2, a_3 and a_4) are summarized for the three different regimes in appendix D. *First*, the central bank responds directly to the price level target (p^n) and the

---

[10]The fixed exchange rate regime should not be interpreted as joining a monetary union, since a monetary union is likely to have other more fundamental effects than those reflected in my analysis. It can be argued that the main reasons for joining a monetary union are of microeconomic origin, i.e. the reduction of trade barriers. These changes would most likely affect the economic structure and hence, the shocks.

[11] The optimal reaction function can also be written in terms of the short nominal interest rate:

$$i_t = i_t^* + p_{t+1}^n - p_{t+1|t}^* - a_1 \Delta h_{t+s+1|t-m} - a_2 \Delta h_{t+s+1|t-k} - a_3 \Delta h_{t+s+1|t-s} - a_4 \Delta e_{t+1}\ ,$$

where p^n is the domestic CPI inflation target, p^* foreign inflation and $i*$ the foreign nominal interest rate.

[12]This is usually the case under targeting rules (see e.g. Svensson (1999)).

expected foreign price level (p^*), because in the long run, this will imply that the real exchange rate is stable and that the foreign price level measured in domestic currency is equal to the price level target. *Second*, it responds to the expected demand shocks ($h_{t+s|t-m}$), in such a way that the exchange rate is expected to neutralize those shocks. The reaction function coefficient for the expected demand shocks (a_1) is, as expected, smallest in the case of a strict price level target regime and largest in the case of an output target regime (see appendix D). *Third*, the central bank also takes into account wage setters' and government expectations of demand shocks, because the wage level will have a direct effect on the CPI price level and an indirect effect on the output level through the real exchange rate channel and the government's fiscal policy will have a direct effect on output. Under a strict price level target regime, the central bank reacts to the wage setter's expectations of the demand shocks and not to his own expectations of the demand shock, because the wage setter's expectations of the demand shock will directly affect the CPI-price level (see equation (9)). *Fourth*, the central bank's reaction to supply shocks (e_t) depends on the target, since there is a trade off between price and output stability. For example, consider a positive supply shock. In this case, there is a tradeoff between price and output stability, because if the central bank tries to stabilize the price level by appreciating the exchange rate this will, at the same time, imply a negative effect on output. These conclusions are also confirmed by appendix D, because a_4 is largest (i.e. stabilizes the price level from the supply shock) in the case of a strict price level target and negative in the case of an output gap target regime (i.e. a positive supply shock implies an increased price level; thus to keep the real exchange rate constant, the central bank must devaluate the currency).

Alternatively, the reaction function can be expressed as a function of expected output, prices and the real exchange rate

$$e_t = p_t^n - p^*_{t|t-m} + b_1 y_{t+s|t-m} + b_2 y_{t+s|t-k} + b_3 y_{t+s|t-s} + b_4 q_{t|t-m} + b_5 q_{t|t-k} + b_6 q_{t|t-s}$$

$$b_6 (p_{t|t-m} - p_{t|t-k}) + b_7 (p_{t|t-m} - p_{t|t-s}) , \qquad (18)$$

where $b_1, b_2, b_3, b_4, b_5, b_6$ and b_7 are also complicated functions of l_y, l_p, a, b, b, t and d. According to (18), the central bank responds to its own expectations of the output gap, prices and the real exchange rate, but it also takes into account the wage setters' and the public sector's expectations of these variables.

In the case of strict exchange rate targeting, the reaction function is simplified to

$$e_t = e_t^*, \tag{19}$$

for in this case, the only task for the central bank is to keep the exchange rate fixed. The hypothetical paths for output, real exchange rate and prices under the different regimes are calculated by plugging the reaction function of the exchange rate into these equations. This implies that the new expressions for output, CPI prices etc. will be functions of variables that all are exogenous to the monetary policy regime. For example, as shown in appendix C, the output gap is a function of $y_t^n, p_t^*, p_{t|t-m}^*, h_t, h_{t|t-m}, h_{t|t-s}, h_{t|t-k}, e_t$ and parameters l_y, l_p, a, b, b, t and d under a floating exchange rate regime. Using the actual path for h and e, the central bank's, the wage setter's and the government's forecasts for h and the parameters defined in Table 2, we have all the information necessary to calculate new hypothetical paths for output, prices and exchange rates under different monetary policy regimes.[13]

5. Macroeconomic stability of alternative monetary policy regimes

It has become quite customary to consider welfare implications by the use of a loss function, where only inflation and output enter as arguments. There are, however, disadvantages with that approach, because other variables might enter the true welfare function. For example, it may be argued that, in small open economies, real and nominal exchange rate variability has a direct effect on welfare, due to the role of the exchange

[13]The central bank, the government and wage setters form their expectations of h and p^* according to the following forecast functions (see e.g. Enders (1995)): $x_{t|t-f} = a^1 x_{t-f} + a^2 x_{t-f-1}$, for x equal to h or p^*.

rate in international trade and financial stability. Therefore, any measure of the performance of the alternative monetary policy regimes in terms of a single welfare criterion would be quite arbitrary. For this reason, I have chosen to compare the regimes separately in terms of the variability of each variable. Standard deviations in output, prices, the real exchange rate and the nominal exchange rate under the alternative regimes are summarized in Table 4 and in Figure 1.

I first discuss the general tradeoffs facing the central bank in a floating exchange rate regime and then, I examine the actual exchange rate regime. For most countries, this can be described as an intermediate regime between inflation targeting and output targeting. Then, I consider a fixed exchange rate regime, comparing it both to hypothetical floating and the actual regime. In general, exchange rate targeting leads to increased output and price volatility.

5.1 Tradeoffs under a floating exchange rate regime

What tradeoffs does the central bank face under a floating exchange rate? According to Table 4 and the efficiency frontier in Figure 1, a strict price level target implies much lower price volatility but only somewhat higher output volatility as compared to the intermediate and the output gap target regimes for all countries. For all countries, the real exchange rate is more stable under strict price level targeting than under intermediate and output gap targeting. In most cases, the nominal exchange rate is more stable under strict price level targeting than under the other regimes.

The real exchange rate and the nominal exchange rate are more stable under a strict price level target, than under the other regimes since the central bank does not respond to all shocks and its response to different shocks is moderate (see appendix D for the reaction-function coefficients under the different regimes). The central bank only responds to supply shocks and the wage setter's expectations of the demand shock, because the direct effect of the demand shock will not affect the price level, only the wage setter's expectations of the demand shock will affect the price level. The central bank's response to supply shocks is more moderate under a strict price level target than under an output gap target regime, because the real exchange rate channel will help neutralize the supply shocks under a price level target regime. For example, a supply

Table 4: Stabilization properties. Standard deviations in percent.

	Australia	Canada	Japan	New Zealand	Sweden	Switzer-land	United Kingdom
Strict exchange rate targeting							
CPI	5.10	2.29	2.99	3.64	6.29	2.44	1.50
Output	2.13	1.57	1.48	2.68	1.89	1.65	2.21
Real exchange rate	6.17	1.86	15.05	4.46	6.02	2.98	5.43
Exchange rate	0	0	0	0	0	0	0
Strict price level targeting							
CPI	0.27	0.16	0.12	0.55	0.34	0.16	0.20
Output	1.57	1.55	1.60	3.01	1.84	1.92	1.97
Real exchange rate	5.51	1.44	7.89	4.28	4.94	2.57	3.35
Exchange rate	5.07	2.71	5.25	3.61	5.14	3.24	1.56
Flexible price level targeting							
CPI	1.59	0.70	0.30	1.78	2.93	1.04	0.43
Output	1.19	1.48	1.46	2.23	1.42	1.37	1.66
Real exchange rate	6.49	1.54	8.16	5.54	4.96	3.00	3.44
Exchange rate	6.09	3.38	5.10	5.87	2.97	2.77	1.76
Output gap targeting							
CPI	12.81	6.34	2.44	5.53	12.57	9.65	3.27
Output	1.10	1.41	1.31	1.65	1.28	1.21	1.44
Real exchange rate	7.26	1.96	9.44	5.61	5.24	4.19	4.25
Exchange rate	15.36	7.61	8.01	9.12	7.89	13.08	4.59
Actual							
CPI	1.37	1.41	2.14	2.18	1.32	1.52	0.60
Output	1.44	1.51	1.52	2.38	1.82	1.77	1.63
Real exchange rate	6.34	3.33	8.57	6.39	4.44	4.09	5.53
Exchange rate	6.91	3.22	8.55	5.56	4.43	3.96	5.21

shock that increases the price level automatically leads to a real exchange rate appreciation (for a constant nominal exchange rate). According to equation (11), a real exchange rate appreciation will dampen the effects of a supply shock. Thus, under a strict price level target, we only have to appreciate the nominal exchange rate somewhat to reach price stability.

An output gap target implies a more stable output pattern, but at the cost of substantially higher price and real and nominal exchange rate volatility, compared to the intermediate and strict price level target regimes for all countries. Thus, there seems to be quite high a "price" to pay in terms of higher price and exchange rate volatility to reach a more stable output pattern. Real and nominal exchange rates are more volatile under an output gap target regime, because there is a strong monetary policy response to different shocks (see appendix D). The central bank tries to set the exchange rate such that the covariance between the real exchange rate and the demand shock is equal to minus one. Comparing the stability properties of the three different floating exchange rate regimes in Table 4 and the efficiency frontiers in Figure 1, we see that flexible price level targeting, or perhaps strict price level targeting, creates the most stable macroeconomic environment.

5.2 The actual monetary policy

Comparing the standard deviation for output and the CPI in Table 4 and Figure 1, we can see that the actual monetary policy, for all countries, seems to be somewhere in between the strict price level target regime and the output gap target regime. Hence, the actual policy seems to best be characterized as an intermediate or a flexible price targeting. But there seem to be quite substantial differences in the choice of monetary policy regimes between different countries. For example, Japan and Canada seem to put much less weight on stabilizing the price level than Sweden. These conclusions are also confirmed by calculating the value of l_p, such that the standard deviation of the actual CPI is equal to the standard deviation of the hypothetical CPI (in the case when $l_y = 1$ and $l_e = 0$). According to Table 5, flexible price level targeting can characterize the monetary policy in Australia, Canada, New Zealand, Sweden, Switzerland and the United Kingdom and output gap targeting can almost characterize the monetary policy in Japan.

Table 5: The ”actual “ value of l_p

Country	l_p
Australia	1.37
Canada	0.71
Japan	0.17
New Zealand	0.89
Sweden	2.02
Switzerland	0.79
United Kingdom	0.93

5.3 A fixed exchange rate regime

A strict exchange rate target would have implied a more volatile price level pattern for all countries, compared to strict price level targeting and flexible price level targeting. If we instead compare the fixed exchange rate regime with output gap targeting, we can see that exchange rate targeting would have implied a more stable price level pattern than under output gap targeting. Thus, in most cases, exchange rate targeting would have implied a more volatile price level pattern. Observe that comparing the stability of the price level and not inflation stability, implies a fairer comparison between the different regimes because exchange rate targeting may be considered as an implicit long-run price level target, where the domestic price level must have a constant relation to the foreign price level over time in order to achieve consistency between the equilibrium real exchange rate and the nominal exchange rate target.

Comparing output volatility under fixed and floating exchange rate regimes, we see that a fixed regime would have implied a more volatile output pattern in most cases. More exactly, output is more volatile under the fixed regime than under output gap targeting and flexible price level targeting, and about the same as under strict price level targeting. Australia, Canada, Sweden and the UK have somewhat lower output volatility under a strict price level target regime and Japan, New Zealand and Switzerland have somewhat higher output volatility under a strict price level target regime compared with the fixed exchange rate regime. There is no clear pattern for the real exchange rate; three countries out of seven have a more stable real exchange rate pattern under the fixed regime than under flexible price level targeting. Thus, exchange rate targeting has the same type of properties as output targeting: Low volatility in one variable (nominal exchange rate or output) implies higher volatility in other variables.

We can also compare the actual monetary policy regime to a hypothetical fixed exchange rate regime. A strict exchange rate target would have implied a more volatile price and output for most countries compared to the actual regime, except for Switzerland and Japan where the actual output is somewhat more volatile than under exchange rate targeting. Somewhat surprisingly, a fixed exchange rate regime does not provide a more stable real exchange rate for all countries. The reason for this is that a central bank targeting the nominal exchange rate responds less vigorously to domestic disturbances than it does under a floating exchange rate regime (the domestic interest rate must follow the foreign interest rate). For example, increased domestic prices (increased wages), due e.g., to a positive cost-push shock lead to a real exchange rate appreciation, since the nominal exchange rate is constant. Eventually, the dampening effect of the real appreciation more than offsets the initial effect of the cost-push shock, and inflation will start to decrease. Lower inflation implies a real exchange rate depreciation, so the cycle will turn again. Although a shock will generate such oscillations in the key variables, the estimated coefficients in the model ensure stability, so that the oscillations diminish. Thus, a strict exchange rate target would have implied a more stable real exchange rate for most countries, but at the cost of higher output volatility and higher price volatility for most countries.

5.4 Monetary policy before and after an explicit inflation target

In the last years, several countries such as New Zealand, Australia and Canada have shifted to a new monetary policy regime characterized by an explicit inflation target. Calculating the value of l_p, such that the standard deviation of the actual CPI is equal to the standard deviation of the hypothetical CPI (in the case when $l_y = 1$ and $l_e = 0$) before and after they shifted to an inflation target regime, we get an indicator of whether these countries put more weight on price stability after adopting an explicit inflation target. According to Table 6, Australia and Canada do so and New Zealand puts about the same weight on price stability after shifting to an inflation target.[14] Hence, the central bank seems to put more weight on price/inflation stability also in practice after shifting to a new monetary policy regime characterized by an explicit inflation target.

Table 6: The value of l_p before and after an explicit inflation target

Country	l_p	Period	l_p	Period
Australia	1.37	1985:1-2000:2	2.49	1993:1-2000:2
Canada	0.71	1971:1-2000:2	1.09	1991:1-2000:2
New Zealand	0.89	1986:1-2000:2	0.82	1990:1-2000:2

6. Sensitivity analysis

6.1 Fiscal policy and macroeconomic stability

The political and academic support for an activist fiscal policy has declined considerably in the last few decades. Experience shows that using fiscal policy to manage aggregate demand tends to lead to excessive government debt, which limits the room for manoeuvre in fiscal policy over time. However, an active fiscal policy responding to the level of activity is particularly beneficial when monetary policy is oriented toward exchange rate targeting, or strict price level targeting. It may therefore be argued that comparisons between these regimes and flexible price level targeting do not do justice to exchange rate or strict price level targeting, if the degree of fiscal policy stabilization is assumed to be the same. Hence, t might be higher under strict price level targeting or exchange rate targeting than under a flexible price level-targeting regime. Moreover, by considering strict price level targeting and a more active fiscal policy, we can analyze whether fiscal policy is a substitute for monetary policy with respect to the stabilization of aggregate demand, so that the central bank can focus solely on controlling the price level.

Table 7 shows the effects of a more active fiscal policy on the standard deviations of the variables in the model. I consider the case where $t = -2$ (i.e. a high degree of fiscal policy stabilization) for all countries instead of the estimated value reported in Table 2. According to Table 7, a more counter-cycle fiscal policy reduces the variability

[14] Australia: the period with an inflation target reduces CPI and output volatility. Canada: the period with an inflation target reduces CPI and increases output volatility. New Zealand: the period with an inflation target reduces CPI and output volatility.

Table 7: An active fiscal policy ($f = -2$). Standard deviations in percent.

	Australia	Canada	Japan	New Zealand	Sweden	Switzer-land	United Kingdom
Strict exchange rate targeting							
CPI	3.67 (5.10)	2.03 (2.29)	2.13 (2.99)	2.95 (3.64)	5.15 (6.29)	2.26 (2.44)	0.90 (1.50)
Output	1.59 (2.13)	1.50 (1.57)	1.39 (1.48)	2.03 (2.68)	1.30 (1.89)	1.41 (1.65)	1.54 (2.21)
Real exchange rate	5.57 (6.17)	1.76 (1.86)	12.34 (15.05)	4.05 (4.46)	5.71 (6.02)	2.80 (2.98)	5.02 (5.43)
Exchange rate	0	0	0	0	0	0	0
Strict price level targeting							
CPI	0.27 (0.27)	0.16 (0.16)	0.12 (0.12)	0.55 (0.55)	0.34 (0.34)	0.16 (0.16)	0.20 (0.20)
Output	1.19 (1.57)	1.49 (1.55)	1.44 (1.60)	1.81 (3.01)	1.38 (1.84)	1.34 (1.92)	1.71 (1.97)
Real exchange rate	4.83 (5.51)	1.28 (1.44)	6.39 (7.89)	3.38 (4.28)	4.10 (4.94)	2.08 (2.57)	2.26 (3.35)
Exchange rate	3.98 (5.07)	2.54 (2.71)	4.16 (5.25)	3.53 (3.61)	4.26 (5.14)	2.92 (3.24)	1.43 (1.56)

Note: Stabilization properties under modest fiscal policy stabilization given in parentheses (i.e. the same as reported in Table 4).

of output considerably both under a strict price level targeting and an exchange rate targeting regime. More precisely, strict price level targeting or exchange rate targeting with a high degree of fiscal policy stabilization generates about the same output variability as a flexible price level targeting regime with a more modest degree of fiscal stabilization. This suggests that a more active fiscal policy responding to the output gap produces a considerable improvement in the price-output variability tradeoff. Turing this result around, this suggests that a more active fiscal policy makes it possible for the central bank to focus more on price stability under a floating exchange rate regime, without sacrificing stability in the real economy.

Furthermore, it is interesting to note that a more active fiscal policy also reduces the variability of the nominal and the real exchange rate with strict price level targeting and the variability of the real exchange rate and prices with exchange rate targeting. The reason for that lies in the effect that wage setters respond to the level of activity in the economy (equation (9)), i.e. a more stable aggregate demand will also imply a more stable wage level and hence, a more stable price level.

6.2 How sensitive is output to changes in the real exchange rate?

In section 3, the output equation and the government reaction function were estimated as a system using a generalized method of moments to get a measure of how sensitive government expenditure is to changes in the output gap (the value of f) and how sensitive real output is to changes in the real exchange rate (the value of b). The point estimates of b (see table 2) seem to be within the realm of reason and, as expected, small countries such as Canada, Sweden and Switzerland have a higher b value than larger countries such as Japan and the United Kingdom, but the t-values suggest some imprecision in the point estimate. Moreover, there might be a simultaneity problem in estimating the output equation, i.e. the real exchange rate and the demand shock might be correlated. Hence, the true value of b might be higher than its estimated value.

Table 1.E in Appendix E shows the macroeconomic stability of alternative monetary policy regimes when output is more sensitive to changes in the real exchange rate. For all countries, I consider the case where b is fifty percent higher than the estimated value reported in Table 2. According to Table 1.E, a higher value of b reduces the variability of the real exchange rate and prices with exchange rate targeting. The reason for that lies in the effect that the wage setters respond to the level of activity in the economy (equation (9)), i.e. a higher b implies that wage setters only have to change their wages somewhat to reach a more stable aggregate demand.

According to table 1.E, we can also see that the macroeconomic stability under flexible price level targeting and strict price level targeting is quite insensitive to changes in b , but a higher value of b reduces the variability of the real exchange rate, the nominal exchange rate and prices with output gap targeting. The reason for that is that when monetary policy becomes more effective in affecting output (b becomes higher), the central bank does not have to change the nominal exchange rate so much to reach output stability, still prices and exchange rates are substantially more volatile with output gap targeting than with strict or flexible price level targeting. This suggests that when monetary policy becomes more effective in affecting demand (b becomes higher), it is possible for the central bank regime to focus more on output stability under a floating exchange rate, without sacrificing stability in prices and exchange rates.

7. Conclusions

This paper has analyzed the stabilizing properties of alternative monetary policy regimes using a small, estimated open-economy model with forward-looking aggregate demand and supply, and with stylized realistic lags in the different transmission channels for monetary policy. In practice, there is a choice between two broad types of monetary policy regimes: a fixed exchange rate regime and a floating exchange rate regime. This paper studies how output, prices and exchange rates would have evolved for some countries (Australia, Canada, Japan, New Zealand, Sweden, Switzerland and the United Kingdom) with a pure floating exchange rate regime, if the central bank had had a different target. I consider four alternative targets for the central bank: (1) exchange rate peg, (2) strict price level targeting, (3) flexible price level targeting and (4) output gap targeting.

Comparing the alternative regimes within the same numerical model makes the results subject to the Lucas' critique. However, in each simulated policy regime, agents are assumed to form expectations consistent with that regime. Furthermore, the parameters in the theoretical model are such that they can reasonably be assumed to be independent of the policy regime. In this sense, the analysis is not subject to the Lucas critique.

The results indicate that flexible or strict price level targeting yields the most stable macroeconomic environment in terms of price, output, real exchange rate and nominal exchange rate variability. An output gap target regime gives a more volatile price level but also a more volatile nominal exchange rate, since there is a strong monetary policy response to different shocks. The results also indicate that a strict exchange rate target would have implied more volatile output and higher price volatility for most countries. Somewhat surprisingly, a fixed exchange rate does not imply a more stable real exchange rate than a floating exchange rate regime. The reason is that a central bank targeting the nominal exchange rate responds less vigorously to domestic disturbances than it does under a floating exchange rate regime.

A more active counter-cyclical fiscal policy reduces both nominal and real variability under both exchange rate targeting and price level targeting. Thus, a more active fiscal policy makes it possible for the central bank regime to focus more on price stability under a floating exchange rate, without sacrificing stability in the real economy. The results also indicate that the actual monetary policy, for most countries, seems to be characterized by a flexible price level target, but there seem to be quite substantial differences in the choice of monetary policy regimes. For example, Japan seems to put much less weight on stabilizing the price level than Sweden and Australia.

References

Alesina, A and Perotti, R. (1995), Fiscal expansions and adjustments in OECD countries, *Economic Policy 21, 207-247.*

Ball, L. (1999), Policy Rules for Open Economies, in Taylor (ed.), *Monetary Policy Rules*, Chicago University press.

Batini, N and Haldane, G. (1999), Forward-Looking Rules for Monetary Policy, in Taylor (ed.), *Monetary Policy Rules*, Chicago University press.

Bernanke, B, Laubach, T, Mishkin, F and Posen, A. (1999), Inflation Targeting, Princeton University Press.

Blanchard, O.J and Katz, L. (1999), Wage Dynamics: Reconciling Theory and Evidence, NBER Working paper 1999:6924.

Clarida, R, Gali, J and Gertler, M (1998), Monetary policy rules in practice some international evidence, *European Economic Review 42, 1033-1067.*

Clarida, R, Gali, J and Gertler, M (2001), Optimal Monetary Policy in Closed vs Open Economics: An Integrated Approach, *American Economic Review 91, 248-252.*

Enders, W. (1995), Applied econometric time series, Jones Wiley& Sons, INC.

Gali, J and Monacelli, T. (2002), Optimal Monetary Policy and Exchange Rate Volatility in a Small Open Economy, manuscript March 2002.

Gottfries, N. (2002), Market Shares, Financial Constraints, and Pricing Behavior in the Export Market, forthcoming in *Economica*.

Lafrance, R, Osakwe, P and St-Amant, P. (1998), Evaluating Alternative Measures of the Real Effective Exchange Rate, Working paper 98-20, Bank of Canada.

Leitemo, K. (2000), The Performance of Inflation Forecast Feedback Rules in Small Open Economies, Norges Bank Working paper 11/00.

McCallum, 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.*

Nilsson, K. (1999), Alternative Measures of the Swedish Real Effective Exchange Rate, Working Paper No. 68. National Institute of Economic Research.

Ohlsson, H and Vredin, A. (1996), Political cycles and cyclical policies, *Scandinavian Journal of Economics 98(2), 203-218.*

Rotemberg, J and Woodford, M. (1999), Interest Rules in an Estimated Sticky-Price Model, in Taylor (ed.), *Monetary Policy Rules*, Chicago University press.

Svensson, L.E.O. (2000), Open-economy inflation targeting, *Journal of International Economics 50, 155-184.*

Svensson L.E.O. (1999), Inflation targeting as a monetary policy rule, *Journal of Monetary Economics 43, 607-654*.

Svensson, L.E.O. (1998), Open-economy inflation targeting, Working paper 1998:638, IIES.

Söderlind, P. (2001), What if the Fed Had Been an Inflation Nutter?, Working Paper No. 443, Stockholm School of Economics.

Appendix A: Derivation of the aggregate demand equation[15]

The aggregate demand equation used in the main text will be derived with some micro foundations in this appendix. Assume that domestic consumers have an additively separable CES utility function of aggregate real consumption with intertemporal elasticity of substitution, s . Under the assumption that real consumption is predetermined for s quarters, intertemporal optimization will imply the first-order condition

$$c_t = c_{t+1|t-s} - s\,(r_{t|t-s} - \bar{r})\,, \tag{A.1}$$

where c_t denotes the deviation from the trend of aggregate real consumption and $r_t - \bar{r}$ is the real interest rate deviation from a long-run mean interest rate. Let aggregate consumption be a Cobb-Douglas function of consumption of domestic and foreign goods (that is, assuming a constant elasticity of substitution equal to unity). Then, it follows that the consumer's decision problem can be written as:

$$\max \; E_{t-s}(C_t^d)^a \;(C_t^*)^{1-a} \tag{A.2}$$

$$\text{s.t} \quad E_{t-s}(P_t\, C_t) \geq E_{t-s}(P_t^d C_t^d + P_t^* C_t^*)\,,$$

where C_t^d and C_t^* denote the consumption of domestic and foreign goods, respectively, and P_t^* is the foreign price level measured in domestic currency. The CPI price level is defined as $P_t = (P_t^d)^a \;(P_t^*)^{1-a}$. Assuming monopolistic competition in the domestic economy, domestic prices are set as a mark-up on wages, i.e. $P_t^d = W_t$ (see e.g. Leitemo (2000)). Solving the problem, we get that domestic demand for domestically produced goods is given by

[15]See McCallum and Nelson (1999) and Svensson (1998) for a similar derivation of aggregate demand.

$$c_t^d = c_{t|t-s} - (w_{t|t-s} - p_{t|t-s}) \tag{A.3}$$
$$= c_{t|t-s} + \left(\frac{1-a}{a}\right) q_{t|t-s} \, ,$$

where $(w - p)$ has been rewritten as the real exchange rate, q, using equation (9) and (10). Next, let us assume that changes in relative prices affect consumption with a lag of s quarters, because the consumption basket adjusts slowly to changes in relative prices. After substituting (A.3) into the first-order condition (A.1), we get

$$c_t^d = c_{t+1|t-s}^d - s\,(r_{t-s} - \bar{r}) - \left(\frac{1-a}{a}\right)\left(q_{t-s+1|t-s} - q_{t-s}\right) \, . \tag{A.4}$$

Assume $\lim_{t\to\infty} c_{t+t|t-s}^d = 0$[16], $\lim_{t\to\infty} q_{t+t|t-s} = 0$ then

$$c_t^d = c_{t+t|t-s}^d - s \sum_{t=0}^{\infty} (r_{t+t-s|t-s} - \bar{r}) - \left(\frac{1-a}{a}\right) \sum_{t=0}^{\infty} \left(q_{t+t-s+1|t-s} - q_{t+t-s|t-s}\right) + \hbar_t^d$$
$$= -s \sum_{t=0}^{\infty} (r_{t+t-s|t-s} - \bar{r}) + \left(\frac{1-a}{a}\right) q_{t-s} + \hbar_t^d \tag{A.5}$$

where a zero-mean demand shock , $\hbar_t^d$, has been added ($\tilde{\hbar}_t^d$ can be seen as a preference shock). Let the foreign demand for home goods (measured as deviations from the trend), be

$$c_t^{*d} = dy_t^* + f^* q_{t-s} + J_t^* \, , \tag{A.6}$$

where f^* is a measure of how sensitive the foreign demand for home goods is to changes in the real exchange rate, y_t^* is the foreign output gap and J_t^* a demand shock.

[16]This assumption presumes that net foreign assets are stationary. Thus, I avoid the problem that a small open economy with infinitely lived consumers that can borrow at an exogenous world interest rate normally has non-stationary net foreign assets.

Foreign demand for home goods can be decomposed into two components: $f^{*}q_{t-s}$ that depends on domestic monetary policy and $h_t^{*} = dy_t^{*} + J_t^{*}$ that is independent of domestic monetary policy. Thus,

$$c_t^{*d} = f^{*}q_{t-s} + h_t^{*}. \tag{A.7}$$

Public demand for domestically produced goods is defined as

$$g_t = \hat{t}y_{t|t-s} + \hbar_t^{g}, \tag{A.8}$$

where g_t is government expenditure (measured as deviations from the steady state), $\hbar_t^{g}$ is a vector of other variables influencing fiscal policy (e.g. elections and government ideology) assumed to be independent of the monetary policy regime. Parameter $\hat{t}$ is a measure of how sensitive government expenditure is to changes in the output gap. Total real aggregate demand for domestically produced goods is defined as

$$y_t = n_1 c_t^{d} + n_2 g_t + n_3 c_t^{*d}. \tag{A.9}$$

n_1 is the share of private domestic demand, n_2 the share of public demand and n_3 the share of foreign demand in total aggregate demand. Substituting (A.5), (A.7) and (A.8) into the output gap equation (A.9) results in

$$y_t = \hat{b}q_{t-s} + ty_{t|t-s} - g\sum_{j=0}^{\infty}(r_{t+j-s|t-s} - \bar{r}) + \hbar_t, \tag{A.10}$$

where $g = n_1 s$, $\hbar_t = (n_1\hbar_t^{h} + n_2\hbar_t^{g} + n_3\hbar_t^{*})$, $\hat{b} = \left(n_3 f^{*} + n_1\left(\frac{1-a}{a}\right)\right)$ and $t = n_2\hat{t}$.

Expression (A.10) is equivalent to equation (1) in the main text.

Appendix B: Data Sources and Definitions

The data set covers Australia (1984:1-2000:2), Canada (1970:1-2000:2), Japan (1974:1-2000:2), New Zealand (1985:1-2000:2), Sweden (1993:1-2000:2), Switzerland (1974:1-2000:2) and the United Kingdom (1993:1-2000:2). The data are seasonally adjusted and all variables are expressed in logs. All data are collected from the OECD database Main Economic Indicator.

Output (y): real GDP

Domestic price level (p): domestic CPI-price level

Domestic wages (w): wage rates (hourly rates in manufacturing)

Government expenditure (g): total government expenditure

Exchange rate (e): the exchange rate index is constructed as a competition-weighted sum of exchange rate series for ten OECD countries.

Foreign price level (p*): the foreign CPI-price index is constructed using the same methodology and trade weights as in the exchange rate index

Appendix C: Solving the model

Under a floating exchange rate regime, the central bank's problem is to choose $\{e_t\}_{t=t}^{\infty}$ so as to minimize

$$\sum_{t=0}^{\infty} d^{t}\left(\frac{l_y}{2} y_{t|t-m}^{2} + \frac{l_p}{2}(p_{t|t-m} - p_t^{n})^{2} \right), \qquad \text{(C.1)}$$

subject to

$$\begin{aligned} y_t &= b(e_{t-s} + p_{t-s}^{*} - p_{t-s}) + t y_{t|t-s} + h_t\,, \\ w_t &= p_{t|t-k} + b y_{t+s|t-k} + e_t \\ p_t &= a\, w_t + (1-a)(p_t^{*} + e_t)\,. \end{aligned} \qquad \text{(C.2)}$$

Solving the problem, we get the optimal reaction function for the nominal exchange rate (written in terms of variables that all are exogenous to the monetary policy regime):

$$e_t = p_t^{n} - p_{t|t-m}^{*} - a_1 h_{t+s|t-m} - a_2 h_{t+s|t-k} - a_3 h_{t+s|t-s} - a_4 e_t\,, \qquad \text{(C.3)}$$

where

$$a_1 = \left(\frac{l_y d a b}{l_y d (a b)^2 + l_P (1-a)^2} \right),$$

$$a_2 = -\left(\frac{l_y d a b(a b(1-t) - abb - (1-t)(1-a)) - l_p ab(1-a)(1-t)}{((1-t)(1-a) + abb)(l_p(1-a)(1-t))} \right)$$

$$a_3 = \left(\frac{t\, l_y d a b}{(l_y d (a b)^2 + l_P (1-a)^2)(1-t)} \right), \text{ and } a_4 = -\left(\frac{(d\, l_y (a b)^2 - l_p(1-a)a)(1-t)}{(1-a)(l_p(1-a)(1-t) + abb)} \right).$$

Using (C.3) and (C.2), we get the following expressions for the CPI-price level and the output gap:

$$p_t = p_t^n + (1-a)(p_t^* - p^*_{t|t-m}))$$

$$+ \left(h_{t+1|t-k} - h_{t+1|t-m}\right)\left(\frac{d\,l_y a\,b(1-a)}{d\,l_y (a\,b)^2 + l_p(1-a)^2}\right) + \left(h_{t+s|t-k} - h_{t+s|t-s}\right)\left(\frac{d\,l_y a\,b\,t(1-a)}{(1-t)(\,l_p(1-a)^2 + l_y(a\,b)^2)}\right)$$

$$-h_{t+s|t-k}\left(\frac{d\,l_y a\,b(tb+(1-t)(1-a))}{l_p(1-t)(1-a)((1-t)(1-a)+abb)}\right) \qquad \text{(C.4)}$$

$$+e_t\left(\frac{d\,l_y(a\,b)^2(1-t)}{l_p((1-a)(1-t)+abb)(1-a)^2}\right)$$

$$y_t = \frac{a\,b(\,p^*_{t-s} - p^*_{t-s|t-m-s})}{(1-t)} + (h_t - h_{t|t-m-s})$$

$$+\left(h_{t|t-m-s} - h_{t|t-k-s}\right)\left(\frac{l_p(1-a)^2}{(d\,l_y(a\,b)^2 + l_p(1-a)^2)(1-t)}\right) + \left(h_{t|t-s-s} - h_{t|t-k-s}\right)\left(\frac{l_p(1-a)^2 t}{(d\,l_y(a\,b)^2 + l_p(1-a)^2)(1-t)^2}\right)$$

$$+h_{t|t-k-s}\left(\frac{(1-t)(1-a)+abb\,t}{(1-t)((1-t)(1-a)+abb}\right) \qquad \text{(C.5)}$$

$$-e_{t-s}\left(\frac{ab(1-t)}{((1-a)(1-t)+abb)(1-t)}\right)$$

Appendix D: Reaction-function coefficients

	Australia	Canada	Japan	New Zealand	Sweden	Switzer-land	United Kingdom
Strict price level targeting							
a_1	0	0	0	0	0	0	0
a_2	-0.65	1.81	1.60	1.18	1.89	0.94	1.61
a_3	0	0	0	0	0	0	0
a_4	12.47	3.09	6.02	8.68	2.88	1.82	8.98
Flexible price level targeting							
a_1	6.05	2.18	4.57	5.93	2.43	1.72	6.58
a_2	-1.04	-4.55	2.99	-6.05	-2.03	0.38	-9.42
a_3	-0.69	-0.42	-0.88	-0.28	-0.24	-0.25	-0.70
a_4	10.75	-0.07	-0.90	4.50	1.10	0.66	2.51
Output gap targeting							
a_1	9.88	2.61	4.73	6.57	3.43	2.78	6.87
a_2	-0.97	-6.36	-3.56	-7.28	-3.91	-0.56	-11.03
a_3	-1.14	-0.51	-0.92	-0.31	-0.33	-0.40	-0.74
a_4	-17.18	-31.61	-69.33	-41.88	-17.83	-11.63	-64.72

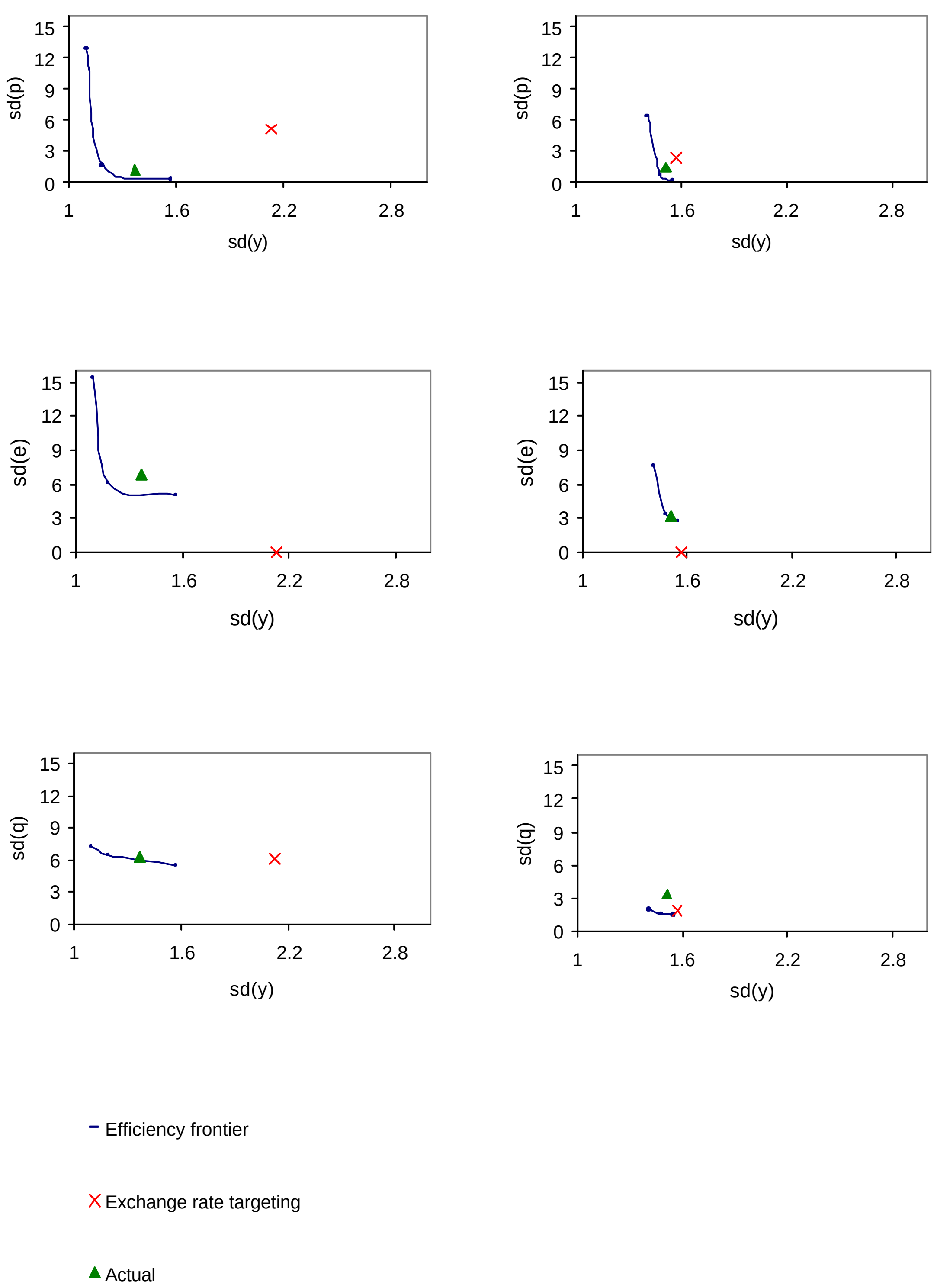
Appendix E

Table 1.E: Macroeconomic stability of alternative monetary policy regimes when output is more sensitive to changes in the real exchange rate (b fifty percent higher than the estimated value reported in Table 2).

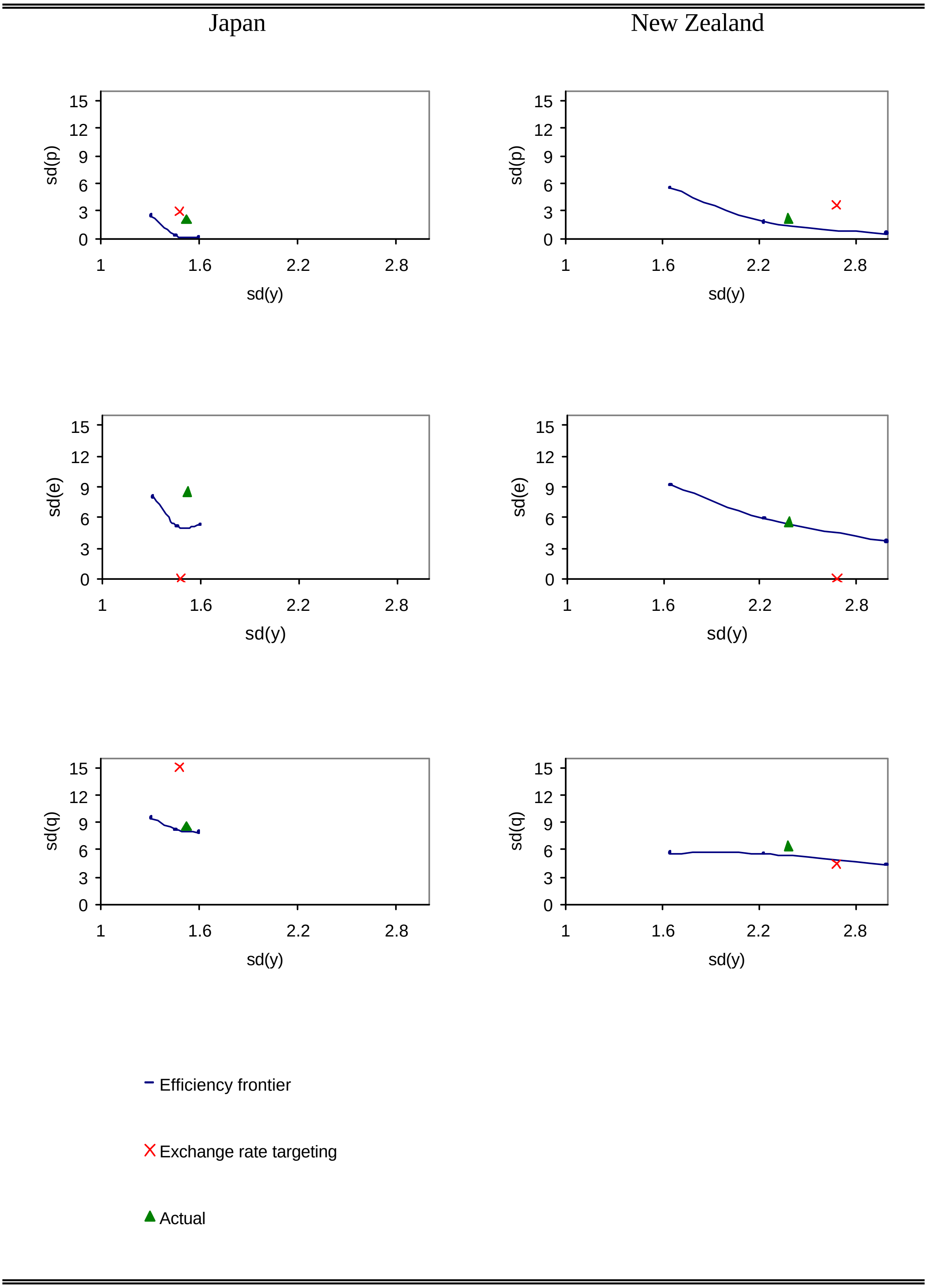
	Australia	Canada	Japan	New Zealand	Sweden	Switzer-land	United Kingdom
Strict exchange rate targeting							
CPI	4.08	1.94	2.41	2.98	4.96	2.02	1.26
Output	2.11	1.59	1.42	2.78	1.76	1.61	2.26
Real exchange rate	5.55	1.60	12.94	3.79	5.35	2.71	4.71
Exchange rate	0	0	0	0	0	0	0
Strict price level targeting							
CPI	0.27	0.16	0.12	0.55	0.34	0.16	0.20
Output	1.59	1.63	1.69	2.97	1.67	2.05	1.99
Real exchange rate	5.24	1.31	7.56	4.18	4.35	2.23	3.28
Exchange rate	4.81	2.62	5.14	3.43	5.10	3.17	1.46
Flexible price level targeting							
CPI	1.43	0.64	0.27	1.62	2.69	0.94	0.38
Output	1.21	1.47	1.51	2.25	1.40	1.34	1.66
Real exchange rate	6.16	1.47	7.67	5.37	4.81	2.86	3.30
Exchange rate	5.45	3.07	4.79	5.57	2.79	2.71	1.73
Output gap targeting							
CPI	8.96	4.50	1.71	3.98	7.86	7.10	2.27
Output	1.12	1.39	1.34	1.67	1.26	1.16	1.43
Real exchange rate	5.08	1.58	7.92	4.54	4.34	3.31	3.40
Exchange rate	11.52	5.63	6.41	6.75	5.91	9.67	3.22

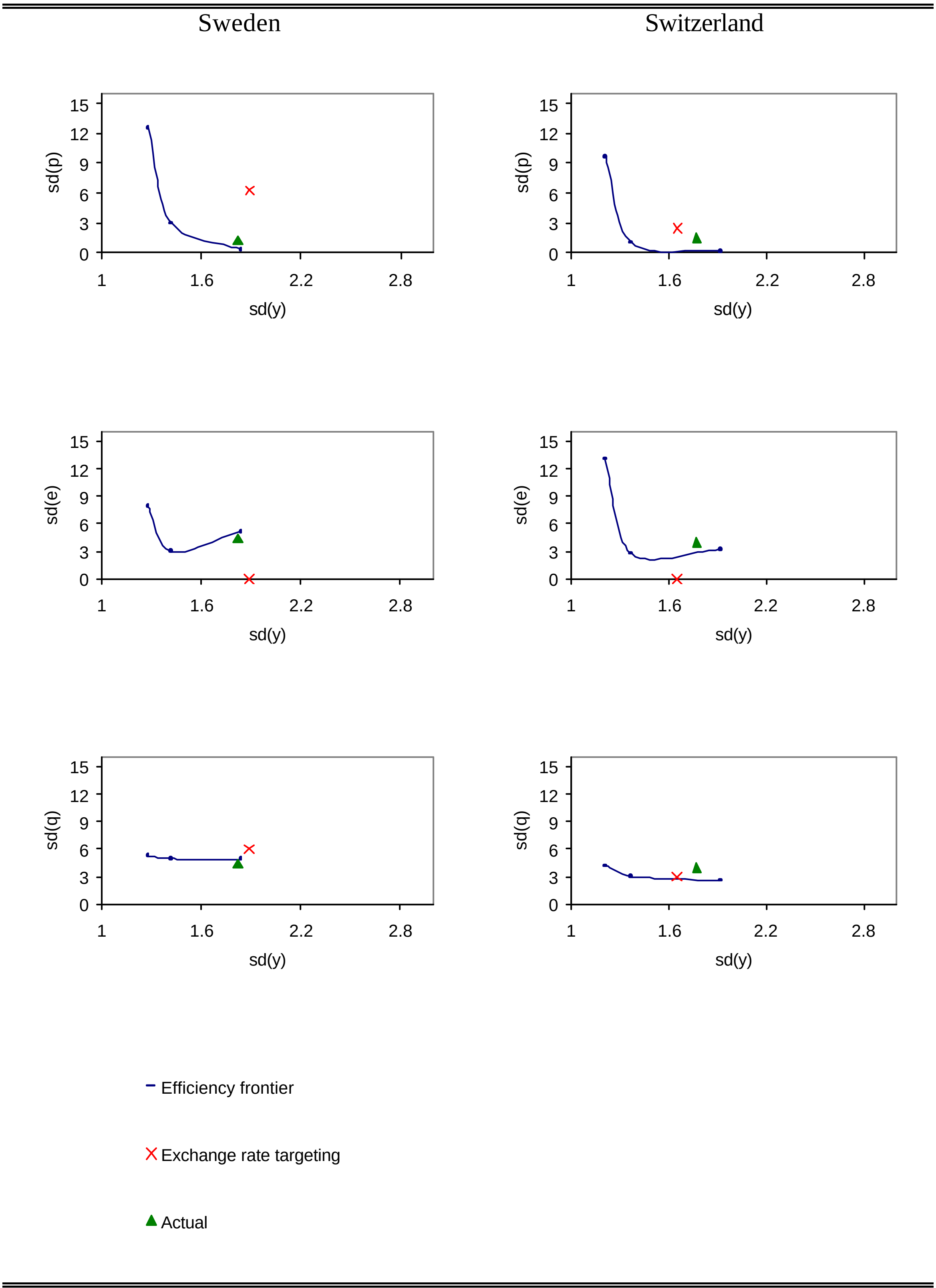
Figure 1: Tradeoffs between output, price, the real exchange rate and nominal exchange rate stability

Australia | Canada



Note: sd = Standard deviation, y = output gap, p = CPI, e = nominal exchange rate, q = real exchange rate.


Japan
New Zealand
sd(p)
sd(e)
sd(q)
sd(y)
15
12
9
6
3
0
1
1.6
2.2
2.8
Efficiency frontier
Exchange rate targeting
Actual



Sweden
Switzerland
sd(p)
sd(e)
sd(q)
sd(y)
15
12
9
6
3
0
1
1.6
2.2
2.8
Efficiency frontier
Exchange rate targeting
Actual

United Kingdom