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SUMMARY

The large literature on equilibrium exchange rates has typically focused on country-by-country estimations of equilibrium exchange rates or on consistent estimations of equilibrium exchange rates for a set of industrial economies. Until the mid-1990s, this approach was in line with a two-tier international monetary system. The first tier consisted in a small number of key currencies: the dollar, the Deutschemark, the yen and the British pound. G7 meetings were supposed to provide a coordination forum for these countries. The second tier consisted in all other currencies. Corresponding exchange rates were a national or regional, not multilateral interest.

Since the mid-1990s, the rising share of emerging countries in global imbalances has made such divide no longer adequate. Consistently, the exchange-rate regime of China has often been accused of being one major building block of global imbalances, and some economists have suggested that the forum for international monetary cooperation should move from the G7 to the G20, a group created in 1999 to discuss financial stability issues.

Such evolutions call for the estimation of consistent sets of equilibrium exchange rates for a large number of currencies. This raises the problem of world consistency since the equilibrium exchange rate of all currencies cannot be determined independently one from another. World inconsistency can result from two problems. First, real effective misalignments of currencies out of the considered sample are implicitly assumed to be the mirror image of those of the currencies under review. Second, only $N-1$ independent bilateral equilibrium exchange rates can be derived from a set of N effective rates. Using panel cointegration techniques, we investigate these two problems by estimating two sets of equilibrium exchange rates, both in effective and bilateral terms, and by varying the assumptions concerning the rest of the world and the numeraire currency. In the first set, we consider 15 currencies of the G20 in a closed setting, *i.e.* without introducing the rest of the world. In the second set, we add the rest of the world. We then derive bilateral equilibrium exchange rates using both methods.

We show that the way the rest of the world is tackled has a major impact on the measure of exchange-rate misalignments, especially for bilateral misalignments. For instance, the extent of renminbi under-valuation against the USD is found between 30% and 60% in 2004, depending on the way the Nth currency problem is tackled. In effective terms, the misalignment ranges from 31 to 45%.

ABSTRACT

This paper proposes a systematic analysis of the problem of world consistency when deriving equilibrium exchange rates. World inconsistency can arise for two reasons. First, real effective misalignments of currencies out of the considered sample are implicitly assumed to be the mirror image of those of the currencies under review. Second, only $N-1$ independent bilateral equilibrium exchange rates can be derived from a set of N effective rates. Here we measure the extent of these two problems by estimating equilibrium exchange rates for 15 countries of the G20 in effective as well as bilateral terms and by varying the assumptions concerning the rest of the world and the numeraire currency. Our results show that the way the rest of the world is tackled has a major impact on the calculation of effective misalignments and especially bilateral misalignments.

JEL Classification: F31, C23.
Keywords: equilibrium exchange rates, BEER approach, world consistency.

COHÉRENCE MONDIALE DES TAUX DE CHANGE D'ÉQUILIBRE

RÉSUMÉ LONG

L'importante littérature sur les taux de change d'équilibre s'est, jusqu'à présent, essentiellement concentrée sur des estimations pays par pays ou sur des estimations cohérentes pour un ensemble de pays industrialisés. Jusqu'au milieu des années 1990, cette approche était en phase avec un système monétaire international hiérarchisé, dominé par un petit nombre de devises-clés : le dollar, le Deutschemark, le yen et la livre Sterling. Les réunions du G7 étaient supposées fournir un forum de coordination pour ces pays. Venaient ensuite les "petites" monnaies, dont les taux de change étaient des sujets d'intérêt seulement au niveau national, voire régional.

Depuis le milieu des années 1990, la part croissante des pays émergents dans les déséquilibres mondiaux a rendu cette distinction inopérante. Ainsi le régime de change de la Chine a-t-il souvent été accusé d'être l'une des sources de ces déséquilibres, et certains économistes ont suggéré de déplacer le forum de coordination monétaire du G7 vers le G20, un groupe créé en 1999 à la suite des crises financières de la fin des années 1990.

De telles évolutions requièrent l'estimation de taux de change d'équilibre pour un grand nombre de monnaies. Ceci soulève un problème de cohérence mondiale puisque les taux de change d'équilibre de tous les pays du monde ne peuvent être déterminés de manière indépendante. Deux phénomènes peuvent être source d'incohérence. D'abord, les désajustements des monnaies restées à l'extérieur de l'échantillon d'étude sont implicitement considérés comme le simple reflet des désajustements de monnaies figurant dans l'échantillon. Ensuite, seuls $N-1$ taux de change bilatéraux indépendants peuvent être déduits d'un ensemble de N taux de change effectifs. En utilisant des techniques de cointégration, nous étudions ici ces deux problèmes en procédant à l'estimation de deux ensembles de taux de change d'équilibre, à la fois en termes effectifs et bilatéraux, et en faisant varier les hypothèses concernant la prise en compte du reste du monde et la monnaie numéraire. Dans un premier temps, nous considérons 15 monnaies du G20 en circuit fermé, c'est-à-dire sans introduire le reste du monde. Dans un second temps, nous introduisons le reste du monde. Nous calculons alors les taux de change d'équilibre bilatéraux selon ces deux méthodes.

Les résultats confirment l'importance de la prise en compte du reste du monde dans la mesure des désajustements de change. Par exemple, la sous-évaluation du renminbi par rapport au dollar US varie de 30 à 60% en 2004, selon la manière dont la question de la Nième monnaie est traitée. En termes effectifs, la sous-évaluation varie entre 31 et 45%.

RÉSUMÉ COURT

Nous proposons une analyse systématique du problème de la cohérence mondiale pour le calcul des taux de change d'équilibre. L'incohérence des calculs peut venir de deux sources. D'abord, les désajustements des monnaies restées à l'extérieur de l'échantillon d'étude sont implicitement considérés comme le simple reflet des désajustements de monnaies figurant dans l'échantillon. Ensuite, seuls $N-1$ taux de change bilatéraux indépendants peuvent être déduits d'un ensemble de N taux de change effectifs. Nous mesurons l'ampleur de ces deux problèmes en estimant des taux de change d'équilibre pour 15 monnaies du G20 en termes effectifs et bilatéraux, et selon différentes hypothèses concernant le reste du monde et la monnaie numéraire. Nos résultats confirment l'importance de cette question pour la mesure des désajustements de taux de change, particulièrement en termes bilatéraux.

Classification *JEL* : F31, C23.
Mots clés : taux de change d'équilibre, approche BEER, cohérence mondiale.

WORLD CONSISTENT EXCHANGE RATES

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1 Introduction

The large literature on equilibrium exchange rates has typically focused on country-by-country estimations of equilibrium exchange rates (Clark and MacDonald, 1998) or on consistent estimations of equilibrium exchange rates for a set of industrial economies (Williamson, 1994; Wren Lewis and Driver, 1998). Until the mid-1990s, this approach was in line with a two-tier international monetary system. The first tier consisted in a small number of key currencies: the dollar, the Deutschemark, the yen and the British pound. G7 meetings[4] were supposed to provide a coordination forum for these countries. The second tier consisted in all other currencies. Corresponding exchange rates were a national or regional, not multilateral interest.

Since the mid-1990s, the rising share of emerging countries in global imbalances has made such divide no longer adequate. In 2005, for instance, advanced economies totalized a current account deficit of USD bn 451. The same year, developing Asian countries and the Middle East together experienced an aggregate surplus of USD bn 327.[5] Consistently, the exchange-rate regime of China has often been accused of being one major building block of global imbalances, and some economists have suggested that the forum for international monetary cooperation should move from the G7 to the G20, a group created in 1999 to discuss financial stability issues.[6]

Such evolutions call for the estimation of consistent sets of equilibrium exchange rates for a large number of currencies. Steps in this direction have been taken by Alberola *et al.* (1999) and Bénassy-Quéré *et al.* (2004). These papers use panel cointegration techniques to derive consistent real, effective equilibrium exchange rates for a group of 12 and 15 currencies, respectively. Then, bilateral equilibrium exchange rates are derived by inverting the weighted matrix of effective rates. However this matrix is bound to be singular since only $(N-1)$ bilateral exchange rates can be

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[4] The G7 is an informal group of the seven most advanced countries, *i.e.* Canada, France, Germany, Italy, Japan, the United Kingdom and the United States. It can meet either on a heads of state and government basis or on a ministers basis. G7-finance meetings have played a role for exchange-rate coordination, especially in 1985 (Plaza agreement) and in 1987 (*Le Louvre* agreement).

[5] IMF, *World Economic Outlook*, September 2005.

[6] See Bergsten (2004) or O'Neill and Hormats (2004). The G20 includes all G7 countries plus Argentina, Australia, Brazil, China, India, Indonesia, Korea, Mexico, Russia, Saudi Arabia, South Africa and Turkey.

derived from N effective rates. Both papers choose to discard one currency — the numeraire one — *i.e.* to remove one line and one column from the matrix. This amounts to assuming that the misalignment of one currency is the mirror image of the misalignments of all other currencies. Yet, this is not necessarily the case since not all countries are covered in the analysis. Specifically, the misalignment of the rest of the world (RoW hereafter) is implicitly aggregated to that of the numeraire currency. Depending on the extent of the RoW misalignment, this may lead to biased estimations of bilateral misalignments.

To solve this problem, the rest of the world can be used as the numeraire, as in Faruqee *et al.* (1999): real effective exchange rates are calculated for a sample of N countries, and N bilateral misalignments are then derived against the RoW which is used as the numeraire. Again, this approach is appropriate to the extent that the RoW misalignment (in effective terms) is the mirror image of that of the N countries of the sample. Even here, this is not necessarily the case, for instance due to world imbalances: if the world current account is negative[7], then discarding the current account of the rest of the world leads to a bias in favor of an over-valuation of all currencies against the rest of the world.

This paper aims at shedding some light on the world consistency problem when deriving equilibrium exchange rates. We rely on the simple model of equilibrium exchange rate proposed by Alberola *et al.* (1999), where the equilibrium exchange rate depends on the net foreign asset position and on a Balassa-Samuelson effect. We apply this model to two different sets of real effective exchange rates, successively. In the first one, 15 currencies of the G20 are considered in a closed setting, *i.e.* the real effective exchange rate of each currency is calculated as the weighted average of bilateral exchange rates against the 14 other currencies. Then, bilateral equilibrium exchange rates are derived by inverting the weighting matrix while discarding one equilibrium rate. In the second experiment, we add a synthetic, rest-of-the world currency to the sample. Hence we have 16 currencies, and each real effective exchange rate is calculated as a weighted average of bilateral rates against the other 15 currencies, including the rest of the world. Bilateral equilibrium rates are ultimately derived in the same way as before. By comparing the two methods and varying the numeraire currency, we are able to measure the importance of correctly accounting for RoW misalignments when deriving world-consistent equilibrium exchange rates.

The present paper uses cointegration analysis on quarterly data over the period 1980.Q1-2004.Q3 to derive equilibrium exchange rates. Hence it follows the BEER tradition initiated by Clark and MacDonald (1998). Working on quarterly data allows us to discard the 1970s from our sample, which is necessary when dealing with emerging economies. Two sets of estimations are successively performed: country-by-country cointegration estimations, and panel cointegration estimations. Comparing the results with both methodologies allows us to point which currencies do not follow the standard pattern. The results turn out to be unsatisfactory regarding both robustness

[7]which has been the case over the past. In 2005, the world deficit represented 10% of the aggregate deficit of advanced economies; in 2001, it represented as much as 80%. See IMF, *op.cit.*

and consistency. Panel estimations of equilibrium real exchange rates have been developed in the early 2000s by a number of authors.[8] The novelty of the present paper is to specifically study the extent of the world consistency problem.
The paper is organized as follows. The theoretical model of equilibrium exchange rate is briefly presented in Section 2. Section 3 describes the data set. Section 4 reports the results of unit root and cointegration tests. Real effective misalignments are derived in Section 5, and bilateral misalignments in Section 6. Section 7 concludes.

2 The model

We rely on the stock-flow model developed by Alberola (2003) and Alberola *et al.* (1999, 2002). The real exchange rate q is defined as the (log) relative price of foreign goods. With p^* denoting the (log) foreign price index and p the domestic one, and s standing for the logarithm of the nominal exchange rate (price of the foreign currency), we have:

$$q = s + p^* - p \tag{1}$$

Denoting α the share of tradable goods in the price index, p^T the price level of tradable goods, and p^{NT} the price level of non-tradable goods (both in logarithms) and referring to foreign prices with a star, the real exchange rate can also be written as follows (the share of non-tradables is assumed to be the same across countries):[9]

$$q = (s + p^{T*} - p^T) + (1-\alpha)\left[\left(p^{NT*} - p^{T*}\right) - \left(p^{NT} - p^T\right)\right] \tag{2}$$

The first term, denoted q^T hereafter, refers to the relative price of tradable goods across countries. It is determined by the equilibrium condition of the balance of payments. The second term (q^{NT} in the following) is proportional to the ratio of the foreign to domestic relative price of non-tradable goods. In emerging countries, non-tradable goods are expected to be cheaper than in industrial countries because wages are lower whereas productivity in this sector is similar. Hence, the real value of the currency is lower (q is higher) due to the non-tradable sector. This is the Balassa-Samuelson effect which is driven by relative productivity in the tradable relative to the non-tradable sector.
The equilibrium exchange rate, denoted $\bar{q}$, is then defined as the one that achieves equilibrium both internally and externally:

$$\bar{q} = \bar{q}^T + \bar{q}^{NT} \tag{3}$$

The external contribution to the equilibrium exchange rate ($\bar{q}^T$) is derived from balance of payment equilibrium when net capital flows correspond to normal adjustment of the net foreign asset position F towards its desired level $\tilde{F}$:

[8] See, for instance Maeso-Fernandez *et al.* (2001, 2004), Égert (2003), Barisone *et al.* (2006).
[9] See MacDonald (1997) for details.

$$B = \eta \left(\tilde{F} - F_{-1}\right) + gF_{-1} \quad (4)$$

where B is the current account, g the growth rate of nominal GDP, F_{-1} is the net foreign asset position at the end of the previous period and $0 < \eta < 1$.
Suppose the net foreign asset position (NFA hereafter) is at its desired level: $F = \tilde{F}$. In this case, the current account must be positive if the NFA is positive in order to keep the NFA-to-GDP ratio constant: $B = gF_{-1} > 0$. Conversely, if the NFA is negative, then the country must run a current account deficit to keep the NFA ratio constant.
Suppose now that domestic asset holders want to increase their NFA towards the desired level ($\tilde{F} > F_{-1}$). In this case, the current account must adjust upward. In emerging countries, the desired NFA position may be negative. If the desired net debt is higher than its present level, then $\tilde{F} < F_{-1}$, which is consistent with a current account deficit. Conversely, if $0 > \tilde{F} > F_{-1}$, then the country should run a current account surplus or adjust it upward in order to reduce its net debt vis-à-vis the rest of the world.
With b and f denoting the ratios of respectively B and F to GDP, we get:

$$b = \eta \left(\tilde{f} - f_{-1}\right) + \frac{g(1+\eta)}{1+g} f_{-1} \quad (5)$$

In turn, the current account will depend on price competitiveness (q^T) and on net income from the NFA:[10]

$$b = \gamma q^T + \frac{r^*}{1+g} f_{-1} \quad (6)$$

where $\gamma > 0$ and r^* is the international interest rate. Putting together Equations (5) and (6), we get the expression of $\bar{q}^T$:

$$\bar{q}^T = \frac{1}{\gamma} \left(\eta \tilde{f} - \left(\eta + \frac{r^* - g(1+\eta)}{1+g}\right) f_{-1}\right) \quad (7)$$

The real equilibrium exchange rate depreciates ($\bar{q}^T$ rises) if the desired NFA increases or if the observed NFA falls.[11] The desired NFA may be influenced by expected interest rate differentials. In the long run, however, the real interest parity should hold, or at least the risk premium should be constant. Therefore, the desired NFA is assumed exogenous here. In the econometric analysis, it will appear in the constant or in the country fixed effects.
The internal contribution to the equilibrium exchange rate ($\bar{q}^{NT}$) derives from a Balassa-Samuelson effect and can be expressed as:

$$\bar{q}^{NT} = (1-\alpha)\left[\left(z^{T*} - z^{NT*}\right) - \left(z^T - z^{NT}\right)\right] \quad (8)$$

[10] For simplicity, we disregard exogenous factors that also impact on the current account.
[11] The sufficient condition for the parenthesis in front of f_{-1} to be positive is that $\eta + r^* - g > 0$, which is likely to be the case, except for a very low adjustment speed η.

where z^i stands for labor productivity in sector i $(i = NT, T)$. In an emerging economy, the productivity differential between the traded-good sector and the non-traded good sector is lower than in an advanced economy. This translates into a positive value of $\bar{q}^{NT}$, *i.e.* the domestic currency is weaker than its purchasing power parity level.
From (3), (7) and (8), we get the real equilibrium exchange rate:

$$\bar{q} = \frac{1}{\gamma}\left(\eta\tilde{f} - \left(\eta + \frac{r^* - g(1+\eta)}{1+g}\right) f_{-1}\right) + (1-\alpha)\left[\left(z^{T*} - z^{NT*}\right) - \left(z^T - z^{NT}\right)\right] \quad (9)$$

The real exchange rate $(\bar{q})$ is expected to be a negative function of the net foreign asset position f and a positive function of relative productivity differentials. Equation (9) can be estimated econometrically.

3 The data

We consider 15 currencies corresponding to Argentina (ARG), Australia (AUS), Brazil (BRA), Canada (CAN), China (CHN), the United Kingdom (GBR), Indonesia (IDN), India (IND), Japan (JPN), Korea (KOR), Mexico (MEX), Turkey (TUR), the United States (USA), South Africa (ZAF) and the Euro composite (ZZM).[12] In a second step, a 16th currency corresponding to the rest of the world (RoW) is added to the analysis.[13] Data are quarterly and cover the period from 1980.Q1 to 2004.Q3. The dependent variable is the real effective exchange rate (q_t)[14], and the two explanatory variables are the stock of net foreign assets (nfa_t) and a proxy for relative productivity differentials $(relp_t)$.[15] q_t and $relp_t$ are in logarithms whereas nfa is expressed as a percentage of GDP:

$$q_t = f(nfa_t, relp_t) \quad (10)$$

The real effective exchange rate for each country is calculated as a weighted average of real bilateral exchange rates against each partner. Bilateral rates are derived with consumer price indices and based in 1990.Q1. They are weighted with the share of each partner in imports and exports of goods and services in 2003. Note that intra-Eurozone trade is excluded and that trade weights are normalized to sum to one across G20 or G20+RoW partners, alternatively (the weighting matrix is reported in the appendix, Table A.2).

[12] Hence, our sample covers all G20 countries except Russia and Saudi Arabia. France, Germany and Italy are grouped into the euro area.

[13] The rest of the world includes 64 countries, which were selected for data availability and altogether represent 15.6% of world GDP. With G20 countries totalizing 83.3% of world GDP, the countries in our study cover 98.9% of world GDP. The countries included in the RoW aggregate are listed in the data appendix (Table A.1).

[14] A rise in q denotes a depreciation in real terms.

[15] See the appendix for a detailed description of the data.

The net foreign asset position of each country is constructed from the Lane and Milesi-Ferretti database.[16] Note that the NFA position for the RoW is defined as the difference between (i) the sum of NFAs across all the countries included in the database[17], and (ii) the sum of the NFAs over our G20 countries or zones. This aggregate NFA is normalized on the corresponding GDP. We calculate the ratio of end-of-year NFA to annual GDP and then linearly interpolate to get quarterly data.
Concerning relative productivity of tradables versus non-tradables, we follow Alberola *et al.* (1999) in using a proxy given by the ratio of the consumer price index (CPI) to the producer price index (PPI). The reason for such approximation is that the CPI contains more non-tradable goods (especially services) than the PPI. Indeed, according to the IMF *International Financial Statistics*, the producer price index covers agricultural and industrial prices for the first commercial transaction. Services are not included in this index, which makes it an acceptable proxy for tradable good prices. Considering that only the CPI includes non-tradable goods, we have:

$$\frac{CPI}{PPI} = \left(\frac{P^{NT}}{P^{T}}\right)^{1-\alpha} \tag{11}$$

where α is the share of tradable goods in the price index, P^T the price level of tradable goods, and P^{NT} the price level of non-tradable goods. This ratio rises with relative productivity in the tradable sector compared to the non-tradable one.
For each country, we calculate this ratio both for the domestic economy and for an aggregate foreign economy which is a weighted average of foreign partners, using the same weights as for real effective exchange rates. Then, we define rpi as the log of the ratio between CPI/PPI in the domestic economy and in the foreign economy:

$$rpi = (1-\alpha)\left[(p^{NT} - p^{T}) - (p^{NT*} - p^{T*})\right] \tag{12}$$

rpi is expected to rise if the relative productivity of the tradable sector (compared to the non-tradable one) increases faster than in the rest of the world. Hence the coefficient on rpi in Equation (10) is expected to be negative, *i.e.* a rise in rpi leads to a real appreciation of the domestic currency. rpi is based on quarterly price data, except for three countries (Argentina, Brazil, China) at the beginning of the period and for the RoW over the whole sample, where a linear interpolation is used.

4 Panel unit root and cointegration tests

As a first step, various panel unit root tests are carried out. Levin and Lin (1992, 1993)[18], Breitung (2000) and Hadri (2000) tests are based on a common unit root process. In other words, in the Dickey-Fuller-type regression:

[16] See Lane and Milesi-Ferretti (2006).

[17] This sum amounts to -5% of world GDP in 2004, consistent with world trade discrepancy which is generally found negative.

[18] See also Levin, Lin and Chu (2002).

$$\Delta y_{it} = \alpha_i + \rho_i y_{it-1} + \varepsilon_{it} \tag{13}$$

where $i = 1, ..., N$, $t = 1, ..., T$ and $\varepsilon_{it} \sim iid\left(0, \sigma_i^2\right)$, the autoregressive coefficient ρ_i is supposed to be identical across individuals: $\rho_i = \rho$ for all countries i. Levin and Lin (LL) and Breitung tests are based on the null hypothesis of a unit root, while the Hadri test uses a null of no unit root. The hypothesis that the autoregressive parameters are common across individuals is a rather restrictive assumption on the dynamics of the series under the alternative hypothesis.

For this reason, various authors extend the Levin and Lin framework to allow for heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Indeed, in the Im *et al.* (2003) test (IPS), the alternative hypothesis of no unit root can be stated as follows: $\rho_i < 0$ for $i = 1, 2, \ldots, N_1$ and $\rho_i = 0$ for $i = N_1 + 1, \ldots, N$. Thus, under the alternative hypothesis, some series may be characterized by a unit root, while some other series can be stationary. Two tests are proposed by Im *et al.*: a group-mean $t-$bar statistic for $\rho_i = 0$ based on the $t-$statistics derived from the N augmented Dickey-Fuller regressions, and a group-mean Lagrange multiplier (LM) statistic which is based on averaging the single-country LM-statistics for $\rho_i = 0$.

Like the IPS test, the Maddala and Wu (1999) test (MW) is not based on the restrictive assumption that the autoregressive coefficient is the same across countries. This test is a non-parametric Fisher-type test that combines the $p-$values from individual unit root tests.

Table 1 reports the results of panel unit root tests for each of our data sets: the one without the RoW (where all weighted averages are calculated against other G20 countries and the RoW is absent from the estimations), and the one with the RoW. According to the six tests (with the exception of IPS $t-$bar for rpi without the rest of the world) both nfa and rpi series contain a unit root at the 5% significance level. Concerning the effective exchange rate, the unit root hypothesis is rejected only by the IPS $t-$bar in both cases (with and without the RoW) and at the 10% significance level by the LL test, in the presence of the RoW. The four other tests indicate that this series is non stationary at conventional significance levels.

As a second step, we proceed to panel cointegration tests. We consider the seven tests proposed by Pedroni (1999, 2004). These tests are based on the null hypothesis of no cointegration and some heterogeneity is introduced under the alternative hypothesis. Indeed, under the alternative hypothesis, there exists a cointegration relationship for each country, and this cointegration relationship is not necessary the same for each country. Pedroni's tests are based on the following regression:

$$q_{it} = \alpha_i + \beta_{1i} nfa_{it} + \beta_{2i} rpi_{it} + \varepsilon_{it} \tag{14}$$

with $i = 1, \ldots, 15$ or 16 (countries) and $t = 1980.Q1, \ldots, 2004.Q3$ (time).

Among the seven Pedroni's tests, four are based on the within dimension (panel cointegration tests) and three on the between dimension (group-mean panel cointegration tests). Both categories of tests are based on the null hypothesis of no cointegration:

Table 1: Panel unit root tests

	q_t	nfa_t	rpi_t
	Without the RoW (N=15)		
LL	-0.5974 (0.27)	0.8247 (0.79)	-0.9129 (0.18)
Breitung	-0.1354 (0.45)	-1.5848^{*} (0.05)	-0.0703 (0.47)
Hadri	16.6593^{***} (0.00)	16.4480^{***} (0.00)	16.4119^{***} (0.00)
IPS-LM	1.1029 (0.13)	-1.8883 (0.97)	1.0033 (0.16)
IPS t-bar	1.9662^{**} (0.02)	1.4690 (0.92)	-1.9179^{**} (0.03)
MW	39.74 (0.11)	15.584 (0.97)	38.63 (0.13)
	With the RoW (N=16)		
LL	-1.5254^{*} (0.06)	1.7581 (0.96)	-0.0554 (0.48)
Breitung	-0.0382 (0.48)	-1.5834^{*} (0.05)	0.8332 (0.79)
Hadri	13.3709^{***} (0.00)	16.9617^{***} (0.00)	14.1347^{***} (0.00)
IPS-LM	1.1160 (0.13)	-1.9153 (0.97)	0.0644 (0.47)
IPS t-bar	-1.9036^{**} (0.03)	2.3513 (0.99)	-0.6872 (0.24)
MW	39.782 (0.16)	16.103 (0.98)	33.736 (0.38)

Note: This table reports the results of the following panel unit root tests: Levin and Lin (LL); Breitung; Hadri; Im, Pesaran and Shin group–mean Lagrange multiplier test (IPS-LM); Im, Pesaran and Shin group–mean t-bar test (IPS t-bar) and Maddala and Wu (MW) test. All tests but Hadri are based on the unit root null hypothesis. p-values are given in parentheses. * (resp. **, ***): rejection of the null hypothesis at the 10% (resp. 5%, 1%) significance level.

Table 2: Panel cointegration tests

	Panel cointegration tests			
	v test	rho test	non parametric t test	parametric t test
Without RoW	3.2892^{***} (0.00)	-2.0716^{**} (0.01)	-1.3836^{*} (0.08)	-2.2863^{**} (0.01)
With RoW	2.2611^{**} (0.01)	-1.0572 (0.14)	-0.4154 (0.33)	-1.4651^{*} (0.07)
	Group-mean cointegration tests			
		rho test	non parametric t test	parametric t test
Without RoW		-1.5872^{*} (0.05)	-1.2442 (0.10)	-2.4834^{***} (0.006)
With RoW		-0.5484 (0.29)	-0.1759 (0.43)	-1.4748^{*} (0.07)

Note: This table reports the results of the seven tests proposed by Pedroni. All tests are based on the null hypothesis of no cointegration. p-values are given in parentheses. * (resp. **, ***): rejection of the null hypothesis at the 10% (resp. 5%, 1%) significance level.

$\rho_i = 1 \ \forall i$, ρ_i being the autoregressive coefficient on estimated residuals under the alternative hypothesis (*i.e.* ρ_i is such that: $\hat{\varepsilon}_{it} = \rho_i \hat{\varepsilon}_{it-1} + u_{it}$).
The difference between panel cointegration and group-mean panel cointegration tests comes from the specification of the alternative hypothesis:

- For the panel cointegration statistics, the alternative hypothesis is given by: $\rho_i = \rho < 1 \ \forall i$.
- For the group-mean panel cointegration statistics, the alternative hypothesis is given by: $\rho_i < 1 \ \forall i$.

Thus, group-mean panel cointegration statistics are more general in the sense that they allow for heterogeneous coefficients across countries under the alternative hypothesis.
Table 2 displays the results of Pedroni's tests. In the closed G20 setting, the null hypothesis of no cointegration is rejected in all cases (but the non-parametric t-test), meaning that there exists a long-term equilibrium relationship between the real effective exchange rate and its two determinants. When adding the rest of the world, the null hypothesis is rejected for three tests. Thus, the results are somewhat mixed. However, simulations made by Pedroni (1997) show that, in small samples, the group-mean parametric $t-$test is more powerful than the other tests, followed by the panel $v-$test. Based on this result, we can conclude that the null hypothesis of no cointegration is rejected in our study.

5 Real effective equilibrium exchange rates

It is now possible to estimate the cointegration vectors for the countries under study. The OLS method leads to superconsistent estimates, but the corresponding distributions are biased and dependent on nuisance parameters associated with the serial

correlation properties of the data. Thus, in order to estimate systems of cointegrated variables, it is necessary to use an efficient estimation procedure. Various procedures exist, such as the Fully-Modified OLS (FM-OLS) method proposed by Phillips and Hansen (1990), or the Dynamic OLS (DOLS) method introduced by Saikkonen (1991) and Stock and Watson (1993) in the context of standard cointegration and by Kao and Chiang (2000) and Mark and Sul (2003) in the context of panel cointegration. Here, we propose to use the panel DOLS procedure. Note that this estimator has the same asymptotic distribution as the FM-OLS one, but has smaller size distortions (see the simulations made by Kao and Chiang, 2000). Roughly speaking, the DOLS procedure consists in augmenting the cointegrating relationship with lead and lagged differences of the regressors to control for the endogenous feedback effect.
Two types of estimation are considered: country-by-country estimations, and a panel estimation with country fixed effects. Using a panel equation for calculating exchange rates relies on the strong assumption of panel homogeneity. However, we only have 99 observations for each country. More importantly, some countries of the sample have experimented structural changes over the estimation period, which reduces the reliability of country-specific estimates. Finally, since the exchange rate is a two-sided variable, we expect some consistency in the results. For instance, the coefficient on the NFA should be at least of the same sign across the countries. Therefore, we proceed to both types of estimations, successively.

5.1 Country-by-country estimations

Table 3 displays the estimated cointegration vectors. With some exceptions, the estimated coefficients are close whether the rest of the world is introduced or not. As expected, the coefficients on nfa and rpi are generally negative. In four countries (the UK, Japan, South Africa, and Canada when the RoW is present) plus the RoW, the coefficient on the NFA position is significantly positive, meaning that higher NFA leads to a real depreciation. This result may be interpreted as the short-run impact of capital flows on the real exchange rate: a rise in the NFA is the result of higher current account due to a depreciated currency. In the longer run, to the extent that the desired NFA does not increase, net capital outflows are bound to vanish and the real exchange rate to come back to its equilibrium level.
When significant, the impact of the relative price variable is negative in all countries but the RoW. However the coefficient varies across countries. It is very large in Japan and, to a lesser extent, in the Eurozone, Mexico, Indonesia and the UK. Conversely, it is non-significant in eight countries.
Hence, country-by-country estimations lead to somewhat mixed results. For nine countries, at least one explanatory variable is significant and the real effective equilibrium exchange rate (REER, hereafter) can be derived as the prediction of the country-by-country model. The results are compared to observed exchange rates in Figures 1 in the case where the RoW is included in the estimations.[19] The REER tends to

[19]Figures 1 only report the REER for which significant cointegrating vectors have been obtained.

Table 3: Cointegration vectors. Country-by-country estimations

	Without RoW		*With RoW*	
	nfa	*rpi*	*nfa*	*rpi*
ARG	−0.852	−0.210	−0.734	−0.291
	(−1.83)	(−1.07)	(−1.43)	(−1.51)
AUS	0.161	−1.379	0.167	−1.792
	(0.35)	(−1.75)	(0.43)	(−1.69)
BRA	**−0.734**	**−0.618**	**−0.819**	**−0.633**
	(−3.44)	(−3.45)	(−4.24)	(−3.68)
CAN	0.348	**−0.976**	**0.390**	**−1.332**
	(1.17)	(−2.19)	(3.30)	(−4.84)
CHN	**−5.00**	−4.312	−3.831	2.348
	(−3.13)	(−1.28)	(−1.49)	(0.72)
GBR	**0.611**	**−1.527**	**0.456**	**−1.297**
	(4.16)	(−3.64)	(3.80)	(−4.07)
IDN	−0.664	**−1.502**	−0.658	**−1.643**
	(−1.47)	(−2.51)	(−1.84)	(−2.81)
IND	−2.056	−0.322	−2.572	1.513
	(−1.22)	(−0.08)	(−1.80)	(0.52)
JPN	**1.879**	**−10.53**	**3.102**	**−8.501**
	(4.06)	(−8.15)	(7.07)	(−11.52)
KOR	−0.216	0.439	−0.513	0.536
	(−0.27)	(0.27)	(−1.39)	(0.94)
MEX	**−1.843**	1.608	−0.858	**−2.862**
	(−2.70)	(1.02)	(−1.39)	(−2.36)
TUR	0.156	−0.215	−0.171	−0.295
	(0.34)	(−0.61)	(−0.28)	(−0.62)
USA	−0.139	−1.521	0.296	−0.482
	(−0.15)	(−0.66)	(0.23)	(−0.20)
ZAF	**0.961**	−1.902	**1.107**	−1.695
	(2.83)	(−1.83)	(2.86)	(−1.09)
ZZM	−0.810	0.164	**−4.013**	**−3.609**
	(−0.16)	(0.04)	(−2.78)	(−2.30)
RoW			**0.523**	**0.591**
			(2.65)	(4.19)

Note: This table reports the estimation of the cointegration vectors using DOLS. Between brackets: t-statistics. In bold: significant at the 5% level.

appreciate over time in the UK and in Japan. Remember however that the NFA is wrongly signed in these two countries. In Canada and South Africa, the REER depreciates over the 1990s and early 2000s and the currency appears overvalued at the end of the period. In Brazil too, the REER tends to depreciate, but this time no misalignment is visible in the early 2000s. In China, after a period of depreciation during the 1980s and the beginning of the 1990s, the REER strongly appreciates in the mid-1990s and 2000s, contrasting with the stability of the observed real exchange rate. In Mexico, no clear trend is visible for the REER and the peso appears overvalued in the early 2000s. In Indonesia, the REER closely follows the observed real exchange rate, with no clear misalignment even around the 1997 crisis. Concerning the Eurozone, the REER tends to depreciate since the end of the 1980s, but there is no important misalignment at the end of the considered period. Finally, after a strong appreciation during the end of the 1980s and the beginning of the 1990s, the REER of the RoW does not show any trend.

This first set of estimations is not satisfactory for several reasons. First, the two explanatory variables are not significant in seven countries, which may be due to the limited number of observations and/or to the existence of structural breaks. Second, the estimations carried out for emerging countries may not deliver results that are consistent with the theoretical model if structural breaks have triggered an adjustment period where short-term patterns are prominent. Finally, having the same explanatory variable impacting in opposite direction on the real exchange rate in two different countries is not consistent at the world level. Hence we need to turn to panel estimations.

5.2 Panel estimation

The cointegration vectors estimated through the DOLS method with country fixed effects are reported in Table 4. The cointegrating coefficients are significant at the 5% level and correctly signed. Furthermore, the estimates are close whether the RoW is present or not.

Figures 2 report the real equilibrium effective exchange rate for each country when the RoW is included, together with observed exchange rates. Not surprisingly, exchange-rate misalignments are generally much larger with these panel estimations than with country-by-country ones. Except for Brazil, the results are very different. In China, and to a lesser extent in Canada, the REER is now stable over the period due to the opposite impact of the NFA and of relative prices. The REER of the UK now depreciates until the end 1990s and there is a very large over-valuation of the pound in the early 2000s. In Indonesia, the exchange rate overshoots during the 1997 crisis and stays slightly undervalued at the end of the period. In Japan, the REER smoothly appreciates over the period and no large misalignment is observed in 2004. In Mexico and South Africa, the REER is globally stable, with a slight appreciating trend on the whole period.

Concerning other countries, the major result is the depreciating trend of the USD (with a 11% over-valuation in 2004). For the euro, the REER is relatively stable, with

Table 4: Cointegration vectors. Panel estimation

	nfa	*rpi*
Without RoW	$-0.484\ (-2.01)$	$-0.771\ (-3.27)$
With RoW	$-0.545\ (-2.07)$	$-0.608\ (-2.58)$

Note: This table reports the estimation of the cointegration vectors using DOLS. Between brackets: t-statistics.

a slight over-valuation in 2004 (1.5%). In Argentina, the 2001 crisis results in a large under-valuation that remains in 2004. In Australia, the REER tends to depreciate over time, and the misalignment is important at the end of the period (around 18% in 2004.Q3). In India, both the REER and the observed exchange rate are relatively stable in the 1990s and 2000s. In Korea, the REER tends to appreciate over the period whereas the observed exchange rate is marked by the 1997 crisis. In Turkey, the REER slightly appreciates over time and the currency appears overvalued in 2004. In the RoW, finally, after a period of appreciation, the REER depreciates during the mid-1980s and stays stable afterwards; large misalignments can be observed, but in 2004, the exchange rate appears close to equilibrium.

Real effective misalignments for 1988.Q1 (largest figure for the RoW) and for 2004.Q3 (our last observation) are reported in Table 5. A positive sign points to currency under-valuation. The comparison of the results without (N) and with (R) the RoW provides a first assessment on the impact of discarding the RoW in the calculations of exchange-rate misalignments.

For some countries, the difference is sizeable. In 2004.Q3, for instance, there is a 13 percentage point differences in the evaluation of the Chinese misalignment, and the misalignment of the euro is ten times higher when the RoW is dropped from the analysis. Note that, with the exception of China, these differences have little to do with the real effective misalignment of the RoW which is weak. Indeed, in 1988.Q1, the impact of including the RoW in the analysis is very small for the euro whereas the misalignment of the RoW is larger.

From these two sets of effective misalignments (with and without the RoW) based on panel data estimations, it is possible to derive bilateral misalignments.

6 Bilateral equilibrium exchange rates

As already mentioned, bilateral misalignments can be derived from effective ones by inverting the weighting matrix which defines effective rates as a function of bilateral ones. With e_i denoting the (log) real bilateral exchange rate of currency i against a numeraire and w_{ij} the weight of country j as a trading partner of country i, the real effective exchange rate of country i goes as:

$$q_i = \sum_j w_{ij}\,(e_i - e_j) \text{ with } \sum_j w_{ij} = 1 \tag{15}$$

Table 5: REER misalignments in 1988.Q1 and 2004.Q3 in percent (panel estimation)

	1988.Q1		2004.Q3	
	Without RoW (N)	*With RoW (R)*	*Without RoW (N)*	*With RoW (R)*
ARG	11.30	6.69	44.67	38.86
AUS	10.52	10.90	**-17.69**	**-18.04**
BRA	5.15	6.84	**-4.88**	**-0.97**
CAN	**-9.36**	**-9.97**	3.60	7.29
CHN	10.52	**-7.78**	31.12	44.56
GBR	8.48	8.60	**-17.58**	**-18.26**
IDN	8.26	5.32	16.99	21.13
IND	**-21.65**	**-21.82**	26.81	21.97
JPN	**-19.61**	**-17.66**	11.05	7.37
KOR	3.72	6.10	17.13	12.03
MEX	14.03	15.01	**-11.89**	**-10.92**
TUR	10.19	8.17	**-13.00**	**-12.31**
USA	8.74	7.95	**-6.55**	**-10.93**
ZAF	**-4.48**	**-4.20**	13.15	14.65
ZZM	**-8.19**	**-9.28**	**-10.04**	**-1.54**
RoW		10.24		**-1.32**

Note: This table reports the misalignments for 1988.Q1 and 2004.Q3 based on the panel DOLS estimation. In bold: overvalued currencies.

Let Q be the vector of the N equilibrium real effective exchange rates previously estimated, and E the vector of the N corresponding bilateral real exchange rates against the numeraire ($N = 15$ or 16 depending on whether the RoW is included or not). Q is a function of E:

$$Q = (I - W)\, E \tag{16}$$

where W is the $(N \times N)$ trade matrix, and I is the identity matrix of order N. Because trade weights sum to one across the N partners, the matrix $(I - W)$ is singular. To circumvent this problem, the redundant effective exchange rate has to be eliminated. Alberola *et al.* (1999), followed by Bénassy-Quéré *et al.* (2004), suggest to discard the row and column corresponding to the numeraire currency. The remaining $(N - 1)$ multilateral exchange rates can then be expressed in terms of the numeraire. Denoting with an asterisk the matrix and vectors where the numeraire currency has been excluded, we get:

$$Q^* = (I - W)^*\, E^* \tag{17}$$

This system can now be inverted. The vector of real bilateral equilibrium exchange rates, denoted E^*, is given by:

$$E^* = (I - W)^{*-1}\, Q^* \tag{18}$$

We are now left with the choice of the numeraire. Here we proceed in two steps. First, the currency of the RoW is used as the numeraire. As already argued, this amounts to assuming that the misalignment of the RoW is the exact mirror image of the misalignment of the other 15 currencies. For the sake of comparison, misalignments are ultimately expressed against the USD by substracting the misalignment of the USD against the RoW. In a second step, the USD is used as the numeraire. Now, it is the USD misalignment that is considered as the mirror image of all other misalignments, including that of the RoW.

In each case, the starting point is one of our two measures of effective misalignments calculated with panel data estimations: against 14 currencies (excluding the RoW) or against 15 currencies (including the RoW). However when the RoW is excluded from the calculation of effective misalignments, it cannot be re-integrated as a numeraire currency (the weighting matrix does not include the RoW). Hence we end up with three measures of misalignments which will be labelled NU (no RoW in effective misalignments, USD as the numeraire), RU (RoW included in effective misalignments, USD as the numeraire) and RR (RoW included in effective misalignments, RoW as the numeraire). As already mentioned, all bilateral misalignments are ultimately expressed against the USD. The results for 1988.Q1 and 2004.Q3 are reported in Table 6.

Not surprisingly, the differences between columns *NU* and *RU* mirror the differences obtained in Table 5 between effective misalignments calculated without the RoW (*N*) and those calculated with the RoW (*R*). In 2004.Q3, for instance, the euro appears 12% overvalued against the USD in the *NU* case but only 1% overvalued in the *RU* case, which derives from the euro being overvalued in effective terms by 10% in the *N* case but only by 1.5% in the *R* case.

In turn, the differences between columns *RU* and *RR* derive from different effective misalignments in the numeraires in both cases. When the USD is used as the numeraire (*RU*), the effective misalignment of the USD is dropped. In 2004.Q3, this misalignment amounts to a 11% over-valuation. This is not equivalent to dropping the slight, 1.3% over-valuation of the RoW in effective terms (*RR*). Indeed, dropping the USD effective misalignment means that all other currencies have a more depreciated (or less appreciated) bilateral equilibrium exchange rate against the USD. This translates into less under-valuation, or more over-valuation, of current bilateral rates compared to equilibrium. For instance, the euro is overvalued by 6.2% in the *RR* case, compared to only 1% in the *RU* case. In 1988.Q1, both the USD and the RoW are undervalued by similar amounts. Consequently, *RU* and *RR* methodologies lead to more similar results.

On the whole, the way the rest of the world is tackled has a large impact on the calculation of effective and especially bilateral misalignments: in 2004.Q3, in four countries (Australia, Brazil, Canada, Eurozone), the misalignment ranges from almost zero to approximately 10%, depending on the methodology. For China, the range of under-valuation is between 30% and 60%. In Japan, it is between 18 and 29%.

Table 6: Bilateral misalignments against the USD in 1988.Q1 and 2004.Q3 (in percent)

	1988.Q1			2004.Q3		
	NU	*RU*	*RR*	*NU*	*RU*	*RR*
ARG	8.40	4.74	2.50	44.55	50.83	46.33
AUS	2.62	3.82	1.60	-9.16	1.77	-2.81
BRA	1.80	3.91	1.55	0.23	12.22	7.92
CAN	-10.45	-11.41	-11.99	3.95	11.26	10.06
CHN	-15.50	-13.84	-15.77	30.48	59.08	55.11
GBR	-0.29	0.93	-1.42	-23.79	-14.03	-18.89
IDN	-1.17	-1.92	-4.20	26.70	42.43	37.72
IND	-27.26	-27.06	-29.21	26.34	35.81	31.42
JPN	-21.67	-21.81	-23.77	18.41	29.42	25.37
KOR	-2.67	-1.00	-3.01	26.45	36.03	31.87
MEX	12.51	13.18	12.64	-11.32	-6.95	-8.03
TUR	1.99	2.06	-0.47	-21.20	-11.11	-16.33
USA	-	-	-2.80*	-	-	3.59*
ZAF	-11.51	-11.12	-13.32	9.54	22.93	18.41
ZZM	-10.77	-11.23	-13.76	-12.45	-0.99	-6.21
RoW	-	6.69		-	4.52	-

Note: A positive sign denotes an under-valuation. * : against RoW.

The RR strategy has been used by Faruqee (1998), among others. Alberola *et al.* (1999) use the RU strategy, while Bénassy-Quéré *et al.* (2004) follow the NU route. Our study highlights the difficulty in moving from effective misalignments to bilateral ones.

7 Conclusion

This paper has addressed the issue of world consistency when deriving equilibrium exchange rates. World inconsistency can result from two problems. First, real effective misalignments of currencies out of the considered sample are implicitly assumed to be the mirror image of those of the currencies under review. Second, only $N-1$ independent bilateral equilibrium exchange rates can be derived from a set of N effective rates. Using panel cointegration techniques, we investigate these two problems by estimating two sets of equilibrium exchange rates, both in effective and bilateral terms, and by varying the assumptions concerning the rest of the world and the numeraire currency. In the first set, we consider 15 currencies of the G20 in a closed setting, *i.e.* without introducing the rest of the world. In the second set, we add the rest of the world. We then derive bilateral equilibrium exchange rates using both methods.

We show that the way the rest of the world is tackled has a major impact on the measure of exchange-rate misalignments, especially for bilateral misalignments. For instance, the extent of renminbi under-valuation against the USD is found between 30% and 60% in 2004, depending on the way the Nth currency problem is tackled. In effective terms, the misalignment ranges from 31 to 45%.

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Data appendix

For the G20 countries, nominal exchange rates and CPIs are generally from the IMF, *International Financial Statistics*, lines rf and 64 respectively. For the Eurozone, we use Eurostat data. Concerning China before 1997, annual CPIs are from national sources and are linearly interpolated within years. Before 1994, Chinese nominal exchange rates are an average between the official exchange rate and market rate (Source: World Bank, 1994). Argentina and Brazil are also submitted to a special treatment: due to the hyperinflation those countries experienced at the beginning of the time sample, real exchange rates based on quarterly nominal exchange rates and CPI are highly volatile. Hence, we use the annual (linearly interpolated to yield quarterly data) real exchange rates provided by the CEPII-CHELEM database before 1995.Q1 for both countries. After 1995.Q1, real exchange rates are computed as for the other countries of the sample.

Concerning the rest of the world (RoW), we consider 64 countries representing 15.6% of world GDP in 2004 and listed in Table A.1. Together with our G20 countries, our sample covers 98.9% of world GDP in 2004. The CPI of the RoW is calculated as a weighted average of the CPIs of each of the 64 countries, which are taken from the World Bank (*World Development Indicators*).

Trade weights are calculated from the CEPII-CHELEM database (see the weighting matrix in Table A.2). Trade flows are harmonized in this database, so that exports and imports are consistent and total world trade is balanced. NFA positions are taken from the Lane and Milesi-Ferretti database (see Lane and Milesi-Ferretti, 2006). In the case of the Eurozone, before 1999, the NFA is calculated as the sum of the 12 Eurozone members as to 2004. The NFA of the RoW is calculated as the difference between the sum of all NFAs of the database and the sum of the NFAs of our G20 countries. These data are linearly interpolated to yield quarterly data.

PPIs are mostly from the IMF, *International Financial Statistics*, line 63. National sources for PPI were used for Turkey, Australia, the Eurozone and China. For the rest of the world, data are taken from World Bank (*World Development Indicators*). As for the CPI, PPI of the RoW is calculated as the weighted average of the PPIs of the 64 considered countries belonging to the RoW. Other authors have used the wholesale price index (WPI) as a proxy for tradable prices. This index takes into account the prices of a number of agricultural and industrial products at various production and distribution stages, and therefore includes imports and import duties. Consequently, the WPI is more general and more representative of the effective price level of traded goods; however it is not available for the whole set of G20 and rest of the world countries, and PPI was therefore preferred in this paper.

The CPI/PPI ratios and real exchange rate of the RoW are linearly interpolated.

Table A.1: Composition of the “Rest of the World”

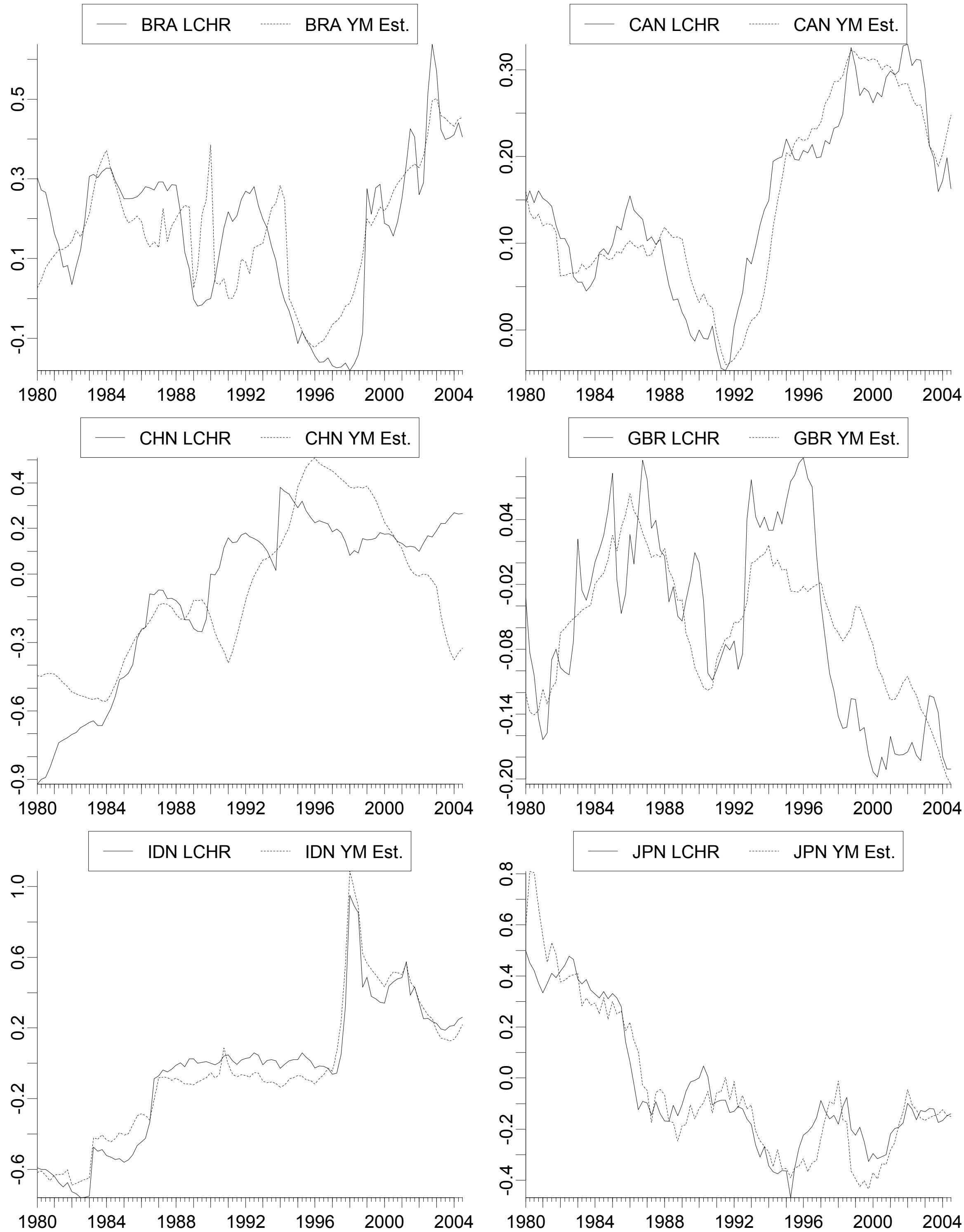
Algeria	Dominican Rep.	Malawi	Senegal
Barbados	Ecuador	Malaysia	Seychelles
Bhutan	Egypt	Mauritius	Sri Lanka
Bolivia	El Salvador	Morocco	St. Kitts and Nevis
Bostwana	Ethiopia	Nepal	St. Lucia
Burkina Faso	Gabon	Nicaragua	St. Vincent and the Grenadines
Burundi	Gambia	Niger	Suriname
Cameroon	Ghana	Nigeria	Swaziland
Central African Rep.	Guatemala	Norway	Sweden
Chile	Honduras	Pakistan	Thailand
Colombia	Hungary	Panama	Togo
Congo	Iran	Papua New Guinea	Tonga
Costa Rica	Jamaica	Paraguay	Trinidad and Tobago
Cote d’Ivoire	Jordan	Philippines	Uruguay
Denmark	Kenya	Rwanda	Vanuatu
Dominica	Madagascar	Saudi Arabia	Venezuela

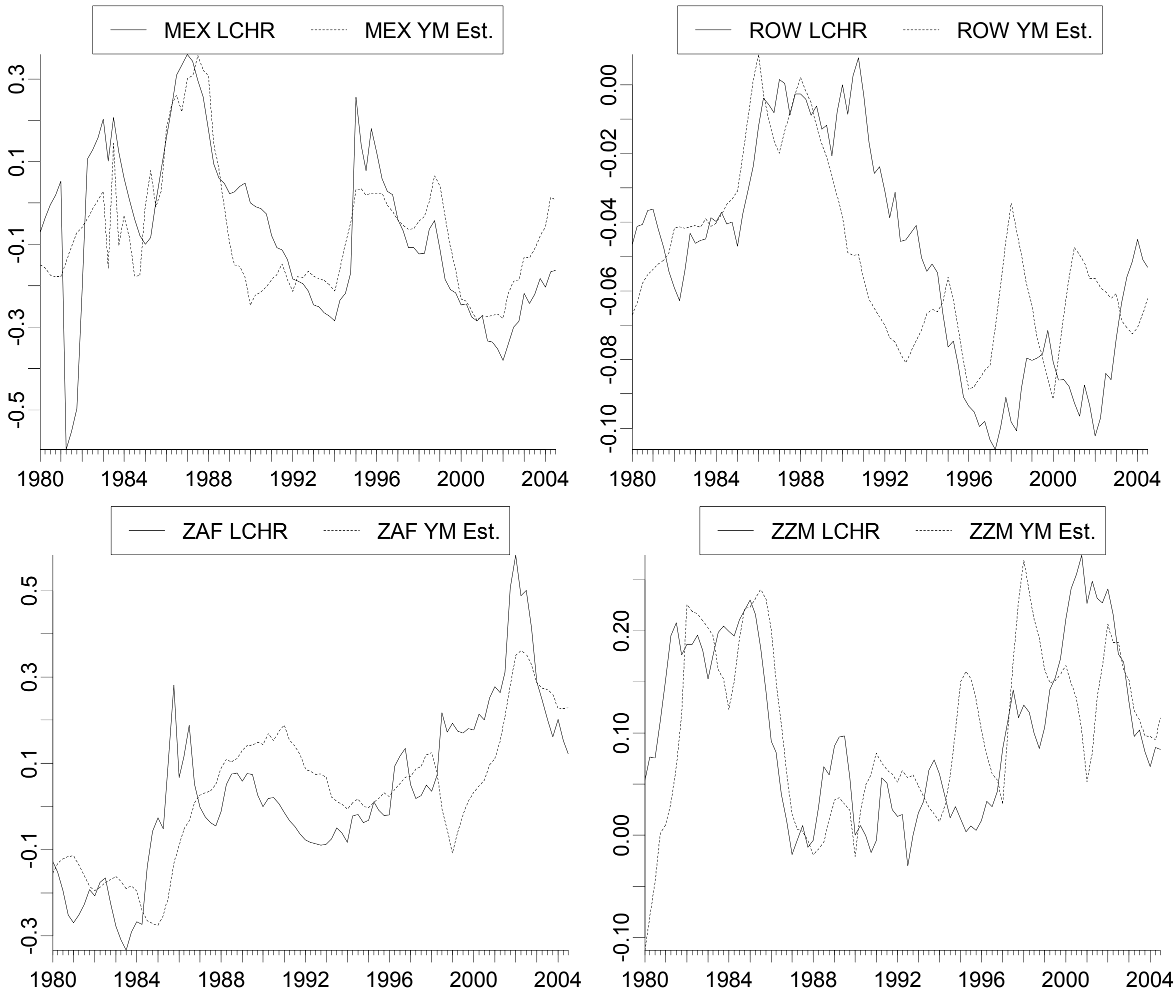
Table A.2: Weighting matrix (2003)

	ARG	AUS	BRA	CAN	CHN	ZZM	GBR	IDN	IND	JPN	KOR	MEX	ROW	TUR	USA	ZAF
ARG	0.0000	0.0046	0.2484	0.0086	0.0809	0.2166	0.0160	0.0034	0.0161	0.0175	0.0145	0.0279	0.1922	0.0066	0.1410	0.0055
AUS	0.0013	0.0000	0.0045	0.0164	0.1089	0.1486	0.0659	0.0314	0.0213	0.1728	0.0618	0.0051	0.2145	0.0023	0.1361	0.0104
BRA	0.0908	0.0057	0.0000	0.0199	0.0707	0.2621	0.0348	0.0060	0.0079	0.0431	0.0249	0.0349	0.2153	0.0040	0.2617	0.0090
CAN	0.0007	0.0045	0.0044	0.0000	0.0352	0.0582	0.0259	0.0021	0.0033	0.0315	0.0102	0.0217	0.0452	0.0010	0.7557	0.0013
CHN	0.0043	0.0198	0.0102	0.0233	0.0000	0.1631	0.0218	0.0115	0.0102	0.2015	0.0867	0.0119	0.1858	0.0040	0.2453	0.0051
ZZM	0.0045	0.0106	0.0148	0.0151	0.0639	0.0000	0.2012	0.0067	0.0117	0.0502	0.0188	0.0106	0.4046	0.0257	0.1547	0.0113
GBR	0.0010	0.0135	0.0057	0.0194	0.0246	0.5795	0.0000	0.0034	0.0109	0.0285	0.0096	0.0030	0.1588	0.0109	0.1179	0.0145
IDN	0.0013	0.0420	0.0063	0.0102	0.0849	0.1264	0.0220	0.0000	0.0277	0.2348	0.0856	0.0041	0.2337	0.0046	0.1134	0.0042
IND	0.0070	0.0317	0.0093	0.0178	0.0833	0.2452	0.0792	0.0308	0.0000	0.0507	0.0464	0.0076	0.1838	0.0083	0.1858	0.0202
JPN	0.0010	0.0328	0.0065	0.0218	0.2110	0.1340	0.0264	0.0334	0.0065	0.0000	0.0739	0.0078	0.2011	0.0025	0.2344	0.0080
KOR	0.0019	0.0275	0.0088	0.0165	0.2123	0.1176	0.0207	0.0285	0.0139	0.1730	0.0000	0.0094	0.1797	0.0046	0.1828	0.0047
MEX	0.0037	0.0023	0.0125	0.0357	0.0296	0.0673	0.0066	0.0014	0.0023	0.0185	0.0096	0.0000	0.0406	0.0005	0.7726	0.0006
ROW	0.0046	0.0169	0.0107	0.0141	0.0854	0.4729	0.0609	0.0147	0.0110	0.0922	0.0333	0.0069	0.0000	0.0140	0.1581	0.0044
TUR	0.0030	0.0036	0.0049	0.0055	0.0336	0.5573	0.0822	0.0053	0.0086	0.0200	0.0158	0.0016	0.1839	0.0000	0.0726	0.0050
USA	0.0032	0.0107	0.0163	0.2161	0.1060	0.1704	0.0451	0.0066	0.0098	0.0967	0.0322	0.1344	0.1474	0.0037	0.0000	0.0046
ZAF	0.0035	0.0225	0.0155	0.0104	0.0610	0.3424	0.1524	0.0067	0.0294	0.0904	0.0229	0.0029	0.1109	0.0070	0.1255	0.0000

Figures 1. REER, country-by-country estimation (with the RoW)

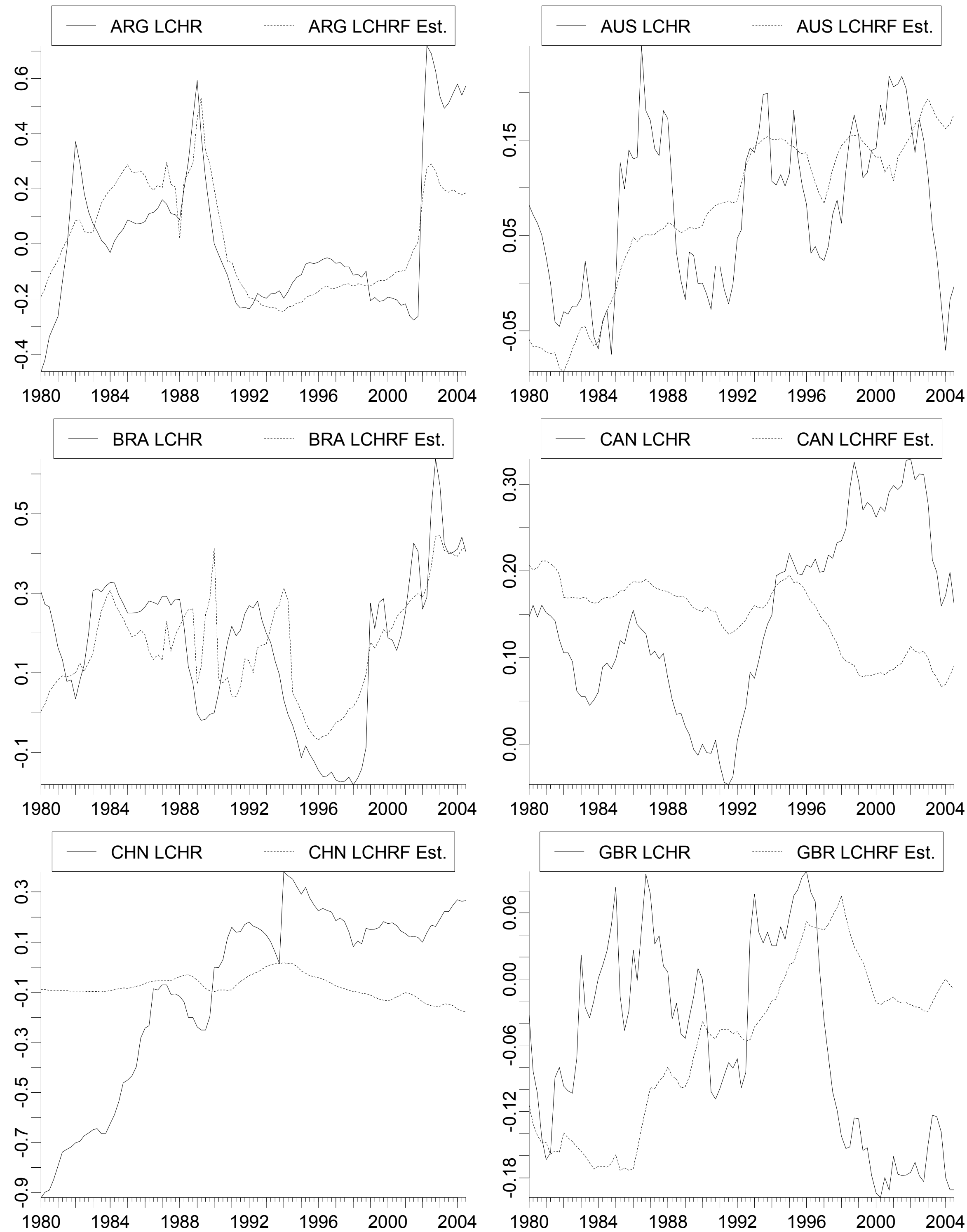
Plain line: observed real effective exchange rate. Dashed line: equilibrium real effective exchange rate. Both are in logarithms.

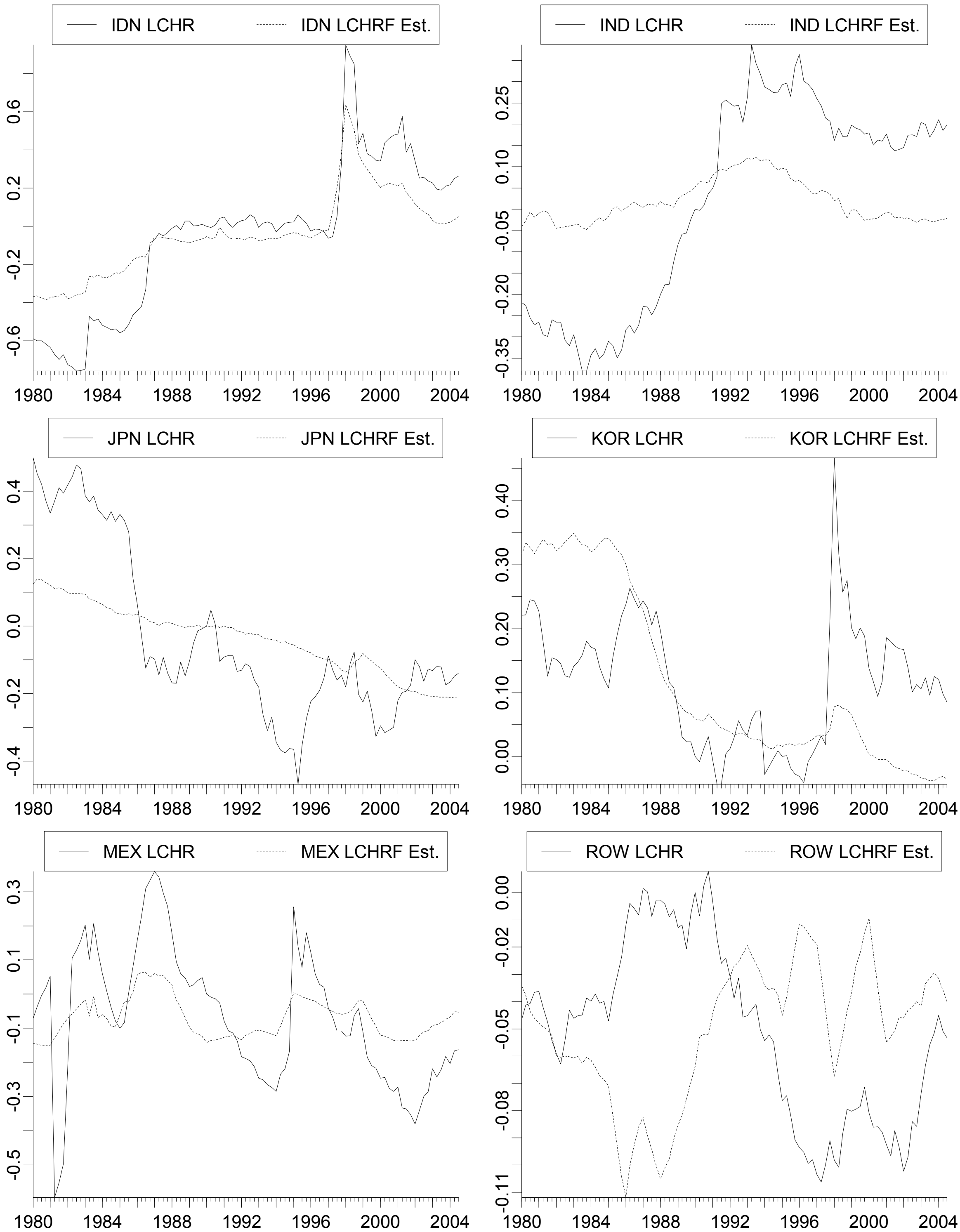


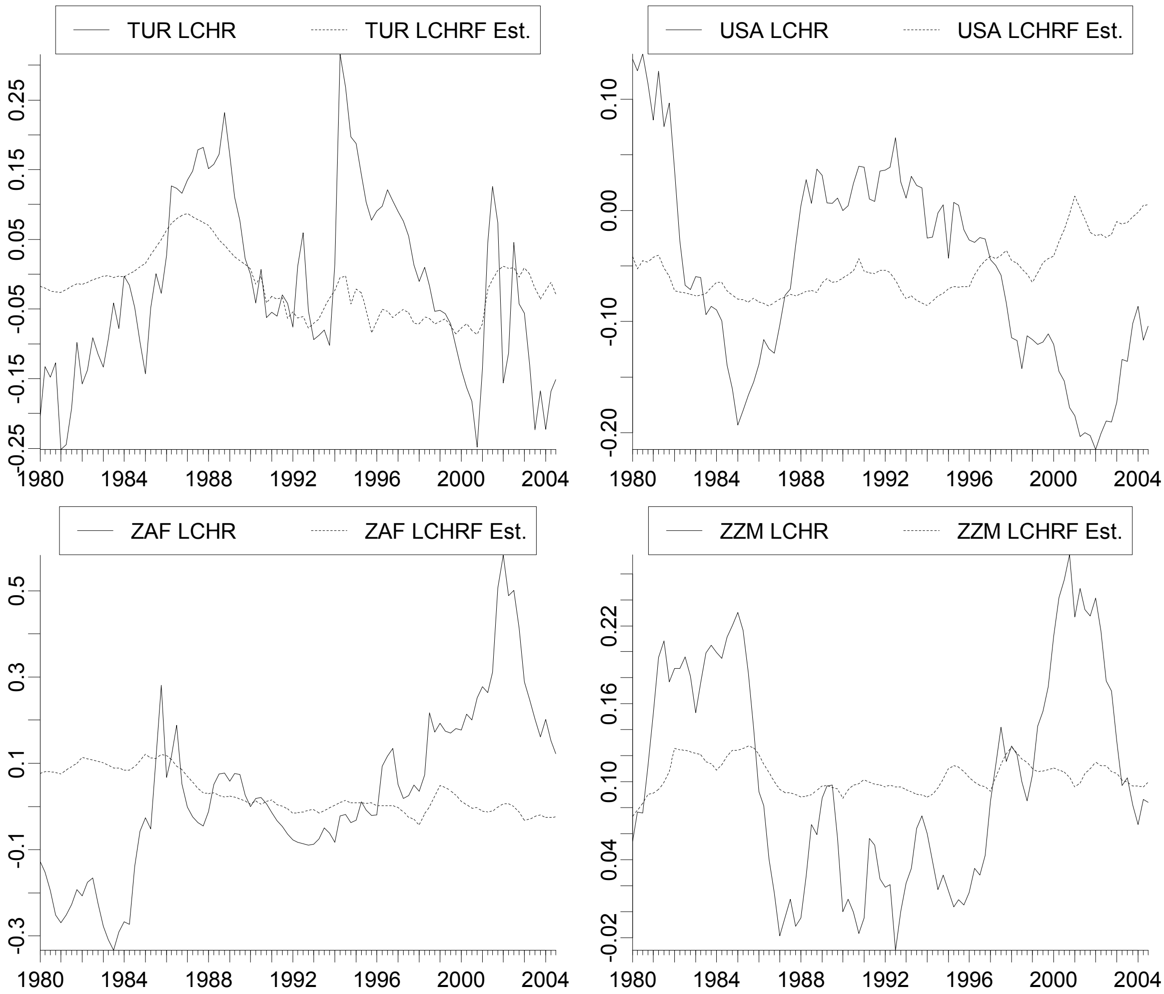

MEX LCHR
MEX YM Est.
ROW LCHR
ROW YM Est.
ZAF LCHR
ZAF YM Est.
ZZM LCHR
ZZM YM Est.
1980
1984
1988
1992
1996
2000
2004

Figures 2. REER, panel estimation (with the RoW)

Plain line: observed real effective exchange rate. Dashed line: equilibrium real effective exchange rate. Both are in logarithms.




IDN LCHR
IDN LCHRF Est.
-0.6 -0.2 0.2 0.6
IND LCHR
IND LCHRF Est.
-0.35 -0.20 -0.05 0.10 0.25
JPN LCHR
JPN LCHRF Est.
-0.4 -0.2 0.0 0.2 0.4
KOR LCHR
KOR LCHRF Est.
0.00 0.10 0.20 0.30 0.40
MEX LCHR
MEX LCHRF Est.
-0.5 -0.3 -0.1 0.1 0.3
ROW LCHR
ROW LCHRF Est.
-0.11 -0.08 -0.05 -0.02 0.00
1980 1984 1988 1992 1996 2000 2004



TUR LCHR
TUR LCHRF Est.
-0.25 -0.15 -0.05 0.05 0.15 0.25
1980 1984 1988 1992 1996 2000 2004
USA LCHR
USA LCHRF Est.
-0.20 -0.10 0.00 0.10
1980 1984 1988 1992 1996 2000 2004
ZAF LCHR
ZAF LCHRF Est.
-0.3 -0.1 0.1 0.3 0.5
1980 1984 1988 1992 1996 2000 2004
ZZM LCHR
ZZM LCHRF Est.
-0.02 0.04 0.10 0.16 0.22
1980 1984 1988 1992 1996 2000 2004

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