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The Forward Rate Unbiasedness Hypothesis
In Inflation-Targeting Regimes

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Abstract

I test the forward rate unbiasedness hypothesis using the Error Correction Model (ECM) of Naka and Whitney (1995). It is shown that the Naka-Whitney treatment of the dynamic is perhaps necessary to ameliorate existing problems associated with testing the hypothesis. However, it is not sufficient due to the sensitivity of the non-linear regression to starting values. Monthly data from October 1985 to May 1998 for New Zealand, Canada, United Kingdom (UK), Sweden, Germany, Japan and South Africa are used to test the forward rate unbiasedness hypothesis. The first four countries are inflation targeting regimes. Germany and Japan have both had very low inflation and South Africa experienced periods of very high inflation followed by periods of low inflation. The null hypothesis is widely rejected. The premia puzzle remains largely unexplained. Interestingly, the forward rate unbiasedness hypothesis holds in two inflation-targeting regimes namely New Zealand and UK. Implications of the Consumption – Asset Pricing Model (CAPM) are used to explain the finding.

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1 Motivation, theory, and empirical issues

The primary objective of this paper is to examine the forward rate unbiasedness hypothesis in New Zealand under the current regime of inflation targeting. I also examine the hypothesis in other inflation-targeting regimes (e.g., Canada, UK and Sweden) and compare the results to some non inflation-targeting countries (e.g., Germany, Japan and South Africa).

Several reasons motivated this research. One is that Naka and Whitney (1995) seem to have resolved the forward premium's anomaly in the G7 countries. Thus, provided the encouragement to test it for New Zealand, particularly since the hypothesis does not seem to have been tested using recent New Zealand data. Second, a reasonably long time series covering the period of inflation targeting became available, which made time series analysis feasible. Third, ever since New Zealand floated its currency in March 1985, the Reserve Bank of New Zealand has never actually intervened in the exchange market, which might lend support to the efficiency argument. Fourth, in 1989 New Zealand officially adopted an inflation-targeting regime, which altered the time series properties of macroeconomic data, the moments and cross moments (e.g., inflation became stationary and the covariance between inflation and the depreciation rate became zero). It will be shown that these changes can significantly affect the relationship between the forward rate and the expected spot rate.

For comparison, some other inflation-targeting regimes are added to the sample. The hypothesis is also tested for the Canadian dollar (CAD/USD), the Pound (GBP/USD), and the Swedish Krona (SDK/USD).[2] Data form Germany (DM/USD) and Japan (YEN/USD) are also tested. Although these two countries have no institutional arrangement for inflation targeting, they have experienced periods of very low-and-stable inflation in the 1980s and the 1990s. The hypothesis is also tested for the South African Rand (SAR/USD). South Africa experienced high inflation in the 1980s and low inflation in the 1990s, but including it in the sample serves as a control variable. The hypothesis is also tested for all currencies with respect to the Deutsche Mark (DM).

To outline the theory behind the forward rate unbiasedness hypothesis I will start with some notations. Let e_t be the natural logarithm of the spot exchange rate, where the level of the spot rate, ε_t is defined as the domestic currency/US dollar (USD). Similarly, let f_t be the natural logarithm of the one-period forward exchange rate, F_t. The domestic currency annualised 30-day interest rate is i_t and the foreign interest rate is i_t^*. The price level P_t is defined by the natural logarithm of the CPI. The covered interest rate arbitrage at one-horizon ensures that:

$$f_t - e_t = i_t - i_t^* \qquad (1)$$

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[2] Sufficient time series for other inflation-targeting countries such as Spain, Finland and Israel are not readily available.

Equation (1) must hold since an investor at home can borrow one unit of the domestic currency by buying $-e_t$ worth of USD, make an investment in US-denominated bonds paying i_t^* per bond and then secure a future domestic currency unit pay-out by selling the return forward at a rate f_t.[3] In general, and particularly in a world without capital control, such a transaction bears no or little risk because it can be carried out at time t. Therefore, gross payments and costs of the initial dollar borrowing must equalise.

The question of interest is whether or not the following relationship

$$f_t = E(e_{t+1} \mid \Omega_t) \tag{2}$$

holds, where E is the *rational expectations* operator given an information set Ω_t. If (2) does not hold, investors can earn arbitrarily large profits by speculating in forward foreign exchange markets and the arbitrage theory is violated.

If the rational economic agent expects the spot exchange rate in the future to be the same as the current forward rate then she will be indifferent between the two transactions under certain conditions. These conditions are (1) that agents are risk-neutral, and (2) that there are identical transaction costs in forward and spot markets. It is therefore important to distinguish between the two hypotheses, rational expectations and the unbiasedness of the forward rate.[4]

The unbiasedness hypothesis has been tested by estimating the following equation:

$$e_t = a + b\, f_{t-1} + u_t\,. \tag{3}$$

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[3] There are issues related to what is called “Siegel’s Paradox,” but they are not important for this paper. See Obstfeld and Rogoff (1999, p. 586) for details.

[4] The first is referred to as the “efficient market” hypothesis. This says that economic agents use all available information to forecast the future spot rate, i.e., they form rational expectations of the future exchange rate. The market efficiency hypothesis states that the market behaves as if traders possessed rational expectations. Market efficiency implies:

$$e_t = E_t e_{t+1} + \phi_{t+1},$$

Where ϕ_{t+1} is a serially independent forecast error with mean zero. Moreover, the error term is uncorrelated with any observed lagged variable. This hypothesis is not directly testable because of the expectations term on the right-hand-side, which is unobservable. Bilson (1981) introduced the second hypothesis that is the “speculative efficiency hypothesis,” which is basically equation (2). The validity of this equation depends on the two conditions stated earlier, risk-neutrality and identical transaction costs in forward and spot markets. Combining equations (2) and the above equation together give:

$$e_t = f_{t-1} + z_t\,,$$

where z_t is an error term. Tests of this equation are not tests of “market efficiency” or “rational expectations” because this equation could only be derived with the auxiliary assumptions of risk-neutrality and identical transaction costs. There are two hypotheses in the above equation: rational expectations and the equality of the forward and the expected spot rates. Nevertheless, a form of this equation has been used to test for the unbiasedness hypothesis.

The parameter a is interpreted as a constant risk premium. To test the hypothesis that the forward rate is an unbiased predictor of the spot rate, the restriction $b=1$ is tested. Various estimation techniques have been used to test this hypothesis. A stronger form - unbiasedness-market efficiency hypothesis and no risk premium - implies testing $a=0$, $b=1$ and that the u_t's are serially uncorrelated and homoscedastic.[5] Wolf (1987) shows that if the restriction $b=1$ holds, serial correlation in the u_t's is still consistent with a time-varying risk premium. Note that when equation (3) is estimated by OLS and when u_t is serially uncorrelated according to the DW statistic, the magnitude of b is usually found to be equal to one.

Developments in the literature on unit roots-cointegration suggest that researchers should not estimate equation (3) by OLS because of the presence of unit roots in the spot and the forward rates, which render standard test statistics not useful.[6] The OLS parameters of equation (3), though, are super-consistent. Although it seems reasonable to use a Fully Modified OLS (FM-OLS) estimation technique, but Phillips and McFarland (1997) argue it may not be appropriate to estimate equation (3). Provided that the spot rate and the forward rate are cointegrated, the following ECM has been used instead:[7]

$$e_t - e_{t-1} = a^* + b^*(f_{t-1} - e_{t-1}) + u_t^* . \tag{4}$$

Again, testing the unbiasedness-market efficiency hypothesis involves testing $b^* = 1$, ($a^* = 0$; $b^* = 1$) jointly, and that u_t^* is serially uncorrelated and homoscedastic. Hodrick (1987), Lewis (1995), and Engel (1996) document the empirical failure of equation (4) in surveys. Most researchers find b^* to be negative. Froot and Thaler (1990) report that the average estimate of b^* across 75 published estimates is -0.88. The fact that the spot and the forward rates are cointegrated, that b in equation (3) is 1, and yet b^* in equation (4) is negative presents a problem. These empirical findings cannot be reconciled with econometric theory.

Fama (1984) offers an explanation of why the OLS coefficient $b^* < 0$. He argues that the rational expectations risk premium on foreign exchange rates must be extremely variable. Also, a large number of empirical papers suggest that conditional variances of exchange rates vary over time.[8]

Cumby and Obstfeld (1981) assume that the risk premium separates the forward rate from the market expected future spot rate. Hansen and Hodrick (1983) use a CAPM type

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[5] For example, see Frenkel (1977), Edwards (1983), and Baillie et al (1983).

[6] For example, see Messe and Singleton (1982) and Baillie and Bollerslev (1989).

[7] For example, see Baillie and Bollerslev (1989), Hakkio and Rush (1989), Barnhart and Szakmary (1991), Liu and Maddala (1992), and Naka and Whitney (1995).

[8] For example, see Cumby and Obstfeld (1984), Hsieh (1984), Domowitz and Hakkio (1985), Mark (1985, 1987), and Lyons (1988).

model to test the same hypothesis. These models imply that the forward rate is not an unbiased predictor of the spot rate. The wedge between the forward rate and the expected spot rate consists of the variance of the spot rate, the covariance between the spot rate and the price level, and the covariance between the spot rate and real consumption. They find that the risk premium is only important in two out of the five exchange rate markets they test. Frankel (1980) investigates the risk premium in six currencies and fails to find it. Frankel (1986) argues that the risk premium must be very small in magnitudes. So far, this model has had limited success in explaining the anomaly of the forward premium.

McCallum (1994) provides a different explanation. He explains the failure of the forward rate unbiasedness hypothesis by a neglect to take into account the fact that monetary authorities pursue interest rate smoothing policies, and avoid exchange rate changes. Therefore, he suggests model (3) and (4) have a missing equation that accounts for the behaviour of the monetary authority. Thus, the models are misspecified.

Naka and Whitney (1995) argue that the dynamics in the error correction model in equation (4) are misspecified. They argue that it is this misspecification that causes estimates of b^* to be negative. They derive another error correction model directly from equation (3). The ECM is derived as follows.

From equation (3) we get

$$u_{t-1} = e_{t-1} - b\,f_{t-2} - a\,. \qquad (5)$$

The only additional assumption is that the error term u_t is given by $\rho\,u_{t-1} + v_t$. By substituting this into equation (5), they obtain:

$$e_t - b\,f_{t-1} = (1-\rho)\,a + \rho(e_{t-1} - b\,f_{t-2}) + v_t\,. \qquad (6)$$

The unit root in the forward rate implies:

$$f_{t-1} = f_{t-2} + \eta_{t-1}\,. \qquad (7)$$

Subtracting e_{t-1} from both sides of equation (6), they arrive at a new dynamic specification:

$$e_t - e_{t-1} = (1-\rho)a + (1-\rho)(b\,f_{t-2} - e_{t-1}) + b(f_{t-1} - f_{t-2}) + v_t \qquad (8)$$

Note that if the error terms v_t and η_{t-1} are (i.i.d.) and uncorrelated then equation (6) and (7) form a triangular system of the type introduced by Phillips (1991) and Phillips and

Loretan (1991).[9] The Naka and Whitney equation (8) should not be viewed as a purely statistical model; similar dynamic equations are observed in CAPM.

Equation (8) seems to ameliorate the existing problems in equation (4) and explains the empirical anomaly rather well. The hypothesis seems to hold in Naka and Whitney's sample of the G7 countries from 1974 to 1991. However, it will be shown in this paper that this procedure is necessary but not sufficient for the null hypothesis to hold. Thus, the forward premium puzzle is still largely unexplained. Interestingly, the hypothesis seems to hold in inflation-targeting regimes, which needs some explanation.

The next section of the paper presents the estimation results using equation (4) and the Naka-Whitney approach (equation (8)). Results suggest that the hypothesis may hold well in many countries and over different samples. Not surprisingly, non-linear estimation techniques based on numerical evaluations algorithm are sensitive to starting values. It will be shown that when the global optimum is distant from the hypothesised values ($a = 0$, $b = 1$ and $\rho = 0$), numerical procedures will typically converge to a local optimum rather than – the more distant – global optimum. It is shown that the results found by Naka and Whitney are not robust and the forward rate unbiasedness hypothesis is rejected in many cases and across different sub-samples. Interestingly, the hypothesis could not be rejected for some inflation-targeting regimes such as New Zealand, UK and, probably, Sweden. Section 3 offers an explanation for the findings using an implication of the CAPM. Section 4 contains a summary.

2. The data and testing the unbiasedness hypothesis

It is important to note that he sample used in this paper is longer than that used in Naka and Whitney (1995) - monthly data from January 1985 to May 1998. Their sample is from January 1974 to April 1991 so their sub-sample from October 1985 to April 1991 overlaps with my sample. Some non-trivial changes in money, interest rates, and inflation were associated with changes in Europe since 1991 that have direct relevance to the forward rate unbiasedness hypothesis. The spot rates (end-of-period), and the forward rates (end-of-period) are from Datastream (Barclays'). The forward rates are 30-day forward contracts. Seven exchange rates are used. Four are inflation-targeting countries namely New Zealand, Canada, UK and Sweden. Two are low-inflation countries, Germany and Japan. Finally, I added South Africa, which experienced periods of very inflation in the 1980s and low inflation in the 1990s. These currencies are the NZD/USD, CAD/USD, GBP/USD, SDK/USD, DM/USD, YEN/USD and SAR/USD. The exchange rate in each case is defined as the US dollar price of one unit of each of the currencies.

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[9] $\begin{bmatrix} v_t \\ \eta_{t-1} \end{bmatrix} \approx i.i.d.(0, \Sigma)$, Where $\Sigma = \begin{bmatrix} \sigma_v^2 & 0 \\ 0 & \sigma_\eta^2 \end{bmatrix}$ and if $\sigma_{v,\eta} = 0, and\ \ f_t$ is strictly exogenous (Naka and Whitney (1995)).

Also, the same hypothesis is tested using the exchange rates defined as the DM price of one unit of each of the currencies.

Baillie and Bollerslev (1989), Hakkio and Rush (1989), Barnhart and Szakmary (1991), Liu and Maddala (1992) and Naka and Whitney (1995) provide evidence that the natural logarithms of the spot exchange rate and the forward rate are unit roots and are cointegrated. Similar results are found in this data set. Results are not reported to save space, however, they are available upon request.

The next few pages contain the parameter estimates and the analysis of the results. Results are reported in tables 1-6. The first three tables are related to equation (4) and (8). The findings are summarised as follows. There is a clear difference between the parameter estimates of equation (4) and (8). Equation (4) results in the usual finding that b^* is negative. However, the parameter b in equation (8) is no longer negative, but closer to unity in magnitude, which confirms the Naka and Whitney (1995) argument that the failure of the unbiasedness hypothesis was due to the misspecified dynamic of equation (4). However, unlike the results reported in Naka and Whitney (1995) these results suggest that the hypothesis hold for samples covering the 1990s, but not during the 1980s. It is important to remember that the full sample in this paper is longer than that of Naka-Whitney. The regressions for the 1990s indicate *no significant* ARCH effects, but those of 1980s show some ARCH effects. The parameters are clearly unstable, as the Chow tests indicate.[10]

Equation (4) – the traditional ECM – is first estimated using OLS. The negative results reported in the literature are confirmed. The results are reported in table 1. The P-values for the Wald statistics are reported for all hypotheses. For the full sample, the hypothesis that $a^* = 0$ cannot be rejected except for the YEN/USD. The hypothesis that $b^* = 1$ is rejected in all cases except in the case of SDK/USD (i.e., b^*=1.54) and DM/USD (i.e., b^*=1.04). The joint hypothesis that $a^* = 0$ and $b^* = 1$, is rejected by the data except in the cases of SDK/USD and DM/USD.

Second, for each inflation-targeting country, the sample is split into an inflation-targeting period and a *pre*-targeting period, and the same hypotheses are tested for each sub-sample.[11] For the other countries the break points of Naka and Whitney (1995) are used. The Naka-Whitney first sub-sample covers the 1980s and is from October 1985 to April 1991. The second sub-sample covers the 1990s and is from May 1991 to May 1998. For the *pre*- inflation targeting sub-samples during the 1980s, the hypothesis that $a^* = 0$

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[10] The Chow test may not be applicable in the presence of ARCH.

[11] The inflation-targeting period for New Zealand is taken from January 1989, which is the date when the Price Targeting Agreement was signed, to 1988. It has been argued that the Reserve Bank of New Zealand started targeting lower inflation at least two years earlier. For Canada, I use January 1991 as a starting date. Inflation targeting in the UK started in October 1992. Inflation targeting starts January 1993 in Sweden. Note that both the UK and Sweden pegged their currencies to the DM prior to inflation targeting, up until September 1992 and November 1992 for the UK and Sweden respectively.

cannot be rejected except in the case of Sweden. The null hypothesis that b^* is equal to one is also rejected by the data.[12]

Results for the inflation targeting periods of the 1990s are slightly different from the periods of *pre* inflation targeting and the 1980s. The UK left the Exchange Rate Mechanism (ERM) in September 1992. This seems to introduce some volatility in the data so the estimation starts in October 1993, i.e., a year later. Also, note that Sweden floated its currency in November 1992 so estimation starts from December 1993. The hypothesis that a^* is equal to zero cannot be rejected for any country.

Interestingly, the hypothesis that b^* is equal to one cannot be rejected for New Zealand and the UK. The joint hypothesis that $a^* = 0$ and $b^* = 1$ also cannot be rejected for New Zealand and the UK. To emphasis that the results for the UK and New Zealand are different from all other currencies, and that they are obtained from the traditional ECM, I reported them here. The numbers in parentheses are the P-values of the Wald statistics.

$e_t - e_{t-1} = a^* + b^*(f_{t-1} - e_{t-1}) + u_t^*$						
	Period	NOB	a^*	b^*	$H0:(a^* = 0, b^* = 1)$	DW
NZD/USD	89:1-98:5	113	0.003 (0.31)	1.46 (0.53)	(0.58)	1.71
GBP/USD	93:10-98:5	56	0.002 (0.46)	0.61 (0.87)	(0.54)	2.22

Next, equation (8) – Naka and Whitney's equation – is estimated using NLLS for the full sample and over the sub-samples defined above. The starting values for the parameters a, b, and ρ are zero, one and zero respectively. The results are reported in table 2.[13] There are marked differences between the magnitudes of the b^*'s in equation (4) and the b's in equation (8). The b's are closer to unity in magnitudes while the b^*'s in equation (4) were either negative or greater then unity in magnitude. To a large extent, this confirms Naka and Whitney (1995) thesis.

In the full sample, the Wald statistic P-values indicate that $a \neq 0$ in all countries except Canada and South Africa. Although the estimated b's are reasonably close to unity in magnitudes, they are significantly different from unity except for Canada and South Africa. Further, the joint hypothesis that $a = 0$ and $b = 1$ does not hold, again except for Canada and South Africa. The hypothesis that $\rho = 0$ cannot be rejected and the DW statistics' P-values, indicate that the residuals are serially uncorrelated. Also note that

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[12] Interpretation of the results should be affected by the presence of ARCH in the first sub-sample.

[13] Using the ML method to estimate the regression does not seem to change the results. This confirms Naka-Whitney.

New Zealand, the UK and Sweden have statistically significant Auto-Regressive Conditional Heteroskedasticity.

Similar results are found in the sub-sample covering the 1980s. The P-Values of the Wald statistic indicates that the hypothesis $a = 0$ is rejected in all countries except New Zealand, Canada and South Africa. The slope parameter b is close to unity in magnitude, but statistically different from unity for all countries except New Zealand, Canada and South Africa. The joint hypothesis that $a = 0$ and $b = 1$ is rejected for all countries except South Africa. The hypothesis that $\rho = 0$ cannot be rejected and the DW P-values indicate that the residuals are serially uncorrelated. The ARCH effects have disappeared from all regressions, except in Sweden and South Africa.

Note how the results change during the 1990s and for all countries. In the second sub-sample, the Wald statistic P-values indicate that the null hypothesis that $a = 0$ cannot be rejected in all cases. The null hypothesis that b is equal to one cannot be rejected. Again, the joint hypothesis that $a = 0$ and $b = 1$ cannot be rejected in all cases. Also, the residuals are serially uncorrelated except, may be, in Japan. The ARCH effects disappeared completely. These results indicate that there is much more support for the forward rate unbiasedness hypothesis during the 1990s rather than the 1980s. Chow tests indicate significant instability in all cases except for the DM/USD exchange rate (Chow test results are not reported, but they are available upon requests).

The same exercise is repeated using the exchange rates with respect to the DM instead of the USD, with the results reported in table 3. Qualitatively, the results are the same as those presented in table 2. The Chow tests indicate parameter instability in the cases of NZD/DM and the GBP/DM only.

In summary, there is a clear difference between the parameter estimates of equation (4) and (8). Equation (4) results in the usual finding that b^* is negative. However, the parameter b in equation (8) is no longer negative, but closer to unity in magnitude, which confirms Naka and Whitney's (1995) argument that the failure of the unbiasedness hypothesis was the result of the misspecified dynamic in equation (4). Unlike the evidence presented in Naka and Whitney (1995), where the hypothesis held across different sub-samples, in this paper the hypothesis seems to hold during the samples covering the 1990s, but not during the 1980s. The regressions for the 1990s indicate *no significant* ARCH effects, but those of 1980s show some ARCH effects. Parameter instability is present as indicated by the Chow tests.
Naka and Whitney (1995) suggest that their results are robust to various estimation techniques such as Maximum Likelihood and Non-linear least squares. But the fact that equation (8) is a non-linear regression make it sensitive to starting values. Next, this sensitivity of the regression to starting values and small sample is checked.

The sum of squared residuals (SSR) in equation (8) is non-linear function of the parameters. In the absence of analytical solutions to the first order conditions of this problem, numerical methods must be used to minimise the residual sum of squares. However, the commonly used algorithms are subject to starting point problems. In the presence of multiple possible values one cannot guarantee that such algorithm will converge to the global optimum. Suppose that SSR is a function of $(a, b \text{ and } \rho)$, and suppose that $(a^1, b^1 \text{and } \rho^1)$ is the argmin of this function. The standard numerical methods find the parameter vector that sets the gradient of the function equal to zero. However, if $\exists\,(a^2, b^2 \text{ and } \rho^2)$ that sets the gradient equal to zero, and if the this parameter vector is close to the starting values used to initialise the algorithm, then the global argmin will not necessarily be recovered.

There is however, a robust solution for this problem. For a *known* value of ρ, it can be shown that the regression becomes linear of the following type as in Davidson and MacKinnon (1993, chapter 10).

$$\Delta e_t + (1-\rho)e_{t-1} = [a,b]\begin{bmatrix} 1-\rho \\ f_{t-1} - \rho\, f_{t-2} \end{bmatrix} + \omega_t, \qquad (9)$$

Under such circumstances the OLS parameter estimates minimise the sum of square residuals. Thus, a grid search over the values of ρ is performed and the parameters a and b that minimise the sum of square residuals are estimated. Also, Wald tests and their P-values can also be obtained.[14] Because all of the samples used in this paper are small, particularly the sub-samples, a bootstrap procedure is used to develop the distributions of the various Wald statistics.[15]

Equation (9) is estimated. The results of the non-linear regressions based on the Naka and Whitney approach that I reported in tables 2 and 3 have changed. New results are

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[14] Although, in the non-linear context, the distribution of the Wald statistic is only asymptotically χ^2_κ (κ independent restrictions) the residuals are divided by $T-3$ to try to be relatively conservative about the magnitude of the standard errors. Dividing by $T-3$ will be equivalent asymptotically to dividing by T. If restrictions are only applied to a subset of parameters the variance-covariance matrix of the subset of the parameters is used. The variance-covariance matrix is estimated by the delta method with partial derivatives being evaluated at the "true" hypothesised parameter values.

[15] Given the joint hypothesis that $a = 0$ and $b = 1$, a vector of standard errors is used as the *population* from which Pseudo random errors are drawn. Pseudo data are formed by randomly sampling (with replacement) from this *population* of errors and adding them to the lagged forward rates. In this exercise the forward rates are assumed exogenous. The Pseudo spot rates at time t are formed by taking the previous period's forward rates and adding to them stochastic error terms, which were obtained by sampling at random from the population of estimated errors. Thus, the r th data sample is formed by implementing the following:

$$e_t^r = f_{t-1} + v_t^r,$$

where v_t^r is sampled at random. The equation is implemented for $t = 2, \ldots T$, where the first observation is set equal to the first observed spot rate; each Pseudo sample thus has the same first observation. From this Pseudo data, and the forward rates that are held constant across all Pseudo-samples, one can estimate the above equation using the grid-search procedure, obtaining Pseudo parameters and the corresponding Wald statistics. Five thousand Pseudo data samples are replicated and from this exercise one can generate empirical distributions for the parameters and the Wald statistics.

reported in tables 4 and 5. It is found that the joint hypothesis $a = 0$ and $b = 1$ is rejected in all cases except for the SDK/USD with a Wald P-value equal to 0.083 in the full sample. The hypothesis cannot be rejected for the DM/USD in the first sub-sample during the 1980s, but only marginally so with a Wald P-value equal to 0.068. Germany experienced lower inflation rates in the 1980s than in the 1990s.

Two interesting cases are found. First, the hypotheses that $a = 0$ and $b = 1$ cannot be rejected in the case of NZD/USD during the period of inflation targeting with Wald P-values of 0.282 and 0.191 respectively. The joint hypothesis that $a = 0$ and $b = 1$ cannot be rejected either with a Wald P-value equal to 0.433. Thus, the evidence in favour of the unbiasedness hypothesis is significant. The regression reaches a global optimum with a value of ρ equal to 0.13. Second the hypotheses that $a = 0$ and $b = 1$ cannot be rejected in the GBP/USD cases during the period of inflation targeting with Wald P-values 0.053 and 0.071 respectively. The joint hypothesis that $a = 0$ 1and $b = 1$ cannot be rejected either with a Wald P-value equal to 0.256. Again, the unbiasedness hypothesis holds well. The regression reaches a global optimum with a value of ρ equal to -0.05. Recall that the NZD/USD and GBP/USD performed equally well in equation (4) (see tables 1).

The hypotheses are rejected in all cases where the exchange rates are defined in terms of the DM except for YEN/DM during the 1990s. Results are reported in table 5.

Figures 1 through 7 show the difference between the local and the global optimum for all the cases involving the USD during the second sub-sample in the 1990s. The hypotheses are rejected when the local optimum – rather than the global optimum – is in the vicinity of ρ equal to zero. The sums of square residuals (SSR) are plotted against grid of ρ values for all seven cases covering the second sub-sample in table 4.

To summarise, the evidence that the forward rate is an unbiased predictor of the expected spot rate is clear in the NZD/USD and the GBP/USD over the inflation targeting sub-samples. This is evident in the results reported in the *old* ECM in table 1 and in the *new* ECM reported in table 4. Weaker, but still significant evidence in favour of the unbiasedness hypothesis is found in the GBP/USD during the inflation-targeting period. Also, the hypothesis seems to hold in the SDK/USD in the first sub-sample and the full sample. The evidence in favour of the hypothesis is marginally significant in the DM/USD during the period of low inflation in Germany during the 1980s. The more elaborate dynamic specified in the ECM of Naka and Whitney (1995) is perhaps necessary to ameliorate existing problems associated with testing the hypothesis. However, it is not sufficient. The favourable results found by Naka and Whitney (1995) are largely due to the numerical techniques used to estimate their ECM.

3 Implications of CAPM

Can we explain these results? Baxter (1994, p. 18) emphasises that short-run movements in the exchange rate are likely to be determined by monetary factors (e.g., inflation). Bernanke and Mishkin (1997, p. 106) argue that uncertain inflation exacerbates relative price volatility (the exchange rate is a relative price). So, a higher variation in inflation might be associated with a higher variation in relative prices (i.e., the exchange rate).

The Consumption – Asset Pricing model (CAPM) may provide an answer because it links the forward rate unbiasedness to the variance of the spot rate (see Obstfeld and Rogoff, 1996, p 585-592). They show that under the assumption that the forward rate f_t, the spot rate e_t, real consumption C_t, and the price level P_t are jointly lognormally distributed, the following relationship can be derived:

$$f_t - E_t(e_{t+1}) = \frac{1}{2} Var_t(e_{t+1}) - Cov_t(e_{t+1}, P_{t+1}) - \theta\, Cov_t(e_{t+1}, C_{t+1}), \qquad (10)$$

where E_t is the rational expectations' operator based on the information set at time t and θ is the constant relative risk-aversion elasticity.

Equation (10) holds for a risk-neutral investor if $\theta=0$. The last term on the RHS is the true risk premium. To calculate the terms on the RHS of equation (10) the first difference of the data is used because of the unit roots.

For the forward rate to be equal to the expected spot rate, the RHS terms should be either identically zero or very close to zero. Some insight can be gained from the information reported in table 6.

First, it is widely accepted that the risk premium (the third term in equation (10)) is very small in magnitude. This is because changes in consumption are not usually very variable, while changes in the spot rate are (see Obstfeld and Rogoff, 1996, p. 592). See also Hansen and Hodrick (1983) and Frankel (1980).[16] Second, table 6 shows that all countries except Germany experienced low inflation in the 1990s. The volatility of inflation has also been significantly reduced in New Zealand, Canada, the UK, and Sweden. The second term in equation (10), the covariance between the depreciation rate and inflation, is likely to be zero under such circumstances. The last column in table 6 reports the correlation between inflation and the depreciation rates, which is clearly very small.[17]

This leaves the first term on the RHS, which is the variance of the depreciation rate, $Var_t(\Delta e_{t+1})$. Table 6 shows that the volatility measured by the standard deviations is reduced significantly in all cases except CAD/USD, DM/USD and YEN/USD, where it remained unchanged during the 1990s. Thus, the forward rate unbiasedness hypothesis has a better chance holding in the second sub-samples since inflation rates are low and

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[16] I actually computed the correlation between real consumption and the exchange rate for New Zealand, Canada, UK, Sweden and Japan using quarterly data. I then experimented with different values for θ (the constant relative risk-aversion elasticity). I found that these correlations to be small and insignificant.

[17] Also see Obstfeld and Rogoff (1996, p.588 footnote 75) who argue that this is likely to be true because goods prices (P_t) are less variable than asset prices (e_t).

stable, the variances of the depreciation rates are small and the risk premia are negligible, particularly in the two inflation-targeting countries, New Zealand and the UK. South Africa experienced a significant reduction in the volatility of the SAR/USD and the correlation between its inflation rate and the spot rate were insignificant, but the hypothesis did not hold. I speculate that the risk premium is high in South Africa, which makes up the wedge between the forward rate and the expected spot exchange rate. Data on consumption are not available for South Africa.

There is an argument suggesting that the results of the NZD/USD and the GPB/USD may be related to the fact that both countries adopted free floating exchange rate policies. This argument sounds reasonable, but it cannot explain why the hypothesis fails to hold in the CAD/USD. Canada also adopted a free floating exchange rate policy. Admittedly, more research is needed in this area to explain the mix of results obtained here.

4 Summary

The forward rate unbiasedness hypothesis was tested for New Zealand and other inflation-targeting countries (i.e., Canada, UK and Sweden) and for some non-inflation targeting, but low-inflation countries such as Germany and Japan. South Africa was added to he sample for control purposes. The unbiasedness hypothesis was rejected in almost all cases and in all samples, except for New Zealand and the UK during the period of inflation targeting.

An implication of the Consumption Asset – Pricing Model (CAPM) was used to explain the results. Given that risk premium is negligible, the forward rate is equal to the expected spot rate when the variance of the depreciation rate and the covariance between the depreciation rate and inflation are close to zero. These conditions seem to exist in New Zealand and the UK. Both countries experienced significant reduction in the volatility of their spot exchange rates with respect to the U.S. dollar. The correlation between the inflation rates and the spot exchange rate were not different from zero. Similar conditions are found in the South African data, but the hypothesis failed to hold. I speculate that the risk premium is significant in South Africa.

The problems associated with testing the forward rate unbiasedness hypothesis can be ameliorated if one estimates a regression equation with an appropriate dynamic specification like that found in Naka and Whitney (1995). Unlike Naka and Whitney (1995), the results here were found to be sensitive to the sample period because, among other factors, changes in the nature of the shocks are likely to affect the variance of the spot rate and the covariance between the spot rate and the price level. Also, the estimation of the non-linear dynamic regression of Naka and Whitney is sensitive to starting values, which does not ensure that the global optimum are in fact found. Thus, although Naka and Whitney's elaboration of the dynamics seems appropriate, it does not in fact demonstrate that the unbiasedness hypothesis holds for all countries and all periods. The premia puzzle remains largely unexplained.

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Table 1: OLS Estimates from $e_t - e_{t-1} = a^* + b^*(f_{t-1} - e_{t-1}) + u_t^*$

Currency	Period	NOB	a^* **,P-value,** $(Wald: H_0: a^* = 0)$	b^* **, P-value,** $(Wald: H_0: b^* = 1)$	**P-value** $Wald: H_0: a^* = 0, b^* = 1$	**DW**
NZD/USD	85:10-98:05	152	-0.004 (0.29184)	-1.10 (0.0005)	(0.0003)	2.09
CAD/USD	85:10-98:05	152	-0.001 (0.17527)	-1.10 (0.0002)	(0.0006)	2.04
GBP/USD	85:10-98:05	152	-0.000 (0.85988)	-0.16 (0.3732)	(0.2167)	1.78
SDK/USD	85:10-98:05	152	-0.005 (0.18252)	1.54 (0.5720)	(0.3338)	1.53
DM/USD	85:10-98:05	152	0.003 (0.31970)	1.04 (0.9646)	(0.6036)	1.91
YEN/USD	85:10-98:05	152	0.007 (0.03957)	-1.84 (0.0069)	(0.0212)	1.85
SAR/USD	85:10-98:05	152	-0.007 (0.19575)	-0.39 (0.1016)	(0.2506)	1.72
Sub-Sample 1			a_1^* **,P-value,** $(Wald: H_0: a^* = 0)$	b_1^* **, P-value** $(Wald: H_0: b_1^* = 1)$	**P-value** $Wald: H_0: a_1^* = 0, b_1^* = 1$	**DW**
NZD/USD	85:10-88:12	39	-0.025 (0.18405)	-2.83 (0.0220)	(0.0075)	2.23
CAD/USD	85:10-90:12	63	0.000 (0.69879)	-0.79 (0.0633)	(0.0017)	2.26
GBP/USD	85:10-92:10	84	-0.003 (0.75613)	-1.51 (0.2999)	(0.1510)	1.83
SDK/USD	85:10-92:12	86	0.016 (0.01799)	3.49 (0.0870)	(0.0535)	1.40
DM/USD	85:10-91:04	67	0.001 (0.83851)	3.71 (0.2359)	(0.2160)	1.90
YEN/USD	85:10-91:04	67	0.013 (0.08593)	-2.80 (0.2165)	(0.2265)	1.90
SAR/USD	85:10-91:04	67	-0.008 (0.32921)	-1.52 (0.1249)	(0.2958)	1.75
Sub-Sample 2			a_2^* **,P-value,** $(Wald: H_0: a^* = 0)$	b_2^* **, P-value** $(Wald: H_0: b_2^* = 1)$	**P-value** $Wald: H_0: a_2^* = 0, b_2^* = 1$	**DW**
NZD/USD	89:01-98:05	113	0.003 (0.31603)	1.46 (0.5386)	(0.5869)	1.71
CAD/USD	91:01-98:05	89	-0.002 (0.05253)	-0.65 (0.0275)	(0.0451)	2.00
GBP/USD	93:10-98:05	56	0.002 (0.46896)	0.61 (0.8759)	(0.5441)	2.22
SDK/USD	93:12-98:05	54	-0.002 (0.57319)	-3.16 (0.0201)	0.05743	2.01
DM/USD	91:04-98:05	85	-0.001 (0.76207)	-0.68 (0.1415)	(0.0373)	1.81
YEN/USD	91:04-98:05	85	0.004 (0.32761)	-1.67 (0.0073)	(0.0258)	1.75
SAR/USD	91:04-98:05	85	-0.008 (0.27479)	-0.17 (0.2460)	(0.0579)	1.74

Shaded area **interpreted** as, the null hypotheses $b^* = 1$ could not be rejected at the 5% levels.

Table 2: NLLS Estimates from $e_t - e_{t-1} = (1-\rho)a + (1-\rho)(bf_{t-2} - e_{t-1}) + b(f_{t-1} - f_{t-2}) + v_t$

	Period	NOB	a , (Wald P-values), $a = 0$	b , (Wald P-values), $b = 1$	ρ ,(Wald P-values), $\rho = 0$	Wald P-values , a =0, b =1	DW P Value	ARCH12
NZD/USD	85:10-98:05	152	-0.030 (0.03377)	0.92 (0.01280)	0.05 (0.52329)	0.00526	0.3813	22.27*
CAD/USD	85:10-98:05	152	0.002 (0.61759)	1.00 (0.80459)	-0.10 (0.90141)	0.59924	0.4421	10.49
GBP/USD	85:10-98:05	152	0.046 (0.00406)	0.87 (0.00678)	0.17 (0.06350)	0.00951	0.4390	28.58*
SDK/USD	85:10-98:05	152	-0.120 (0.04617)	0.93 (0.03977)	0.26 (0.00242)	0.06869	0.4822	15.46
DM/USD	85:10-98:05	152	-0.037 (0.00161)	0.92 (0.00049)	0.02 (0.79292)	0.00141	0.4131	2.68
YEN/USD	85:10-98:05	152	-0.294 (0.00031)	0.93 (0.00028)	0.07 (0.07566)	0.00112	0.3348	7.79
SAR/USD	85:10-98:05	152	-0.008 (0.54508)	0.99 (0.48880)	0.15 (0.05171)	0.73441	0.5597	55.22*
SUB-SAMPLE 1			a_1 , (Wald P-values), $a_1 = 0$	b_1 (Wald P-values), $b_1 = 1$	ρ_1 (Wald P-values), $\rho_1 = 0$	Wald P-values, a_1 =0, b_1 =1	DW P Value	ARCH12
NZD/USD	85:10-88:12	39	-0.048 (0.27493)	0.88 (0.14657)	-0.02 (0.91587)	0.03671	0.4042	8.19
CAD/USD	85:10-90:12	63	0.004 (0.40967)	0.99 (0.91488)	-0.13 (0.30338)	0.00406	0.3411	11.66
GBP/USD	85:10-92:10	84	0.065 (0.01518)	0.88 (0.02746)	0.06 (0.63107)	0.02284	0.1632	15.16
SDK/USD	85:10-92:12	86	-0.284 (0.01741)	0.84 (0.01510)	0.28 (0.05161)	0.02331	0.1834	28.21*
DM/USD	85:10-91:04	67	-0.482 (0.00871)	0.91 (0.00253)	-0.08 (0.52103)	0.00333	0.1796	6.11
YEN/USD	85:10-91:04	67	-0.590 (0.00005)	0.88 (0.00004)	-0.09 (0.44951)	0.00008	0.2569	8.22
SAR/USD	85:10-91:04	67	-0.123 (0.06583)	0.85 (0.05907)	0.23 (0.11903)	0.15048	0.4223	21.00#
SUB-SAMPLE 2			a_2 , (Wald P-values), $a_2 = 0$	b_2 , (Wald P-values), $b_2 = 1$	ρ_2 (Wald P-values), $\rho_2 = 0$	Wald P-values, a_2 =0, b_2 =1	DW P Value	ARCH12
NZD/USD	89:01-98:05	113	-0.013 (0.25968)	0.96 (0.20768)	0.11 (0.20952)	0.32094	0.2495	10.48
CAD/USD	91:01-98:05	89	-0.002 (0.64129)	0.99 (0.86232)	-0.00 (0.95289)	0.49761	0.4426	10.26
GBP/USD	93:10-98:05	56	0.053 (0.07465)	0.88 (0.10000)	-0.06 (0.67164)	0.11412	0.4849	14.59
SDK/USD	93:12-98:05	54	-0.224 (0.08570)	0.88 (0.08319)	0.15 (0.31219)	0.20082	0.3722	9.64
DM/USD	91:05-98:05	85	-0.047 (0.07208)	0.89 (0.06745)	0.15 (0.20295)	0.18668	0.3712	5.26
YEN/USD	91:05-98:05	85	-0.330 (0.06296)	0.93 (0.06367)	0.24 (0.03188)	0.17465	0.3313	7.82
SAR/USD	91:05-98:05	85	-0.001 (0.92543)	0.99 (0.91036)	0.12 (0.21300)	0.98396	0.4133	11.54

Shaded areas **interpreted** as, the null hypotheses could not be rejected at the 5% level.
Asterisk means significant at the 5% level.
means significant at the 10% level.

Table 3: NLLS Estimates from $e_t - e_{t-1} = (1-\rho)a + (1-\rho)(b f_{t-2} - e_{t-1}) + b(f_{t-1} - f_{t-2}) + v_t$

Currency	Period	NOB	a , (Wald P-values), $a = 0$	b , (Wald P-values), $b = 1$	ρ ,(Wald P-values), $\rho = 0$	Wald P-values , a =0, b =1	DW P Value	ARCH12
NZD/DM	85:10-98:05	152	0.003 (0.36297)	0.94 (0.05295)	-0.07 (0.36853)	0.12156	0.4266	14.73
CAD/DM	85:10-98:05	152	0.014 (0.02993)	0.94 (0.00625)	-0.00 (0.91662)	0.01952	0.3972	4.54
GBP/DM	85:10-98:05	152	0.044 (0.03810)	0.95 (0.04137)	0.19 (0.01730)	0.11442	0.3339	1.94
SDK/DM	85:10-98:05	152	-0.023 (0.22173)	0.98 (0.20397)	0.16 (0.05000)	0.39727	0.5106	1.69
YEN/DM	85:10-98:05	152	-0.183 (0.00038)	0.92 (0.00006)	-0.70 (0.93227)	0.00018	0.3657	2.07
SAR/DM	85:10-98:05	152	-0.314 (0.08617)	0.94 (0.05965)	0.08 (0.32945)	0.14651	0.4207	11.03
SUB-SAMPLE 1			a_1 , (Wald P-values), $a_1 = 0$	b_1 (Wald P-values), $b_1 = 1$	ρ_1 (Wald P-values), $\rho_1 = 0$	Wald P-values, a_1 =0, b_1 =1	DW P Value	ARCH12
NZD/DM	85:10-88:12	39	-0.025 (0.02958)	0.83 (0.02392)	-0.18 (0.27813)	0.06019	0.4154	10.42
CAD/DM	85:10-90:12	63	0.046 (0.00650)	0.87 (0.00264)	-0.07 (0.58269)	0.00766	0.4084	7.08
GBP/DM	85:10-92:10	84	0.123 (0.03602)	0.88 (0.03443)	0.18 (0.16812)	0.10347	0.0929	2.49
SDK/DM	85:10-92:12	86	-0.029 (0.57628)	0.97 (0.57770)	0.05 (0.76370)	0.85475	0.0008	2.76
YEN/DM	85:10-91:04	67	-0.257 (0.00276)	0.90 (0.00041)	-0.12 (0.31999)	0.00037	0.1699	7.23
SAR/DM	85:10-91:04	67	-0.066 (0.03123)	0.86 (0.01616)	0.07 (0.62206)	0.03898	0.5277	4.89
SUB-SAMPLE 2			a_2 , (Wald P-values), $a_2 = 0$	b_2 , (Wald P-values), $b_2 = 1$	ρ_2 (Wald P-values), $\rho_2 = 0$	Wald P-values, a_2 =0, b_2 =1	DW P Value	ARCH12
NZD/DM	89:01-98:05	113	0.000 (0.92173)	0.95 (0.19415)	0.07 (0.48341)	0.40331	0.4530	6.19
CAD/DM	91:01-98:05	89	0.013 (0.12552)	0.93 (0.07504)	0.05 (0.67225)	0.20240	0.4075	14.48
GBP/DM	93:10-98:05	56	0.017 (0.64524)	0.98 (0.73771)	0.21 (0.15059)	0.40760	0.2508	15.10
SDK/DM	93:12-98:05	54	-0.139 (0.15929)	0.90 (0.14694)	0.17 (0.26049)	0.16331	0.2829	2.43
YEN/DM	91:05-98:05	85	-0.214 (0.07802)	0.90 (0.07374)	0.15 (0.20075)	0.20195	0.3588	5.46
SAR/DM	91:05-98:05	85	-0.008 (0.70797)	0.98 (0.71351)	0.07 (0.51457)	0.93224	0.2704	8.00

Shaded areas **interpreted** as, the null hypotheses could not be rejected at the 5% levels.

Table 4: Grid Search Estimates $e_t - e_{t-1} = (1-\rho)a + (1-\rho)(b f_{t-2} - e_{t-1}) + b(f_{t-1} - f_{t-2}) + v_t$

	Period	NOB	a, (Wald P-values), $a = 0$	b, (Wald P-values), $b = 1$	ρ, (Wald P-values), $\rho = 0$	Wald P-values, a =0, b =1
NZD/USD	85:10-98:05	152	-0.52 (0.00)	-0.01 (0.00)	0.95 (0.00)	0.00
CAD/USD	85:10-98:05	152	-0.30 (0.00)	-0.04 (0.00)	0.99 (0.00)	0.00
GBP/USD	85:10-98:05	152	0.41 (0.00)	0.17 (0.00)	0.87 (0.00)	0.00
SDK/USD	85:10-98:05	152	-0.12 (0.01)	0.94 (0.01)	0.26 (0.02)	0.07
DM/USD	85:10-98:05	152	-0.49 (0.00)	0.02 (0.00)	0.92 (0.00)	0.00
YEN/USD	85:10-98:05	152	-4.55 (0.00)	0.05 (0.00)	0.94 (0.00)	0.00
SAR/USD	85:10-98:05	152	3.85 (0.00)	0.14 (0.00)	1.00 (0.00)	0.00
SUB-SAMPLE 1			a_1, (Wald P-values), $a_1 = 0$	b_1 (Wald P-values), $b_1 = 1$	ρ_1 (Wald P-values), $\rho_1 = 0$	Wald P-values, a_1 =0, b_1 =1
NZD/USD	85:10-88:12	39	-0.53 (0.00)	-0.08 (0.00)	0.91 (0.00)	0.00
CAD/USD	85:10-90:12	63	0.05 (0.00)	-0.16 (0.00)	0.99 (0.00)	0.00
GBP/USD	85:10-92:10	84	0.52 (0.00)	0.08 (0.00)	0.91 (0.00)	0.00
SDK/USD	85:10-92:12	86	-0.19 (0.01)	0.89 (0.00)	0.07 (0.53)	0.13
DM/USD	85:10-91:04	67	-0.05 (0.03)	0.91 (0.01)	-0.09 (0.54)	0.09
YEN/USD	85:10-91:04	67	-5.37 (0.00)	-0.09 (0.00)	-0.88 (0.00)	0.00
SAR/USD	85:10-91:04	67	-0.12 (0.01)	0.86 (0.01)	0.23 (0.07)	0.02
SUB-SAMPLE 2			a_2, (Wald P-values), $a_2 = 0$	b_2, (Wald P-values), $b_2 = 1$	ρ_2 (Wald P-values), $\rho_2 = 0$	Wald P-values, a_2 =0, b_2 =1
NZD/USD	89:01-98:05	113	-0.01 (0.22)	0.97 (0.16)	0.12 (0.22)	0.40
CAD/USD	91:01-98:05	89	-0.36 (0.00)	-0.08 (0.00)	-0.93 (0.00)	0.00
GBP/USD	93:10-98:05	56	0.05 (0.08)	0.89 (0.10)	-0.06 (0.67)	0.30
SDK/USD	93:12-98:05	54	-1.77 (0.00)	0.11 (0.00)	0.90 (0.00)	0.00
DM/USD	91:05-98:05	85	-0.41 (0.00)	0.13 (0.00)	0.91 (0.00)	0.00
YEN/USD	91:05-98:05	85	-3.79 (0.00)	0.20 (0.00)	0.94 (0.00)	0.00
SAR/USD	91:05-98:05	85	5.29 (0.00)	0.12 (0.00)	1.00 (0.00)	0.00

Shaded areas **interpreted** as, the null hypotheses could not be rejected at the 5% level.
P values are obtained by bootstrapping.

Table 5 Grid Search Estimates $e_t - e_{t-1} = (1-\rho)a + (1-\rho)(b f_{t-2} - e_{t-1}) + b(f_{t-1} - f_{t-2}) + v_t$

Currency	Period	NOB	a , (Wald P-values), $a = 0$	b , (Wald P-values), $b = 1$	ρ ,(Wald P-values), $\rho = 0$	Wald P-values , a =0, b =1
NZD/DM	85:10-98:05	152	-0.02 (0.00)	-0.10 (0.00)	0.92 (0.00)	0.00
CAD/DM	85:10-98:05	152	0.23 (0.00)	-0.02 (0.00)	0.94 (0.00)	0.00
GBP/DM	85:10-98:05	152	0.80 (0.00)	0.19 (0.00)	0.95 (0.00)	0.00
SDK/DM	85:10-98:05	152	-1.25 (0.00)	0.15 (0.00)	0.97 (0.00)	0.00
YEN/DM	85:10-98:05	152	-0.27 (0.00)	0.94 (0.00)	0.20 (0.02)	0.00
SAR/DM	85:10-98:05	152	-0.84 (0.00)	0.18 (0.00)	0.98 (0.00)	0.00
SUB-SAMPLE 1			a_1 , (Wald P-values), $a_1 = 0$	b_1 (Wald P-values), $b_1 = 1$	ρ_1 (Wald P-values), $\rho_1 = 0$	Wald P-values, a_1 =0, b_1 =1
NZD/DM	85:10-88:12	39	-0.11 (0.00)	-0.21 (0.00)	0.83 (0.00)	0.00
CAD/DM	85:10-90:12	63	0.05 (0.00)	0.85 (0.000)	0.01 (0.92)	0.01
GBP/DM	85:10-92:10	84	0.94 (0.00)	0.13 (0.00)	0.86 (0.00)	0.00
SDK/DM	85:10-92:12	86	-1.20 (0.00)	0.06 (0.00)	0.92 (0.00)	0.00
YEN/DM	85:10-91:04	67	-3.68 (0.00)	0.16 (0.00)	0.93 (0.00)	0.00
SAR/DM	85:10-91:04	67	-0.26 (0.00)	0.28 (0.00)	0.92 (0.00)	0.00
SUB-SAMPLE 2			a_2 , (Wald P-values), $a_2 = 0$	b_2 , (Wald P-values), $b_2 = 1$	ρ_2 (Wald P-values), $\rho_2 = 0$	Wald P-values, a_2 =0, b_2 =1
NZD/DM	89:01-98:05	113	-0.03 (0.00)	0.07 (0.00)	0.94 (0.00)	0.00
CAD/DM	91:01-98:05	89	0.16 (0.00)	-0.02 (0.00)	0.91 (0.00)	0.00
GBP/DM	93:10-98:05	56	0.93 (0.00)	0.19 (0.00)	0.99 (0.00)	0.00
SDK/DM	93:12-98:05	54	-1.29 (0.00)	0.14 (0.00)	0.92 (0.00)	0.00
YEN/DM	91:05-98:05	85	-0.35 (0.02)	0.92 (0.02)	0.22 (0.05)	0.08
SAR/DM	91:05-98:05	85	-1.05 (0.00)	0.06 (0.00)	0.98 (0.00)	0.00

Shaded areas **interpreted** as, the null hypotheses could not be rejected at the 5% levels.
P values are obtained by bootstrapping.

Table 6: Inflation and the depreciation rate

Country	Period	NOB	Mean	STD	Student t (H_0^{μ})	F ($H_0^{\sigma^2}$)	STD	F($H_0^{\sigma^2_{\Delta e_t}}$)	Correlation $(\Delta e_t, \Delta P_t)$
New Zealand	85Q1-88Q4	16	2.10	1.04	8.16*	7.90*	9.21	7.82*	-0.037
	89Q1-98Q1	37	0.65	0.37			3.29		-0.056
Canada	85:10-91:12	63	0.36	0.30	7.21*	2.25*	1.15	0.78	-0.029
	92:01-98:05	89	0.12	0.20			1.30		0.051
UK	85:10-92:11	84	0.44	0.30	5.84*	2.77*	4.02	4.36*	-0.036
	93:11-98:05	56	0.25	0.18			1.92		-0.010
Sweden	85:10-92:12	86	0.48	0.53	7.15*	5.80*	3.46	1.76*	0.071
	93:12-98:05	54	0.09	0.22			2.60		0.089
Germany	85:10-91:04	67	0.12	0.19	-3.36#	0.49	3.84	1.55	-0.144
	91:05-98:05	85	0.23	0.27			3.07		-0.104
Japan	85:10-91:04	67	0.14	0.280	1.69	0.97	4.06	1.64	0.064
	91:05-98:05	85	0.07	0.283			3.17		0.039
South Africa	85:10-91:04	67	1.18	0.468	7.12*	0.97	4.64	5.86*	0.057
	91:05-98:05	85	0.73	0.473			1.92		0.156

- The UK departed from the Exchange Rate Mechanism (ERM) in September 1992, and established an inflation-targeting regime in November 1992. For this reason, I removed 12 months of data from the sample. Sweden floated in November 1992 so 12 months are removed.
- The data are monthly except for New Zealand, which are quarterly.
- Inflation is defined as $(P_t - P_{t-1})*100$, where P_t is the natural logarithm of the CPI.
- Depreciation's rate is defined as $(e_t - e_{t-1})*100$. Exchange rates are in terms of the USD.
- NOB is the number of observations.
- STD is the standard deviations.
- Students' t statistic tests $H_0 = \mu_1 = \mu_2$ vs. $H_a : \mu_1 > \mu_2$ or (#) $H_a : \mu_1 < \mu_2$ inflation.
- F tests $H_0 : \sigma_1^2 = \sigma_2^2$ vs. $H_a : \sigma_1^2 > \sigma_2^2$.
- Asterisk means significant at the 5% level.

Figure 1: Minimum SSR vs. Grid of Rho Values
NZD/USD

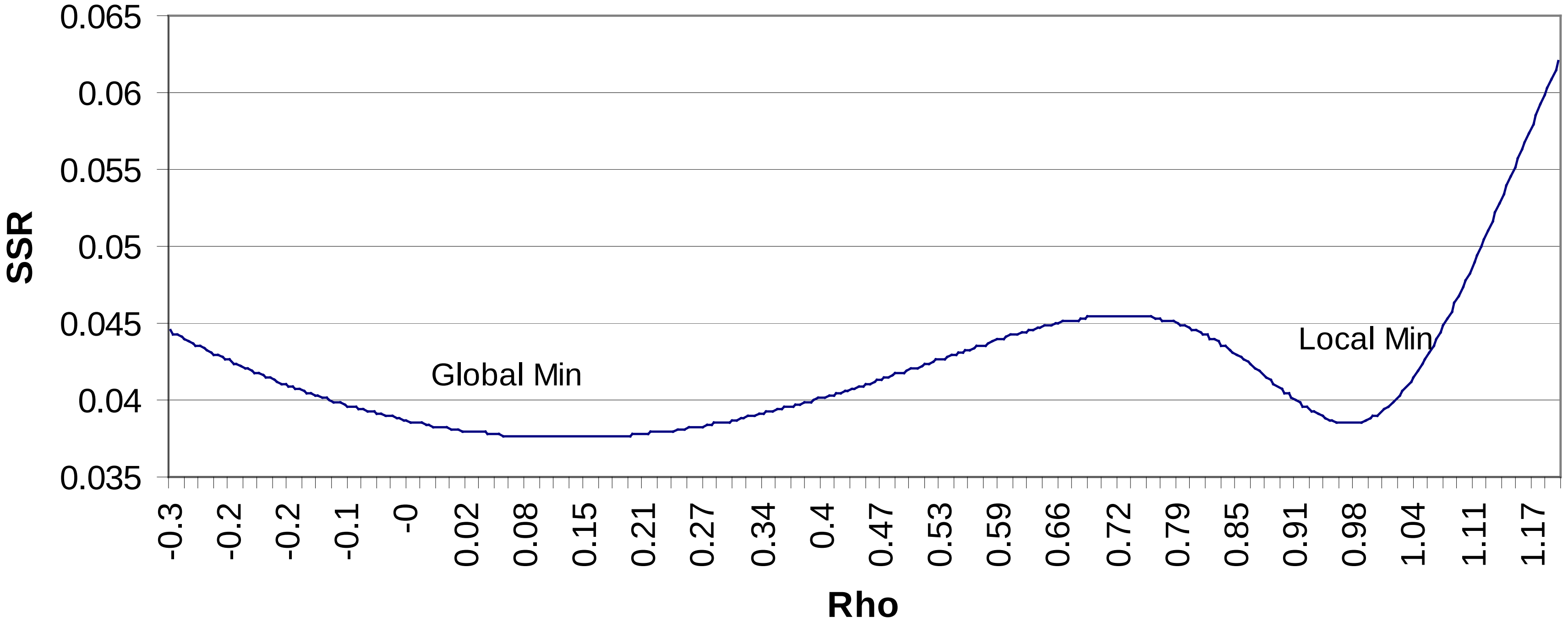

Figure 2: Minimum SSR vs. Grid of Rho Values
CAD/USD

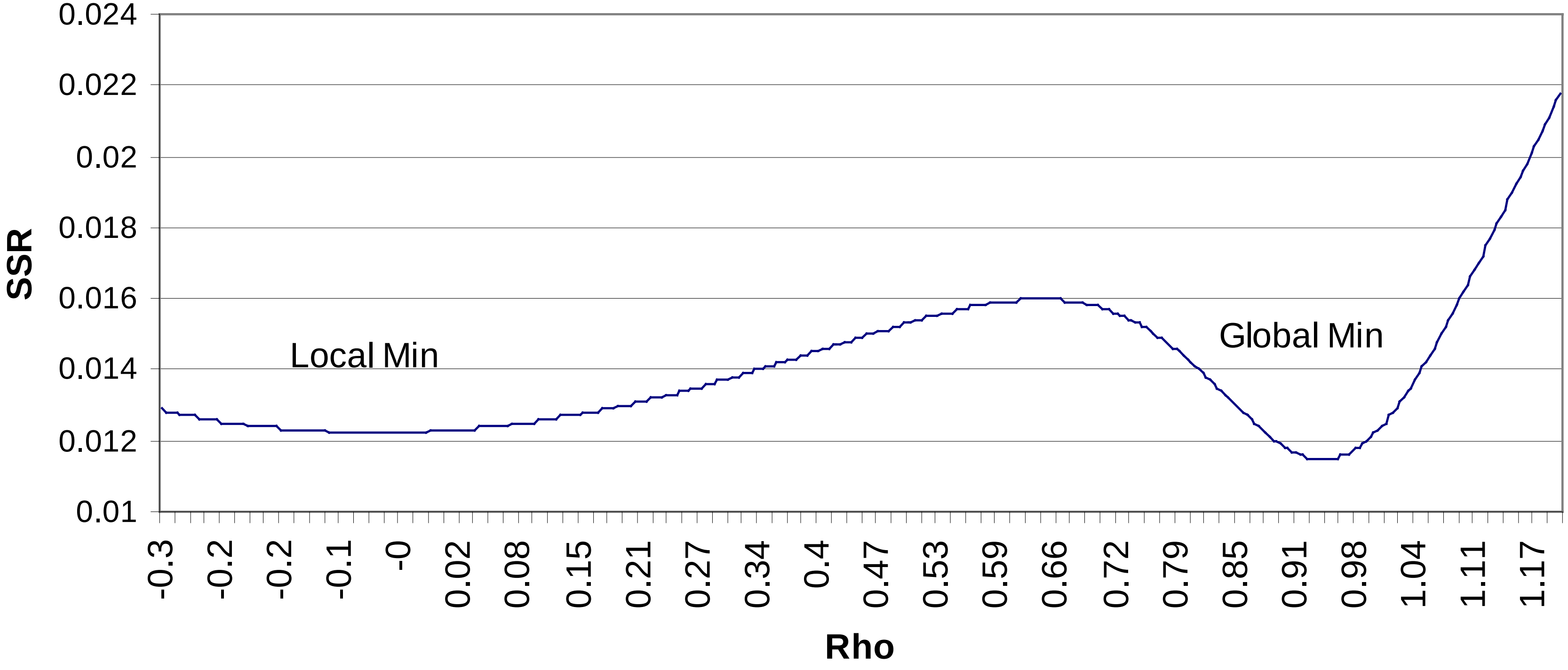

Figure 3: Minimum SSR vs. Grid of Rho Values
GBP/USD

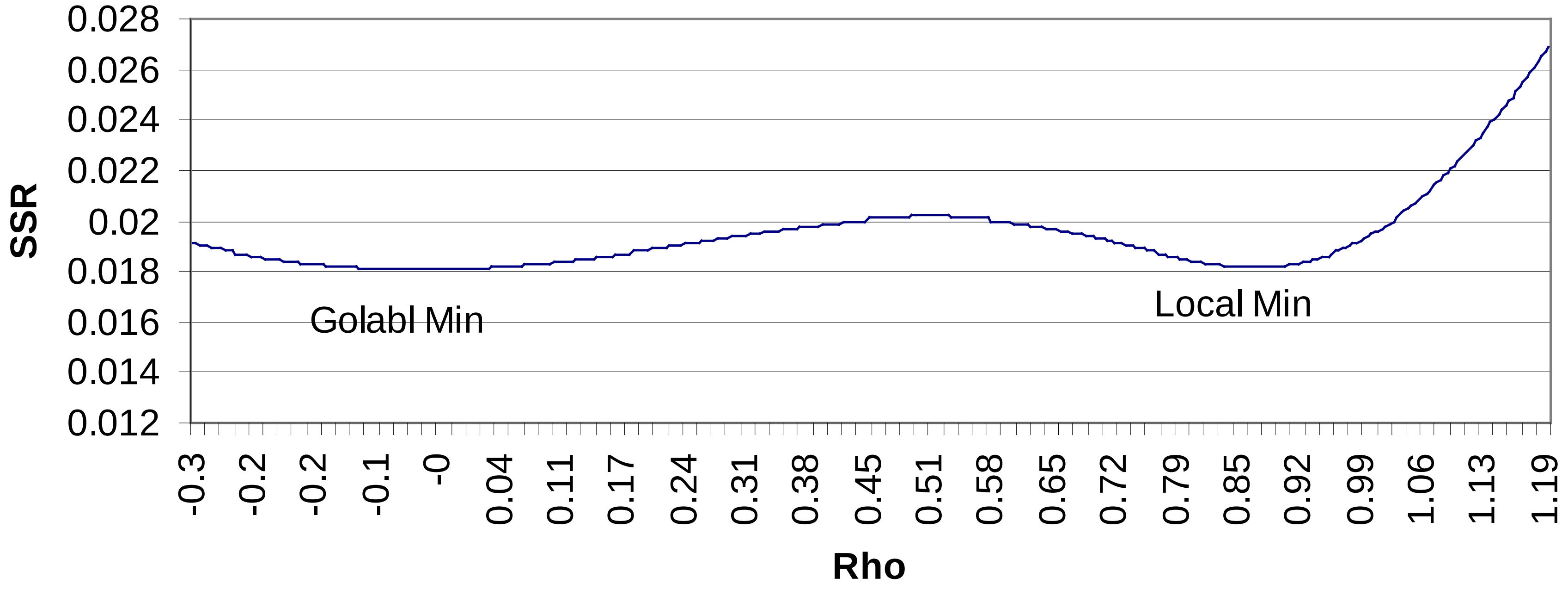

Figure 4: Minimum SSR vs. Grid of Rho Values
SDK/USD

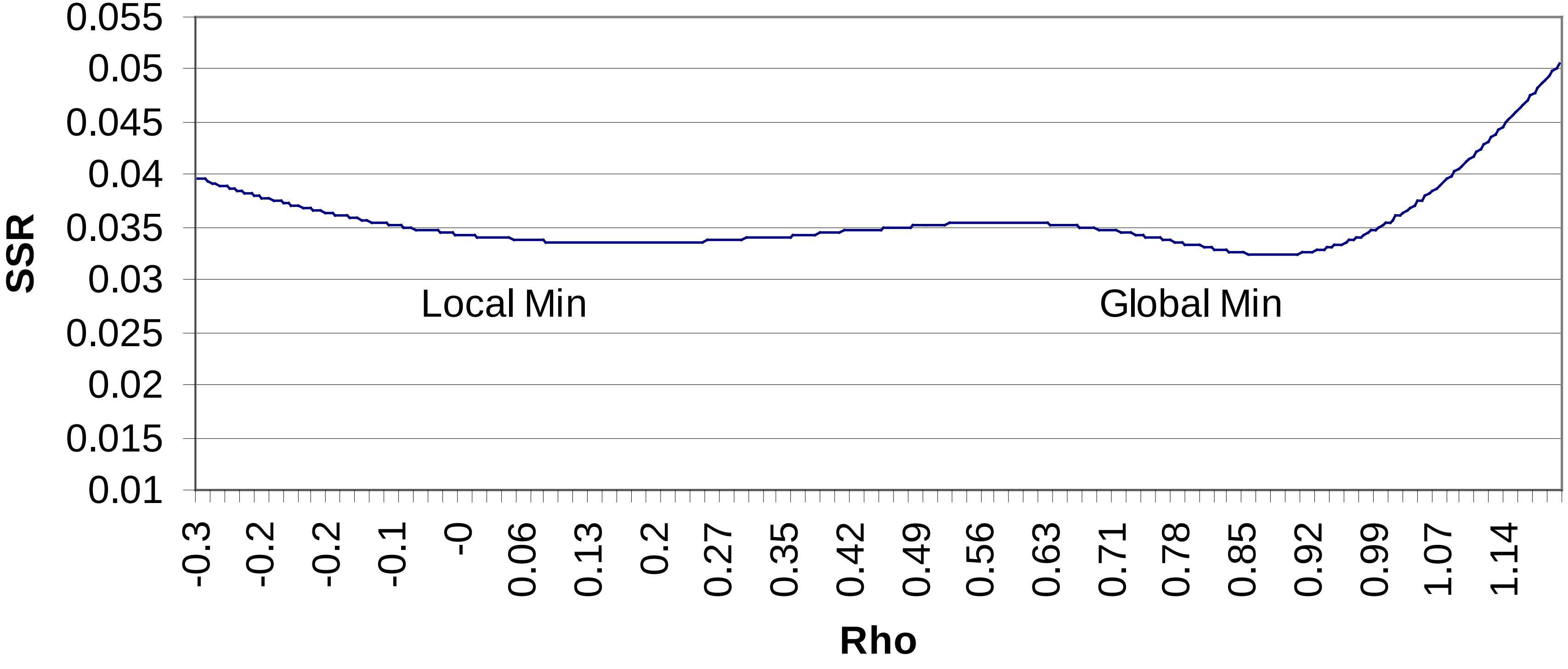

Figure 5: Minimum SSR vs. Grid of Rho Values
DM/USD

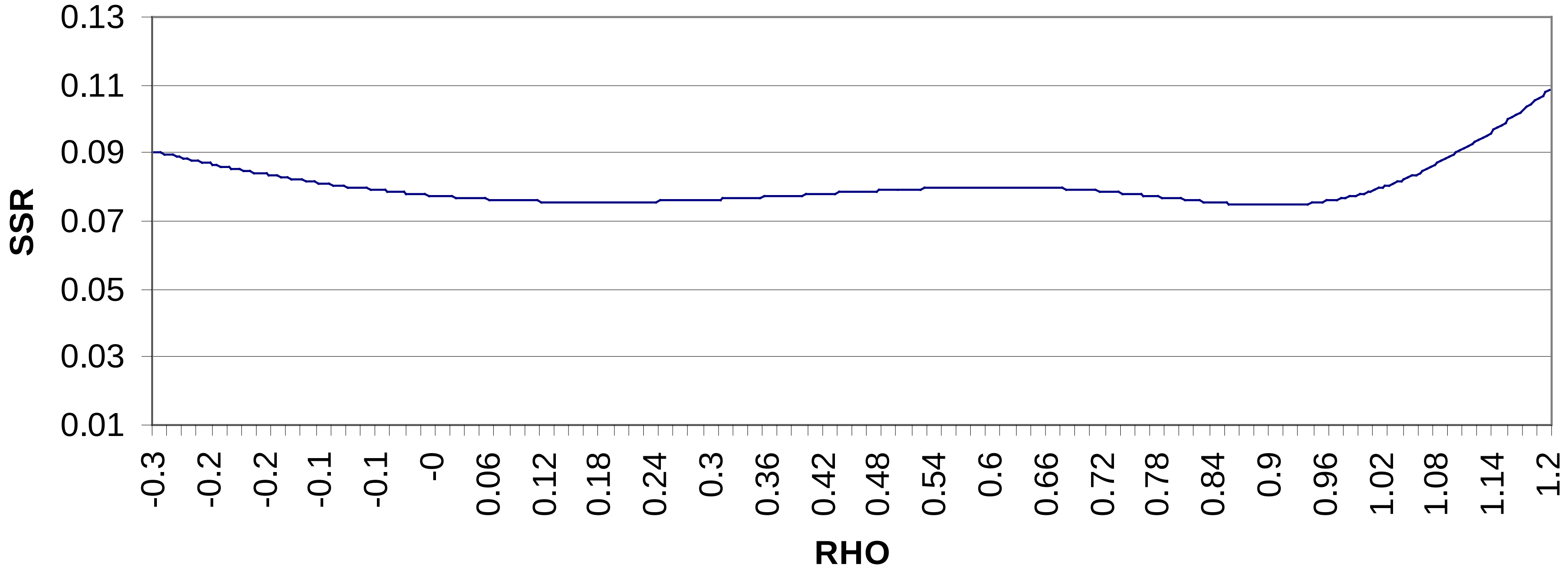

Figure 6: Minimum SSR vs. Grid of Rho Values
YEN/USD

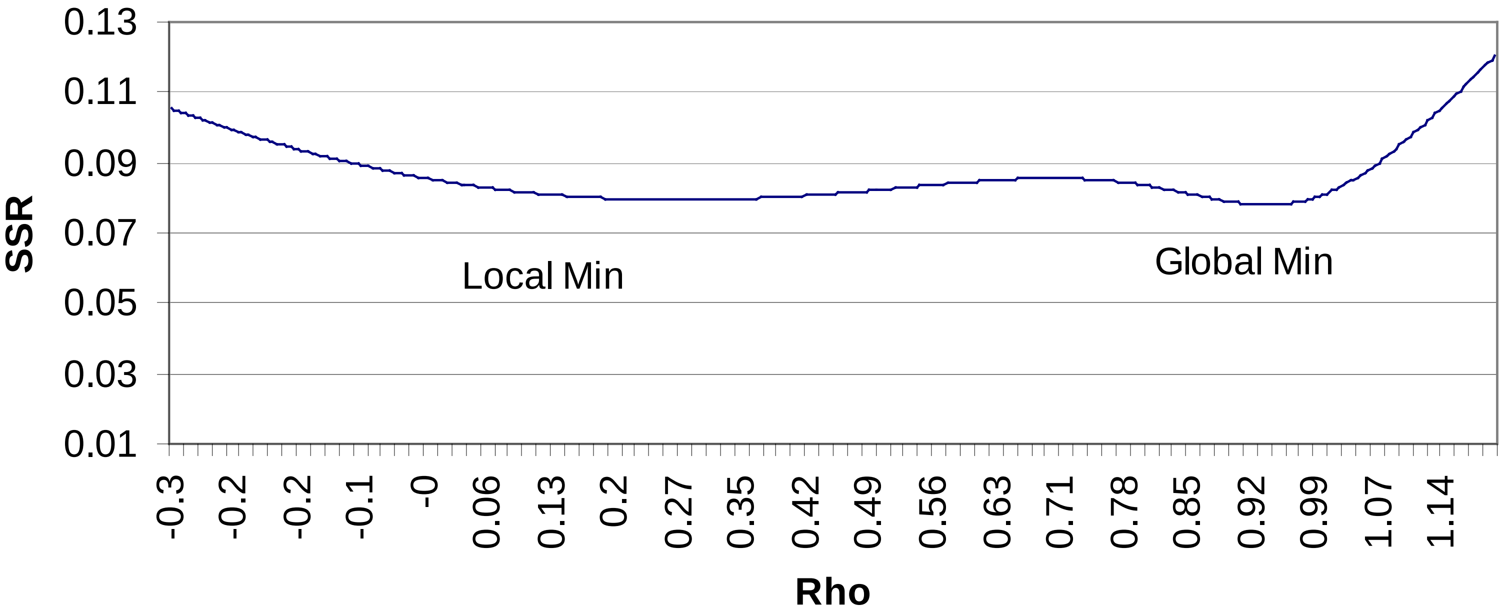

Figure 7: Minimum SSR vs. Grid of Rho Values
SAR-USD