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Exchange rate misalignments: A comparison of China today against recent historical experiences of Japan, Germany, Singapore and Taiwan

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Xinhua He*, Duo Qin** and Yimeng Liu***

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Abstract

The familiar claim of Chinese currency manipulation is generally asserted without reference to empirical evidence. To investigate the legitimacy of the claim, we ask if the undervalued misalignment found in the real effective exchange rate (REER) of the Chinese renminbi (RMB) over the past decade has any recent historical precedents. Four cases are examined: the Japanese yen, the Deutsche mark, the Singapore dollar and the Taiwan dollar. Panel-based misalignment estimates of the REER of the four currencies are obtained using quarterly data from the late 1970s to the early 2000s. Our estimates suggest that there are precedents to the recent misalignment of the RMB in terms of magnitude, duration or breadth of currency coverage, and that a net build-up in foreign asset does not necessarily result in currency misalignment. In addition to finding little empirical justification for the claim of Chinese currency manipulation, we note that REER misalignment runs a risk of propagating inflation in the home economy.

JEL classification: F31; F41; O57; C23

Keywords: REER misalignment, RMB, yen, D-mark, Singapore dollar, Taiwan dollar

> *"…that men do not learn much from the lessons of history is the most important of lessons history has to teach."*
>
> – *Aldous Huxley*

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Tiivistelmä

Kiinan valuuttakurssin manipuloinnista esitetään usein väitteitä ilman, että väitteiden tueksi esitetään juurikaan empiiristä näyttöä. Näiden väitteiden todenmukaisuuden tarkastelemiseksi tässä keskustelualoitteessa tutkitaan, löytyykö taloushistoriasta esimerkkejä sellaisesta valuuttakurssien epätasapainosta, joka vastaisi Kiinan juan renminbin (RMB) reaalisen kauppapainoisen valuuttakurssin (REER) viimeaikaista kehitystä. Tutkimuksessa keskitytään neljään esimerkkiin: Japanin jeniin, Saksan markkaan sekä Singaporen ja Taiwanin dollariin 1970-luvun lopulta 2000-luvun alkupuolelle. Neljännesvuosiaineistoon perustuvat paneeliestimoinnit osoittavat, että viimeaikaisesta taloushistoriasta löytyy esimerkkejä, jotka vastaavat sekä suuruudeltaan että kestoltaan juan renminbin reaalikurssin kehitystä. Tulokset osoittavat myös, ettei valuuttavarannon kasvu välttämättä johda valuuttakurssin epätasapainoon. Tukea väitteille, joiden mukaan Kiina manipuloisi valuuttansa kurssia, ei juuri löydy. Lisäksi tulokset viittaavat siihen, että reaalisen kauppapainoisen kurssin epätasapaino voi johtaa inflaation kiihtymiseen kotimarkkinoilla.

JEL: F31; F41; O57; C23

Asiasanat: reaalinen kauppapainoinen valuuttakurssi (REER), juan), jeni, Saksan markka, Singaporen dollari, Taiwanin dollari

1 Introduction

It is fashionable – even received wisdom − in certain political and business circles to attribute prevailing global trade imbalances to "Chinese currency manipulation." Indeed, demands for faster appreciation of the *renminbi* (RMB) to restore global trade balances reached a rather shrill pitch on September 29, 2010, just days before a national mid-term election, with the US House of Representatives overwhelmingly passing a bill imposing retaliatory import duties on Chinese goods to punish the country for "manipulating" its exchange rate to unfair export advantage. Given the deep acceptance of this perceived Chinese cheating, the dearth of scholarly studies presenting hard evidence of China's currency manipulation (or even methodical discussions of what might constitute currency manipulation) is striking. Perhaps the most important study in this respect is Staiger and Stykes (2008), who, using a combination of international law analysis and trade models, find little in the way of economic or legal grounds to support China's alleged currency manipulation.

The present study delves into this issue from empirical and historical angles. Although our approach differs from the more theoretical work of Staiger and Stykes (2008), we share their basic notion of treating the issue from a combined economic-legal perspective. Our legal analysis relies on *stare decisis*, the common law principle of standing by precedent embraced by US jurisprudence.[1]

Currency misalignments are fairly common, so the label "currency manipulation" is typically reserved for special instances of prolonged and substantial misalignment. Hence, our enquiry starts by asking whether the severity of misalignment in the real effective value of the RMB over the past decade was, in fact, prolonged and substantial, and if so, how the Chinese misalignment compares to recent historical precedents. Our misalignment estimates are taken from Qin and He (2011), whose study is based on quarterly time series for the period 1999-2008. Misalignment is defined primarily as long-run deviation from the real effective exchange rate (REER) measured against a multilateral currency basket of 22 economies that account for roughly 70 % of China's total foreign trade. Investigation of historical precedent entails international comparison of similar cases. A favourite example is the appreciation of the Japanese yen since the mid-1980s. We also look at the less-discussed cases of Germany, Singapore and Taiwan, due to their similar experiences with export-led growth and current account surpluses in recent decades. To facilitate the compari-

[1] *Stare decisis* is shorthand for the Latin expression *stare decisis et quieta non movere*, which means "to stand by what is decided and not disturb what is settled."

son, we estimate quarterly REER misalignment series for the yen, the Deutsche mark (D-mark), the Singapore dollar and the Taiwan dollar, respectively, over relevant historical periods following the approach proposed in Qin and He (2011).

We ask the following:

- Are the Qin and He estimates of RMB misalignment, especially undervalued misalignment, more severe or prolonged than those of the other four economies?
- Do the long-run coefficients in the REER models of the four economies corroborate standard theories or those estimated for the China model?
- Have relative net foreign assets played a significant and substantive role in equilibrating the REER in accordance with the relevant economy's surplus position?

A positive answer to any of above questions is treated as empirical evidence of RMB manipulation. Notably, all of our comparison economies initially implemented managed floats and then moved to freer exchange rate regimes during their observation periods.[2] China, in contrast, maintained a *de facto* fixed exchange rate regime for most of the observation period used in Qin and He (2011).

Qin and He point out that the length and magnitude of undervalued misalignment of the RMB appear distinctly more severe when narrowly measured vis-à-vis the US dollar and the euro. Thus, we ask if the misalignment estimates of the four economies are sensitive to the choice of trading partners vis-à-vis the home economy. (For example: Are our Japanese yen undervalued misalignment estimates more severe when we restrict trading partners to the US and Euroland?)

Finally, we consider how the movement of misalignment estimates for the home economy interacts with inflation and economic growth. This question is included mainly because the Japanese economy fell into a deflationary and zero-interest liquidity trap after a period of relentless yen appreciation in the late 1980s and early 1990s (e.g. McKinnon et al., 1999). We assume Chinese policymakers are well aware of Japan's experience.

[2] For more description of the exchange rate regimes of these economies, see McKinnon and Ohno (2001), Deutsche Bundesbank (1999), MAS (2001) and Chou and Shih (1995).

Before proceeding to the full discussion, it is necessary to clarify two points. First, our present investigation is focused on the cross-country comparison of the estimated REER misalignments. We do not intend to elaborate on the consequences of the misalignments or deny the existence of many historical differences between the recent RMB case and the four cases of our choice. Second, we are aware of the situation that there is no universally agreed method of estimating REER misalignments and that the method we adopt may not be the optimal. Nevertheless, that should not affect the comparison as long as the same method is applied to all the cases.

The rest of the paper is organised as follows. The next section briefly describes the relevant background of the four economies, compares their positions with China and summarises the literature on exchange rate misalignment estimates of the four economies. Sections 3 and 4 describe our modelling method and related data issues. Our main estimation results are discussed in section 5, where comparison with the results of the China model is also made. The last section concludes and offers a few lessons and policy considerations.

2 Background of four economies for comparison

As mentioned, Japan is the most popular comparison country in recent discussions of currency manipulation (see e.g. IMF World Economic Outlook, 2010; McKinnon and Schnabl, 2003; Yu, 2010). Japan's export-led growth took off in the 1970s, and its conspicuous economic success brought down enormous mercantile trade pressure. The 1985 Plaza Accord between the US, France, Germany, the UK and Japan was an attempt to cool the situation, but it led to substantial yen appreciation against the dollar. This "ever-higher yen syndrome" has been blamed for exacerbating Japan's post-1990 recession and deflationary episode (McKinnon and Ohno, 2001). Figure 1 presents Japanese GDP growth rates, inflation, openness ratios, and the yen exchange rate versus US$ from the late 1970s to 2000 (see the left-side four graphs). By comparing the relevant graphs in Figures 1 and 3, we see that present-day China far exceeds Japan of that period in terms of openness.

Singapore and Taiwan also experienced misalignments akin to China's. Singapore maintained a large current account surplus for several years, as shown from the third left-side graph of Figure 2. Singapore, a relatively small and very open economy, had total trade around three times of its GDP during the 1980s and the 1990s (the second left-side graph of Figure 2). Taiwan's experi-

ence somewhat presages the mainland; there was continued currency appreciation pressure during the late 1980s and early 1990s stemming from a bulging current account surplus and rapid trade growth (see right-side graphs in Figure 2). In Taiwan's case, too, the trade-to-GDP ratio in the observed period was much higher than in China today. Taiwan, like Singapore is relatively small and foreign trade accounts a substantial part of its economy. Germany (and specifically West Germany prior to reunification) seems our best comparison. Its trade-to-GDP ratios during the 1980s were similar to the current Chinese level (see the second right-side graph in Figure 1), and after the Plaza Accord, the D-mark experienced a period of appreciation and Germany posted large current account surpluses (see right-side graphs in Figure 1).

There is a sizeable body of literature on estimating the exchange rate misalignment of the four currencies under consideration. Table 1 provides a summary of some previous estimates relevant to the historical periods of interest. It is immediately clear from the table that estimates vary depending on the modelling approach selected. Where the estimates seem most in agreement is the undervaluation of the yen in the early 1980s. It is also apparent that most estimates, especially those showing undervaluation, show little concurrence with the external trade and current account surplus positions of the economies. Considering the lack of regular time series in these estimates and the large difference in method, data coverage and choice of exchange rate indices (e.g. some use bilateral rates and others use REER), we merely threat them as rough references and perform our own estimations to compare the misalignment situation of those historical periods with the RMB misalignment estimates obtained by Qin and He (2011). The next three sections report our estimation method and main results.

3 Modelling method

Empirical studies often model the real equilibrium exchange rate as the long-run solution conditioned upon a set of economic fundamentals such as productivity differentials. Misalignment is then derived from deviations of the actual REER from its long-run solution (IEO, 2007; numerous IMF publications). Obviously, differences in choice of data, variable and model specification result in different long-run equilibrium rate estimates and their accompanying misalignment estimates. Fortunately, this is only a minor concern in the comparative context as long as the selection criteria re-

main consistent across cases under consideration. We follow essentially the panel model procedure employed in Qin and He (2011), who deal with the shortcoming of the panel procedure of assumed homogeneity of all trading partners by applying a country-by-country modelling procedure to estimate the bilateral currency misalignment series of the home country versus each of its trading partners. Moreover, for the sake of consistency of model specification in cross-country comparison and simplicity, we stay with the theoretical approach in Qin and He (2011), i.e. we determine the real equilibrium rate from two fundamentals: productivity differentials and the relative size of net foreign assets.[3] The first factor is approximated alternatively by the relative real per capita income and ratio of the consumer price index (CPI) to the producer price index (PPI). The second factor is represented by relative per capita net foreign assets.

Denote r_{it} as the CPI-based real exchange rate of a home economy vis-à-vis economy *i*. Our basic panel model has two versions:

$$\begin{aligned} \ln(r_{it}) &= \alpha_{1i} + \beta_{11}\ln(GDP_{it}) + \beta_{12}NFA_{it} + u_{1it} \\ \ln(r_{it}) &= \alpha_{2i} + \beta_{21}\ln(RPI_{it}) + \beta_{22}NFA_{it} + u_{2it} \end{aligned} \quad , \tag{1}$$

where GDP_i, RPI_i and NFA_i denote respectively the relative real per capita GDP, the relative CPI-PPI ratios, the relative per capita net foreign assets between the home economy and economy *i*. In the standard theoretical setting, all β coefficients in (1) are normally expected to be positive. Specifically, $\beta_{11} \geq 0$ and $\beta_{21} \geq 0$ are expected due to the Balassa-Samuelson effect. Opposite signs may occur, however, when there is imperfect substitution between tradable and non-tradable goods, or imperfect competition (Benigno and Theonissen, 2003; MacDonald and Ricci, 2007; MacDonald and Dias, 2007). Likewise, β_{12} or β_{22} may become negative when sustained foreign direct investment results in deterioration of the country's NFA position and appreciation of its currency (Burgess et al., 2003).

Model (1) is estimated by the panel dynamic OLS (DOLS) method developed by Kao et al. (1999) (see also Kao and Chiang, 2000). Since the method entails cointegration, panel unit-root

[3] We tried to add the factor of real interest rate differentials, but found it virtually impossible to get consistently defined cross-country quarterly time-series data for the historical periods of interest. Fortunately, the identical variable coverage here with that used in Qin and He (2011) makes the estimates comparable – even if our reason for excluding the interest rate differentials (i.e. the lack of a free international capital market in China during the sample period) is different.

tests are carried out on the individual variables prior to estimation and on the residuals after estimation using one lead and one lag of the difference variable terms. When the long-run coefficient estimate of an explanatory variable is statistically insignificant, we re-estimate the model excluding the corresponding variable to check whether the exclusion results in significant omitted-variable bias.

Once relatively satisfactory estimation results are obtained, we use residuals from the panel DOLS estimation of (1) to derive a pair of misalignment series of the REER for each of the four economies concerned, m_{1t} and m_{2t}, by taking the trade-weighted geometric mean:[4]

$$\begin{aligned} m_{1t} &= \exp\left\{\sum_{i=1}^{n} w_{it} u_{1it}\right\} \\ m_{2t} &= \exp\left\{\sum_{i=1}^{n} w_{it} u_{2it}\right\} \end{aligned}, \qquad (2)$$

where w_{it} denotes the trade weight of economy *i* vis-à-vis the total foreign trade of the home economy under consideration. Obviously, the difference between m_{1t} and m_{2t} reflects the effect of choice of proxy variables for productivity differentials. When $|m_{2t}| > |m_{1t}|$, i.e. price differentials generate a larger misalignment than income differentials, we take this as evidence of "unfair" competiveness. As discussed above, Japan, Germany, Singapore and Taiwan are the home economies modelled one by one in turn.[5]

A major policy concern under a controlled exchange rate regime is the inflationary/deflationary impact of exchange rate adjustments. In the present Chinese case, we assume the government is well aware of the danger of repeating the Japanese experience of currency appreciation and subsequent "lost decade."[6] In this vein, we ask if such macroeconomic impact of exchange rate adjustments is due to the rate misalignment. We test for this by performing a Granger non-

[4] We adopt geometric, rather than arithmetic, mean. The geometric mean is widely used by the IMF, BIS and many other international organisations.

[5] For Germany, we only consider West Germany prior to the reunification in 1990.

[6] For discussion on whether excess yen appreciation was the main cause of the stagnation of the Japanese economy, see e.g. McKinnon et al. (1999), Heng (2009), Hayashi and Prescott (2002), Hamada and Okada (2009), Krugman (1998), Posen (1998) and Obstfeld (2009).

causality test on the estimated misalignment series with inflation and GDP growth for each home economy.

4 Data coverage and related issues

The quarterly data used mostly begin in the mid-to-late 1970s. Where quarterly data are unavailable (e.g. in the case of population), simple interpolation is used to produce quarterly series. The detailed data sources are given in the appendix. The fact that the historical periods of interest go back to two to three decades poses a serious data restriction on the numbers of trading partners that we can include. Selection of trading partners is based on the ranking of trade shares with the home economy in point. Data permitting, we try to include those with the highest ranks.

Our data set covers 17 economies: Australia, Canada, France, Germany, Italy, Japan, Korea, Malaysia, the Netherlands, the Philippines, Singapore, Sweden, Switzerland, Taiwan, Thailand, UK and US. Since several Malaysian series start from 1983, Malaysia is excluded from the panel samples for the Japanese yen and the D-mark.[7] Both samples start from 1977 whereas the Japanese sample ends in 2000 and the German sample ends in 1990. The samples for the Singapore and Taiwan dollars cover the period of 1984−2000. Time series of the trade shares these panels cover in the total trade of the home economies are plotted in Figure 4. As seen from these graphs, trade shares vary during the sample periods, but remain well above 50 % most of the time. The significant decrease of the shares in the Taiwan case is due to rapid growth of trading with mainland China. We would have like to include China in all the four panels as it becomes an increasingly important trading partner from the late 1980s onwards, but are prevented from doing so due to lack of data. In the German case, too, we cannot include several trading partners that ranked higher in their trading weights than some of those included for Asian economies due to inadequate data.

Since the representativeness of panel-based REER series is susceptible to the trade coverage our selected panels, we check the representative adequacy by comparing our panel-based REER series with the series published by the IMF and the BIS (see right side of Figure 4).[8] The REER

[7] The trade weights of Malaysia in the Japanese and German total trades were roughly 2 per cent and 0.3 per cent respectively during 1980-90.
[8] IMF's publication does not cover Taiwan.

graphs suggest our panel-based series are relatively similar to the IMF and BIS series on the whole. There is some discrepancy in the German series but that is more pronounced between the IMF and the BIS series than between our series and the IMF and BIS series. Taiwan presents the largest discrepancy as the BIS series do not cover Malaysia, the Philippines or Thailand (three economies whose trading weights with Taiwan traditionally rank well above some of the countries covered in the BIS panel, e.g. Belgium, Finland, Greece, Ireland, Mexico, Portugal and Spain). Hence, our REER is likely more representative than the BIS series.

Qin and He (2011) show that the RMB misalignment series are sensitive to panel choice. Their estimates from a sub-panel of the US and Euroland countries differ substantially from the results based on a full panel of 22 economies. Here, we adopt the same strategy and construct a sub-panel of the US and the countries in the full panel, which are from Euroland for separate estimation.

5 Empirical results and comparison

Our key estimation results are reported in Table 2.[9] A striking feature is that the coefficient estimates for NFA_{it} are negative and small in the full-panel estimations (although insignificant in the Singapore and Taiwan models, and the GDP version of the Japan model). This result is similar to the China case as shown in Tables 2−4 in Qin and He (2011). This finding implies that relatively large net foreign asset differentials due to sustained current account surplus of a home economy does not necessarily result in a positive and significant long-run effect on the REER of its currency. Singapore, for example, has the highest current account surplus among the four (see Figure 2) even if NFA_{it} remains insignificant in all versions of the Singapore model and seems to confirm the previous study of Montiel (1997). The finding imposes serious doubt on theories that assume as the key condition an equilibrium current account balance position for equilibrium REER.

Table 2 also reports key sub-panel estimation results, i.e. sub-panels that include only the US and Euroland economies. If we compare the sub-panel results with those from the full panel, we see the biggest difference is in the Japan case, where the coefficient estimates of NFA_{it} become sig-

[9] Unit-root test, run on individual variables of $\ln(r_{it})$, $\ln(GDP_{it})$, $\ln(RPI_{it})$ and NFA_{it} shows that all the series are first-difference stationary. The test on the residuals after the DOLS estimation confirms stationarity as well. The test results are not reported to keep the paper short.

nificantly positive, albeit very small. This likely reflects the fact that the repeated yen appreciations that began in the late 1980s were driven largely by pressures from the US and other Western partners.

Figure 5 plots the estimated misalignment series of the four economies along with the misalignment series of the RMB estimated by Qin and He (2011) to facilitate comparison. Two pairs of misalignment series (one for the GDP_i version of the model and the other the RPI_i version) are drawn for each economy (one pair from the full-panel estimation and the other the sub-panel estimation). This lets us examine the misalignment situation of the four currencies in turn.

Japanese Yen

Here, it is discernible from the first row of Figure 5 that the yen remains undervalued throughout the first half of 1980s, reaching 15−20 % when estimated by the GDP_i version of our model, and over 25 % with our RPI_i version. The misalignment series switched into a sustained overvaluation phase after 1985, with the exception of two brief periods (around 1990-1 with the bursting of stock and real estate price bubbles and in 1997 with the launch of speculative attacks on Asian currencies). The yen's overvalued misalignment peaks around 1995 at above 20 % when estimated by the GDP_i version of the model and above 40 % with the RPI_i version. On the whole, these estimates do not differ substantially from what has been reported in the literature. In fact, they are relatively close to those obtained by Bénassy-Quéré et al. (2009). If we look at the undervalued period of the RMB during the early-to-mid-2000s (see the last row of Figure 5), the magnitude (5−10 %) is far less than that of the yen during the early 1980s prior to the 1985 Plaza Accord. Moreover, we see two noticeable differences. The RMB was distinctly more undervalued against the US$ and the euro than the yen, which experienced misalignments that remained more or less the same whether evaluated by the full panel or sub-panel of the US and the Euroland. Moreover, the yen misalignment estimates by the RPI_i version of the model were more severe than those of the GDP_i version − the opposite of the RMB case. These results suggest that the Japanese case during the early 1980s was more severe, more universal in terms of currency coverage and more relative price-based than the Chinese case during the mid-2000s. This finding confirms previous studies showing that the Japanese trade sector experienced rapid productivity growth during the decade starting from the mid-1970s, especially versus the US (Marston, 1986; McKinnon and Ohno, 2001).

Nevertheless, from our comparative perspective, this finding is somewhat unexpected as the Japanese economy of the 1980s is generally believed to have been freer than that of China in the 2000s, both in terms of exchange rate management and price-setting of traded goods.

Deutsche Mark

Like the yen, we see the D-mark is undervalued during the first half of the 1980s, but to a lesser degree (hitting a maximum of about 10 %, see second row of Figure 5). Similar to the yen, the misalignment estimates are also larger in magnitude from the RPI_i version of the model than the per-capita-income-based version (the GDP_i coefficient estimate becomes insignificant in the sub-panel case), and the difference between the full-panel and the sub-panel estimates is largely indiscernible. Unlike the yen, the undervalued margin of the D-mark ebbs away gradually after the 1985 Plaza Accord without significant over-correction. Our estimates during the first half of the 1980s are consistent to the history prior to the Plaza Accord and in agreement with those by Fischer and Sauernheimer (2002). Roughly, the length and severity of the undervalued misalignment in the D-mark of the 1980s are comparable to the full-panel result of the RMB during the mid-2000s, although the RMB misalignment is less pronounced in the relative-price version of the model. Again unlike the RMB case, the full-panel and sub-panel results in the D-mark case do not differ much, indicating that the misalignment in the D-mark during the 1980s was more universal than that of the RMB during the 2000s.

Singapore Dollar

Our estimation shows that the Singapore dollar went from being greatly overvalued prior to 1985 to a period of undervaluation in the late 1980s. It then became slightly overvalued during the 1990s in the run-up to the 1997 Asian financial crisis. The undervalued misalignment is around 2−5 % in the late 1980s when estimated using the full-panel data set, and reaches over 10 % in the sub-panel estimation (see the price-based model version). The latter result resembles the RMB case, although the sub-panel feature in the RMB case is far more pronounced from the per-capita-income version of the model than the price-based version. Taken as a whole, our results are quite similar to those of MacDonald (2004). What is particularly interesting in the present case is that we find no evidence of the Singapore dollar being substantially undervalued during the 1990s prior to the Asian crisis,

despite of the fact that the country's current account surplus continues to rise (see the third graph on the left side of Figure 2). This result suggests that persistent current account surpluses do not necessarily imply a downward exchange-rate misalignment.

Taiwan Dollar

The misalignment series of the Taiwan dollar from the two model versions are the closest of the four currencies (see the fourth row of Figure 5). Otherwise, the misalignment series share certain similarities with those of the Singapore dollar, which is found to be undervalued during the mid-1980s, followed by a sustained overvaluation lasting until the 1997 Asian crisis. Here, the overvaluation starts earlier and is much more pronounced than in the case of the Singapore dollar. This is likely due to speculation driven by the widely held expectation of continued Taiwan dollar appreciation and rapid growth in Taiwan's current account surplus from expanding foreign trade. Interestingly, the difference between the full-panel estimates and the sub-panel estimates are the largest of the four cases. During the mid-to-late-1980s, the undervalued misalignment is around 5 % for over two years when estimated using the full-panel data set. The period extends to over three years and reaches over 15 % when estimated by the sub-panel data set. This situation closely resembles the RMB case, indicating that the appreciation expectation or pressure at the time was heavily based on US and the Western regional perspectives.

These misalignment estimates provide us a concise historical perspective on the recent RMB misalignment situation. The magnitude and currency coverage of the undervalued misalignment of the Japanese yen prior to the Plaza Accord is more severe than the RMB during the early-to-mid-2000s. The RMB undervalued situation is more comparable to the D-mark case during the 1980s in terms of both magnitude and length. The currency-limited nature of the RMB undervaluation (i.e. the undervaluation is more severe when evaluated against the US$ and the euro than a large set of currencies) echoes the situation of the Taiwan dollar and Singapore dollar in the mid-1980s.

If we look at the adjustment process of those undervalued periods of the four currencies, we notice that the adjustment processes in the Japanese yen and the Taiwan dollar are more volatile than those of the D-mark and the Singapore dollar. History tells us that while the Japanese economy sank into recession and deflation during the 1990s and Taiwan experienced higher inflation and lower growth in the 1990s, Singapore enjoyed fairly robust and stable economic growth right up to

the 1997 Asian crisis.[10] These differing experiences lead us to the question how the dynamics of REER misalignment adjustment interact with the dynamics of key macroeconomic variables such as inflation and GDP growth. Since it is beyond the scope of the present study to specify a full macro model of an open economy, we simply seek primary answers to the question by means of a Granger non-causality test. Interestingly, our test based on a three-variable VAR (Vector AutoRegression) (GDP growth, inflation and REER misalignment) results in no Granger causality between GDP growth and REER misalignment series for any of the economies, including China. Therefore, the test results reported in Table 3 are based on a two-variable VAR. It is obvious from the table that the evidence is decisively one-sided – it is the REER misalignment that Granger-causes inflation rather than vice versa. In other words, the REER disequilibrium is shown to have a leading and "error-correction" impact on the inflation dynamics.[11] In particular, this finding corroborates diagnoses of the Japan's liquidity trap by economists such as McKinnon et al. (1999) and Obstfeld (2009), and provides a sound basis for concern about the danger of over-adjusting exchange rates as Chinese policymakers continue their efforts to fight inflation.

6 Concluding remarks

The empirical results obtained here provide no positive answers to any of our initial three questions. The long-run coefficient estimates of the REER models of the four economies do not corroborate the standard theories more than those estimated of the China model by Qin and He (2011). The role of relative net foreign assets is marginal and nonstandard. Moreover, we find precedents to Qin and He's RMB misalignment estimates in the estimated misalignment series of the four economies considered in the present study. The undervaluation of the Japanese yen prior to 1985 was found to be more severe, more universal and more price-differential-based than that of the RMB during the mid-2000s. The Singapore dollar was not found to be undervalued in the ten years spanning 1987 to the Asian crisis, despite a rapid increase of the country's current account surplus. In short, the empirical evidence here suggests that RMB "manipulation" during the last decade has been no more substantial than that of the Japanese yen, the D-mark, the Singapore dollar or the Taiwan dollar in

[10] It is difficult to discuss Germany because of the reunification.
[11] Note that the error terms in model (1) would become effectively error-correction terms for inflation if we extend (1) into the error-correction model and assume rigidity of the nominal rate due to a controlled exchange rate regime.

the recent history. Moreover, there is no evidence that a fixed exchange rate regime results in more severe rate misalignments or pricing differentials than regimes with freer exchange rate policies, or that the currency of an economy is necessarily undervalued if the economy experiences a rapid build-up in net foreign assets.

Finally, our study suggests that the volatility in exchange rate disequilibrium subsequent to the rate adjustment is likely to propagate into a home economy via inflation. Policymakers should thus be wary of the possible side-effect of exchange rate over-adjustment on inflation when such adjustment is considered for correcting a current account surplus.

Appendix

Variable definitions

HE: Home economy, i.e. Japan, Germany, Singapore, Taiwan; subscript *i* = trading partner country *i* in the panel.

r_i = (CPI(HE)/CPI$_i$)(e_i /e(HE currency)); e = exchange rate per US$; all r_i series are adjusted to 2000Q1 = 1.

GDP$_i$ = (per capita GDP(HE)/ per capita GDP$_i$)(e_i /e(HE currency)).

RPI$_i$ = (CPI(HE)/ PPI(HE))/(CPI$_i$ / PPI$_i$).

NFA$_i$ = (per capita NFA(HE)/ per capita NFA$_i$); NFA is calculated as the historical sum of current account balance.

W$_i$ = (HE's export$_i$ + HE's import$_i$)/(sum of HE's exports and imports to all economies in the panel).

Data sources and derivation

Exchange rates: Post-1999 data for French franc, D-mark, lire and guilder are from Datastream; Taiwan dollar: 1977Q1-1980Q1 from IFS (IMF International Financial Statistics CD-ROM), 1980Q2-2000Q4 from Taiwan Quarterly Economic Indicators; rest from IFS.

CPI: Germany, Korea and Taiwan from Datastream; rest from IFS, 2005=100.

PPI: France before 1998, German and Taiwan from Datastream; rest are wholesale prices or producer prices from IFS, 2005=100.

Population (annual): Germany from Datastream; rest from IFS. Quarterly series are interpolated.

Current account balance in US$: Taiwan post-1979 data from Datastream; Malaysia data for 1984-1998 and Singapore data for 1977-1994 are annual and used as end-year observations; rest from *IFS*.

Exports and imports: Taiwan: 1977-1987 from Taiwan Monthly Statistics of Exports and Imports; 1988-2000 from Datastream; rest from IMF Direction of Trade Statistics.

GDP in constant price: Australia, Canada, France, Germany, Italy, Japan, Korea, the Netherlands, Sweden, Switzerland, UK, US derived from IFS (except for Italy and Sweden of 1977-79, which in turn are derived from Datastream). Singapore and Taiwan calculated from Datastream. Malaysia for 1984-1987 and Thailand for 1977-1992 calculated from annual IFS data and interpolated into quarterly frequency (the rest of period calculated from IFS). Philippines for 1977-1980 calculated from Datastream annual data and interpolated into quarterly frequency; post-1981 period calculated from IFS. Series with significant seasonal fluctuations are seasonally adjusted using Eviews.

REER (BIS) taken from BIS website www.bis.org/statistics/eer/index.htm. *REER* (IMF) from IFS.

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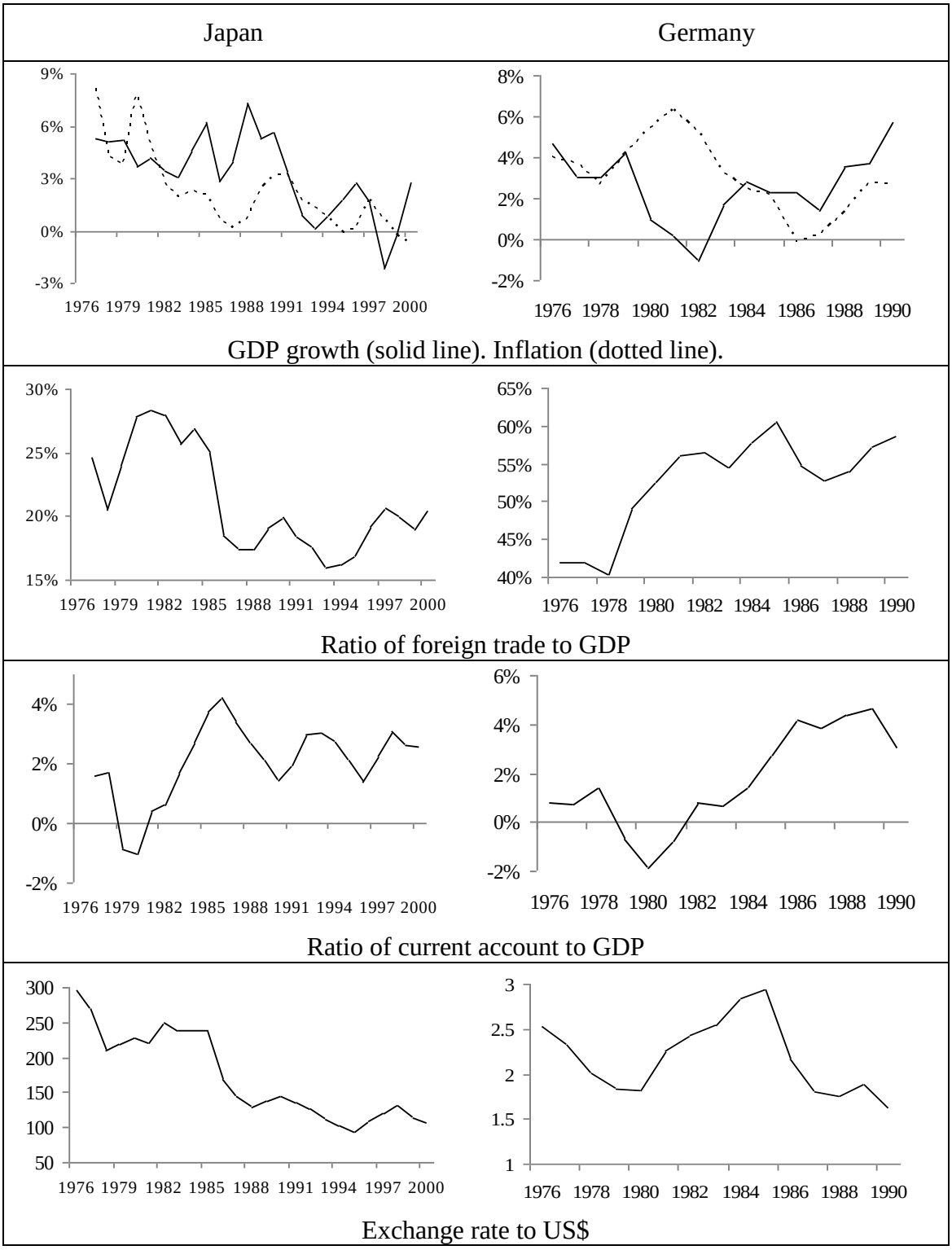
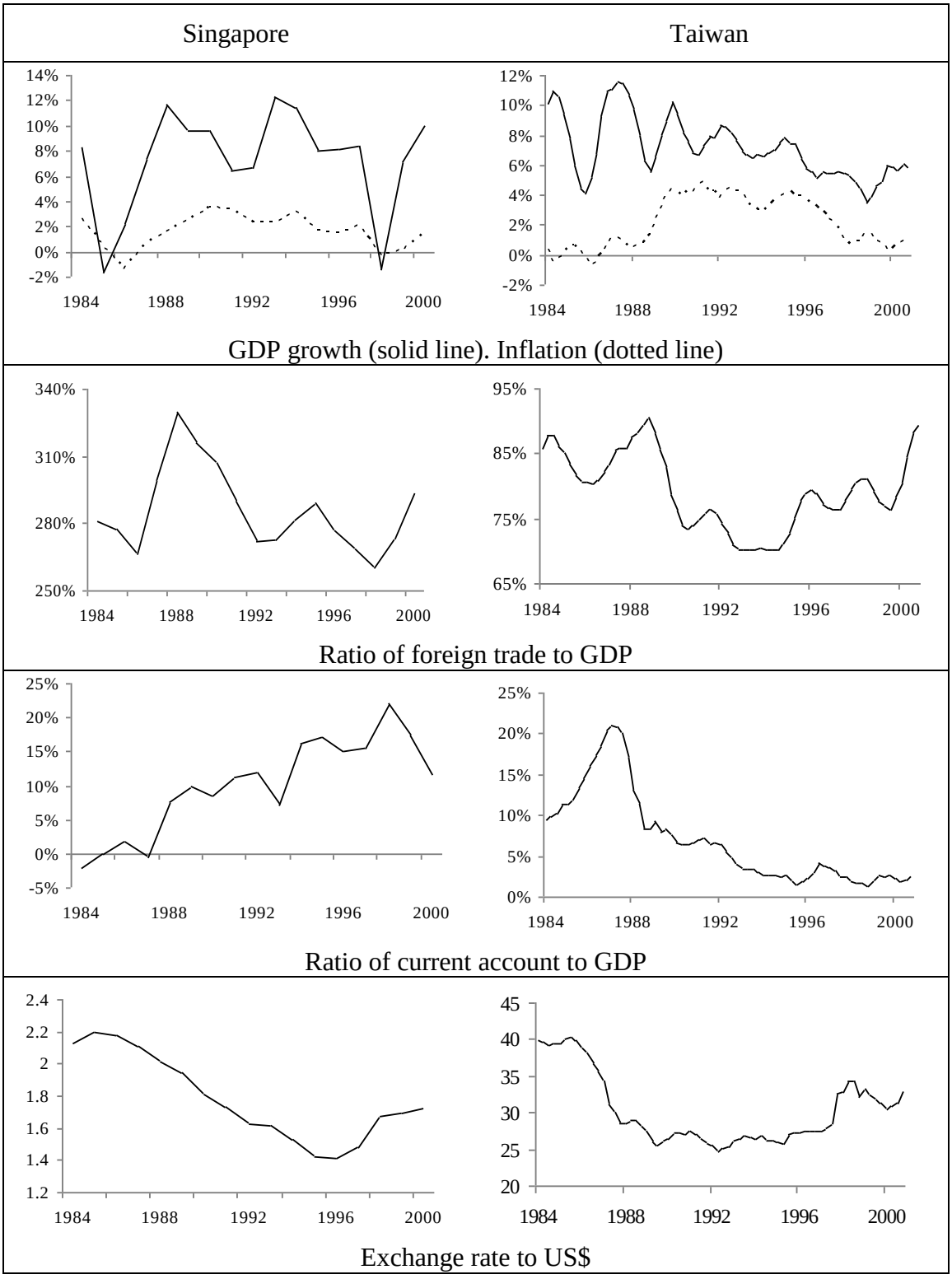
Figure 1 Main macroeconomic indicators: Japan and West Germany



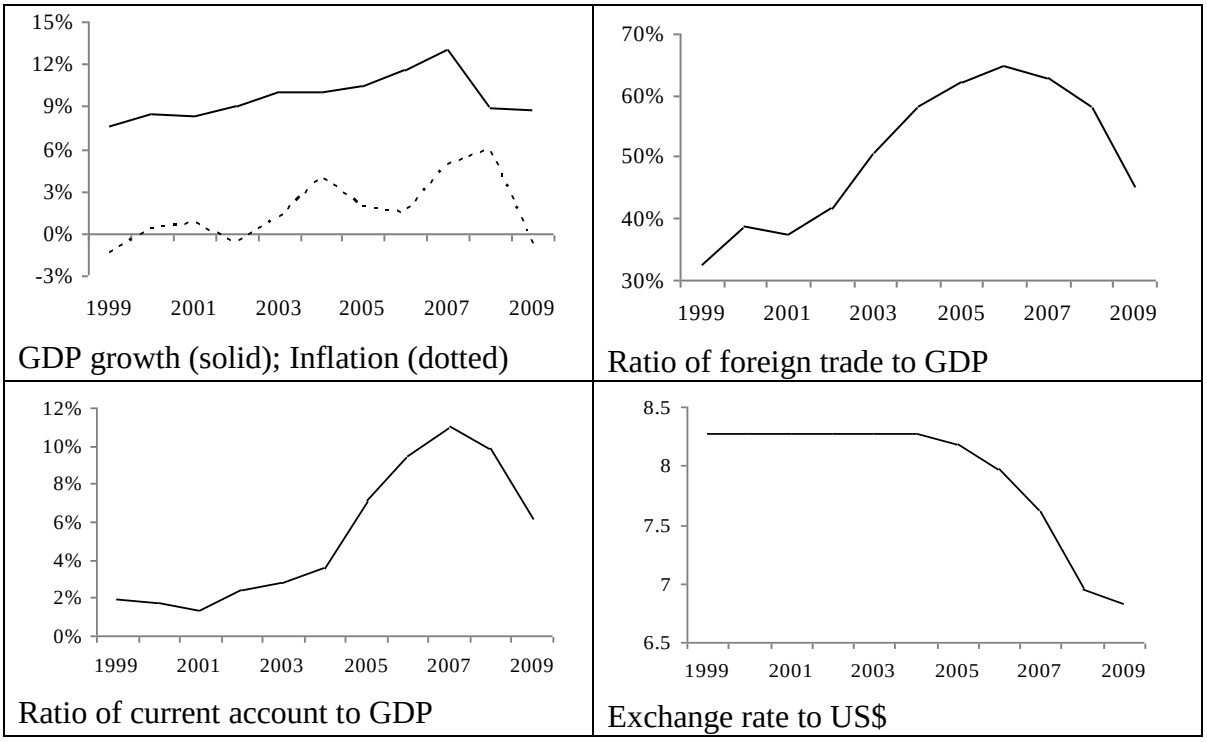
Data source: IMF IFS in annual frequency.

Figure 2 Main macroeconomic indicators: Singapore and Taiwan



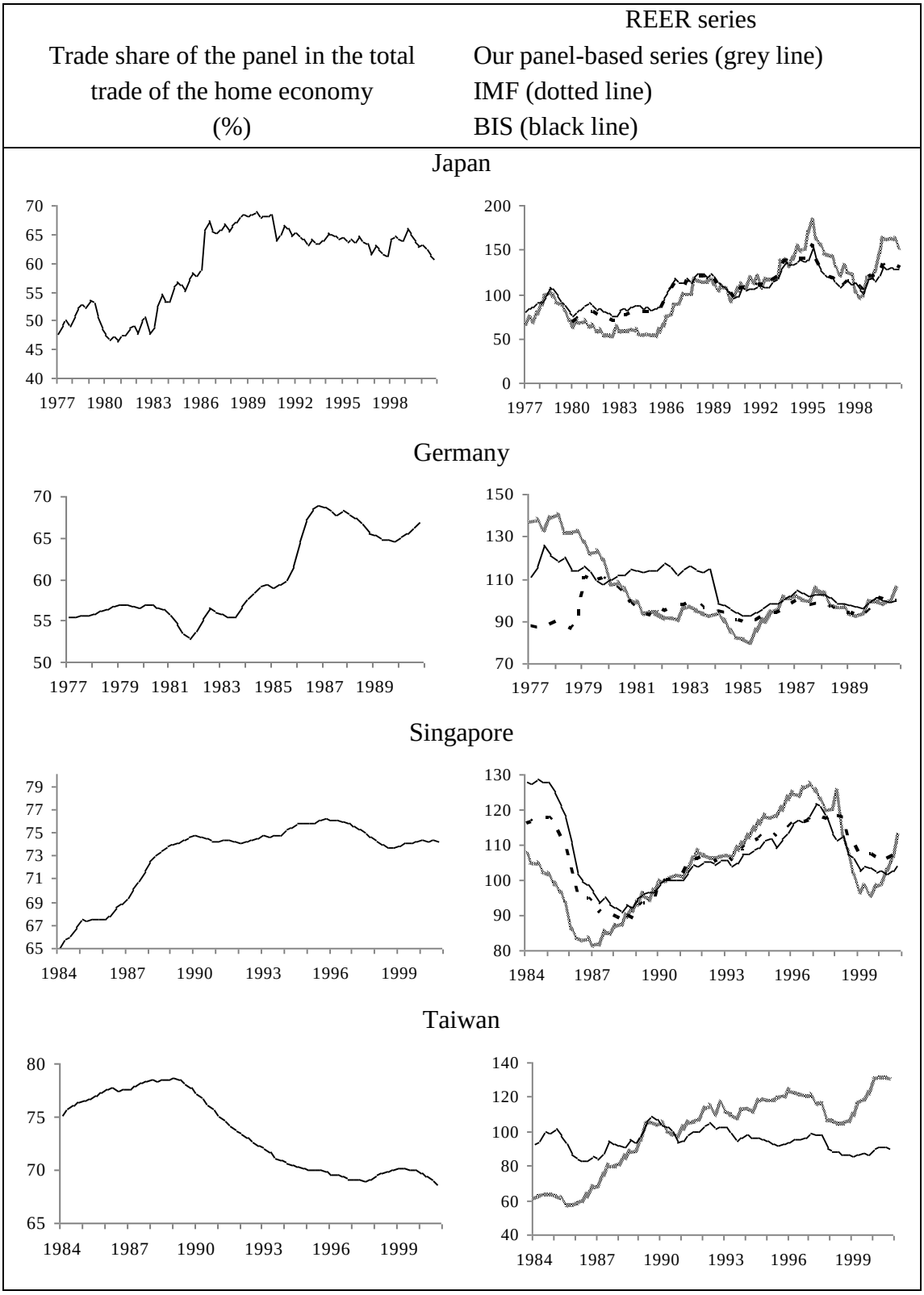
Data sources: For Singapore, IMF IFS in annual frequency. For Taiwan, Datastream in quarterly frequency; some trends are taken as quarterly moving averages.

Figure 3 Main macroeconomic indicators: China



Data sources: IMF IFS for the period 1999-2008 in annual frequency; 2009 data are from China Statistics Abstracts 2010.

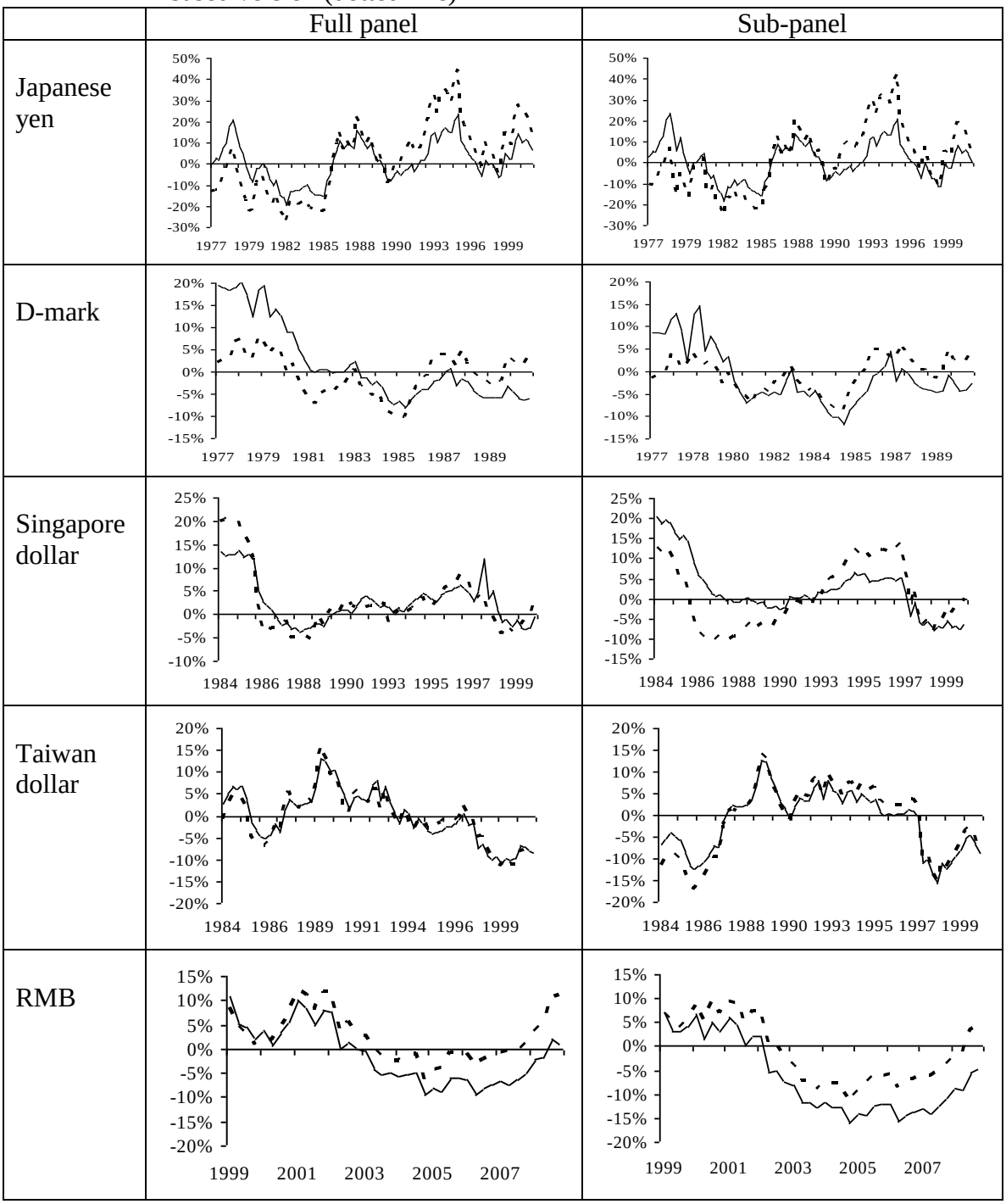
Figure 4 Trade shares of the panels and REER series



Data sources: IMF IFS, BIS and Datastream. IMF source lacked Taiwan dollar REER.

Figure 5 REER misalignment series

GDP-based version (solid line)
RPI-based version (dotted line)



Note: For the RMB misagliment series, the full panel consists of 22 trading partners and the sub-panel 7 partners covering the US and the Euro-zone countries from the full panel (see Qin and He, 2011).

Table 1 Sample of previous estimates of exchange rate misalignments

Study	Data	Misalignment estimates	Approach
		Japanese Yen	
Song (1997)	1975-1991 quarterly	REER (graph): Overvalued during 1980-82 for over 10%; undervalued around 5% during 1984-5; slightly overvalued 1986-89; undervalued about 10% in 1990.	NATREX model
Clark and McDonald (1998)	1960-1996 annual	REER (graph and table): Undervalued slightly 1983-86; 10-17% undervaluation in 1990.	BEER
Isard and Mussa (1998)	Not specified	REER (table): 35% undervalued in 1985; 31% overvalued in 1995.	MBF (IMF)
Jeong and Mazier (2003)	1981-2000 annual	REER & bilateral rate to US$ (graph): Undervalued during 1980-89, around 20% in REER and 35% in bilateral rate to US$ in 1985.	FEER
Miyagawa et al. (2004)	1980-2000 annual	Nominal bilateral rate to US$ (table): Undervalued around 10-200+% during 1980-85; overvalued around 10-50% during 1987-2000, except 1990.	PPP
Bénassy-Quéré et al. (2009)	1980-2004 quarterly	REER (graph and table): Undervalued over 20% during 1980-85; overvalued 1986-2001 except 1990 and 1997-98; 1988Q1: overvalued around 17-20% in REER or 21-24% in real bilateral rate to US$	BEER and panel cointegration
		Deutsche Mark	
Clark and McDonald (1998)	1960-1996 annual	REER (graph and table): Undervalued up to 20% during 1973-80; slightly overvalued during 1981-88; 2% undervaluation in 1990.	BEER
Stein (1997)	1975-1993 quarterly	REER (graph): Slightly overvalued during 1982-83; undervalued up to 5% during 1984-90 except for a brief overvaluation around 1988.	NATREX model
Isard and	Not spe-	REER (table):	MBF (IMF)

Mussa (1998)	cified	6% undervalued in 1985.	
Fischer & Sauernheimer (2002)	1973-1998 quarterly	REER (graph): Overvalued in late 1970s up to 10%; slightly undervalued around 1981 and 1985-86; overvalued from 1987 to early 1990s, reaching 20% in 1990.	NATREX model

Singapore Dollar

Montiel (1997)	1960-1994 annual	REER: Undervalued up to 5% during 1980-85 and 1990-91; overvalued up to around 10% during 1986-89 and 1992-93.	BEER
Chinn (2000)	1970-1997 monthly	Bilateral real rate to US$ (graph and table): Undervalued in the 1990s, except around 1991 and 1996; about 6% undervalued in May 1997.	PPP / BEER
Rajan and Siregar (2002)	1984-2000 quarterly	REER (graph): Undervalued during 1984-89 and 1993-98, with misalignment of less than 5%.	NATREX
MacDonald (2004)	1983-2003 quarterly	REER (graph): Overvalued up to about 8% during 1984-85 and 1997; mildly undervalued during 1986-87; clearly undervalued during 1998-2001.	BEER

Taiwan Dollar

Chinn (2000)	1970-1997 monthly	Bilateral real rate to Japanese yen and US$ (graph and table): Overvalued up to 20% during 1990-93, and undervalued up to 20% during 1993-6 to the yen. Undervalued by 9% May 1997 to the US$.	PPP / BEER
Miyagawa et al. (2004)	1980-2000 annual	Nominal bilateral rate to US$ (table): Undervalued during 1980-96, from over 400% in 1981 to 3% in 1993; undervalued again after the East Asian crisis up to over 30% in 2000.	PPP

: NATREX stands for "natural real exchange rate," BEER for "behavioural equilibrium exchange rate," FEER for "fundamental equilibrium exchange rate," MBF for "macroeconomic balanced framework" and PPP for "purchasing power parity."

Table 2 Key estimation results of model (1)

	The upper equation of (1)		The lower equation of (1)	
Conditioning variables	$\ln(GDP_{it})$	NFA_{it}	$\ln(RPI_{it})$	NFA_{it}
Japanese yen; sample period: 1977Q1−2000Q4; full panel				
DOLS s.d.	0.3365 0.0075	-0.0001 0.0001	1.4666 0.0656	-0.0003 0.0001
$\bar{R}^2$	0.9974		0.9952	
Japanese yen; sample period: 1977Q1−2000Q4; sub-panel				
DOLS s.d.	0.3528 0.0082	0.0005 0.0002	1.9462 0.0743	0.0008 0.0003
$\bar{R}^2$	0.9985		0.9973	
D-mark; sample period: 1977Q1−1990Q4; full panel				
DOLS s.d.	0.3658 0.0231	-0.0006 0.0001	0.9167 0.0904	-0.0003 0.0001
$\bar{R}^2$	0.9980		0.9978	
D-mark; sample period: 1977Q1−1990Q4; sub-panel				
DOLS	0.0679	-0.0011	1.329	-0.0002
s.d.	0.0385	0.0003	0.0964	0.0002
$\bar{R}^2$	0.9984		0.999	
Singapore dollar; sample period: 1984Q1−2000Q4; full panel				
DOLS s.d.	0.2969 0.0121	-0.000006 0.0001	0.5399 0.0419	-0.0001 0.0001
$\bar{R}^2$	0.9983		0.9974	
Singapore dollar; sample period: 1984Q1−2000Q4; sub-panel				
DOLS s.d.	0.2827 0.0189	-0.0003 0.0002	0.1932 0.0677	-0.0002 0.0002
$\bar{R}^2$	0.9975		0.9965	
Taiwan dollar; sample period 1984Q1−2000Q4; full panel				
DOLS s.d.	0.2556 0.0118	-0.00004 0.00006	0.7264 0.0412	-0.00008 0.00007
$\bar{R}^2$	0.9987		0.9983	
Taiwan dollar; sample period 1984Q1−2000Q4; sub-panel				
DOLS s.d.	0.1458 0.0177	0.0003 0.0003	0.2285 0.0685	0.0003 0.0004
$\bar{R}^2$	0.9985		0.9979	

Note: s.d. = standard deviation.

Table 3 Granger non-causality tests: misalignments m_{1t} and m_{2t} versus inflation

	m_{1t}		m_{2t}	
Panel	$m_{1t} \rightarrow$	$\rightarrow m_{1t}$	$m_{2t} \rightarrow$	$\rightarrow m_{2t}$
Japan (full)	4.6268 [0.0009]	0.7205 [0.610]	3.8844 [0.0033]	1.3919 [0.2362]
(sub-panel)	3.6965 [0.0046]	0.4844 [0.7869]	2.1445 [0.0685]	0.8379 [0.5267]
Germany (full)	3.1223 [0.0243]	2.0273 [0.1075]	3.8990 [0.0087]	1.0235 [0.4060]
(sub-panel)	2.7111 [0.0423]	1.7842 [0.1495]	4.1545 [0.0062]	1.1376 [0.3516]
Singapore (full)	2.6896 [0.0404]	3.0114 [0.0256]	4.1441 [0.0053]	0.7951 [0.5335]
(sub-panel)	2.7288 [0.0382]	1.7920 [0.1436]	5.0468 [0.0015]	1.0700 [0.3802]
Taiwan (full)	0.5614 [0.7290]	1.0330 [0.3986]	0.5077 [0.7691]	1.3789 [0.2532]
(sub-panel)	1.2995 [0.2785]	0.7206 [0.5816]	0.9662 [0.4471]	0.9670 [0.4430]
China (full)	3.3776 [0.0230]	1.0765 [0.3876]	1.7282 [0.1729]	1.1148 [0.3700]
(sub-panel)	4.0518 [0.0106]	0.8606 [0.6000]	2.7041 [0.0515]	0.6813 [0.6110]

Note: The signs $m_{it} \rightarrow$ and $\rightarrow m_{it}$ indicate, respectively, whether misalignment G-causes inflation and whether inflation G-causes misalignment. Statistics in brackets are probability values; Japan and Taiwan 5 lags; Germany, Singapore and China 4 lags.

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