CENTRE
D'ÉTUDES PROSPECTIVES
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INTERNATIONALES

No 2008 – 01
March

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CONTENT

NON TECHNICAL SUMMARY 4
ABSTRACT 5
RÉSUMÉ LONG NON TECHNIQUE 6
RÉSUMÉ COURT 7
1. INTRODUCTION 8
2. THE BEER FRAMEWORK: POTENTIAL DETERMINANTS OF THE EXCHANGE RATE 10
3. THE DATA 13
4. TESTS AND ESTIMATIONS OF THE COINTEGRATING RELATIONSHIP 14
5. EQUILIBRIUM EXCHANGE RATES AND CURRENCY MISALIGNMENTS 16
6. TEMPORAL ROBUSTNESS 25
7. CONCLUSION 27
REFERENCES 28
LIST OF WORKING PAPERS RELEASED BY CEPII 35

HOW ROBUST ARE ESTIMATED EQUILIBRIUM EXCHANGE RATES?
A PANEL BEER APPROACH

NON TECHNICAL SUMMARY

Estimating equilibrium exchange rates encounters a series of methodological difficulties. First, a concept of equilibrium exchange rate needs to be selected. On the one hand, the purchasing power parity (PPP) approach, although relevant in the very long run, does not provide any insight of exchange-rate adjustments that would be consistent with world imbalances being unraveled. On the other hand, the medium-run, fundamental equilibrium exchange-rate approach (FEER) of Williamson (1983), may excessively focus on current-account adjustment, underestimating the plasticity of the international monetary system and the existence of alternative adjustment variables. In-between, the behavioral equilibrium exchange-rate approach (BEER) introduced by Faruqee (1995) and Clark and MacDonald (1998) provides a cointegration-based view of equilibrium exchange rates where the impact of external imbalances on exchange rates is estimated directly rather than indirectly in the FEER approach, by inverting the trade-balance equation.

The second question is that of the currencies under scrutiny and the relevant estimation technique. The literature is roughly split in two strands. On the one hand, a number of papers provide individual estimates for emerging or developing countries, mostly based on reduced-form equations, excluding developed economies from the analysis (see e.g. Edwards, 1994). On the other hand, papers investigating exchange rate misalignments in developed economies generally focus on G3 or at most G7 countries. This divide of the literature appears increasingly at odds with the implication of emerging countries in the financing of the US current-account deficit. For this reason, real exchange rate misalignments should not be investigated regardless of large emerging countries. The Group of Twenty (G20), which includes both the largest industrial and emerging economies, may then appear as one relevant grouping when investigating real exchange rate misalignments.

However, including recently open countries in the analysis raises the issue of possible structural breaks, due to the opening-up of financial and goods markets. This is a strong argument in favor of the use of (potential non-stationary) panel econometrics. Indeed, nonstationary panel procedures help by increasing the span of the data — which is generally small when studying exchange rates series — and so raising the power of unit root and cointegration tests. As a matter of fact, panel data analysis has been increasingly used to investigate real exchange rate dynamics, mostly to test the PPP hypothesis. In this paper, we investigate the robustness of the BEER approach to equilibrium exchange rates in a panel cointegration framework, when both industrial and emerging economies are included in the analysis. A special attention is paid to the Balassa-Samuelson effect embodied in the unobservable relative productivity of the tradable and non-tradable sectors. Since the measurement of relative productivity in the tradable versus non-tradable sectors is itself problematic, various proxies are proposed here, based on relative price indices, GDP per capita or the relative productivity per person employed. This allows us to study the impact of the measure retained for relative productivity on real exchange rates misalignments.

Our aim is to assess the robustness of estimated equilibrium exchange rates in a multi-country framework. The robustness is studied in four directions, successively. First, we investigate the impact of using alternative proxies for relative productivity. Second, we analyze the impact of estimating the equilibrium equation on one single panel covering G20 countries, or separately for G7 and non-G7 countries. Third, we measure the influence of the choice of the numeraire on the derivation of bilateral equilibrium rates. Finally, we study the temporal robustness of the estimations by dropping one or two years from the estimation period. Our main conclusion is that BEER estimations are quite robust to these successive tests, although at one point of time misalignments can differ by several percentage points depending on the methodology. The choice of the productivity proxy is the most sensible one, followed by the country sample. In contrast, the choice of the numeraire and the time sample have a relatively limited impact on estimated misalignments.

ABSTRACT

This paper is concerned with the robustness of equilibrium exchange rate estimations based on the BEER approach for a set of both industrial and emerging countries. The robustness is studied in four directions, successively. First, we investigate the impact of using alternative proxies for relative productivity. Second, we analyze the impact of estimating the equilibrium equation on one single panel covering G20 countries, or separately for G7 and non-G7 countries. Third, we measure the influence of the choice of the numeraire on the derivation of bilateral equilibrium rates. Finally, we study the temporal robustness of the estimations by dropping one or two years from the estimation period. Our main conclusion is that BEER estimations are quite robust to these successive tests, although at one point of time misalignments can differ by several percentage points depending on the methodology. The choice of the productivity proxy is the most sensible one, followed by the country sample. In contrast, the choice of the numeraire and the time sample have a relatively limited impact on estimated misalignments.

JEL Classification: F31; C23.

Keywords: equilibrium exchange rates, BEER, productivity, panel cointegration.

LA ROBUSTESSE DES ESTIMATIONS DE TAUX DE CHANGE D'EQUILIBRE :
UNE APPROCHE BEER EN PANEL

RESUME LONG NON TECHNIQUE

L'estimation de taux de change d'équilibre se heurte à un certain nombre de difficultés. En premier lieu, il est nécessaire de choisir un concept de taux de change d'équilibre. D'un côté, l'approche de la parité des pouvoirs d'achat (PPA), bien que pertinente à très long terme, ne donne aucune information quant aux ajustements de taux de change qui seraient nécessaires pour résorber les déséquilibres globaux. D'un autre côté, à moyen terme, l'approche fondamentale du taux de change d'équilibre (FEER) de Williamson (1983) peut sembler trop focalisée sur l'ajustement du compte courant, sous-estimant la plasticité du système monétaire international et l'existence de variables d'ajustement alternatives. Entre ces deux approches figure le taux de change d'équilibre comportemental (BEER) de Faruqee (1995) et Clark et MacDonald (1998), reposant sur les techniques de cointégration. Dans cette approche, l'impact des déséquilibres extérieurs sur les taux de change est estimé directement, et non plus de manière indirecte comme dans le cas de l'approche FEER, au travers de l'inversion de l'équation de balance commerciale.

En second lieu, il convient de choisir l'échantillon de devises à retenir ainsi que la méthode économétrique appropriée. Schématiquement, la littérature peut être divisée en deux courants. D'un côté, divers travaux fournissent des estimations individuelles pour les pays émergents ou en développement, généralement fondées sur des formes réduites, excluant les pays développés de l'analyse (Edwards, 1994). D'un autre côté, les travaux portant sur la détermination des mésalignements dans les pays industrialisés se focalisent généralement sur les pays du G3 ou du G7. Une telle scission de la littérature semble décalée au regard de l'importance des pays émergents dans le financement du déficit courant des Etats-Unis. Pour cette raison, les mésalignements de taux de change ne doivent pas être étudiés sans tenir compte des pays émergents. Le G20, qui inclut les plus grands pays industrialisés et émergents, semble constituer un groupe de pays cohérent pour l'étude des mésalignements de taux de change réels.

Toutefois, l'inclusion de pays émergents dans l'analyse soulève la question de possibles ruptures structurelles, liées à l'ouverture des marchés financiers et des marchés des biens. Cet argument plaide en faveur de l'utilisation des techniques de l'économétrie des données de panel non stationnaires. En effet, les procédures en économétrie des données de panel non stationnaires permettent d'accroître l'échantillon disponible — qui est souvent de taille réduite dans les études sur les taux de change — et ainsi d'augmenter la puissance des tests de racine unitaire et de cointégration. En conséquence, l'économétrie des données de panel est de plus en plus utilisée pour étudier la dynamique des taux de change réels, et notamment pour tester l'hypothèse de PPA. Nous étudions ici la robustesse de l'approche BEER de détermination des taux de change d'équilibre dans un contexte de cointégration en panel, lorsque l'échantillon comprend simultanément des pays développés et des pays émergents. Une attention particulière est accordée à l'effet Balassa-Samuelson, pris en compte au travers de la productivité relative non observable dans les secteurs des biens échangeables et non échangeables. Puisque la mesure de la productivité des biens échangeables par rapport aux biens non échangeables pose elle même problème, diverses

mesures sont utilisées ici, fondées sur les indices de prix relatifs, le PIB par tête et la productivité relative par personne employée. Ceci nous permet d'étudier l'impact de la mesure retenue pour la productivité relative sur les mésalignements de taux de change réels.

Notre objectif est ainsi d'étudier la robustesse des estimations de taux de change d'équilibre fondées sur l'approche BEER pour un ensemble de pays développés et émergents. La robustesse est étudiée selon quatre axes. Nous nous intéressons tout d'abord à l'impact de l'utilisation de différentes mesures de productivité relative. Nous analysons ensuite l'impact de l'échantillon de pays retenu en estimant l'équation d'équilibre sur un seul panel couvrant les pays du G20 et sur deux sous-ensembles correspondant aux pays du G7 d'une part et non G7 de l'autre. Nous mesurons l'influence du choix du numéraire dans le calcul des mésalignements bilatéraux. Enfin, nous étudions la robustesse temporelle de nos estimations en enlevant successivement une ou deux années de la période d'estimation. Nos résultats montrent que les mesures BEER sont relativement robustes à l'ensemble de ces tests, bien que pour certaines dates, les mésalignements diffèrent de plusieurs points de pourcentage selon la méthodologie retenue. Le choix de la mesure de productivité relative est le plus sensible, suivi du choix de l'échantillon d'estimation. A l'inverse, les choix concernant le numéraire et la période d'estimation ont un impact relativement limité sur les mésalignements estimés.

RESUME COURT

Cet article traite de la robustesse des estimations de taux de change d'équilibre fondées sur l'approche BEER pour un ensemble de pays développés et émergents. La robustesse est étudiée selon quatre axes. Nous nous intéressons tout d'abord à l'impact de l'utilisation de différentes mesures de productivité relative. Nous analysons ensuite l'impact de l'échantillon de pays retenu en estimant l'équation d'équilibre sur un seul panel couvrant les pays du G20 et sur deux sous-ensembles correspondant aux pays du G7 d'une part et non G7 de l'autre. Nous mesurons l'influence du choix du numéraire dans le calcul des mésalignements bilatéraux. Enfin, nous étudions la robustesse temporelle de nos résultats en enlevant successivement une ou deux années de la période d'estimation. Nos résultats montrent que les mesures BEER sont relativement robustes à l'ensemble de ces tests, bien que pour certaines dates, les mésalignements diffèrent de plusieurs points de pourcentage selon la méthodologie retenue. Le choix de la mesure de productivité relative est le plus sensible, suivi du choix de l'échantillon d'estimation. A l'inverse, les choix concernant le numéraire et la période d'estimation ont un impact relativement limité sur les mésalignements estimés.

Classification JEL: F31; C23.

Mots clés : taux de change d'équilibre, approche BEER, productivité, cointégration en panel.

HOW ROBUST ARE ESTIMATED EQUILIBRIUM EXCHANGE RATES? A PANEL BEER APPROACH

Agnès Bénassy-Quéré[*], *Sophie Béreau*[**], *Valérie Mignon*[***]

1. INTRODUCTION

Estimating equilibrium exchange rates encounters a series of methodological difficulties.[1] First, a concept of equilibrium exchange rate needs to be selected. On the one hand, the purchasing power parity (PPP) approach, although relevant in the very long run (see Rogoff, 1996), does not provide any insight of exchange-rate adjustments that would be consistent with world imbalances being unraveled. On the other hand, the medium-run, fundamental equilibrium exchange-rate approach (FEER) of Williamson (1983), may excessively focus on current-account adjustment, underestimating the plasticity of the international monetary system and the existence of alternative adjustment variables.[2] In-between, the behavioral equilibrium exchange-rate approach (BEER) introduced by Faruqee (1995) and Clark and MacDonald (1998)[3] provides a cointegration-based view of equilibrium exchange rates where the impact of current-account imbalances on exchange rates is estimated directly rather than indirectly in the FEER approach, by inverting the trade-balance equation.

The second question is that of the currencies under scrutiny and the relevant estimation technique. The literature is roughly split in two strands. On the one hand, a number of papers provide individual estimates for emerging or developing countries, mostly based on reduced-form equations, excluding developed economies from the analysis (see e.g. Edwards, 1994). On the other hand, papers investigating exchange rate misalignments in developed economies generally focus on G3 or at most G7 countries. This divide of the literature appears increasingly at odds with the implication of emerging countries in the financing of the US current-account deficit (see Figure 1).

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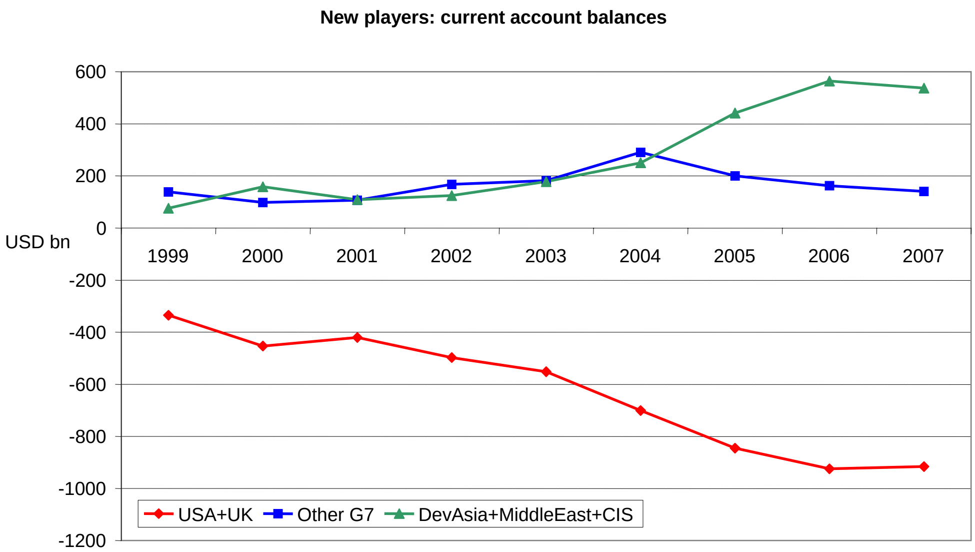
[1] For extensive literature surveys, see MacDonald (1997), Egert (2003), Driver and Westaway (2004) and Egert, Halpern and MacDonald (2006).

[2] See Bénassy-Quéré, Béreau and Mignon (2008a).

[3] See also the recent contribution by MacDonald and Dias (2007).

Figure 1. New players: current account balances.



Source: WEO, forecasts for 2007.

However, including both industrial and developing countries in one single econometric assessment of equilibrium exchange rates encounters specific difficulties. Indeed, recently open economies such as China obviously experimented structural breaks over the past twenty years. Looking forward, emerging countries will likely behave more like industrial economies, which justifies the use of panel econometrics. Specifically, non-stationary panel procedures can be helpful by increasing the span of the data — which is generally small when studying exchange rates series, especially in emerging countries — and so raising the power of unit root and cointegration tests. As highlighted by Shiller and Perron (1985), Perron (1989, 1991) and Pierce and Snell (1995), the span of the period under study is more important than the data frequency for the power of unit root and cointegration tests. When structural breaks affect time series, relying to panel econometrics is an obvious alternative to time series analysis since it allows increasing the span of the data by including information from various countries.

Panel data analysis has been increasingly used to investigate real exchange rate dynamics, mostly to test the PPP hypothesis (see Banerjee (1999) and Baltagi and Kao (2000) for a survey). In this paper, we investigate the robustness of the BEER approach to equilibrium exchange rates in a panel cointegration framework, when both industrial and emerging economies are included in the analysis. A special attention is paid to the Balassa-Samuelson effect embodied in the unobservable relative productivity of the tradable and non-tradable sectors. As stressed by Chinn (1997), since the late 1980's, there has been a renewed interest for productivity growth as a determinant of the real exchange rate dynamics. However, despite the huge literature on this issue, robust evidence in favor of the Balassa-Samuelson effect is weak. The measurement of relative productivity in the tradable versus non-tradable sectors is itself problematic. Four proxies are proposed here, based on relative price indices, GDP per capita or the relative productivity per person employed.

Our contribution is fourfold. First, we investigate the impact of various potential determinants of the real exchange (net foreign asset position, relative productivity, interest-rate differential and terms of trade) for a sample of both industrial and emerging economies. Second, as previously mentioned, we systematically investigate the impact of four different proxies of productivity differentials. Third, we analyze the influence of the choice of the numeraire currency when deriving bilateral equilibrium exchange rates. Finally, we investigate the temporal robustness of our BEER estimations.

The paper is organized as follows. Section 2 briefly presents the potential determinants of exchange rates in a BEER context. Section 3 is devoted to the presentation of the data. Panel unit root and cointegration tests, together with the estimation of cointegration relationships are reported in Section 4. Section 5 derives effective and bilateral misalignments. In Section 6, the temporal robustness of BEER estimations is investigated. Section 7 concludes.

2. THE BEER FRAMEWORK: POTENTIAL DETERMINANTS OF THE EXCHANGE RATE

We rely on the BEER approach introduced by Clark and MacDonald (1998), and on its parsimonious version proposed by Alberola *et al*. (1999, 2002) and Alberola (2003).[4] Defining the real exchange rate q as: $q= e + p^* - p$ where e is the nominal exchange rate, p and p^* are respectively the price level in domestic and foreign currency, all variables being in logarithms, and retaining the set of all potential determinants investigated in our analysis, the equilibrium exchange rate results from the following estimation:

$$q_t = f(nfa_t, relp_t, rtot_t, dr_t) \quad (1)$$

where *nfa* denotes the net foreign asset position (NFA) in percentage of GDP, *relp* a measure of relative productivity in the traded-goods sectors (relative to the non-traded goods one), in logarithm, *rtot* the logarithm of terms of trade and *dr* the real interest-rate differential. The real exchange rate is expected to depreciate (q to rise) if the NFA position falls (because net interest receipts are reduced), if productivity in the traded-goods sector falls relative to the rest of the world (Balassa-Samuelson effect)[5], if terms of trade are reduced (the trade balance declines) or if the foreign real interest rate rises relative to the domestic one.

Equation (1) derives from an uncovered interest parity condition where the expected, real exchange rate depends on *nfa*, *relp* and *rtot*; a risk premium that depends on the NFA position is also consistent with the equation. Alternatively, (1) can be viewed as a stock-

[4] See also Bénassy-Quéré *et al*. (2004, 2008b) and MacDonald and Dias (2007).

[5] An alternative interpretation of the impact of productivity in the tradable sector on the real exchange rate is that a positive productivity shock in tradables leads to a rise in future income, hence on demand for both tradables and non-tradables. Because non-tradables cannot be imported, their relative price rises, which amounts to an exchange-rate appreciation; see, e.g. Schnatz *et al*. (2003).

flow equilibrium where the trade balance must be in line with net interest receipts so that the NFA position stays constant in percentage of GDP.[6]

The parsimonious version of the model drops *rtot* and *dr*, which may be thought irrelevant in a long-run relationship:

$$q_t = f(nfa_t, relp_t) \tag{2}$$

A major issue when estimating (1) or (2) is the relative productivity measure. Denoting π^{T} and π^{NT} the log of productivity in the traded and non-traded goods sectors, respectively, and flagging foreign variables with a star, we have:

$$relp_t = (\pi^T{}_t - \pi^{NT}{}_t) - (\pi^{T*}{}_t - \pi^{NT*}{}_t) \tag{3}$$

In the origninal Balassa-Samuelson model, π refers to total factor productivity, which cannot be measured directly and is difficult to estimate.[7] In this paper, four alternative proxies of relative productivity are used: two indirect measures based on relative price indices[8], a labor productivity measure and a measure based on the GDP per capita.

- *CPI-to-PPI ratio*: we first follow Alberola *et al*. (1999, 2002) in proxying relative productivity in the traded-goods sector by the consumer-price-to-producer-price ratio. The idea is that, unlike the consumer price index (CPI), the producer price index (PPI) only covers tradable goods.[9] Denoting α the share of tradables in the economy, we have:

$$\ln\left(\frac{CPI}{PPI}\right) = \left[(1-\alpha)\left(p^{NT}\right) + \alpha p^{T}\right] - p^{T} = (1-\alpha)\left(p^{NT} - p^{T}\right) \tag{4}$$

The perfect competition equilibrium implies the equality between prices and marginal costs. Assuming the unit cost of labor and of capital to be equal across sectors, this implies $(p^{\mathrm{NT}} - p^{\mathrm{T}}) = (\pi^{\mathrm{T}} - \pi^{\mathrm{NT}})$. We then use the relative CPI-to-PPI ratio:

$$\ln\left(\frac{CPI}{PPI}\right) - \ln\left(\frac{CPI^*}{PPI^*}\right) = (1-\alpha)\left[\left(\pi^{T} - \pi^{NT}\right) - \left(\pi^{T*} - \pi^{NT*}\right)\right] \tag{5}$$

[6] See Iimi (2006) among others. MacDonald (1998b) provides a survey of the literature relating to the relationship between the real exchange rate and the interest rate differential.
[7] See, among others, Canzoneri *et al*. (1999) and Schnatz *et al*. (2003) for a review of the drawbacks related to the use of the total factor productivity (TFP). However, De Gregorio *et al*. (1993, 1994) and Chinn and Johnston (1996) do use TFP since it allows them to study the relative importance of supply shocks — proxied by TFP — and demand shocks (see also Strauss, 1995).
[8] Such a measure has been widely used in the empirical literature as a proxy for relative sectoral productivity (see Alberola *et al*. (1999) among others).
[9] PPI covers only agricultural and industrial prices for the first commercial transaction (see IMF *International Financial Statistics*).

In the estimation of Equation (1) or (2), the coefficient on this proxy of *relp* is expected to be –1.[10] However, the CPI/PPI ratio can be affected by factors unrelated to the Balassa-Samuelson effect, e.g. relative demand effects, tax changes, or the nominal exchange rate itself.[11]

- *Services versus agriculture and industry deflators*: here we assimilate the non-tradable sector to services, whereas the tradable sector is assumed to cover both agriculture and industry. This allows us to proxy *relp* based on the corresponding deflators. Denoting p^{serv}, p^{agr}, and p^{ind} the three deflators (in logarithm), we have:

$$relp = \left[p^{serv} - \left(\beta p^{agr} + (1-\beta)\, p^{ind}\right)\right] - \left[p^{serv*} - \left(\beta^{*} p^{agr*} + (1-\beta^{*})\, p^{ind*}\right)\right] \qquad (6)$$

where β represents the share of agriculture in tradables (β* in the foreign country). As for the CPI-to-PPI ratio, we expect a negative sign for this variable.[12]

- *Labor productivity*: output per unit of labor, based on the number of persons employed, is frequently retained for studying the Balassa-Samuelson effect empirically (see Hsieh (1982), Marston (1987) and Canzoneri *et al*. (1999), Schnatz *et al*. (2003) for instance).[13] The expected sign on labor productivity is again negative, meaning that an increase in productivity is expected to come along with to a real appreciation of the currency. One problem however is that productivity growth may arise in the non-tradable sector rather than in the tradable one. In this case, the coefficient on labor productivity may be mitigated or its sign may even be reversed (see Schnatz *et al*., 2003). Considering Asian-Pacific countries, Chinn (1997) concludes that relative prices lead to more reliable results than relative productivity measures (except for a small subset of countries).

- *GDP per capita*: this last measure of productivity is less precise than the previous one but more widely available, especially for emerging countries. It however encounters the same difficulty as labor productivity since the origin of productivity growth (whether the tradable or the non-tradable sector) is not defined.

[10] See MacDonald (1997). This unit elasticity does not hold if the link between productivity and the real exchange rate is not interpreted as a Balassa-Samuelson effect but rather as a relative demand effect for tradables and non-tradables. See Schnatz *et al*. (2003), Chinn (2005, 2006).
[11] See Engel (1995) for a list of the main drawbacks linked to the use of the CPI-to-PPI ratio. Chinn (2005) also mentions that CPI is an imperfect measure of non-tradable prices.
[12] For a detailed study with various measures of non-tradable goods prices, see Engel (1995).
[13] Retaining this measure of productivity means that both supply and demand shocks affect real exchange rates.

3. THE DATA

As mentioned in the introduction, we want to cover both industrial and emerging countries. Here we concentrate on 15 countries or areas belonging to the Group of the Twenty (G20), a country grouping created in 1999 to tackle financial stability issues that has sometimes been viewed as a possible substitute for the G7 on international monetary issues.[14] More specifically, our sample includes 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 Area (ZZM).

As previously mentioned, the dependent variable is the real effective exchange rate *(q)* and the explanatory variables are (*i*) the stock of net foreign assets *(nfa)*; (*ii*) several measures of productivity differentials, $relp^x$: the relative CPI-to-PPI ratio *(x=cpi/ppi)*, the ratio of prices in services to prices in agricultural and industrial sectors (x=*serv/agrind*), the relative GDP per capita *(x=gdpcap)*, the relative GDP per person employed *(x=lprod)*; (*iii*) the relative terms of trade *(rtot)* and (*iv*) the interest rate differential *(dr)*. All those series are in logarithms except *nfa* which is expressed as share of GDP in percentage points. Data are annual and cover the period from 1980 to 2005.

The real effective exchange rate for each country is calculated as a weighted average of real bilateral exchange rates against each partner. Bilateral real exchange rates are derived from nominal rates and consumer price indices (CPI); they are based in 2000.[15] The weights have been calculated as the share of each partner in imports and exports of goods and services in 2005.[16] Intra-Eurozone flows have been excluded and trade weights have been normalized to sum to one across the partners included in the sample.

This can be written as follows:

$$Q_{i,t} = \frac{E_{i,t}}{\prod_{j \neq i} E_{j,t}^{w_{ij}}} \quad \text{where } w_{ij} = \frac{(X+M)_{ij}}{(X+M)_i} \quad \text{and} \quad \sum_{j \neq i} w_{ij} = 1 \tag{7}$$

where $Q_{i,t}$ is the real effective exchange rate of country *i* expressed in terms of currency *i* per unit of USD (an increase in the exchange rate corresponds to a real depreciation of currency *i*). $E_{i,t}$ denotes the real bilateral exchange rate of currency *i* vis-à-vis the USD and $E_{j,t}$ is the real bilateral exchange rate of currency *i* against the different trade partners *j*. w_{ij} are the trade weights, X_i and M_i being respectively the exports and the imports of country *i*.

Denoting the variables in logarithms in lower cases and log-linearising (7), we obtain:

$$q_{i,t} = \sum_{j \neq i} w_{ij}\left(e_{i,t} - e_{j,t}\right) = \sum_{j \neq i} w_{ij} e_{ij,t} \tag{8}$$

[14] See, e.g., O'Neill and Hormats (2004).
[15] Source: World Bank *World Development Indicators (WDI)* for nominal exchange rates and CPI data except for the EUR/USD exchange rate which was extracted from *Datastream* and China's real exchange rate which was calculated with GDP deflator *(WDI).*
[16] Source: IMF Direction of Trade Statistics *(DOTS).*

The net foreign asset position is built using the Lane and Milesi-Ferretti database from 1980 to 2004.[17] The 2005 data is calculated by adding the current account position to the 2004 NFA value.[18] Regarding the different measures of productivity differentials, we first calculate the CPI-to-PPI ratio with data based in 2000 and extracted from *WDI* and *IFS* (IMF *International Financial Statistics*) databases. The second proxy we consider is the ratio of prices in services to the weighted average of prices in agricultural and industrial sectors. Data are based on nominal and real added-values in the three sectors and are taken from *WDI*. Finally, we also use GDP per capita in PPP and GDP per person employed which were extracted respectively from *WDI* and Groningen online databases. For each proxy *x*, we take as *relp* the difference between the country considered and the weighted average of its partners:

$$relp_{i,t}^{x} = x_{i,t} - \sum_{j \neq i} w_{ij} x_{j,t} \qquad \text{with } x = cpi/ppi,\ serv/agrind,\ gdpcap,\ lprod \tag{9}$$

The same calculation is carried out for relative terms of trade $rtot_{i,t}$ which is the difference between the logarithm of the terms of trade in the considered country, $tot_{i,t}$ and its average value for trade partners:

$$rtot_{i,t} = tot_{i,t} - \sum_{j \neq i} w_{ij} tot_{j,t} \tag{10}$$

In the same way, the interest rate differential is calculated as follows:

$$dr_{i,t} = r_{i,t} - \sum_{j \neq i} w_{ij} r_{j,t} \tag{11}$$

where $r_{i,t}$ and $r_{j,t}$ refer to the real interest rates of the countries *i* and *j*, respectively.[19]

4. TESTS AND ESTIMATIONS OF THE COINTEGRATING RELATIONSHIP

4.1. Panel unit root and cointegration tests

Since Equation (1) is a long-term relationship, the following condition is required in order to derive reliable estimates: if the variables are characterized by a unit root, they have to be cointegrated. Consequently, the first step is to test for the presence of a unit root in the different variables. Table 1 in the Appendix reports the results of five panel unit root tests. Levin and Lin (1992, 1993)[20], Breitung (2000) and Hadri (2000) tests are based on a common unit root process. The first two tests (Levin-Lin and Breitung) consider the unit root as the null hypothesis, 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, we also consider two other tests. The IPS (Im, Pesaran and Shin, 2003) test allows for

[17] Source: http://www.imf.org/external/pubs/cat/longres.cfm?sk=18942.0

[18] Source: IMF *International Financial Statistics (IFS),* March 2007. Unfortunately, valuation effects cannot be included in the 2005 figure because the composition of gross assets and liabilities is not available.

[19] All data are taken from *WDI*, except the values for Germany (included in data for the Euro Area) before 1999 which were extracted from the European Central Bank database.

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

heterogeneity in the value of the autoregressive coefficient under the alternative hypothesis. Thus, under the alternative hypothesis, some series may be characterized by a unit root, while some other series can be stationary. Like IPS, 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.

At the 1% significance level, the real effective exchange rate can be considered as a unit root process, which is a common finding. Concerning the explanatory variables, the net foreign asset position and the two proxies of relative productivity based on price indices are characterized by the presence of a unit root. Considering now the two other productivity proxies, they can be considered as integrated of order 1 since only the LL test rejects the null of a unit root. This departing result with the LL test may be related to its restrictive assumption of homogeneity. Turning to relative terms of trade, results are somewhat mitigated since the conclusions frequently depend upon the considered test. Indeed, this series is non stationary according to Breitung, IPS and Hadri tests at the 1% significance level, while the null hypothesis of a unit root is rejected with LL and MW tests. Finally, the null hypothesis of a unit root is rejected according to four tests for the real interest rate differential series.

Overall, our results suggest that the interest-rate differential series is integrated of order 0, while the other series can be considered as I(1). As a consequence, we do not include the interest rate differential in our long-term relationships.[21] As a consequence, two models are successively estimated:

- A benchmark model: $q_t = f(nfa_t, relp^x_t)$
- An extended model, including terms of trade : $q_t = f(nfa_t, relp^x_t, rtot_t)$

with x = *cpi/ppi*, *serv/agrind*, *gdpcap* and *lprod*, corresponding to a total of eight models.

We now proceed to panel cointegration tests. We consider here the seven tests proposed by Pedroni (1999, 2004). These tests are based on the null hypothesis of no cointegration. Some heterogeneity is introduced under the alternative hypothesis since there exists a cointegration relationship for each country, and this relationship is not necessarily the same for each country. Among the 7 Pedroni's tests, 4 are based on the within dimension (panel cointegration tests) and 3 on the between dimension (group mean panel cointegration tests). Group mean panel cointegration statistics are more general in the sense that they allow for heterogeneous coefficients under the alternative hypothesis. Overall, if the null hypothesis of no cointegration is rejected, then it is possible to estimate the cointegration relationships.

[21] It should be noted that this result is consistent with the conclusions generally obtained in the literature, suggesting that real exchange rate movements are unrelated to real interest rate differentials on the long run (see, for instance, Campbell and Clarida (1987), Meese and Rogoff (1988), Baxter (1994) and MacDonald (1998b) for a survey). One main exception is MacDonald and Nagayasu (2000): using a panel data set for 14 industrialized countries, they show that a significant cointegrating relationship exists between real exchange rates and real interest rate differentials.

Table 2 in the Appendix displays the results of Pedroni's tests. As it is frequently the case[22], the results issued from Pedroni's tests are mixed. At least one test rejects the null hypothesis of no-cointegration for five of the considered models. In the following, we concentrate on these five models which generally include terms of trade in the cointegration relationship:

- Benchmark model: $q=f(nfa,relp^x)$ with $x = cpi/ppi$
- Extended model: $q=f(nfa,relp^x,rtot)$ with $x = cpi/ppi$, *serv/agrind*, *gdpcap*, *lprod*

4.2. Estimations of cointegrating relationships

It is now possible to estimate the panel cointegration vectors. 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.

Table 3 in the Appendix reports the DOLS estimations of the cointegrating vectors. All the coefficients have the negative expected signs. A 1 percent-of-GDP rise in the NFA position leads to a real appreciation of 0.28 to 0.47%, depending on the model. The coefficients on price indices-based relative productivity proxies are close to -1, as expected.

5. EQUILIBRIUM EXCHANGE RATES AND CURRENCY MISALIGNMENTS

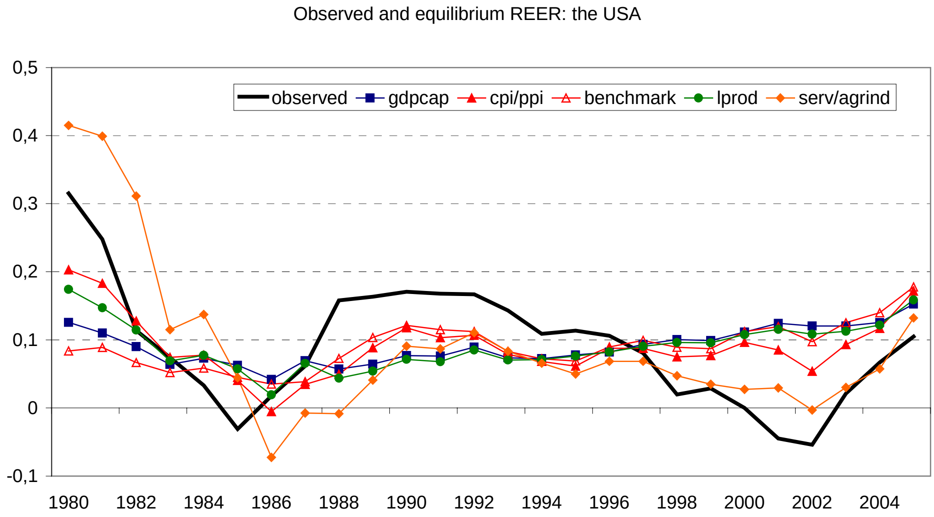
5.1. Equilibrium exchange rates

As already mentioned, the BEER approach considers the forecast of the cointegration relationship as a measure of the real equilibrium exchange rate. Figures 2a to 2d report the evolution of observed and equilibrium effective exchange rates issued from our five considered models for the four countries that are at the center of the debates on world imbalances: the United States, the Euro area, Japan and China. The various measures of equilibrium exchange rates generally move closely together over time, delivering consistent messages concerning exchange-rate misalignments. For instance, the US dollar is found undervalued between 1987 and 1996 and overvalued from 1998 to 2005; the Euro is shown to be overvalued between 1987 and 1996, undervalued between 1999 and 2002 and overvalued between 2003 and 2005; the yuan appears undervalued between 1990 and 2005. Finally, the yen appears overvalued around 1994 and again around 2000, but undervalued in the most recent period. Only the BEER based on the *serv/agrind* measure of productivity delivers substantially different diagnoses on equilibrium rates. For other measures, all

[22] See Bénassy-Quéré *et al*. (2004, 2006, 2008b) for instance.

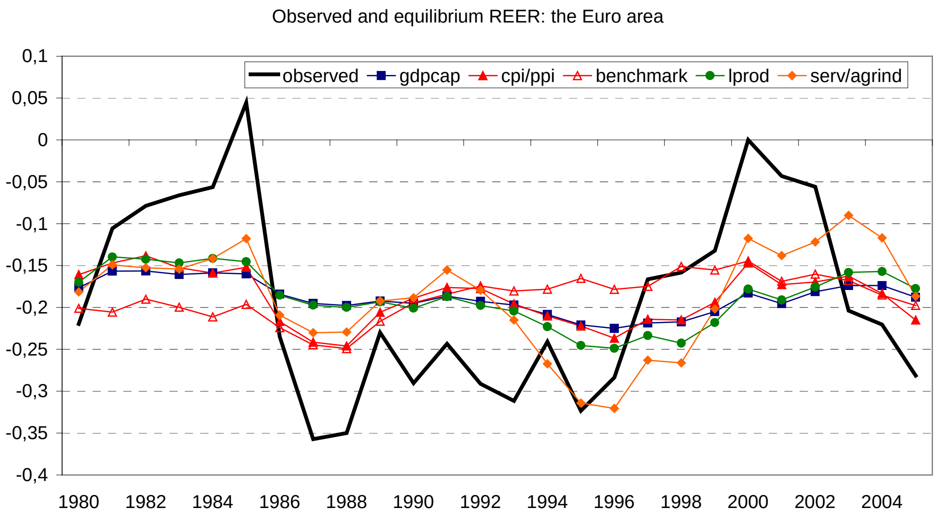
BEER point in the same direction. They depreciate after 1986 in the United States, appreciate in Japan and China and do not present any trend in the Euro area.

Figure 2a. Observed and equilibrium real effective exchange rates, USA



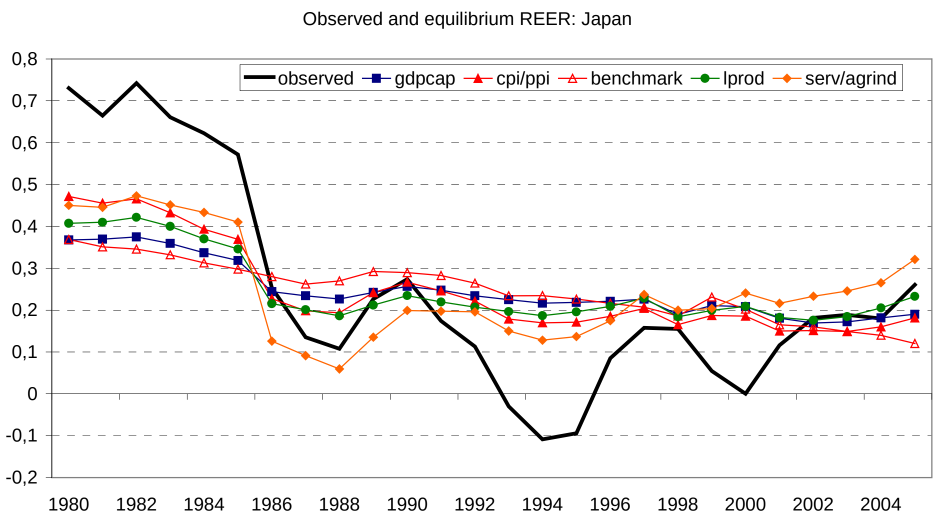
Source: Authors' calculations.

Figure 2b. Observed and equilibrium real effective exchange rates, Euro area



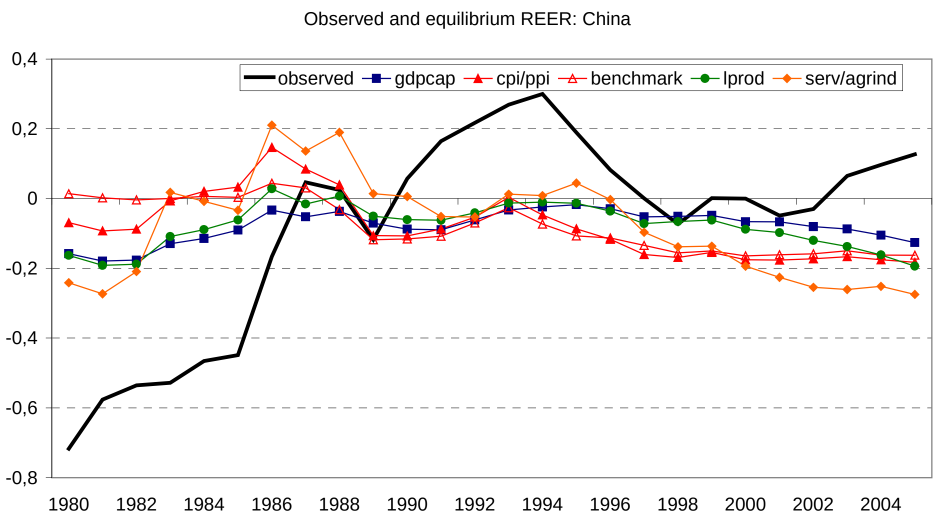
Source: Authors' calculations.

Figure 2c. Observed and equilibrium real effective exchange rates, Japan



Source: Authors' calculations.

Figure 2d. Observed and equilibrium real effective exchange rates, China



Source: Authors' calculations.

5.2. Effective misalignments in 2005

Table 1 reports the effective misalignments for 2005 for each BEER model. The four countries represented in Figure 1 are indicated in bolded characters. For the USD and the Euro, the diagnosis on misalignments is rather homogenous across the five models, with a 3 to 7% over-valuation for the USD and a 7 to 10% over-valuation for the Euro. For the yuan, all five models point to a large under-valuation, but the range is rather large: from 25 to 40%, which reflects the various estimations available in the literature. Finally, for the yen, one model (based on the *serv/agrind* measure of productivity) points to an over-valuation in 2005 whereas the other four conclude that the yen is undervalued by 3 to 14%. The same qualitative divergence is found for India, which confirms the fragility of the *serv/agrind* model.

Table 1. Effective misalignments in 2005 (in %)

Model	Benchmark	Extended			
Productivity measure	cpi/ppi	cpi/ppi	serv/agrind	gdpcap	lprod
ARG	47.9	63.5	40.0	43.6	49.4
AUS	-17.0	-4.3	-2.2	-7.9	-3.6
BRA	-15.7	-29.2	-15.8	2.2	-5.2
CAN	2.0	8.4	11.4	6.4	9.0
CHN	**28.9**	**31.0**	**40.2**	**25.3**	**32.1**
ZZM	**-8.4**	**-6.7**	**-9.5**	**-9.4**	**-10.4**
GBR	-19.2	-15.9	-15.9	-13.0	-11.4
IDN	8.1	13.1	43.1	41.8	45.1
IND	19.8	9.7	-14.5	14.1	11.6
JPN	**14.0**	**7.9**	**-6.1**	**7.1**	**2.8**
KOR	1.0	-12.4	-22.1	-11.6	-16.2
MEX	-10.8	-15.8	-17.3	-14.0	-18.0
TUR	-1.8	-1.6	-24.3	-30.5	-30.3
USA	**-7.3**	**-6.7**	**-2.8**	**-4.8**	**-5.4**
ZAF	3.4	3.6	21.8	15.4	14.4

Note: a negative (resp. positive) sign denotes an overvaluation (resp. undervaluation).

For all other countries, the misalignments reported in Table 1 are of the same sign across the different models, although in some cases (Brazil, Indonesia, Korea, Turkey), the amount of misalignment varies substantially across the models.

5.3 Robustness checks

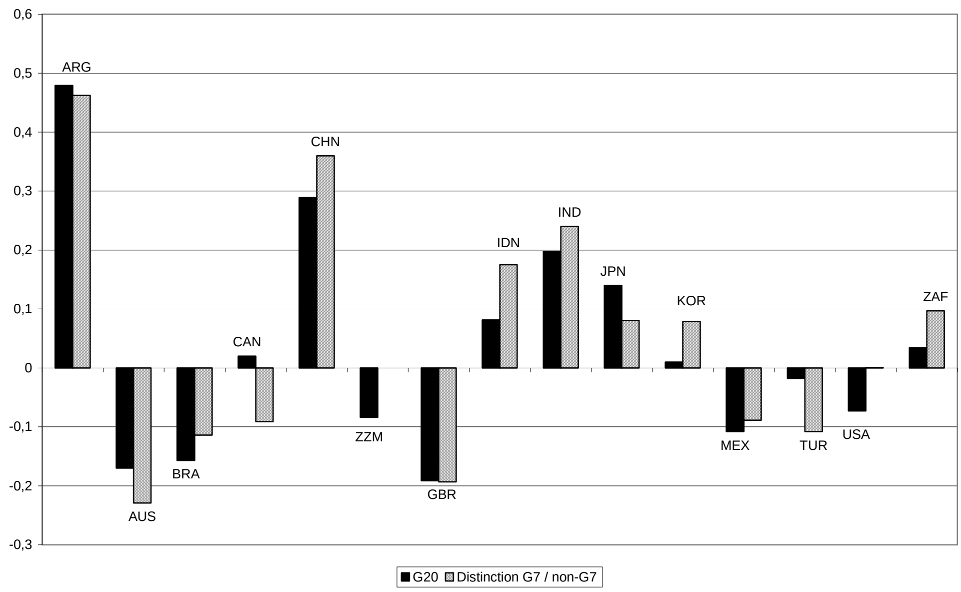
As previously mentioned and highlighted by Schnatz *et al*. (2003) among others, it is difficult to determine *a priori* the impact of a rise in productivity on real exchange rates, if the proxy for productivity does not correctly focus on the tradable sector.[23] One implication is that relative productivity may impact differently on real exchange rates in emerging countries compared to advanced economies. The same problem arises with the NFA position, since the evolution of NFAs observed in emerging countries over the sample

[23] For a brief survey, see also Chinn and Johsnton (1996).

period may reflect adjustment towards equilibrium levels, after the financial account has been liberalized.

As a robustness check, we re-estimate effective misalignments by dividing our sample in two more homogenous groups: a group of countries belonging to the G7 (Canada, United Kingdom, Japan, USA, and the Euro area), and a group composed by the remaining countries. To illustrate the results, Figure 3 reports the effective misalignments in 2005 for the whole sample and the two sub-samples (G7 and non-G7 countries), for the benchmark model with the *cpi/ppi* measure of productivity.[24] With some exceptions, the misalignments appear globally similar across three different samples. Interestingly, East-Asian currencies (except the yen) appear more undervalued in 2005 when the sample is split between G7 and non-G7 countries. Conversely, the US dollar and the yen appear less misaligned in this case.

Figure 3. Effective misalignments in 2005 with G7/non-G7 estimations in % (benchmark model).



Note : a negative (resp. positive) sign denotes an overvaluation (resp. undervaluation).

Figures 4 and 5 further represent the dynamics of the misalignment derived from the benchmark model based either on the whole sample or on differentiated G7 and non-G7 samples, for two currencies: the yuan and the Euro. The dynamics are very close whatever the considered sample, although at some specific points the amount of the Euro misalignment may differ depending on the sample used.

[24] To avoid too many figures and tables, robustness checks results are presented only for the benchmark model with the *cpi/ppi* measure of productivity. The complete results for the four other models are disposable upon request to the authors.

Figure 4. Effective misalignments with G7/non-G7 estimations: China (benchmark model).

Figure 5. Effective misalignments with G7/non-G7 estimations: Euro area (benchmark model).

5.4. Bilateral misalignments

When moving from effective to bilateral equilibrium exchange rates, an additional difficulty arises: the Nth currency problem. Indeed, only *N*-1 bilateral exchange rates can be derived from a set of *N* effective rates. This problem has been well identified in the literature and tackled in different ways.[25] The simplest one is to drop one equilibrium exchange rate and use the *N*-1 other rates to derive bilateral rates against the dropped currency that is used as the numeraire. Here we study the robustness of bilateral misalignment estimates by measuring the sensitiveness of the results to the choice of the numeraire.

Denoting q_i the real effective exchange rate of country *i*, e_i the log of the bilateral exchange rate of country *i* against the numeraire currency, and w_{ij} the share of the country *j* in the trade of the country *i*, we have:

$$q_i = \sum_j w_{ij}(e_i - e_j) \qquad \text{with } \sum_j w_{ij} = 1 \tag{12}$$

Let *Q* be the vector of the *N* equilibrium effective real exchange rates previously estimated, and let *E* be the vector of the *N* corresponding bilateral real exchange rates against the numeraire, with N = 15. It is possible to express *Q*, with the numeraire currency being the last element, as a function of *E* as follows:

$$Q = (I - W)E \tag{13}$$

where W is the (N×N) trade matrix, and I is the identity matrix of order N.

Since (I-W) contains only (N-1)×(N-1) independent elements, it must be singular. As a consequence, only (N-1) bilateral equilibrium exchange rates may be deduced from the N effective equilibrium exchange rates. In order to circumvent this problem, we have to eliminate the redundant multilateral exchange rate. To this end, the row and the column corresponding to the numeraire currency are discarded, and the remaining (N-1) multilateral exchange rates are expressed relative to the numeraire.[26]

We can write :

$$Q^* = (I - W)^* E^* \tag{14}$$

where the asterisk indicates that the numeraire currency has been deleted. The vector of real bilateral equilibrium exchange rates, denoted as E*, is thus given by:

$$E^* = (I - W)^{*-1} Q^* \tag{15}$$

[25] See Isard and Faruqee (1998) and *Carton et al.* (2007), for a review.
[26] See Alberola *et al*. (1999) and Bénassy-Quéré *et al*. (2004, 2006, 2008b) for further details.

Equation (15) allows us to compute the matrix of the bilateral exchange rates for the whole period. Corresponding bilateral misalignments, when using the USD as the numeraire, are given in Table 2 for 2005.

Table 2. Bilateral misalignments against the USD in 2005 (in %).

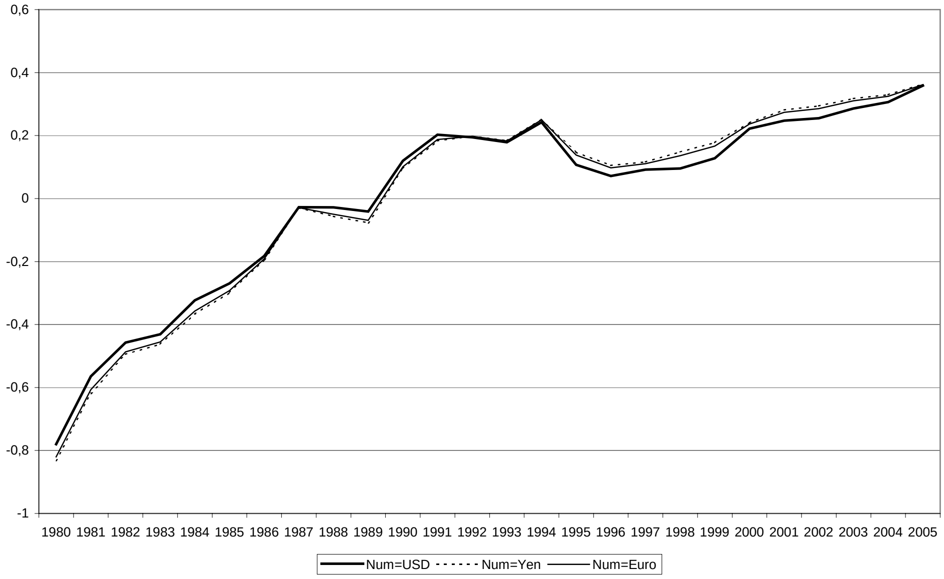
	Benchmark	Extended model			
Productivity	Cpi/ppi	Cpi/ppi	lprod	gdpcap	Serv/agrind
ARG	49.7	60.3	36.5	52.0	52.7
AUS	-4.0	5.8	1.7	4.2	5.5
BRA	-5.9	-18.8	-12.3	8.6	2.7
CAN	3.9	9.8	11.4	11.7	10.0
CHN	35.8	34.7	36.2	38.1	34.0
ZZM	-5.9	-4.7	-12.6	-8.4	-9.2
GBR	-19.6	-16.0	-22.4	-17.2	-14.8
IDN	21.7	23.2	44.4	56.2	52.5
IND	25.0	14.7	-12.9	21.2	16.2
JPN	24.5	17.4	1.5	20.3	12.4
KOR	15.6	0.9	-12.9	5.2	-3.7
MEX	-8.0	-13.5	-16.5	-12.3	-16.0
TUR	-3.0	-2.6	-31.7	-34.7	-33.8
ZAF	6.8	6.5	18.0	18.8	15.5

Note: a negative (resp. positive) sign denotes an overvaluation (resp. undervaluation) against the US dollar which is used as the numeraire.

The problem in using the dollar as the numeraire is that it amounts to dropping the information on the USD effective misalignment, which happens to be non-zero in 2005 (see Table 1). To check the robustness of our bilateral estimates, we have calculated additional sets of equilibrium bilateral rates using different numeraires. For the sake of comparability, these calculated rates are ultimately converted into bilateral rates against the US dollar. As an illustration, Figures 6 and 7 respectively report the results issued from our benchmark model for the yuan and the Euro, using three different numeraires: the USD, the Euro and the yen. The misalignments are found very close, whatever the numeraire used, and this is also the case for the other currencies of the sample.[27] The robustness of the results may be related to our specification where each variable is expressed relative to the other countries of the sample.

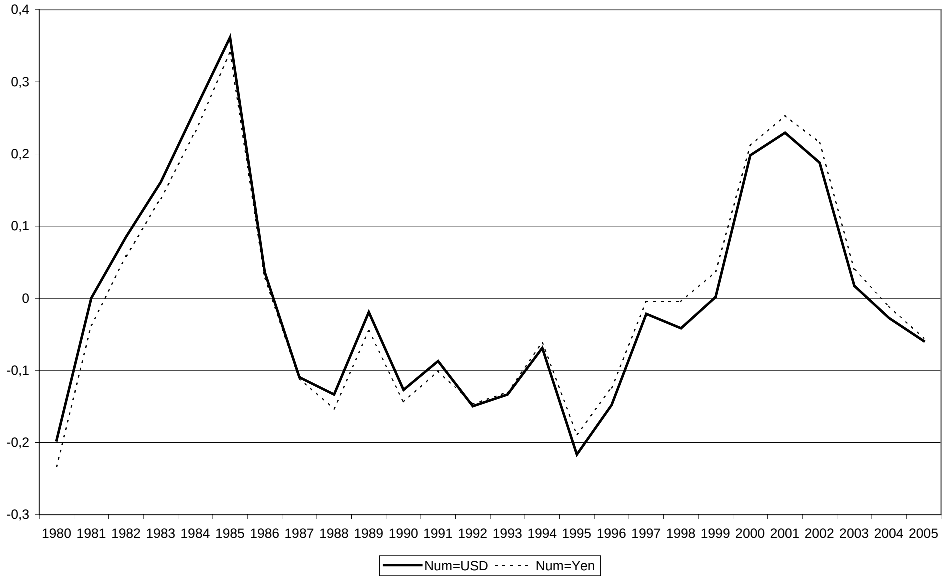
[27] To avoid too many tables and figures, detailed results are not reported here, but are available upon request to the authors.

Figure 6. Yuan misalignments vis-à-vis the USD, with different numeraires (benchmark model).



Source: author's calculations.

Figure 7. Euro misalignments vis-à-vis the USD, with different numeraires (benchmark model).



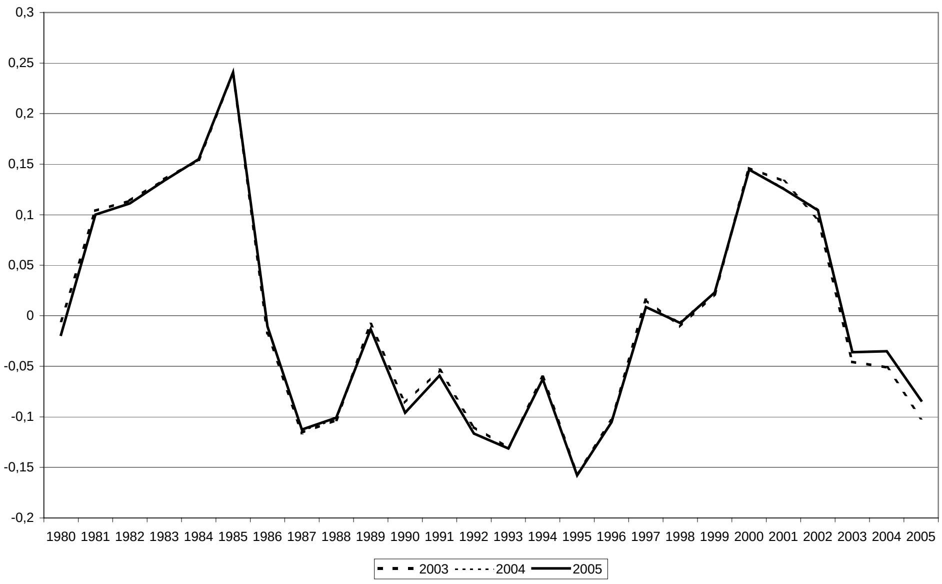
Source: author's calculations.

6. TEMPORAL ROBUSTNESS

Another concern when calculating equilibrium exchange rates is that these target rates may in fact closely follow observed rates, which would depart from the notion of long-run equilibrium. This is especially the case in the FEER methodology where the lack of current-account adjustment pushes forward the needed exchange-rate adjustment (see Bénassy-Quéré *et al.*, 2008a). Here we investigate the stability of BEER estimates by estimating the panel cointegration relationship successively on the whole sample and on sub-samples that ignore the last observations. This allows us to (*i*) apprehend the stability of the BEER equation, and (*ii*) investigate the influence on the last observations on the estimated misalignments.

Figures 8 and 9 report the effective misalignments of the Euro and USD (benchmark model) on the whole period and when one or two years are dropped.[28] More specifically, three samples are considered: 1980-2003, 1980-2004, and the whole 1980-2005 period. Considering the global path of the misalignments, this figure illustrates that effective misalignments are quite similar: the influence of the last points on the global time path is very limited. In other words, our cointegrating relationships are quite robust to the considered sample.

Figure 8. Euro effective misalignments. Temporal robustness (benchmark model).



Source: author's calculations.

[28] The results for the other models and other currencies are available upon request to the authors.

Figure 9. USD effective misalignments. Temporal robustness (benchmark model)

Source: author's calculations.

When focusing on the end of the sample (Table 3), some differences however show up. For instance, the USD appears less overvalued (by up to 5%) when the last years are dropped from the estimation period, which can be related to the increase in world imbalances in 2004 and 2005. The estimates for the Euro are more stable. On the whole, our estimations and misalignments seem to be relatively robust from a temporal viewpoint.

Table 3. Effective misalignments of the Euro and the USD since 2000, based on different estimation periods (benchmark model)

	Euro			*USD*		
	2003	2004	2005	2003	2004	2005
2000	14.6	14.6	14.5	-13.9	-11.2	-11.2
2001	13.3	12.6	12.6	-21.4	-16.3	-16.4
2002	9.6	10.5	10.4	-20.9	-15.1	-15.2
2003	-4.5	-3.5	-3.6	-14.8	-10.3	-10.4
2004	-5.1	-3.5	-3.5	-11.4	-7.2	-7.3
2005	-10.1	-8.4	-8.4	-12.2	-7.1	-7.3

In columns: 2003: estimation on the 1980-2003 period, 2004: estimation on the 1980-2004 period, 2005: estimation on the whole period. Source: author's calculations.

7. CONCLUSION

This paper is concerned with the robustness of equilibrium exchange rate estimations based on the BEER approach initiated by Faruqee (1995), MacDonald (1998a) and Clark and MacDonald (1998). The robustness is studied in four directions, successively. First, we study the impact of using alternative proxies for relative productivity. Second, we analyze the impact of estimating the equation on one single panel covering G20 countries, or separately for G7 and non-G7 countries. Third, we measure the influence of the choice of the numeraire on the derivation of bilateral equilibrium rates. Finally, we study the temporal robustness of the estimations by dropping one or two years from the estimation period.

Our main conclusion is that BEER estimations are quite robust to these successive tests, although at one point of time misalignments can differ by several percentage points depending on the methodology. The choice of the productivity proxy is the most sensible one, followed by the country sample. In contrast, the choice of the numeraire and the time sample have a relatively limited impact on estimated misalignments.

REFERENCES

Alberola, E. (2003), "Misalignment, liabilities dollarization and exchange rate adjustment in Latin America", *Banco de España documento de trabajo* n° 0309.

Alberola, E., Cervero, S.G., Lopez, H. and A. Ubide (1999), "Global equilibrium exchange rates: Euro, Dollar, 'ins', 'outs' and other major currencies in a panel cointegration framework", *IMF Working Paper* 99/175.

Alberola, E., Cervero, S.G., Lopez, H. and A. Ubide (2002), "Quo vadis euro?", *European Journal of Finance* 8 (4), December.

Baltagi, B.H. and C. Kao (2000), "Nonstationary panels, cointegration in panels and dynamic panels: a Survey", *Advances in Econometrics*, 15, Elsevier Science, 7-51.

Banerjee, A. (1999), "Panel data unit root and cointegration: an overview", *Oxford Bulletin of Economics and Statistics*, Special Issue, 607-629.

Baxter, M. (1994), "Real exchange rates and real interest differentials: have we missed the business-cycle relationship?", *Journal of Monetary Economics*, 33, 5-37.

Bénassy-Quéré, A., Béreau, S. and V. Mignon (2008a), "Equilibrium exchange rates: a guidebook for the Euro-Dollar rate", *CEPII Working paper*, forthcoming.

Bénassy-Quéré, A., Duran-Vigneron, P., Lahrèche-Révil, A. and V. Mignon (2004), "Burden sharing and exchange-rate misalignments within the group of Twenty", *in* Bergsten, F. and J. Williamson, eds., *Dollar Adjustment: How Far? Against What?*, pp. 69-94, Institute of International Economics Special Report 17.

Bénassy-Quéré, A., Lahrèche-Révil, A. and V. Mignon (2006), "World-consistent equilibrium exchange rates", *CEPII Working Paper* 2006-20, December.

Bénassy-Quéré, A., Lahrèche-Révil, A. and V. Mignon (2008b), "Is Asia responsible for exchange-rates misalignment within the G20?", *Pacific Economic Review*, 13(1), 46-61.

Breitung, J. (2000), "The local power of some unit root tests for panel data", in B. Baltagi (ed.), *Advances in Econometrics*, Vol. 15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels, Amsterdam: JAI Press, 161-178.

Campbell, J.Y. and R.H. Clarida (1987), "The Dollar and real interest rates", *Carnegie Rochester Conference Series on Public Policy*, Vol. 27, 103-140.

Canzoneri, M.B., Cumby, R.E. and B.T. Diba (1999), "Relative labor productivity and the real exchange rate in the long run: evidence for a panel of OECD countries", *Journal of International Economics*, 47, 245-266.

Carton, B., Hervé, K. and N. Terfous (2007), "Méthodes d'estimation des taux de change d'équilibre fondamentaux dans un modèle de commerce bouclé", *Document de travail de la DGTPE*, 2007/12, December

Chinn, M.D. (1997), "Sectoral productivity, government spending and real exchange rates: empirical evidence for OECD countries", *NBER Working Paper* 6017.

Chinn, M.D. (1997), “The usual suspects? Productivity and demand shocks and Asia-Pacific real exchange rates”, *Pacific Basin Working Paper Series*, PB97-06.

Chinn, M. D. (2005), “A primer on real effective exchange rates: Determinants, overvaluation, trade flows and competitive devaluation”, *NBER Working Paper* 11521, July 2005.

Chinn, M.D. (2006), “Real exchange rates”, *New Palgrave Dictionary*.

Chinn, M.D. and L. Johnston (1996), “Real exchange rate levels, productivity and demand shocks: evidence from a panel of 14 countries”, *Working Paper*, Department of Economics, University of California.

Clark, P.B. and R. MacDonald (1998), “Exchange rates and economic fundamentals: a methodological comparison of BEERs and FEERs”, *IMF working paper* 98/67, May.

De Gregorio, J., Giovannini, A. and H. Wolf (1993), “International evidence on tradables and nontradables inflation”, *European Economic Review*, 38, 1225-1244.

De Gregorio, J. and H.C. Wolf (1994), “Terms of trade, productivity, and the real exchange rate”, *NBER Working Paper* 4807.

De Gregorio, J., Giovannini, A. and T. Krueger (1994), “The behavior of nontradable good prices in Europe: Evidence and interpretation”, *Review of International Economics*, 2, 284-305.

Driver, R.L., and P.F. Westaway (2004), “Concepts of equilibrium exchange rates”, *Bank of England working paper* n° 248.

Edwards, S. (1994), “Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries”, in J. Williamson (ed.), *Estimating Equilibrium Exchange Rates*, Institute for International Economics, Washington D.C., 61-92.

Egert, B. (2003), “Assessing equilibrium exchange rates in acceding countries: do we have DEER with BEER without FEER? A critical survey of the literature”, *Focus on Transition* 2/2003, Oesterreichische Nationalbank , Vienna.

Egert, B., Halpern, L. and R. MacDonald (2006), “Equilibrium exchange rates in transition economies: taking stock of the issues”, *Journal of Economic Surveys*, 20, 257-324.

Engel, C. (1995), “Accounting for U.S. real exchange rate changes”, *NBER Working Paper* 5394.

Faruqee, H. (1995), “Long-Run determinants of the real exchange rate: a stock-flow perspective”, *IMF Staff Papers* 42(1), 80-107.

Hadri, K. (2000), “Testing for unit roots in heterogeneous panel data”, *Econometrics Journal*, 3, 148-161.

Hsieh, D.A. (1992), “The determination of the real exchange rate: the productivity approach”, *Journal of International Economics*, 12, 355-362.

Iimi, A. (2006), “Exchange rate misalignment: An application of the behavioral equilibrium exchange rate (BEER) to Bostwana”, *IMF Working Paper* 06/140.

Im, K.S., Pesaran, M.H. and Y. Shin (2003), “Testing for unit roots in heterogeneous panels”, *Journal of Econometrics*, 115, 53-74.

Isard, P. and H. Faruqee (1998), “Exchange rate assessment: extensions of the macroeconomic balance approach”, *IMF Occasional Paper* 167.

Kao, C. and M.H. Chiang (2000), “On the estimation and inference of a cointegrated regression in panel data”, in B. Baltagi and C. Kao, eds, *Advances in Econometrics*, 15, 179-222, Elsevier Science.

Levin, A. and C.F. Lin (1992), “Unit root tests in panel data: Asymptotic and finite sample properties”, *Discussion Paper* 56, Department of Economics, University of California at San Diego.

Levin, A. and C.F. Lin (1993), “Unit root tests in panel data: new results”, *Discussion Paper* 92-93, Department of Economics, University of California at San Diego.

Levin, A., Lin, C.F. and J. Chu (2002), “Unit root tests in panel data: Asymptotic and finite sample properties”, *Journal of Econometrics*, 108, 1-24.

MacDonald, R. (1998a), “What determines the real exchange rate? The long and the short of it”, *Journal of International Financial Markets, Institutions and Money*, 8, 117-153.

MacDonald, R. (1998b), “What do we really know about real exchange rates?” *Oesterreichische Nationalbank Discussion Paper* 28.

MacDonald, R. and P. Dias (2007), “Behavioural equilibrium exchange rate estimates and implied exchange rate adjustments for ten countries”, Workshop on Global imbalances, Peterson Institute of International Economics, Washington D.C., February.

MacDonald, R. et J. Nagayasu (2000), “The long-run relationship between real exchange rates and real interest rate differentials: A panel study”, *IMF Staff Papers*, 47(1).

Maddala, G. and S. Wu (1999), “A comparative study of unit root tests and a new simple test”, *Oxford Bulletin of Economics and Statistics*, 61, 631-652.

Mark, N. and D. Sul (2003), “Cointegration vector estimation by panel Dynamic OLS and long-run money demand”, *Oxford Bulletin of Economics and Statistics*, 65, 655-680.

Marston, R. (1987), “Real exchange rates and productivity growth in the United States and Japan”, in Arndt, S. and J.D. Richardson, *Real and financial linkages among open economies*, MIT Press, Cambridge.

Meese, R. and K. Rogoff (1988), “What is real? The exchange rate-interest differential relation over the modern floating-rate period”, *Journal of Finance*, Vol. XLIII, 933-948.

O’Neill, J. and R. Hormats (2004), “The G8: Time for a change”, *Global Economics Paper* n°112, Goldman Sachs.

Pedroni, P. (1999), “Critical values for cointegration tests in heterogeneous panels with multiple regressors”, *Oxford Bulletin of Economics and Statistics*, S1, 61, 653-670.

Pedroni, P. (2004), “Panel cointegration. Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis”, *Econometric Theory*, 20, 597-625.

Perron, P. (1989), “Testing for a random walk: a simulation experiment of power when the sampling interval is varied”, in *Advances in Econometrics and Modeling*, edited by B. Jaj, Kluwer Academic Publishers, 47-68.

Perron, P. (1991), “Test consistency with varying sampling frequency”, *Econometric Theory*, 7, 341-368.

Phillips, P.C.B. and B.E. Hansen (1990), “Statistical inference in instrumental variables regression with I(1) processes”, *Review of Economic Studies*, 57, 99-125.

Pierce, R.G. and A.J. Snell (1995), “Temporal aggregation and the power of tests for a unit root”, *Journal of Econometrics*, 65, 333-345.

Rogoff, K. (1996), “The purchasing power parity puzzle”, *Journal of Economic Literatur*e, Vol.34(2), 647-668.

Saikkonen, P. (1991), “Asymptotically efficient estimation of cointegrating regressions”, *Econometric Theory*, 58, 1-21.

Schnatz, B., Vijselaar, F. and C. Osbat (2003), “Productivity and the (« synthetic ») euro-dollar exchange rate”, *European Central Bank Working Paper Series* n°225.

Shiller, R. and P. Perron (1985), “Testing the random walk hypothesis: power versus frequency of observations”, *Economics Letters*, 18, 381-386.

Stock, J. and M. Watson (1993), “A simple estimator of cointegrating vectors in higher order integrated systems”, *Econometrica*, 61, 783-820.

Strauss, J. (1995), “Real exchange rates, PPP and the relative price of nontraded goods”, *Southern Economic Journal*, 61(4), 991-1005.

Williamson, J. (1983), *The Exchange Rate System*, Institute for International Economics, Washington, DC (MIT Press, Cambridge, MA, 1983).

APPENDIX. PANEL UNIT ROOT TESTS, COINTEGRATION TESTS AND COINTEGRATING VECTORS

Table 1. Panel unit root tests

Variable	LL	Breitung	IPS	MW	Hadri
q	-2.00 (0.02)	-1.00 (0.16)	-2.43 (0.01)	46.18 (0.03)	6.97 (0)
nfa	0.08 (0.53)	-1.62 (0.05)	0.52 (0.70)	27.68 (0.58)	8.16 (0)
rpi	-1.88 (0.03)	-1.99 (0.97)	-0.67 (0.25)	32.63 (0.34)	9.17 (0)
rprod	-2.65 (0.04)	2.83 (0.99)	-0.91 (0.18)	34.94 (0.24)	7.35 (0)
rgdppc	-2.78 (0.002)	1.10 (0.86)	0.61 (0.73)	30.83 (0.42)	14.38 (0)
rgdpppe	1.93 (0.03)	0.47 (0.68)	1.78 (0.96)	33.29 (0.31)	13.28 (0)
rtot	-3.17 (0.001)	1.81 (0.96)	-2.26 (0.02)	53.70 (0.005)	8.26 (0)
dr	-3.84 (0)	-3.65 (0)	-5.58 (0)	85.28 (0)	2.57 (0.005)

Note: p-values are given in parentheses.

Table 2. Pedroni panel cointegration tests

Panel cointegration tests: q=f(nfa,rpi)				*Group mean cointegration tests: q=f(nfa,rpi)*		
v test	rho test	non parametric t test	Parametric t test	rho test	non parametric t test	parametric t test
1.55	-0.85	-1.89*	-2.51**	0.48	-1.47	-2.89***
Panel cointegration tests: q=f(nfa,rpi,rtot)				*Group mean cointegration tests: q=f(nfa,rpi,rtot)*		
0.92	-0.13	-1.58	-1.64*	1.31	-0.85	-1.15
Panel cointegration tests: q=f(nfa,rprod)				*Group mean cointegration tests: q=f(nfa,prod)*		
0.64	-0.19	-0.87	-1.19	1.23	-0.05	-1.29
Panel cointegration tests: q=f(nfa,rgdppc)				*Group mean cointegration tests: q=f(nfa,rgdppc)*		
0.96	0.06	-0.36	-0.18	1.42	0.43	-0.41
Panel cointegration tests: q=f(nfa,rgdpppe)				*Group mean cointegration tests: q=f(nfa,rgdpppe)*		
1.10	-0.04	-0.65	-0.59	1.32	-0.06	-0.74
Panel cointegration tests: q=f(nfa,rprod,,rtot)				*Group mean cointegration tests: q=f(nfa,rprod,,rto)*		
0.30	0.43	-0.62	-0.40	1.98**	0.19	0.06
Panel cointegration tests: q=f(nfa,rgdppc,rtot)				*Group mean cointegration tests: q=f(nfa,rgdppc,rtot)*		
0.72	0.54	-0.10	-0.09	2.16**	0.99	0.39
Panel cointegration tests: q=f(nfa,rgdpppe,rtot)				*Group mean cointegration tests: q=f(nfa,rgdpppe,rtot)*		
0.88	0.57	-0.30	-0.13	1.99**	0.55	-0.48

Note: *: rejection of the null hypothesis at the 10% significance level, **: at the 5% significance level, ***: at the 1% significance level.

Table 3. Cointegrating vectors

Regressors	*nfa, rpi*	*nfa, rpi, rtot*	*nfa, rprod, rtot*	*nfa, rgdppc, rtot*	*nfa, rgdpppe, rtot*
nfa	-0.331	-0.283	-0.374	-0.472	-0.317
rpi	-0.829	-0.878			
rtot		-0.419	-1.041	-0.332	-0.453
rprod			-0.906		
rgdppc				-0.038	
rgdpppe					-0.067

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