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Economic Fundamentals and Managed Floating Exchange Rate Regime in Singapore

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"Pegging the Singapore dollar to a basket of currencies instead of a fixed rate to the US dollar and having a transparent system were claimed by the government of Singapore to have enabled the country to weather the Asian financial crisis better. This empirical paper reviews the claim by testing the consistency of observed Singapore dollar real exchange rate against the country's key real economic fundamentals. Employing the concept of Natural Real Equilibrium Exchange Rate (NATREX), our study finds that the real effective exchange rate has floated around the NATREX rate in 1990's. Hence, our test results support the official statement.

I. Introduction

"Pegging the Singapore dollar to a basket of currencies instead of a fixed rate to the US dollar; and having a transparent system have enabled the Republic to weather the Asian financial crisis better, said Senior Minister Lew Kuan Yew."

[The Strait Times, 6th October 1999]

Despite a series of turbulence events in the world economy and the country's own structural changes in various fronts, Singapore's economy had successfully maintained a remarkable performance during the past three decades. High GDP per capita growth rates, driven partly by rapid expansions in trade sector, were achieved while at the same time maintaining a relatively modest annual rate of inflation (Table 1A-1C). Most impressively, Singapore was one of the few economies in East Asia to have maintained both positive growth rate and low inflation at the peak of the East Asian Financial crisis in 1998.[1]

Given the country's high degree of openness to trade flows where total values of export and import averaging around 280% to 400% of GDP in 1980s and 1990s,[2]

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1. In terms of GDP per capita, Singapore did experience a negative growth rate, albeit a modest rate of 1.6% (East Asian Economic Perspectives (2000)).

2. Krugman (1995) places the country in the league of "super-trading" nations.

fluctuations in the domestic currency have significantly influenced the fluctuations in the domestic price. Therefore the ability of the Monetary Authority of Singapore (MAS) to prudently manage the country's exchange rate policy is arguably one of the key policies contributing to the macroeconomic stabilities in general, and the stability of the domestic price level in particular (Lu and Yu (1999) and MAS (2000)). Indeed, keeping imported-inflation low by letting Singapore dollar to appreciate steadily against its major trading partners' currencies had been the policy anchor of the Monetary Authority of Singapore in 1980s and 1990s (MAS (2000)).

However, an active interventionist strategy in managing nominal exchange rate level may often create instability elsewhere in the economy, as observed real effective rate fails to reflect changes in economic fundamentals (Obstfeld and Rogoff (1995)). Calvo *et al*. (1995) have also shown that if observed real exchange rate falls significantly below its equilibrium level (an undervaluation of the local currency against major trading partners' currencies), this situation could lead to an inflationary pressure in the domestic economy. Given the impressive performance of the macroeconomic indicators of the country, can we, therefore, conclude that the exchange rate management in Singapore had indeed been consistent with prevailed economic fundamentals and market conditions?

The objective of this study is to evaluate the performance of the country's exchange rate policy from quarter 1, 1983 to quarter 3, 1993. We pose two narrow but pertinent policy questions: 1) to what extent had the real exchange rate been justified by the economic fundamentals? and 2) had the Singapore dollar been persistently and significantly misaligned (over- or under-valued) from its equilibrium rate ?

To address those two fundamental questions, our study employs the concept of the Natural Real Exchange Rate Equilibrium (NATREX) developed by Stein (1994 and 1996). The NATREX is the equilibrium exchange rate produced by domestic economic fundamentals. A currency is misaligned if the observed real exchange rate deviates from its NATREX rate. Accordingly, the study will apply the cointegration technique to estimate long-run relationship between the fundamental variables and the exchange rate variable. Having the theoretically generated equilibrium level of exchange rate, we can address the two questions in the paper.

The paper is organized as follows. Section II briefly looks at Singapore's basic key domestic macroeconomic indicators and the country's exchange rate policy. Section III introduces the theoretical model and the empirical model. Data and Empirical tests are presented in Section IV. The paper ends with a brief closing remark Section V.

II. Brief Stylized Facts of the Economy and Exchange Rate Policy

1. Brief Stylized Facts

In early to late-1980s, Singapore's economy experienced an average GDP per capita growth rate at about 5% per annum, the slowest among the newly industrialized economies in East Asia (Table 1A). The relatively low average growth rate was largely caused by two years of economic slowdowns in 1985-1986, driven by global economic recession between early- to mid-1980s. During those two years of temporary slowdowns, Singapore's exports

and imports had contributed only around 20% of the country's total GDP. In fact, Singapore had experienced its only total trade deficit in two decades (1980s and 1990s) in 1986.

The period of 1990s however saw an impressive economic recovery and sustainable economic growth rates in Singapore. The country established itself as one of the fastest growing nations in East Asia. Singapore's GDP growth rate even outpaced those rates of fast growing neighboring countries such as Indonesia and Thailand. Significant and persistent trade surpluses sustained the rapid growth rate (Table 1A and 1C).

During the five years period before the break of the East Asian crisis, Singapore was experiencing its best years in the past two decades. The GDP grew as fast as 11 percent in one year with its maximum annual trade surplus at around 16 percent of GDP. The stability of the country's macroeconomic performance was also remarkable. The standard deviations for both GDP per capita growth rate and trade balance were relatively low when compared to their means, respectively. In contrast, Korea and Thailand had experienced periods of trade balance deficits. Indonesia, Hong Kong and Taiwan, on the other hand, only managed to post relatively modest trade balance surpluses between 1992 to 1996 (Table 1C).

Clearly, Singapore's ability to manage its inflation rate has been the country's most impressive accomplishment during the past two decades (Table 1B). Between 1980 to 1988, Singapore's inflation rate was averaging above 3 percent per annum. The fluctuations in the domestic price level were significant during this period of 1980s, reflected by a relatively higher standard deviation with respect to its mean.

In a sharp contrast, the MAS had successfully suppressed the inflation rate to a mere average of 2.3% - 2.9% during the era of the managed appreciation of the Singapore dollar (1987-1996). More importantly, the stability of the price level was equally impressive (low standard deviation with respect to its mean). Looking at Table 1B, Taiwan was the only country that had managed to post an equally outstanding record of inflation rates.

2. Overview of the Exchange Rate Policy

Amid the uncertainty in the world economies in 1972 that led to the floating of the Pound Sterling, and the subsequent dismantling of the Sterling Area, Singapore switched its parity from Pound Sterling to the US dollar. In June 1973, the Monetary Authority of Singapore (MAS) led the Singapore dollar to float but keeping active intervention practices in the foreign exchange market to keep the Singapore dollar exchange rate float within an undisclosed band against a trade-weighted basket of currencies of the country's major trading partners.

During the past three decades, three key institutions have been playing major roles in the management of the Singapore dollar: 1) the Board of Commissioners of Currency of Singapore (BCCS, established in 1967), 2) the Monetary Authority of Singapore (MAS, established in 1971), and 3) the Government of Singapore Investment Corporation (GSIC, established in 1981). The first two institutions are largely complementary. The BCCS was set up as a currency board authority, responsible for the issue and redemption of the local currency. The MAS, in the other hand, plays a role of the central bank (conducts both the monetary and exchange rate policies and supervises the financial sector). The last institution, the GSIC, manages the investment of the long-term government reserve assets.

Like a conventional currency board, the BCSS is responsible to ensure that the currency in circulation is (at least) 100% backed by external assets. The discipline of maintaining a high ratio of foreign reserve against domestic monetary aggregates (M1 and M2) has been closely maintained. This prudent practice limits the ability of the MAS to expand domestic credit simply by printing money. In turns, this strategy helps instill a high degree of market confidence in the local currency. However, unlike the conventional currency board regime, there are no pre-announced exchange rates. In fact, the MAS, as a de facto central bank, has a large degree of independence to conduct its monetary policy.

A major shift in the monetary policy took place in early 1980s. The MAS abandoned its policy of targeting the level of money supply or interest rate and began to target the nominal exchange rate as the anchor of the overall monetary policy of the country. Since then, the key objective of the monetary policy is to insulate the economy from the imported inflation. The Singapore dollar is allowed to float within an undisclosed target band. The central parity/level in the target band is determined by the fluctuations of the currencies of the countries that are the main sources of imported inflation and competition in the export markets. Neither the central parity nor the band-width is completely fixed, being periodically reviewed so as to ensure that they are "consistent with economics fundamentals and market conditions" (Williamson (1998)). To illustrate the flexibility of the country's exchange rate policy, the MAS allowed the Singapore dollar to depreciate by about 20 percent during the height of the East Asian crisis; while more recently, it is suspected to have intervened heavily in the market to prop up the Singapore dollar during the bearishness against regional currencies following sharp falls in the NASDAQ (The Straits Times, May 12, 2000).

3. Trends in Effective Exchange Rates and Export Competitiveness

Figures 1 shows close co-movements in the real effective exchange rate (REER) and nominal effective exchange rate (NEER) of the Singapore dollar. In early 1990s, Singapore experienced a much faster nominal appreciation rate than real appreciation. This trend reflects how the Singapore's price level continued to be more and more competitive relative to its trading partners' price levels. The domestic consumer price index grew at a stable and modest rate in 1990s (Figure 2). But more importantly, the weighted price index (WTPI) had been in a persistent decline since late 1984. The trend in WTPI reflected lower inflation rate in the domestic economy compared to most of the trading partners' rates. The declining rate of WTPI contributed to a moderate appreciation trend in the real effective exchange rate, despite the managed appreciation policy of the nominal exchange rate. In fact, the real effective exchange rate in 1990's was lower than its rate in early 1980s (Figure 1).

III. The Natural Real Equilibrium Exchange Rate (NATREX)

While the preceding discussion of trends in effective exchange rates and macro-economic indicators are indicative, it is important to determine consistency of the observed real effective exchange rate against the underlying macroeconomic fundamentals. Accordingly, we appeal to the concept of a Natural Equilibrium Real Exchange Rate (NATREX) model developed by Jerome Stein (1994, 1996). The NATREX is the rate that is

determined by the prevailing economic fundamentals in the economy. The model allows us to generate an equilibrium benchmark based on an implementable theory (Stein and Paladino (1998)). Thus, our equilibrium benchmark is not derived from any atheoretical process. As Stein and Paladino (1998) have emphasized, the NATREX model

"is directly amenable to empirical testing, without making any subjective judgment of what is: anticipated or unanticipated, permanent or transitory changes."

The background discussions on the NATREX in this section will be as terse as possible. The model is a positive one. It takes government policies as given and do not assume that the policy is welfare optimizing one. The natural real equilibrium exchange rate is the rate that is determined by real economic fundamentals in the country. The NATREX will vary through time depending on the changes in the fundamentals. It is a moving equilibrium exchange rate, a complete contrast from the underlying hypothesis of the PPP model. Any deviations from that equilibrium rate at any point of time would be considered as evidences of the currency's misalignment. Hence a currency is argued to be misaligned if its observed real rate can not be justified by the fundamentals prevailing in the economy.

The basic structural equations of the NATREX model are the followings.[3]

$$S(k, F; Z, u)\ I(k, y, R, r : Z, u) = CA(R, y, F, r : Z, u);\ u = 0, \tag{1}$$

$$r + \boldsymbol{r}(t) = r^*;\ \boldsymbol{r}(t) = E\{\Delta R^*[Z(t)]\}, \tag{2}$$

$$dF/dt = -A(R, y, F, r : Z, u) = L(R, k, F, r : Z), L = I - S, \tag{3}$$

$$dK/dt = I \tag{4}$$

Note: R = real exchange rate; r = domestic real interest rate; r^* = foreign real interest rate; S = saving; I = investment; k = capital stock; F = foreign debt; CA = Current Account; y = productivity; u = deviation of rate of capacity utilization; $\boldsymbol{r}(t)$ = risk premium; Z = the vector of fundamental variables. This vector Z includes mainly real exogenous fundamental variables explaining the movements of real exchange rate and current account variable.

Equation (1) is also referred as the macroeconomic balance equation. It states that excess investment over saving ($I - S$) equals to current account deficit. The equilibrium real exchange rate will adjust to ensure that the current account deficit equals to investment (I) less saving (S). (I-S) > 0 represents foreign borrowing, and vice versa. Equation (2) is the uncovered interest rate parity model with Asymptotically Rational Expectation (Stein (1994)). It is basically the portfolio balance equation. Equation (3) and Equation (4) capture

3. Refer to Stein (1994 and 1996) for more detail analysis on the theory part of the model.

the changes in the foreign debt level and the investment level respectively over the period.

In short, the NATREX model adds dynamic stock - flow interactions (Equation (3) and (4)) to the standard macroeconomic approach balance model. The inclusion of the dynamic equations allows the NATREX to vary over time, reflecting the changes on the fundamental variables. In the medium-run, an economy may face an imbalance level of current account. In the long-run, however, the foreign debt and capital stabilize. The evolution of the real exchange rate under the NATREX model can therefore be captured as:

$$dR/dt = [R_k\ dk/dt + R_F\ dF/dt] + R_z\ dZ/dt \qquad (5)$$

where R_k, R_F, and R_z are partial derivatives with respect to capital, debt, and fundamental variables, respectively.

Given k and F are functions of the fundamental variables (Z) - see Equation (1) and Equation (4), the trajectory of the real exchange rate under this model can therefore be expressed in terms of the fundamental variables.

$$dR/dZ = \partial R/\partial Z + [(\partial R/\partial k)dk/dZ + (\partial R/\partial F)dF/dZ] \qquad (6)$$

where $\partial R/\partial Z$ is direct effect of the fundamental variables to the real exchange rate variable. $[(\partial R/\partial k)dk/dZ]$ and $[(\partial R/\partial F)dF/dZ]$ are the effects of fundamental variables to the real exchange rate through their impacts on k and F (indirect effects).

In summary, the impacts of the fundamental variables on the trajectory of the real exchange rate under the NATREX model can be explained through a direct and an indirect way. What is important for the empirical application of the model is to find the appropriate set of fundamental variables included in vector (Z_t). For most applications of the NATREX, the vector (Z_t) includes the terms of trade, productivity variable, world interest rate and saving/expenditure.

1. Single Equation Estimation[4]

We refer to the real exchange rate determined by real fundamental variables in the economy as the natural equilibrium real exchange rate (ERER). The general working model of the ERER is the following single-equation econometric model:

$$erer_t = f(z_t) \qquad (7)$$

where z_t is a vector of economic fundamentals: {g, r^*, prd, tot and pol}. Small letters represent natural logs. g is real government spending, r^* is world real interest rate, prd is productivity, tot is terms of trade and pol is a dummy variable. These variables capture open

4. The use of the single-equation estimation can be commonly found in most of the recent studies (see Edwards and Savastano (1999)).

economy properties of Singapore that rely heavily on international trade (*tot*) and financial sector (r^*). In addition, the economic performance of the country depends heavily on its high total factor productivity (*prd*), facilitated largely by active government expenditure policy (*g*). This set of selected variables has also been quite commonly accepted as exogenous fundamental determinants of the real exchange rate movements in earlier empirical studies (Edwards and Savastano (1999)).

To estimate *erer*, we regress the following equation (Equation (8)):

$$reer_t = \beta_0 + \beta_1 g_t + \beta_2 r_t^* + \beta_3 prd_t + \beta_4 tot_t + \beta_5 pol_t + \beta_6 t + \varepsilon_t \qquad (8)$$

Variables (*g*, r^*, *prd* and *tot*) are defined before. *reer* is a natural log of observed real effective exchange rate (REER), and *t* is a time-trend variable. Equation (8) is seeking the best fit of the REER on the country's relevant exogenous economic fundamentals. β_0 and ε_t are constant and error term respectively. A time trend (*t*) is added to capture the effects of missing fundamentals such as capital stock (Montiel (1997)). A dummy variable *pol* is also introduced to capture a sudden change in the REER trend from a depreciating one to an appreciating one in mid-1980's (Figure 1).[5] Using the coefficient estimates obtained from regressing Equation (8), we construct the equilibrium effective exchange rate (*erer*).

What The Theories Say About Coefficient β*'s* Based on the basic concepts of Mundell-Fleming open economy IS-LM model, a rise (a decline) in the ratio of government consumption of tradable will result in a balance of payment surplus (deficit). In turn, the payment surplus (deficit) will appreciate (depreciate) the local currency. Thus, $\beta_1 > 0$.

When the return for foreign currency dominated assets (r^*) rises beyond that of local currency dominated assets (*r*), investors shift its portfolio away from local assets to foreign assets. Given everything else remains the same, the real rate of Singapore dollar depreciates. This concept of interest rate parity theory implies that $\beta_2 < 0$.

A rise in local productivity and in terms of trade raises capital intensity/investment. The country experiences an improvement in the balance of payment, which eventually appreciates the domestic currency. Thus β_3 and β_4 are positive.

IV. Data and Empirical Tests

1. Data

The data set covers the period of quarter 1, 1983 to quarter 3, 1999. REER is obtained from J.P. Morgan's real effective exchange rate index series. This index captures real effective exchange rate of Singapore dollar against its 22 major trading partners.

5. A combination of the policy shift in the management of the Singapore dollar (to managed appreciation) and other factors such as the global depression during the early-to-mid-1980's were responsible for the sudden shift in the NEER and REER trend of the Singapore dollar.

Three-month U.S. dollar libor rate (adjusted by annualized U.S. consumer price) and terms of trade data (direct price of export / direct price of import) are obtained from IFS, IMF (various years). Productivity index (gross domestic product per capita) and real government expenditure data (adjusted by GDP deflator) are collected from Yearbook of Statistics, Singapore (various years). Dummy variable (*pol*) equals to zero from quarter 1, 1983 to quarter 2, 1986 and to one, otherwise.

2. Empirical Tests

To test the properties of the relevant series, the ADF Unit-Root test will be conducted on all relevant variables. We will then test for any presence of long-run relationship among those variables in Equation (8). The Johansen Maximum Likelihood Cointegration test will be applied to evaluate the cointegration relationship.

Unit-Root Test To determine the order of integration of each variable, we use the standard ADF regression:

$$\Delta X_t = \delta_1 + \delta_2 t + \delta_3 X_{t-1} + \sum_{i=1}^{k} \beta_i \Delta X_{t-i} + \varepsilon_t \qquad (9)$$

where $X = \{reer, tot, g, r^*, prd, pol\}$ with all variables in logs, and t is the time trend. The ADF test shows that all the variables are integrated of order 1 (Table 2). The Akaike Criteria test determines the appropriate number of lag periods.

However, given the potential presence of structural breaks in many time-series variables, the low-power of ADF test may not be sensitive enough to differentiate a stationary series from that of a non-stationary series. To evaluate the unit-root property more structurally, we apply another unit-root test introduced by Banerjee, Lumsdaine and Stock ((BLS), 1992). Their work investigates further the possibility that aggregate economic time series can be characterized as being stationary around "a single or multiple structural breaks". Banerjee, Lumsdaine and Stock extend the Dickey-Fuller t test by constructing the time-series of rollingly computed estimators and their t statistics.

For the BLS Unit-Root test, we report the unit-root test at the level. Both the minimal and maximal Dickey-Fuller t test statistics of the BLS rolling test are found to be significantly larger than each critical value, respectively (Table 3). These test results confirm the findings of the ADF tests that the null hypothesis of nonstationarity at 5% critical value can not be rejected at the level for all the key variables.[6]

Johansen Maximum Likelihood Cointegration Test. Given all variables are I(1), we apply the Johansen full information maximum likelihood procedure to Equation (8). The likelihood ratio test indicates that there is one cointegrating equation at 5% significance level

6. The BLS rolling unit-root test results at the first difference for all variables are found to be significantly smaller than their respected 5% critical values. Hence all variables are found to be I(1), confirming the ADF test-results. The trend and dummy variables were not included on this test.

(Table 4). The size and sign of estimates for each coefficient are both significant and consistent with the theory.

Consistent with the characteristics of the domestic economy, our results show that two most influential variables in explaining the fluctuations of the real effective exchange rate of the Singapore dollar are the productivity rate (*prd*) and the world interest rate (r^*). In 1990s, Singapore's overall productivity level has been rated among the best in the world. The World Competitiveness Yearbook (2000) listed Singapore as the second most competitive country, based on its national productivity level and other indicators, in the world (second only to the United States). In addition, with the rapid development of the financial sector in the country, particularly since early 1980s, the Singapore dollar is expected to be sensitive to the fluctuations in the returns of foreign assets.

Using the estimated coefficients, we calculate *erer* (Figure 3). The positive (negative) difference (misalignment) between the *reer* and the *erer* captures the measured overvaluation (undervaluation) of the Singapore dollar. Figure 3 and Figure 4 show that the *reer* had not been persistently and significantly misaligned from its *erer*, except during the world recession (1985-1986). Even during the 1997-1999 financial crisis period, the *reer* was undervalued at most by only less than 2%.

Has the policy been a stable one, particularly since mid-1980s when the MAS let the Singapore dollar to appreciate gradually? The regime can be considered stable if its misalignment rate is found to be a stationary series (I(0)). In another words, if *reer* has been a stable rate, then we should find *reer* to be cointegrated with the economic fundamentals during the sub-period of quarter 1, 1987 to quarter 3, 1999.

To evaluate the stability of the reer series, we conduct another cointegration test on Equation 8, excluding variable *pol*.[7] The cointegration test result is posted in Table 5. We find one cointegration vector at 5% significance level. We can, therefore, conclude that the managed appreciation policy adopted between 1987-1997 and the more flexible regime of the exchange rate policy since 1998, have successfully kept the observed real effective exchange rate of the Singapore dollar to be cointegrated with the domestic economy's real fundamentals, i.e., the policies have been a stable set.

V. Brief Concluding Remarks

Our study has shown that the observed real effective exchange rate of the Singapore dollar had mostly floated around its natural real equilibrium exchange rate (NATREX), albeit periods of moderate misalignments. After the turbulent period of early-to mid-1980s, the policy of managed appreciation of the Singapore dollar had successfully kept the real effective exchange rate consistent with the fundamentals in the economy during a decade before the break of the East Asian financial crisis in 1997 (Table 6). Looking at several key macroeconomic indicators, outstanding performances were reported during the 1987-1996 period when there was a modest rate of under-valuation with the Singapore dollar. In general, rapid GDP per capita growth rates and low unemployment rates were accompanied by

7. The dummy variable *pol* is no longer relevant as we are only focusing on the period starting 1987.

moderate inflation rates.

Even during the peak of the East Asian financial crisis (1997-1998), the level of misalignment was relatively moderate (less than 1%). The weak demand in the economy and the region had lowered the country's inflation rate. But the overall unemployment rate remained stable at 2.8%, and the economy still managed to push for 2.6% annual growth rate of the GDP per capita. Devereux (1998) attributes the overall performance of the Singapore economy during the crisis period to the country's management of the local currency. The study argues that the exchange rate policy in Singapore was more effective in insulating the domestic economy from foreign price shocks than the currency board system in Hong Kong was during the crisis. Clearly, the empirical findings in our study confirm the overall effectiveness of the exchange rate policy in Singapore during the past two decades.

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Table 1A GDP Per Capita Growth Rate in (%)

	Mean	Maximum	Minimum	Standard Deviation
Period: 1980-1988				
Hong Kong	6.18	11.82	–0.64	3.99
Korea	6.39	9.95	–3.61	4.27
Taiwan	6.59	11.49	1.74	3.25
Singapore	5.34	9.72	–3.16	4.03
Indonesia	4.12	6.52	–0.80	2.43
Thailand	4.86	11.41	2.90	2.85
Period: 1989-1997				
Hong Kong	3.05	5.37	1.50	1.33
Korea	6.04	8.22	3.99	1.65
Taiwan	5.58	7.14	4.12	0.88
Singapore	6.86	10.56	4.46	2.02
Indonesia	5.94	7.19	3.12	1.27
Thailand	6.37	10.28	–2.72	3.75
Period: 1992-1996				
Hong Kong	3.30	5.37	1.86	1.53
Korea	5.88	7.61	4.48	1.49
Taiwan	5.34	5.76	4.85	0.37
Singapore	7.17	10.56	4.46	2.61
Indonesia	5.80	6.49	5.40	0.43
Thailand	6.76	7.74	4.86	1.17

Source: ICSEAD (2000).

Table 1B Inflation Rate (%): Percentage Change of the GDP Deflator Index

	Mean	Maximum	Minimum	Standard Deviation
Period: 1980-1988				
Hong Kong	8.58	15.22	3.87	3.52
Korea	9.25	24.11	4.71	6.78
Taiwan	4.44	16.20	0.56	5.69
Singapore	3.31	11.45	–2.35	4.34
Indonesia	11.35	30.99	–0.15	8.93
Thailand	5.08	12.71	1.45	3.63
Period: 1989-1997				
Hong Kong	7.74	12.25	2.56	2.70
Korea	6.99	10.86	3.15	2.53
Taiwan	2.97	3.93	1.85	0.89
Singapore	2.93	4.81	1.14	1.39
Indonesia	8.85	12.57	5.36	1.96
Thailand	4.97	6.12	3.32	0.98
Period: 1992-1996				
Hong Kong	6.71	9.71	2.56	2.74
Korea	6.67	7.66	3.89	1.58
Taiwan	2.79	3.93	1.89	0.92
Singapore	2.32	3.27	1.14	0.95
Indonesia	8.12	9.88	5.36	1.71
Thailand	4.54	5.75	3.32	0.97

Source: ICSEAD (2000).

Table 1C Trade Balance as % of GDP

	Mean	Maximum	Minimum	Standard Deviation
Period: 1980-1988				
Hong Kong	4.66	9.88	−2.08	5.03
Korea	0.84	7.94	−7.42	5.48
Taiwan	9.72	19.79	−1.19	6.89
Singapore	−1.96	7.12	−8.76	4.44
Indonesia	2.30	8.29	−1.00	2.73
Thailand	−3.02	2.03	−7.16	3.21
Period: 1989-1997				
Hong Kong	3.43	11.51	−4.34	5.64
Korea	1.18	2.71	−4.11	1.89
Taiwan	3.49	7.50	1.89	1.92
Singapore	11.19	15.58	6.92	3.19
Indonesia	1.19	2.98	−1.34	1.62
Thailand	−4.54	1.39	−7.52	2.76
Period: 1992-1996				
Hong Kong	1.57	7.03	−4.34	4.69
Korea	−1.63	0.05	−4.11	1.52
Taiwan	2.34	3.84	1.89	0.84
Singapore	12.40	15.58	7.90	3.37
Indonesia	1.02	2.98	−1.34	1.98
Thailand	−5.12	−3.74	−6.73	1.34

Source: ICSEAD (2000).

Table 2 ADF Unit-Root Test

Variable	ADF Test-Statistics (At the Level)	ADF Test-Statistics (At the First Difference)
Reer	–1.548	–3.721
Pol	–1.6638	–5.8753
r^*	–1.7015	–4.5629
Prd	–3.0896	–9.9580
Tot	–2.733	–6.609
G	–1.938	–6.606

All variables are tested to be integrated of order 1 at 5% critical value.

Akaike Information Criteria (AIC)

Variable	# of Lags	At the Level	At the First Difference
reer	1 (1)[b]	–7.8149	–7.8254
pol	1 (1)	–4.1589	–4.1168
r^*	1 (1)	–4.3792	–4.3741
prd	1 (1)	–7.8859	–8.2200
tot	2 (1)	–7.176	–7.121
g	3 (1)	–3.097	–3.040

[b]/ ( ) captures the number of lags for the variable at its first difference.

Table 3 The BLS Rolling Unit-Root Test

Variable (At the Level)	$\hat{t}_{DF}^{Max}$	$\hat{t}_{DF}^{Min}$
reer	2.030	–1.145
g	0.217	–4.080
prd	0.837	–0.410
r^*	–0.850	–4.820
tot	–1.020	–3.900

BLS' s Critical values at 5% (for the sample size up to 100):

(1). the maximum: –1.49

(2). the minimum: –5.01

Table 4 JOHANSEN Cointegration Test

Period: 1983:01 to 1999:03
Observations: 67
# of Lags: 1

Eigenvalue	Likelihood Ratio	5% Critical Value
0.4247	122.16[a]	114.9
0.4066	85.11	87.31
0.2922	50.15	62.99
0.2397	27.00	42.44
0.0696	8.65	25.32
0.0553	3.81	12.25

[a]/ 1 cointegrating equation at 5% significance level.

Normalized Cointegrating Coefficients:

$$reer = -7.576 - 0.261\ pol + 0.154\ g - 0.066\ r^{*} + 1.441\ prd + 0.519\ tot - 0.012\ t$$
$$(0.035) \quad (0.053) \quad (0.024) \quad (0.246) \quad (0.270) \quad (0.003)$$

( ) are the standard errors; coefficient estimates are significant at 5% level.

Table 5 Stability Test based on Johansen Maximum Likelihood Cointegration Test (Period: Quarter 1, 1987 - Quarter 3, 1999)

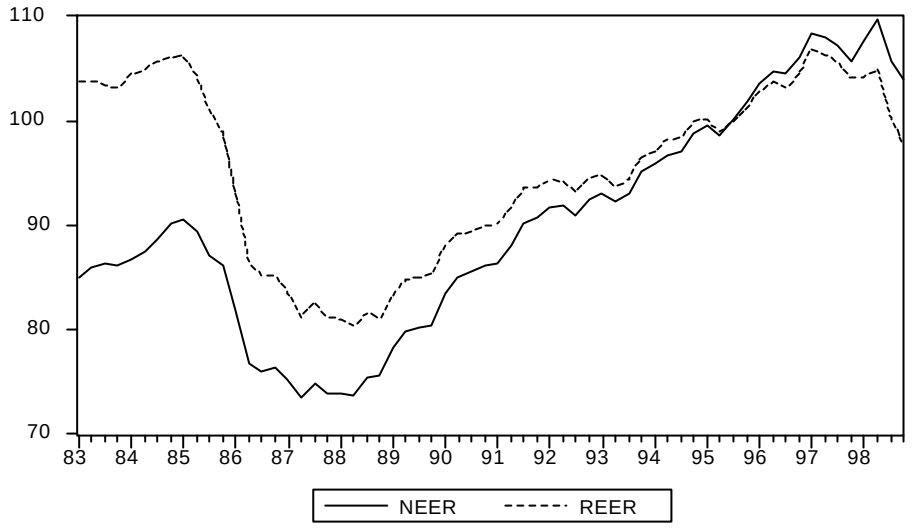
Eigenvalue	Likelihood Ratio	5 Percent Critical Value	Hypothesized No. of Cointegrating Vector(s)
0.6015	105.836[a]	87.31	None
0.3958	58.908	62.99	At most 1
0.2803	33.212	42.44	At most 2
0.2249	16.437	25.32	At most 3
0.0653	3.445	12.25	At most 4

[a]/ Likelihood Ratio indicates 1 cointegrating equation at 5% significance level.

Table 6 Misalignment Rates and Selected Key Macroeconomic Indicators

(Annual Average in %)	1980 - 1986	1987 - 1996	1997 - 1998
Unemployment Rate[*]	3.63%	2.78%	2.83%
GDP per capita Growth Rate[*]	4.30%	7.29%	2.59%
Inflation Rate[*]	3.34%	3.14%	0.15%
Misalignment Rate[**]	–2.18%	–0.20%	–0.93%
(negative implies an undervaluation)			

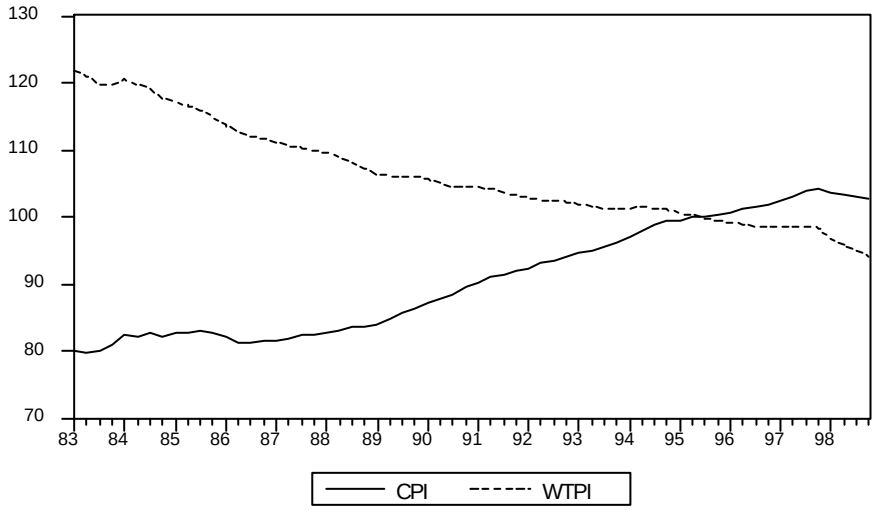
Source: ([*]) Yearbook of Statistics, Singapore and ICSEAD (2000).
([**]) Authors' own calculations.



Note: A rise in the index implies an appreciation of the Singapore dollar against the country's major trading partners' currencies.

Source: IFS, IMF (various years) and J.P. Morgan exchange rate index series.

Figure 1 Nominal Effective Exchange Rate (NEER) and Real Effective Exchange Rate (REER)



Source: IFS, IMF (various years).

Figure 2 Consumer Price Index (CPI) and Weighted Price Index (WTPI) (1995=100)

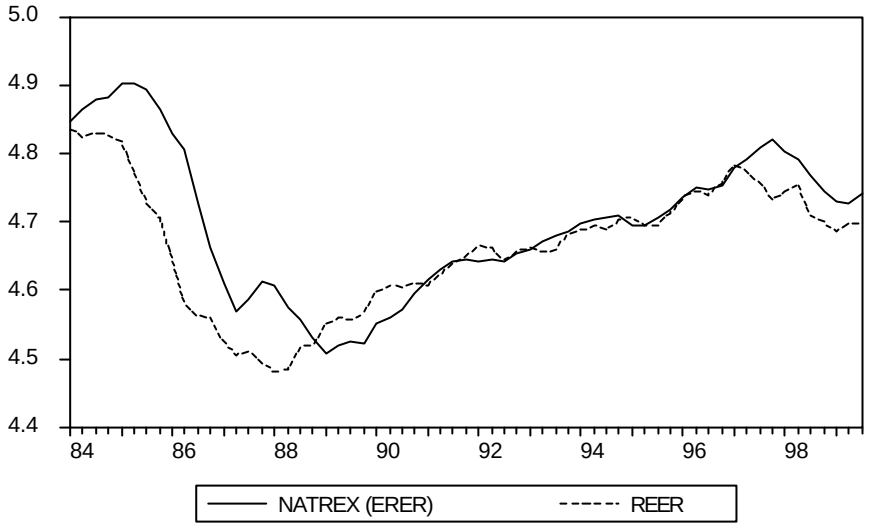
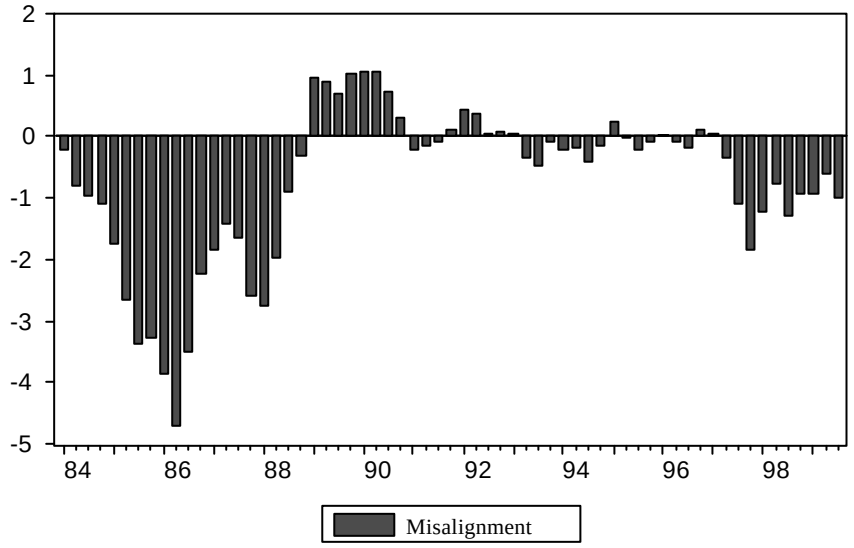


Figure 3 REER and NATREX (Equilibrium Real Exchange Rate (ERER)) (Y-axis shows the natural log-value)



Note: Misalignment rate = ((REER – NATREX) / NATREX) ∗ 100

A positive (negative) misalignment rate implies an overvaluation (undervaluation) of the Singapore dollar.

Figure 4 Misalignment Rate (in %)