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SUMMARY

The aim of the paper is to give some insights about the possible undervaluation of the Chinese currency. Firstly, we review the "usual suspects" for undervaluation by looking at different economic indicators. Secondly, we address the issue of the "Balassa effect", by comparing China with other emerging countries. We try to measure the gap between the evolution of the real exchange rate in China and what would have resulted from a "normal" Balassa effect. We use two methods to assess this gap: cross-section estimations and panel cointegration. We evidence a lack of Balassa effect in China, consistent with the fact that the real exchange rate did not appreciate despite the rapid catching up.

Thirdly, we use a FEER (*Fundamental Equilibrium Exchange Rate*) approach in order to get another idea of the existence and the size of the renminbi's misalignment. We use the NIGEM model for representing the foreign trade of China, the United States, Euro area, South Korea and Japan. We calculate the real effective exchange rate that is consistent with sustainable current accounts. Our results show that China's real exchange rate was highly undervalued in 2002 and 2003 in effective terms and even more against the US dollar. Using the model with different assumptions, we analyse how the magnitude of currencies misalignments are modified with a lower deficit target for China. As expected, the renminbi's misalignment is less pronounced. Moreover, if we have taken into account the disguised unemployment, undervaluation would have been still weaker. An other interesting result is that the dollar's misalignment is only weakly affected by the renminbi's misalignment. This suggests that a revaluation of the renminbi would only have a small effect on the US external deficit.

ABSTRACT

In this paper, we try to measure the size of a possible misalignment in the Chinese real exchange rate by two ways. On one hand, we address the issue of the "Balassa effect", by which the real exchange rate of a catching-up country should appreciate. We compare China with other emerging countries, in order to assess the size of a "normal" "Balassa effect". On the other hand, we follow the FEER (*Fundamental Equilibrium Exchange Rate*) approach. We use the NIGEM model for representing the foreign trade of China, the United States, the Euro area, South Korea and Japan. We calculate the real effective exchange rate that is consistent with sustainable current accounts. Both methods yield an undervaluation of the renminbi.

JEL Classification: JEL: F31, F33
Key Words: Renminbi, Balassa effect, BEER, FEER

TAUX DE CHANGE REEL D'EQUILIBRE EN CHINE

RÉSUMÉ

L'objectif de ce papier est de s'interroger sur la possible sous-évaluation du renminbi. Nous regardons tout d'abord si la monnaie chinoise montre des signes révélateurs d'une sous-évaluation en examinant différents indicateurs économiques. Nous nous intéressons alors à l'effet Balassa, en comparant la Chine avec d'autres pays émergents. Nous mesurons l'écart entre l'évolution du taux de change réel chinois et l'évolution telle qu'elle devrait résulter de l'effet Balassa. Nous estimons cet écart en recourant à deux méthodes économétriques: des estimations en coupe ainsi que des tests de racine unitaire et de cointégration sur données de panel. Nous mettons en évidence l'absence d'un effet Balassa pour la Chine. Ce premier résultat est compatible avec l'absence d'appréciation du taux de change réel chinois et ce malgré le processus rapide de rattrapage.

En vue de compléter cette première analyse, nous utilisons l'approche FEER, approche dite du taux de change d'équilibre fondamental. Les taux de change d'équilibre sont calculés à partir des équations du commerce extérieur de la Chine, des Etats-Unis, de la zone euro, de la Corée du Sud et du Japon du modèle multinational Nigem et correspondent aux taux de change effectifs réels compatibles avec des balances courantes soutenables. Nos résultats suggèrent que le taux de change réel de la Chine était fortement sous-évalué en 2002 et 2003 en termes effectifs, cette sous-évaluation réelle étant plus marquée vis-à-vis du dollar. Nous analysons la sensibilité de ces résultats au choix de la cible de balance courante chinoise. Avec une cible de déficit plus faible, le mésalignement du renminbi apparaît moins prononcé. En outre, si l'on tient compte du chômage déguisé, on peut penser que cette sous-évaluation devrait être encore plus faible. Enfin, nous mettons en évidence le fait que le mésalignement du dollar est peu sensible à celui du renminbi. Ceci suggère qu'une réévaluation de la monnaie chinoise ne devrait exercer qu'un faible impact sur la correction du déficit courant américain.

RÉSUMÉ COURT

Dans cet article, nous nous interrogeons sur la sous-évaluation du taux de change réel de la Chine. Pour apprécier l'existence et l'ampleur de cette distorsion, nous utilisons deux approches. Tout d'abord, nous nous intéressons à l'effet Balassa, qui prévoit l'appréciation tendancielle du taux de change réel des pays émergents au cours de leur processus de rattrapage. Nous comparons la Chine à d'autres économies émergentes, afin de mesurer un effet Balassa. Enfin, nous utilisons l'approche FEER (taux de change d'équilibre fondamental). Les taux de change d'équilibre sont calculés à partir des équations du commerce extérieur de la Chine, des Etats-Unis, de la zone euro, de la Corée du Sud et du Japon du modèle multinational Nigem et correspondent aux taux de change effectifs réels compatibles avec des balances courantes soutenables. Les deux approches conduisent à un diagnostic de sous-évaluation du renminbi.

Classification *JEL* : JEL: F31, F33
Mots-clefs : Renminbi, effet Balassa, BEER, FEER

REAL EQUILIBRIUM EXCHANGE RATE IN CHINA[1]

Virginie Coudert[2] *and Cécile Couharde*[3]

1. INTRODUCTION

China's exchange rate regime can be considered as a *de facto* peg to the dollar, as the exchange rate against dollar has not changed since 1995. Because of this peg, the dollar depreciation in 2003 and 2004 resulted in a depreciation of the renminbi (RMB) against third currencies. This triggered a debate on the appropriate level of the Chinese currency. As China runs an external surplus, this situation is perceived as generating "unfair" competitiveness. Consequently, Chinese authorities have been under pressure to introduce more flexibility in exchange rate regime, since that time (Goldstein, 2003, IMF, 2004a and 2004b). However, from a Chinese point of view, there is no clear incentive to move or to revalue the renminbi.

The supposed undervaluation of the renminbi has been discussed in different international forums since the G7 meeting of September 2003 in Dubai, whose public communiqué advocated for "greater flexibility of exchange rates". Indeed, there are some of the "usual suspects" that characterise an undervaluation. The real effective exchange rate has depreciated, along with the dollar since the beginning of 2002, as Chinese inflation has been low: 0.8% in 2002, 1.2% in 2003, even if it increased in 2004. Other signs of undervaluation are the surging forex reserves and the current account surplus. Some papers have pledged for a revaluation as this suspected undervaluation might yield too much competitiveness to Chinese products. Especially, as the United States might reduce their large current account deficit with China through exchange rate movements, if a revaluation occurs. Another drawback of this possible undervaluation of the Chinese currency is the fact that it contributes to the world deflation: the low price of Chinese products would draw down domestic prices in the importing countries. However, this latter view does not resist to a thorough analysis, as the one by Kamin and alii (2004).

A diagnosis of a renminbi undervaluation was already present in the late nineties. According to this view, the 1994 devaluation, which cuts the exchange rate by 33%, gave China a substantial competitive advantage, leading to a surge in Chinese exports. This could explain the fact that China was not affected by the wave of devaluations, triggered by the "Asian" crises of 1997. An extreme variant of this view is to consider this Chinese devaluation as a remote cause of the Asian crises, as the neighbouring countries have to

1 This paper was presented in the 5th international conference of the Association of Public Economic Theory, Peking University August 25th-29th, 2004. We thank Agnès Bénassy and Francisco Serrranito for their comments on an earlier version of the paper. The opinions expressed are those of the authors and do not reflect the views of the institutions they belong to.

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adjust their exchange rates. An opposite view is that the 1994 devaluation was neutral, for it only adjusted the official rate to the parallel floating rate (Fernald and alii, 1999). Some studies, such as the one by Xiaopu (2002), even consider that the renminbi was overvalued at the end of the nineties. Recently, some papers conclude to an undervaluation of the renminbi, although they use different methods of assessment (Jeong and Mazier, 2003; Bénassy and alii, 2004).

In 2004, pressures towards a nominal revaluation softened and market expectations of revaluation decreased, though they are still present in the forward forex market. First, the inflation was raising in China, paving the way to a gradual real appreciation of the currency, which releases the pressure on the nominal exchange rate. Second, the external surplus also decreased, softening the pressures from international competitors. Third, the dollar depreciation against third currencies was smaller than during the previous year, giving way to a stabilisation of the renminbi. Nevertheless, the problem of the possible revaluation is still an issue for the Chinese economic policy.

According to Bergsten (2004), China's peg to the dollar explains the reluctance of Asian countries to let their currencies rise against the dollar and the limited fall of the dollar's effective exchange rate, despite its substantial decline from 2002 to 2004 against several currencies. As a result, the necessary adjustment of the US current deficit is impeded and world growth is dampened as the adjustment burden relies only on a few number of countries, such as the euro area, where exchange rates are flexible but the rate of growth is already low. On the contrary, Dooley and alii (2004) think that the issue of undervaluation is linked to the very low productivity of millions of workers in China, who need to join the "modern" sector in the coming years. In this framework, the so-called undervaluation of the currency may simply be a recipe for absorbing the disguised unemployment.

This paper investigates the Chinese exchange rate policy and its economic implications. The rest of the paper is organised as the following. Section 2 gives some insights about the possible undervaluation of the Chinese currency. We try to assess the presence of a misalignment by different economic indicators. Then, we address the issue of the "Balassa effect", in the framework of a BEER (*Behavioural Equilibrium Exchange Rate*) approach. We compare China with other emerging countries and we evidence the lack of real exchange rate (RER) appreciation in recent years, that would correspond to a "normal" "Balassa effect". Section 3 goes deeper into the question of undervaluation, by following a FEER approach (*Fundamental Equilibrium Exchange Rate*). We use the NIGEM model[4] for representing the foreign trade of China, the United States, Euro area, South Korea and Japan. We calculate the real effective exchange rate (REER) that is consistent with sustainable current accounts. Section 4 concludes.

[4] NIGEM (National Institute Global Economic Model) is a multinational model developed by the National Institute of Economic and Social Research (NIESR).

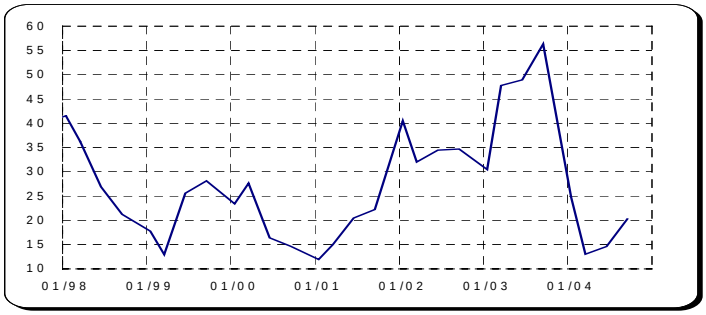
2. IS THE RENMINBI MISALIGNED ?

2.1 The usual « suspects »

There have been some signs of undervaluation of the real exchange rate of China during the recent years. First, the current account has been in surplus, which is atypical for an emerging country. It reached $ 35 billions in 2002, and has decreased since that time. Nevertheless, in the first three quarters of 2004, it was still on an annual trend of around $ 16 billions (Figure 1). In a context of a booming activity, this surplus may seem a little puzzling. It is sometimes interpreted as a sign of competitiveness advantage for Chinese exports, raising the issue of undervaluation. However, it could also be explained by the very high saving rate.

On the financing side, the surplus matches a particularly high national saving rate, especially from the household sector, which more than compensates the high investment rate. According to Modigliani and Cao (2004), the household saving rate reached 30% by the early nineties. They explain this impressive figure in the framework of the Life Cycle Theory by the rate of growth of income and the population structure, resulting from the demographic policy. In countries like China, male children traditionally used to pay for their retired parents. The Chinese policy of the only child makes the following of this tradition more hazardous. In response, households have increased their saving rate, to face their own needs during their retirement. The gross national saving rate in percentage of GDP was as high as 43.1% in 2002, and the preliminary assessment gave 47.6% for 2003 (IMF, 2004a). Despite the high investment rate (40.3% in 2002, estimated to 44.4% of GDP in 2003), this situation of abundant saving results in a current account surplus.

Figure 1: Current Account, in billions of US dollars (annualised quarterly data)



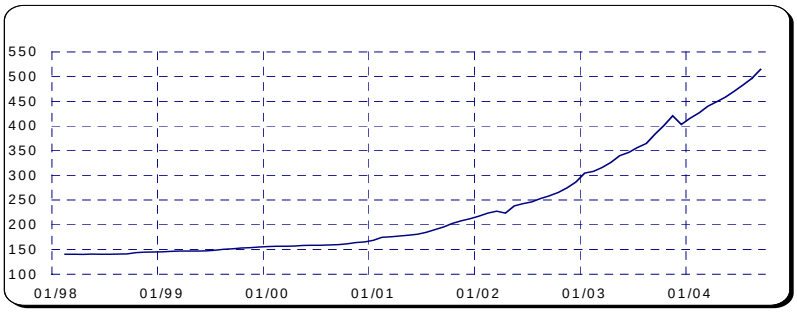
Source : Bloomberg

Second, the accumulation of reserves has accelerated since the beginning of 2002. They have grown more than three-fold since the beginning of 2000; total reserves amounted to $ 514 billions at the end of September 2004 (Figure 2). This is the result of repeated interventions by the central bank, in order to impede the renminbi appreciation. This is also the sign of a disequilibrium in the foreign exchange market, where private demand for

renminbi exceeds supply. In the absence of interventions of the monetary authorities, the Chinese currency would spontaneously appreciate, which also can be read as a sign of undervaluation.

Theoretically, there should be an automatic adjustment to this process: the accumulation of forex reserves should boost monetary creation, and generate inflation, that causes real exchange rate to appreciate, despite the peg. However, in reality, this adjustment takes time and does not seem to work so well in the case of China. On the one hand, interventions are partly sterilised. On the other hand, the consumer price index showed signs of deflation from 1998 on until the beginning of year 2003, despite a sharp two-digit increase in monetary aggregates. One interpretation could be an atypical transmission mechanism from money to prices, in an economy where prices are still partly administered.

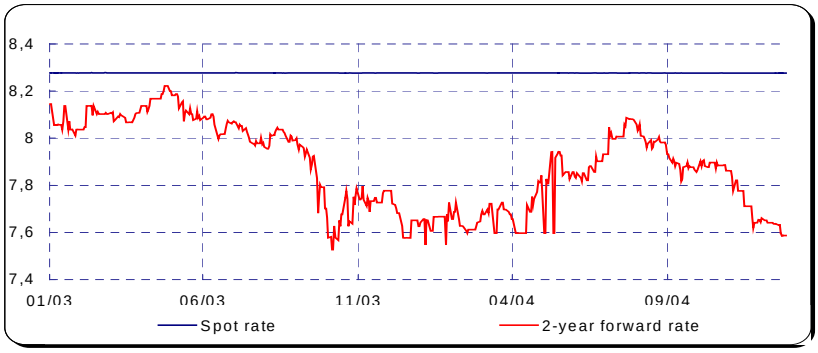
Figure 2: Foreign exchange reserves, in billions of US dollars



Source : IMF

Aside the official interventions, the appreciation pressures in the foreign exchange market can also be read in the forward rates (Figure 3). Expectations for a revaluation began to rise in 2003 and were especially high around the Dubai G7 meeting, in September 2003. At that time, the forward market indicated an expectation of revaluation of nearly 10% of the renminbi. At the end of December 2004, it still indicated an expectation of 9% revaluation.

Figure 3: Renminbi/US dollar spot and forward exchange rates

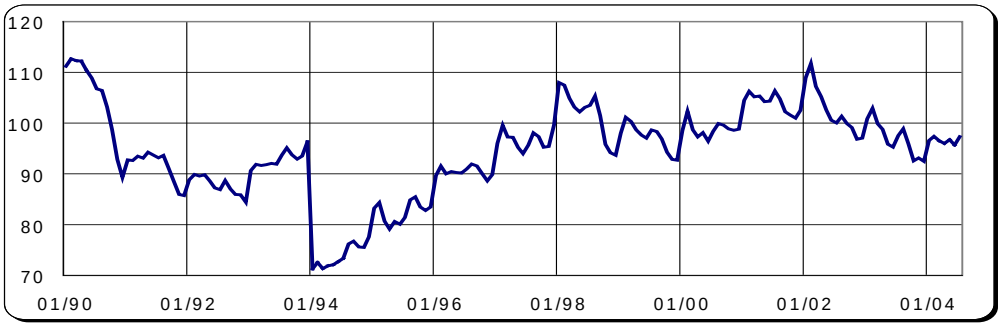


Source : Bloomberg

Third, the real effective exchange rate of the renminbi has been depreciating since the beginning of 2002 (Figure 4). From February 2002 to October 2004, it depreciated by 18%. The movement is linked to the dollar evolution against third currencies and also to the low inflation in China. This depreciation has a rationale in the case of the dollar, because of the huge US external deficits. However, it is more questionable that it also applies to China, which raises the question of the exchange rate regime.

Obviously, the recent depreciation of the real effective exchange rate is not sufficient for detecting an undervaluation. A major drawback for drawing any conclusions is the lack of a reference period. There was a strong devaluation in 1994 that allowed to fill the gap between black and official markets and to unify the foreign exchange market. It was followed by an appreciation period between 1994 and 1998, which is not completely cancelled by the recent depreciation.

Figure 4: Real effective exchange rate in China, year 2000=100



An increase stands for an appreciation

Source : Banque de France

2.2 The Balassa effect

As regards to the long term evolution, the real effective exchange rate in China has not shown an appreciation trend since the beginning of the nineties (Figure 4). This is in contradiction with the "Balassa effect", which predicts real appreciation for catching-up countries. Here, we try to measure the gap between the evolution of the real exchange rate in China and what would have resulted from the "normal" Balassa effect. This would give us first proxies of a possible undervaluation. We use two methods to assess this gap: cross-section estimations and panel cointegration.

The "Balassa-Samuelson" effect, first formulated by Balassa (1964) and Samuelson (1964), describes the distortion in purchasing power parity (PPP) resulting from the international differences in relative productivity between the tradable goods sector (constituted more or

less by manufacturing and agriculture) and the non-tradable goods sector (roughly speaking, services). Accordingly, during the development process, productivity tends to increase more quickly in the tradable goods sector than in the services sector. Given that the prices of tradable goods are set by international competition, an increase in productivity in this sector leads to an increase in wages, which is not detrimental to competitiveness. Since this increase in wages spreads across the economy as a whole, there is a rise in relative prices in the non-tradable goods sector, where productivity has not grown at the same pace. Given that the price index is an average of these two sectors, there is an increase in the prices of domestic goods relative to those from abroad, which results in an appreciation of the real exchange rate.

To make it more concrete, let us take the example of an emerging economy whose exchange rate is calculated against the currency of an advanced foreign country, marked *, for instance the United States. The real exchange rate of the emerging country is defined as:

$$\dot{q} = \dot{e} + \dot{p} - \dot{p}^{*} \tag{2.1}$$

where q and e are the real and nominal exchange rate against dollar respectively; p and p^* are the final demand price index in the emerging country and the United States respectively. The lower-case variables marked with a dot indicate rates of growth (logarithmic derivatives). The nominal exchange rate is expressed as the number of dollars per domestic currency unit; therefore, an increase in the nominal and real exchange rate stands for an appreciation.

The relative price of tradable goods, $\dot{q}_T$ between the two countries is given by

$$\dot{q}_T = \dot{p}_T + \dot{e} - \dot{p}_T^{*} \tag{2.2}$$

where $\dot{p}_T$ stands for the tradables price index. By subtracting the two equations (2.1) and (2.2), we can express the real exchange rate as the total of the relative price for tradable goods between the two countries $\dot{q}_T$ and the difference between the two countries of relative prices for goods across the board and the exposed sector *T*:

$$\dot{q} = \dot{q}_T + [(\dot{p} - \dot{p}_T) - (\dot{p}^{*} - \dot{p}_T^{*})] \tag{2.3}$$

An equivalent expression can be obtained by expressing the final demand price as a weighted average of prices in the two sectors:

$$\dot{p} = \dot{p}_T + (1-\gamma)(\dot{p}_N - \dot{p}_T) \tag{2.4}$$

where $\dot{p}_N$ is the price index in the non-tradable goods sector *N*, and γ is the share of tradable goods in final demand. As this definition is also valid for the United States, the real exchange rate set out in equation (2.1) can be written:

$$\dot{q} = \dot{q}_T + (1-\gamma)\left[(\dot{p}_N - \dot{p}_T) - (\dot{p}_N^* - \dot{p}_T^*)\right] - (\gamma - \gamma^*)(\dot{p}_N^* - \dot{p}_T^*) \quad (2.5)$$

The rise in the relative price of non-tradable goods compared with that of tradable goods may stem from a variety of factors, from the supply or the demand side. For Balassa (1964), it results from larger productivity gains in the manufacturing sector in catching-up countries. To see this, let us start by determining the relative price of non-tradable goods compared with tradable goods in a single economy; this relative price is also called the "internal exchange rate", given that it compares the price of domestic goods with those exposed to international competition. After setting the usual assumptions (see for example, Coudert, 2004), it may be expressed as follows:

$$\dot{p}_N - \dot{p}_T = \frac{\alpha_N}{\alpha_T}\dot{\theta}_T - \dot{\theta}_N \quad (2.6)$$

where $\dot{\theta}_i$ designates the total factor productivity in sector i $i = T, N$ and α_i the share of labour in the sector's value added. Thus, the relative price of non-tradable goods, i.e. the "internal exchange rate", appreciates with productivity gains in the tradable goods sector. Generally, we have: $\dot{\theta}_T > \dot{\theta}_N$ and , $\frac{\alpha_N}{\alpha_T}\dot{\theta}_T > \theta_N$ i.e. the relative increase in the productivity in tradable goods leads to an appreciation of the "internal exchange rate", especially in emerging countries.

When considering the external real exchange rate between two countries, this expression is written as

$$\dot{q} = \dot{q}_T + (1-\gamma)\left((\frac{\alpha_N}{\alpha_T}(\dot{\theta}_T - \dot{\theta}_T^*) - (\dot{\theta}_N - \dot{\theta}_N^*)\right) \quad (2.7)$$

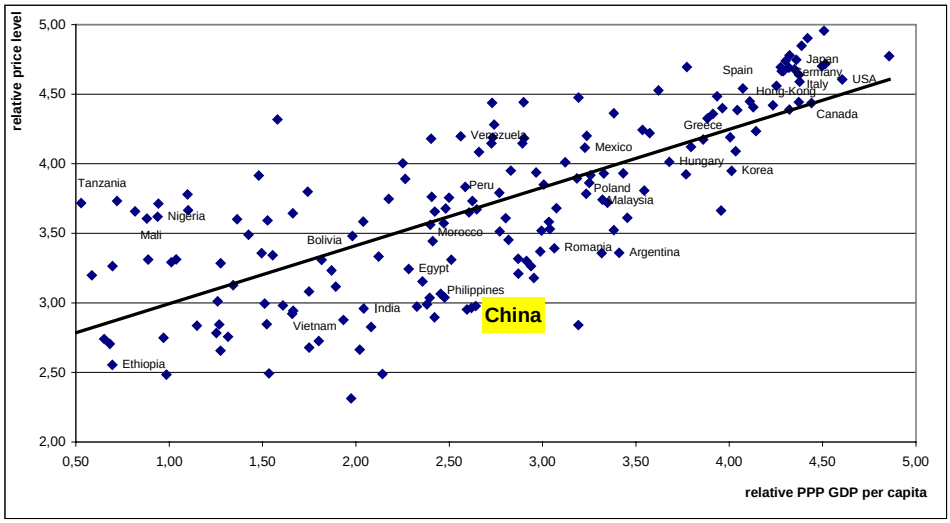
According to equation (2.7), the real exchange rate of an emerging country has a tendency to appreciate because the productivity gains in the tradable sector are higher than in the reference advanced country, while there is not such great difference for the non tradable sector. Therefore the second term at right of the equation is generally positive.

2.3 Cross-section estimations

In this framework, one way to assess the misalignment of currencies is to use a Purchasing Power Parity (PPP) criterion corrected by a Balassa effect. A first approximation of this method can be given by a cross-section regression in the spirit of Rogoff (1996), De Broeck and Slok (2001) or others surveyed by Edwards and Savastano (1999). The PPP GDP per capita is generally taken as a proxy for the relative productivity differentials between sectors and used in a regression with the relative price levels of a group of countries.

Figure 5 provides an illustration of this type of regression. Countries are sorted by their GDP per capita relative to the United States on the horizontal axis and by their price level on the vertical axis. Data concern the year 2003; they were extracted from the CEPII-CHELEM database and taken in logarithms. Relative price levels of different countries are calculated by dividing GDP in dollars by GDP in PPP, and then by the price level of the United States. Therefore, these relative price levels can be assimilated to deviations of the exchange rates to PPP.

Figure 5: Relative price levels and GDP per capita compared to the United States in 2003 (1)



(1) Sub-sample of countries with PPP GDP per capita greater than 5% of the US; data are taken in logarithm.

Source : Authors' calculations using CHELEM database, CEPII.

We start from a large sample of 173 countries for the year 2003, including all advanced, emerging and developing countries for which data are available. We then make the calculations on different sub-samples, in order to have more homogeneous data. In sub-sample 1, we drop the group of very poor countries, with PPP GDP per capita smaller than 5% of the United States' one. Sub-sample 2 retains only emerging and developing countries with PPP GDP of less than 70% of the US level. Sample 3 is composed by medium-type countries with PPP GDP per capita comprised between 5 and 70% of USA.

Figure 5 is made on sub-sample 1. The slope indicates the average appreciation of the real exchange rate to be expected from a 1% increase in relative GDP per capita across countries. It ranges between 0.42 and 0.58, depending on the sample used for the estimates (table 1).

For example in sub-sample 1, we obtain :

$$Log\left(P / P^{US}\right) = \underset{(15.60)}{0.583}\ Log\left(GDP / GDP^{US}\right) + \underset{(16.69)}{2.01} \qquad (2.8)$$

number of observations = 139; R^2 =0,645.

Where P indicates the price level, calculated as indicated above, GDP is the PPP GDP per capita and t-statistics are in brackets below.

In this framework, the fitted values could be interpreted as a kind of reference exchange rate for a PPP parity taking into account the Balassa effect. Countries above the regression line are considered to have high prices relatively to other countries of the same living standards, meaning an overvalued exchange rate. Countries below the line can be thought to have low prices, which accounts to an undervalued exchange rate. That is the case for China, which is under the regression line in Figure 5.

Numerical results are displayed on table 1. Although the estimated slope of the regression is somewhat different across the samples, changing the sample does not modify much the order of magnitude of China's misalignment. In all cases, China had an undervalued exchange rate in 2003. The range of undervaluation goes from 43 to 50%. The misalignment is less pronounced in sub-samples 1 and 3 than in the whole sample, because they exclude some very poor countries, especially those experiencing a war or severe social troubles, which make their prices abnormally high.

Table 1: Estimated misalignment for China exchange rate for 2003, using several samples

	Whole sample	Sub-sample 1	Sub-sample 2	Sub-sample 3
PPP GDP per capita relative to the US	All countries	>5%	<70%	>5% and <70%
Number of countries	*173*	*136*	*152*	*115*
Slope of the regression	*0.42*	*0.58*	*0.34*	*0.53*
R^2	*0.55*	*0.64*	*0.38*	*0.47*
Estimated misalignment for China's exchange rate	-50.5%	-43.7%	-47.9%	-43.4%

Source: CEPII-CHELEM, authors' calculations.

In order to check the results, we performed the same regression, excluding a group of very small countries. We dropped all countries with a population smaller than 1 million habitants. The rationale is that the presence of these countries may distort results, by abnormally high prices. Indeed, the group includes very small states, especially some tiny islands, where average price levels are high, because of transport costs and tourism activity. Therefore, we expect calculated undervaluation to be smaller in the new sample. However results are only weakly affected by this change (table 2). The estimated undervaluation of Chinese exchange rate is only slightly smaller, ranging from 41 to 49%.

Table 2: Estimated misalignment for China exchange rate for 2003, using several samples of countries of more than 1 million habitants

	Whole sample	Sub-sample 1	Sub-sample 2	Sub-sample 3
PPP GDP per capita relative to the US	All countries	>5%	<70%	>5% and <70%
Number of countries	*145*	*111*	*127*	*93*
Slope of the regression	*0.41*	*0.59*	*0.32*	*0.51*
R^2	*0.56*	*0.64*	*0.37*	*0.45*
Estimated misalignment for China's exchange rate	-49.2%	-41.8%	-45.6%	-41.3%

Source: CEPII-CHELEM, authors' calculations.

This cross-section approach can give a first insight. However, it is not sufficient, for two reasons. First, it uses only one year of data. Second, it relies on price level comparisons, that are difficult to assess. In the following section, we take over these two drawbacks, by using panel data on a large period, instead of one given year and using real exchange rates in evolution, instead of relying on price level estimations.

2.4 Panel data estimations

We estimate a Balassa-Samuelson effect, using formula (2.3). This formula, which ascribes the Balassa effect to the difference between the two zones of relative inflation between goods taken as a whole and tradable goods is the simplest to use, since unlike the usual formulations, it does not require knowing the weighting between the sectors and the productivity gains.

The dependant variable is the real bilateral exchange rate against the US dollar, as defined in equation (2.1). The explanatory variable is the relative price index, calculated as the ratio of the consumer price index to the producer price index in difference between the home country and the United States, usually considered as a proxy for the relative price between all goods and tradables.

We consider twenty one emerging countries corresponding to Argentina, Brazil, Chile, Colombia, Mexico, Peru, Indonesia, Malaysia, Philippines, Thailand, South Africa, Turkey, Poland, Hungary, Czech Republic, Slovakia, Slovenia, Estonia, Lithuania, Latvia, Estonia and China. The sample covers quarterly data for the period 1980q1 to 2002q4. The panel is unbalanced, because of the unavailability of some countries data. In particular, for China, the prices data only cover the period from 1998q1 to 2002q4. Data are extracted from the IMF's IFS database and Datastream.

We start by checking the time series characteristics of the sample. Accordingly, we test for unit roots to confirm that the variables are indeed integrated. Testing for unit roots in panel data entails the advantage of increasing the power of the test by exploiting simultaneously cross-section and time series information. As the size of the sample is large, the test

statistics conveniently converge asymptotically to the standard normal distribution. We carried out our panel unit root tests on the basis of the Im and al. (2003) test (IPS-t-test).

The structure of the IPS t-test is based on N augmented Dickey-Fuller regressions:

$$\Delta y_{it} = \rho_i y_{i_{t-1}} + \sum_{j=1}^{p_i} \varphi_{it} \Delta y_{it-j} + \alpha_i + \gamma_i t + \varepsilon_{it} \text{ for } t = 1,...,T \; ; \; i = 1,...,N \qquad (2.9)$$

where T is the length of the sample, N is the cross-section dimension. The term Δy_{it-j} represents lagged dependent variables with country-specific lag length p_i. α_i, γ_i are country-specific coefficients, α_i being an intercept (fixed effects) and γ_i the trend coefficient. The error term ε_{it} is distributed as a white-noise random variable, with possibly different variance for each member of the panel.

The null hypothesis is that all series have a unit root, that is $H_0 : \rho_i = 0$ for all countries i. The test allows for heterogenity in the value of the autoregressive coefficient under the alternative hypothesis, that is $H_1 : \rho_i < 0$ for at least one country i.

Table 3 reports results. The test used here is the group-mean t-bar statistic based on the t-statistics derived from the N augmented Dickey-Fuller regressions. According to the test, the null hypothesis cannot rejected. Therefore, we consider that the panel data for real bilateral exchange rate series are I(1). The same result holds for relative prices series.

Table 3: Panel unit root IPS test

Variable	Real bilateral exchange rate	Relative price ratio
t-bar[1]	-1.05976	-1.30559
p. value	0.28925	0.19169

(1) statistic t-bar with OLS estimations

To perform panel cointegration tests, we apply the seven tests proposed by Pedroni (1999). The relationship estimated is the following one:

$$y_{it} = \alpha_i + \gamma_i t + \theta t + \beta_1 x_{1,it} + ... + \beta_K x_{K,it} + \varepsilon_{it} \qquad (2.10)$$

where K is the number of regressors and β the elasticities. The deterministic elements are defined as above and θt are common time effects.

Among the seven Pedroni's tests, four are based on the within dimension (panel cointegration tests) and the three others on the between dimension (group mean panel cointegration tests). All tests are based on the null hypothesis of no cointegration for all countries i. Under the alternative hypothesis, for the panel statistics, there is cointegration for all countries i. However, the group mean panel cointegration statistics allow for heterogeneity across countries under the alternative hypothesis. Table 4 displays the results of Pedroni's test. All panel and group mean statistics reject the null hypothesis of no cointegration at the 5% threshold, except the panel adf statistics. Therefore, it seems reasonable to proceed under the assumption that the variables are cointegrated.

Table 4: Pedroni panel cointegration test

Panel cointegration tests				Group mean cointegration tests		
v-stat	rho-stat	Pp-stat	adf-stat	Rho-stat	pp-stat	Adf-stat
5.70681	-3.80223	-3.18772	-1.51547	-3.67805	-3.71498	-1.93603
(0,0000)*	(0.0001)*	(0.0014)*	(0.1296)	(0.0002)*	(0.0002)*	(0.0052)**

p-values are given in parentheses.
*: rejection of the null hypothesis at the 5% significance level (p-values less than 0,05)
**: rejection of the null hypothesis at the 5% significance level (p-values less than 0,10)

Source: Author's calculations

In order to estimate the cointegration vectors for the considered countries, we use the Fully-Modified Ordinary Least Squares (FM-OLS) proposed by Phillips and Hansen (1990). According to Pedroni, this method leads to more robust results when working with small size samples than the standard OLS method. We consider two types of estimation: a country by country estimation and a panel estimation with fixed effects. Table 5 displays the cointegration vectors estimated country by country.

Table 5: Coefficients of the relative prices in the cointegration vectors,Country by country estimates

Argentina	-1.45 (-28.17)	Turkey	-0.84 (-6.41)
Brazil	-0.60 (-6.97)	Poland	-1.44 (-13.65)
Chile	-1.94 (-24.83)	Hungary	-0.16 (-29.24)
Colombia	-1.99 (-10.36)	Czech Republic	-1.07 (-4.91)
Mexico	-0.57 (-3.28)	Slovakia	0.79 (-0.64)
Peru	-1.20 (-33.10)	Slovenia	0.73 (-0.47)
Indonesia	-2.31 (-41.08)	Estonia	-2.69 (-7.59)
Malaysia	-1.73 (-11.19)	Lithuania	-3.45 (-12.62)
Philippines	-0.96 (-11.08)	Latvia	-3.50 (-15.13)
Thailand	-1.84 (-7.94)		
South Africa	-3.09 (-7.91)	China	0.64 (-2.43)

t-statistics are given in parentheses.

The coefficients on relative price index generally have the expected sign, supporting a Balassa effect. However, for 3 countries out of 21, the sign is not the expected one. This is the case for China. This striking feature may be interpreted as a failure of the Balassa effect to explain the Chinese exchange rate behaviour. Another hypothesis is that this is due to the small size of the sample for this country.

The cointegration vector obtained by the panel estimations with fixed effects is shown in table 6. The explanatory variable is significant and correctly signed.

Table 6: Cointegration vectors. Panel estimations with fixed effects

Variables	Cointegration vectors
Relative price ratio	-1.37 (-60.89)

Source: Author's calculations

We calculate the real bilateral equilibrium exchange rate of each country as the fitted values obtained with the coefficient of relative price in the panel cointegration vector and with country intercepts. As usual, the misalignments are obtained by comparison with the observed real exchange rate. Table 7 reports the results for the year 2002. The renminbi appears undervalued by almost 18%.

Table 7: Real bilateral exchange rate misalignments in 2002

Countries with overvalued currencies		Countries with undervalued currencies	
Brazil	6.1	Argentina	-43.6
Hungary	3.3	Chile	-5.8
Czech Republic	3.8	Colombia	-22.6
Lithuania	32.3	Peru	-10.9
Latvia	5.8	Indonesia	-14.3
		Philippines	-19.7
		Thailand	-16.0
		South Africa	-43.5
		Turkey	-7.3
		Poland	-4.2
		Slovakia	-13.3
		Slovenia	-17.0
		Estonia	-4.3
		China	**-17.8**

Source: Author's calculations

2.5 Why is there no Balassa effect at work in China ?

Results show a lack of Balassa effect in China, although it is confirmed in a large sample of countries. Moreover, there is a large gap between the prediction made with a Balassa model and the actual behaviour of the exchange rate in China. It is interesting to ask why is China atypical on this issue.

The Balassa effect rests on several restrictive assumptions, that may not be fulfilled in China. A central assumption of the Balassa effect that does fit to China economy is that the economy can be broken down into two sectors: one producing tradable goods, exposed to international competition, where large productivity gains are observed; the other "non-tradable" goods, where external trade is too limited to influence price formation. This assumption seems to hold for China, where productivity gains have been very high in the tradable goods sector for the last decade. However, Chinese prices are still administered in the context of a socialist economy; so the usual link between productivity and prices may be distorted.

Moreover, a whole set of assumptions linked to the Balassa model clearly does not hold in China. It concerns the perfect mobility of factors of production. First, there is no perfect international mobility of capital in China, because of the exchange controls. Second, internal labour mobility is also restricted, as regulation prevents the labour force to move freely, for example from low-productivity agricultural provinces to the high productivity regions. This policy is aimed at avoiding a massive rural exodus, which would create poverty and social restlessness in urban areas. As a result, wages do not equalise across provinces and also across sectors. Indeed, disparities are important across the 31 regions of China, as regards to prices, wages and productivity.

3. FURTHER INVESTIGATIONS WITH FEERs

The assessments on equilibrium exchange rates are not always very convincing, because they rely on a large set assumptions. Therefore, it is advisable to cross-check the results of different methods. In order to get another idea of the existence and the size of the RMB misalignment, we propose to use now a FEER approach. According this approach, the equilibrium exchange rate is defined as the real effective exchange rate at which a country could achieve simultaneously both of the basic objectives of macroeconomic policy. These objectives are usually formulated as "internal balance" meaning non-inflationary full employment, and "external balance", meaning a balance of payments position that appeared sustainable and desirable.

The equilibrium exchange rates are obtained by using already existing econometric models. This includes either simulations based on a complete multinational model, in the general equilibrium approach proposed by Williamson (1985), or the development of a more limited model representing the long-term end of the trade equations in a partial equilibrium approach. Because of its greater transparency, we have deliberately adopted here the partial equilibrium approach.

3.1 The theoretical framework

The trade equation approach relies on a model for foreign trade that explains current account outcomes by a measure of economic activity and the real exchange rate. That enables one to calculate the change in the real exchange rate needed to achieve a current account target when activity is at some normal, sustainable level.

The current account CA is considered as a function of the real exchange rate, Q, the domestic and foreign incomes, Y and Y^* and the interest paid on the net foreign debt D:

$$CA = CA(Q, Y, Y^*) - rD \tag{3.1}$$

Interest payments are assumed to be exogenous relatively to the exchange rate. The current account is also equal to the excess of domestic savings S over investment I:

$$CA = S - I \tag{3.2}$$

As Faruqee and Isard (1998, 2001), we start by considering that an equilibrium saving-investment position exists for each country, linked to structural macroeconomic features. This is supposed to lead to a sustainable level of capital flows. This equilibrium saving–investment position is assumed to be independent of the real exchange rate and is estimated exogenously. This gives us a target value for the current account, $\overline{CA}$.

Internal equilibrium is defined on the basis of the potential growth rates estimated separately from the long-term model. The internal equilibrium is thus exogenous to the model insofar as potential growth is assumed to be independent of the real exchange rate.

The equilibrium real exchange rate is the value of the real exchange rate $\overline{Q}$ that implicitly satisfies the following equation:

$$CA(\overline{Q}, \overline{Y}, \overline{Y}^*) = \overline{CA} \qquad (3.3)$$

with $\overline{Y}$, $\overline{Y}^*$ the potential output of domestic and foreign country in the considered period.

As the effective exchange rate of one country is a multilateral variable, it impacts the trade of several countries. This is why FEERs need to be calculated simultaneously if we consider several countries as it done here.

To calculate exchange rates in a multilateral framework, we use a theoretical framework based on a recursive method of calculation. This comparative-static method generates a point estimate of medium-run equilibrium exchange rates, rather than a short to long-run time path of the equilibrium exchange rate. More precisely, we adopt the resolution method developed by Borowski and Couharde (2003). It rests on the construction of a long-term model of foreign trade derived from the NIGEM model, where all the countries considered in our study (the United States, Japan, Euro area, South Korea and China) are explicitly modelled.

3.2 The resolution method

We begin by writing a long-term model for foreign trade[5], based on NIGEM. The 14 equations of this long-term model are given in Appendix 1. Each trade-balance component (equations of export and import quantities, trade price equations) is estimated in NIGEM in the form of an error-correction model. We only retain the long-term component of each equation, as we are interested in long-term movements and not in short-term adjustments. The multi-country model is resolved by log-linearising its equations for all periods. This gives the quarter-by-quarter deviations of exchange rates from their equilibrium values. Not all the relationships are log-linear; the current account equation, for example, is a case in point; consequently, we linearise these equations in the neighbourhood of each quarter.

The simultaneous resolution, for all five countries, of the model allows to express a currency's misalignment as a function of the only variables that are exogenous to the model: the output gaps and the deviations of the current accounts from their medium-run equilibria. A simplified analytical resolution is given in Appendix 2 for three countries. By construction, if all economies are at their potential growth and have reached their current-account balance targets, the exchange rates are at their equilibrium values. The

[5] By strict logic, we should examine not only trade but factor income (paid to and received from the rest of the world), as the countries' asset stocks are not null in each period. Persistent current-account imbalances can generate major shifts in the level of net assets held abroad, which could have a feedback effect on net flows of interest and thus on real exchange rates. Unlike exports and imports of goods and services, factor income is not directly linked to exchange rates in the NIGEM model. Moreover, in the static approach used here, dynamic factors are by definition ignored. In particular, the static approach supposes that the current-account balance of the base period has fully adjusted to past variations in growth and competitiveness.

misalignment of currency i (q_i), measured as the deviation of its real effective exchange rate from its equilibrium value, can thus be written as:

$$q_i = \sum_{j=1}^{5} \beta_{ij} \left(ca_j - \overline{ca}_j \right) + \sum_{j=1}^{5} \gamma_{ij} og_j \qquad (3.4)$$

where og_j designates the output gap in GDP % of country j, $\left(ca_j - \overline{ca}_j \right)$ the deviation of the current account from its equilibrium value, in % of GDP, and β_{ij}, γ_{ij} are derived from estimated parameters. This is equivalent to the following formulation:

$$q_i = \sum_{j=1}^{5} \beta_{ij} \left(ca'_j - \overline{ca}_j \right) \qquad (3.5)$$

where ca'_j stands for country j's structural current account, that is the current account that would be observed in the present year if output gaps were null and the effects of past exchange rate changes had fully materialised.

Equation (3.5) states that the misalignment of currency i does not only depends on the country i economy. It can be expressed as a linear combination of the deviations of the structural current accounts from their equilibrium values for all considered countries. By definition, the parameters β_{ij} measure the elasticity of the misalignment of currency i to the deviation of the structural current account from its equilibrium in country j. They are function of the model's structural parameters (the trade elasticities), the intensity of trade between the two countries i and j and the specific characteristics of each economy: the degree of openness (measured by the import share of GDP) and the intensity of external constraints (measured by the export-to-import ratio).

The diagonal coefficients β_{ii} are expected to be negative and the crossed coefficients, β_{ij} with $j \neq i$, positive, if the condition of Marshall-Lerner is satisfied. This means that a country's exchange rate is considered as undervalued if its structural current account is above its target. In this situation, ceteris paribus, the currencies of the other countries j would tend to be overvalued. The resolution of the model amounts to computing the coefficients β_{ij} for the five considered countries on average over the period 2000-2002 (Table 8). The diagonal of this matrix displays the FEER sensitivity of each country to the deviation from its own current account target; non–diagonal elements represent crossed elasticities of FEERs to the deviation from current account targets of the other countries. Unsurprisingly, the diagonal elements are negative - confirming that the Marshall-Lerner

condition is fulfilled for all countries in the long run - and their magnitude is generally higher than crossed coefficients.

Table 8: Elasticities of deviations from FEER with respect to deviations from current account targets, β_{ij} in equation (3.5)

	Deviation of the effective exchange rate[1] from its equilibrium value				
With respect to the deviation of structural current account from target value ($ca'_j - ca^*_j$) of					
	Dollar	Yen	Euro	Won	Renminbi
The United States	**-10.4**	4.2	6.8	5.9	3.0
Japan	2.4	**-6.9**	2.1	3.5	2.4
Euro area	1.7	1.1	**-4.8**	1.8	0.9
South Korea	0.2	0.2	0.3	**-2.4**	0.2
China	0.3	0.5	0.4	0.3	**-4.0**

(1) Real effective exchange rate in consumer price terms. A rise in the real effective exchange rate corresponds to a real appreciation.

Source: Authors' calculations from NIGEM

An important result is that the five countries considered are characterised by a relatively high level of sensitivity, the United States and South Korea displaying respectively the highest and the lowest one. The level of these elasticities can be explained first by the trade openness. Indeed, the magnitudes of the sensitivities of misalignment β_{ii} are inversely related to the degree of trade openness[6]. The larger the degree of openness, the less sensitive the misalignment to the imbalance of the country involved. In other words, only a small adjustment of the exchange rate is required to reduce the imbalances of a very open economy. The United States, which is characterised by a low openness degree, as shown in Table 9, has a very high elasticity, whereas South Korea displays a low elasticity.

Table 9: Degree of trade openness[7], 2002

The United States	Japan	Euro area	South Korea	China
0.11	0.08	0.13	0.28	0.24

Source: Authors' calculations from NIGEM.

6 Cf. Appendix 2.

7 Share of imports of goods in GDP.

While China has an openness degree close to South Korea's one, it is characterised by a higher elasticity, β_{ii}. Trade price elasticities and the export-to-import ratio, which define for each country the Marshall-Lerner condition, can explain this feature. As shown in table 10, the Marshall-Lerner condition is fulfilled for China but at a lower degree than in South Korea. This means that its trade reacts less strongly to an exchange rate change. A higher change in parities is thus required to adjust large trade imbalances. As regards the crossed sensitivities, they are positively related to the size of the macroeconomic linkages between countries. The highest crossed elasticity for Chinese economy is the one with the United States and Japan.

Table 10: The Marshall-Lerner condition, 2002

	The United States	Japan	Euro area	South Korea	China
Export-to-import ratio (τ)	0.59	1.23	1.19	1.07	1.11
Export price elasticity (ε_x)	0.52	1.19	0.69	1.13	0.50
Import price elasticity (ε_m)	0.75	0.61	0.41	0.50	0.95
Marshall-Lerner condition ($\tau\varepsilon_x + \varepsilon_m - 1$)	0.05	1.07	0.23	0.71	0.51

Source: Authors' calculations from NIGEM.

3.3 Defining the internal equilibrium and structural current accounts

Internal and external equilibria are difficult to assess for catching-up countries especially when they are experiencing a transition to market economy, as China. As regards internal imbalances, Isard and Faruqee (1998) recommend computing domestic output gaps, which are not available for non OECD countries, by using a Hodrick-Prescott filter. This is a practical way to deal with the issue of internal equilibrium, although the concept of the output gap itself may be questionable for transition countries. Here we use output gaps extracted from OECD figures for the industrialised countries (the United States, Japan and Euro area) and we compute output gaps by applying a Hodrick-Prescott filter for China and South Korea.

The structural current account is the current account position that would result in the present year if output gaps were null and the effects of past exchange rate changes had fully materialised. In other words, the structural current account is the current account that would be observed in the medium-long run if the real exchange rates remained at their current values and the activity was at its potential output.

The approach used here is similar to the one developed by Bayoumi and Faruqee (1999) at the IMF. It assumes that the total impact of real exchange rates on trade quantities is felt within three years. For Bayoumi and Faruqee (1999), the lag structure is the following: 60% of the effect during the first year, 25% in the second year and 15% in the third year (as

in the MULTIMOD estimations). In this case, the current account could be expressed by equation (3.6)[8]:

$$ca_{i,t} = -\mu_i\left[(\tau_i\varepsilon_{xi} + \varepsilon_{mi})\left(0.6q_{i,t} + 0.25q_{i,t-1} + 0.15q_{i,t-2}\right)\right] + \mu_i\, q_{i,t} + \mu_i\left(\tau_i\eta_{xi}\, og^*_{i,t} - \eta_{mi}\, og_{i,t}\right) \quad (3.6)$$

where:

$og^*_{i,t} = \sum_{j\neq i}\alpha_{ij}\eta_{mj}og_{j,t}$ is the impact of the other countries output gaps on the current account of country i.

τ_i is the export-to-import ratio of country i

μ_i is the share of imports in GDP of country i

The structural current account is then given by fixing the real exchange rate at a constant value in equation (3.6) :

$$ca'_{i,t} = -\mu_i\left(\tau_i\varepsilon_{xi} + \varepsilon_{mi} - 1\right)q_{i,t-2} \quad (3.7)$$

Subtracting equation (3.7) from (3.6), and reorganising the lags in equation (3.6), we get an expression of the difference between the structural current account and the observed one:

$$\begin{aligned} ca'_{i,t} = {} & ca_{i,t} - \mu_i\ (\tau_i\ \varepsilon_{xi} + \varepsilon_{mi})\ \left[\ \left(\tilde{q}_{i,t} - q_{i,t}\right) + 0.40\left(q_{i,t} - q_{i,t-1}\right) + 0{,}15\ \left(q_{i,t-1} - q_{i,t-2}\right)\right] \\ & + \mu_i\left(\tilde{q}_{i,t} - q_{i,t}\right) + \mu_i\left[\eta_{mi}\, og_{i,t} - \tau_i\,\eta_{xi}\, og^*_{i,t}\right] \end{aligned} \quad (3.8)$$

Equation (3.8) shows that the structural current account is equal to the observed current account corrected by two types of terms: lags in the exchange rate changes and output gaps of the home country and its partners.

In this paper, we use a more complex lag structure, for we take the quarterly model NIGEM to assess the impact of the lagged exchange rates changes during the 12 following quarters. The numerical resolution generates current accounts adjusted from the effect of output gaps of the home country and its partners.

3.4 Two approaches for defining the external equilibrium

As regards external equilibrium, the problem is to choose the appropriate definition for what constitutes a sustainable current account balance. Two methods are proposed: the first one relates to a normative assessment based on the determination of "structural" capital flows; the second one is obtained by estimating empirical saving-investment balances across countries in relation to the economic fundamentals.

[8] We apply the specifications used in the simplified three-country model given in Appendix 2.

Under the first approach, according to Williamson (1994), the relevant assets to calculate sustainable current accounts are "structural" capital flows. However, they cannot be determined from an analysis of the balance of payments alone, as the long-term operations recorded here do not necessarily involve structural (i.e., long-term) capital. For this reason, the "desirable" level of the current account is linked to the net external position compatible with the country's debt cycle and demographic characteristics. However, as Williamson himself recognises, his approach can produce current-account deficit levels for some countries that are not sustainable in the medium term. Therefore he suggests applying the conventional sustainability rule, which consists in stabilising the debt-to-GDP ratio at a given level. The standard sustainability constraint implies that a country with a deficit must be able to generate sufficient trade surpluses in the future to repay existing debt or at least to stabilise the debt-to-GDP ratio at a sustainable level, in the spirit of Milesi-Feretti and Razin (1996). On this criterion, a current-account deficit that complies with the rule is deemed sustainable and can continue to be financed by capital inflows (Williamson, 1994). Following this first approach, Mahar and Williamson (1998) calculated a set of current account outcomes for all countries and/or regions of the world[9]. The main advantage of this study is to provide current accounts targets consistent at a world level, from which consistent equilibrium exchange rates can be derived. This is why we have used it here as inputs for the model. Table 11 displays equilibrium current accounts derived from the study by Williamson and Mahar (1998) for the five countries considered.

Table 11 : Equilibrium current account, in % of GDP

	The United States	Japan	Euro area	South Korea	China
Current account targets	-2.0	1.9	0.6	-0.2	-2.8

Source: Williamson and Mahar (1998)

Mahar and Williamson (1998) assessed that a current account deficit of 2.8 percent of GDP is a reasonable objective for China, over the following years. This estimation was made on the ground that China is a developing country, that can be expected to invest more than its domestic savings, which is in line with the catching-up process. They thought that China would have no difficulty in importing enough capital to finance such a deficit, especially because of the catching-up process.

However, Williamson (2003) recognised that the current account target of -2.8% that he postulated in his former paper, was too low. He now considers that a deficit target of 1% or a balanced current account is a more reasonable for China. Therefore, we also consider that our second approach is more appropriate, for it yields a current account target of -1.5% for China.

Under this second approach, the external balance is defined as the "normal" position of excess domestic savings over investment. This "normal" position is derived from the fitted

[9] allowing for the world statistical discrepancy.

values of an econometric model of saving-investment balances. This estimation relates investment and saving flows to their medium-term structural determinants, notably the fiscal position, demographic variables and relative country size (Debelle and Faruqee, 1998).

Following this approach and in the spirit of the study by Chinn and Prasad (2000), Jeong and Mazier (2002) calculated values of equilibrium current accounts by estimating a model of the saving-investment balance. The following panel regression of the current account was estimated for the period 1981-2000 on 19 industrialised countries and 18 emerging countries:

$$CA_{it} = a_1 GOV_{it} + a_2 DEP_{it} + a_3 Y_{it} + a_4 FDI_{it} + a_5 NFA_{it} + a_6 OPEN_{it} + a_7 GAP_{it} + b_i + c_t + u_{it} \quad (3.9)$$

where CA is the current account; GOV, the budget surplus, both in percentage to GDP; DEP, the dependency ratios; Y, the per capita income in % of the US; FDI, net foreign direct investment; NFA, net foreign assets; $OPEN$, openness ratio, computed as the sum of exports and imports divided by GDP; GAP, the output gap.

The signs of coefficients obtained for emerging countries are in line with the regression findings by Chinn and Prasad (2000). The emerging countries regression shows a positive effect of the government surplus on the saving-investment balance, while the dependency ratios have a negative effect on the equilibrium current account. The regression analysis suggests also a positive effect of relative per capita income, which reflects that countries at most advanced stages of development tend to be capital exporters. Among the other variables tested in the regression analysis, the net inflows of FDI permits a deterioration of the current account. Openness, which is viewed as enhancing a country's ability to attract foreign capital, is also found to have a negative effect on the current account ratio to GDP. The positive coefficient of the foreign assets reflects the direct contribution to the current account of the factor income provided by the foreign assets.

When this equation is applied to China, the results show a saving-investment norm of -1.5% of GDP. This seems more credible, than the current account target of -2.8% of GDP found by Williamson and Mahar (1998). In both estimations, a current account deficit is obtained, instead of the surplus recorded in recent years. As the saving-investment balance approach relies on an econometric analysis and less on relatively *ad hoc* judgements about equilibrium capital flows, it is often viewed as more relevant for the determination of equilibrium current accounts. Nevertheless the saving-investment norms derived from the econometric analysis are also uncertain, especially for emerging countries that undertake major structural reforms and experience major changes in their economy (Isard and alii, 2001). According to Mogliani and Cao (2004), the high saving rate reached in China in the early 1990s could be explained by the explosive growth pattern of the economy and the specific demographic policy. Nevertheless, according to the these authors, the personal saving rate has already passed its crest: nothing ensures that the Chinese growth will continue at the same pace in the coming years and the dependency ratio has already fallen. As these structural changes underlie structural capital flows, one must recognise that Chinese saving-investment balance could be significantly impacted by the future.

3.5 Calculated misalignments

We derive effective real exchange rate misalignments, as described in equation (3.5). We also compute simultaneously bilateral real exchange rate misalignments. Two sets of equilibrium current accounts are successively used: the first one is based on the work by Williamson and Mahar (1998); the second one - that we consider more appropriate for China - on the saving-investment norms estimated by Jeong and Mazier (2002) and described in the previous section.

First, we use current account targets by Williamson and Mahar (1998). Table 12 presents the results for the five considered countries. The yen, the euro, the won and the renminbi were undervalued by 10 to 33% in 2002 and 2003 in terms of effective exchange rates, while the overvaluation of the dollar seemed more substantial at 35%. Although there are large uncertainties on these results, the size of these misalignments is high enough to raise serious doubts on these five currencies. These results are largely due to large imbalances on the external accounts but also to the high level of misalignment elasticities to imbalances, as previously explained. Because of their features (trade price elasticities, trade openness, import-to-export ratio), these economies seem not very sensitive to variations in their exchange rates (except South Korea). Therefore, large movements in the exchange rate are needed to reach an equilibrium rate, able to correct a large external imbalance. As the dollar is overvalued against all the other considered currencies, the bilateral undervaluations against the dollar are more pronounced, especially for the renminbi.

Table 12: Exchange rate misalignments[1], in %, based on current accounts targets of Williamson and Mahar (1998) [2]

	U.S. dollar	Yen	Euro	Won	Renminbi
For year 2002					
Effective exchange rate[3]	+37	-16	-17	-18	-33
Bilateral rate versus U.S. $	-	-36	-34	-43	-59
For year 2003					
Effective exchange rate[2]	+35	-20	-10	-18	-30
Bilateral rate versus U.S. $	-	-37	-27	-42	-54

(1) A positive sign indicates currency overvaluation and a minus sign currency under-valuation

(2) The current account targets are given in Table 11

(3) Real effective exchange rate, deflated by CPIs.

Source: Authors' calculations

Second, we use the saving-investment norms made by Jeong and Mazier (2002). This modifies the Chinese equilibrium current-account target to –1.5% of GDP, instead of –2.8% previously. This assumption is more likely and also closer to observation. Since equilibrium current accounts are globally consistent, it is not possible to change a single country's external target without changing the others. We assume then that the lower deficit-target in China is matched by a move to lower surplus or larger deficit targets in the other countries.

Table 13 displays the assumptions and results. As expected, a lower deficit target in China results in lower currency misalignments (than in table 12), since for all countries, a lower change in the exchange rate is required to restore the current account equilibrium. However, misalignments remain high, especially in bilateral terms, which suggests that exchange rates movements may be not sufficient to enhance the international adjustment of current account imbalances.

Table 13: Exchange rate misalignments[1] in %, with revised assumptions on current account targets

	The United States	Japan	Euro area	South Korea	China
Assumptions on current account targets, in % of GDP	-2.5	1.9	0.5	-0.2	-1.5
	U.S. dollar	Yen	Euro	Won	Renminbi
For year 2002					
Effective exchange rate[2]	+32	-14	-14	-16	-27
Bilateral rate versus U.S. $	-	-31	-29	-37	-49
For year 2003					
Effective exchange rate[2]	+29	-18	-7	-15	-23
Bilateral rate versus U.S. $	-	-33	-22	-35	-44

(1) A positive sign indicates currency overvaluation and a minus sign currency undervaluation

(2) Real effective exchange rate in consumer-price terms.

Source: Authors' calculations

3.6 What would be the implications of a renminbi's revaluation?

Recently, the international debate has focused on the "sustainability" of the currencies of the major countries, especially the renminbi. The common suspicion has been that the renminbi is undervalued and the question is whether this undervaluation has become unsustainable. This could be the case if it prevents the adjustment of external imbalances of other countries, especially the United States. The FEER approach could be also used to answer this question. In this framework, if a country as China has a bigger structural current account surplus than is needed to maintain a sustainable balance of payments position for the foreseeable future, then its currency is undervalued. Moreover, as China is a large country, there is a good reason to think that renminbi's undervaluation influences its partners' equilibrium exchange rates and, more generally, the international adjustment of current account imbalances.

The crossed elasticities, which measure the sensitivity of a country's currency misalignment relative to its partners external imbalances, indicate whether a country's currency misalignment can be influenced by its partners' equilibrium exchange rates. As shown in Table 8, the highest crossed elasticity for the United States is the one with the Japan (2.4) and the euro area (1.7). In fact, the dollar's effective equilibrium exchange rate seems only weakly affected by the renminbi's misalignment (elasticity of 0.3). This suggests that a revaluation of the renminbi would have only a small effect on the US external deficit.

3.7 Uncertainties

One drawback of the FEER approach is the difficulty to define the internal equilibrium for catching up countries, like China. As internal equilibrium is calculated on a statistical basis, growth rates, around 8-10% per year in the last decade, could give a fallacious impression of an economy growing at its potential growth. However, this is not really true, as far as some part of the labour force could be seen as in a situation of "disguised" unemployment. This idea is developed by Dooley and alii (2004). According to them, the Chinese economy has hundred of millions of workers, that are kept in under-productive jobs, in order to avoid a massive rural exodus that would yield unemployment and raise poverty. Progressively these workers will join more productive sectors, open to foreign competition. They assess that around 20 millions workers are joining the productive sector each year. This number is also cited by Lok (2004).

This figure is also confirmed by Chinese sources, that give a number of 150 millions workers in a situation of disguised unemployment in rural areas, 10 millions of which are allowed to migrate each year to a more productive sectors in towns. These migrants add to the 10 millions of young people reaching the age of 18 each year, therefore entering the labour market (unless studying). In this condition, internal equilibrium is not achieved in the recent period, and despite the 10% growth rate, the output gap could be considered as negative. In this framework, it is possible that there is no undervaluation of the exchange rate.

By construction, the FEER method explains the current account by two factors, a competitiveness factor, represented by real exchange rates and a demand factor, proxied by relative output gaps. However, the current account surplus, observed in 2003 in China, may be due to other determinants. The high Chinese saving rate, that depends on exogenous factors like demographic structure, is another element of explanation. In the last decade, the structural high saving rate has obviously contributed to limit imports in consumption goods. It is likely that in the future, the diffusion of western way of life will boost Chinese households consumption, and that the current account surplus will disappear, independently of the evolution of the exchange rate. In this case, the calculated misalignment of the exchange rate would also diminish.

3.8 Comparisons with previous results

Summarising all results obtained in this paper, we get an estimated undervaluation comprised between 18% and 54%. This large misalignment is in line with other available estimates derived either from FEER or BEER approaches (Jeong and Mazier, 2003; Bénassy-Quéré and alii, 2004). Table 14 shows that these studies also find a large undervaluation of the renminbi, especially against the dollar in the early 2000s. Other studies also suggest that the renminbi exchange rate is undervalued, although they do not provide an exact calculation. For example, Williamson (2004) estimates that the Chinese currency is undervalued on the order of 15 to 25%, Bergsten (2004) gives a similar figure: between 20 to 25%.

Using FEER approach, all estimations find a large undervaluation of the renminbi, because, in the early 2000s, the structural current account in China is found greater than the "normal" one. The size of the undervaluation depends on the current account target that is set and also of the models parameters.

Table 14: Estimates of the renminbi's equilibrium exchange

Author	Method	Type of exchange rate	Period	Undervaluation (-)
Jeong and Mazier (2003)	FEER with a current account target of –1.5%	REER dollar	2000	-33% -60%
Wren-Lewis (2004)	FEER, with a current account target of 0	dollar	2002	-28%
This paper	FEER with a current account of -1,5%	REER dollar	2003	-23% -44%
Goldstein, (2004)	Simplified FEER , with a current account of 1%	REER	203	-15-30%
Bénassy-Quéré et alii (2004)	BEER, panel of G20 countries	dollar	2003	-47%,-44%
This paper	Regression in level, sample of 93 emerging and developing countries	dollar	2003	-41%
This paper	BEER, panel of 21 emerging countries	dollar	2002	-18%
Wang (2004)	BEER, 1 country	REER	2003	Near 0

Using BEER approach, the estimations generally rely on the Balassa effect, predicting a real appreciation of the exchange rate along with the catching-up, when tested on a large sample of countries. As there was no real appreciation in China despite the rapid GDP growth, it is not surprising that these models result in an undervaluation of the renminbi. In the study of Bénasy and alii (2004), another variable is included in the model : net foreign assets are supposed to yield an appreciation of the currency, which is validated on a large sample of countries. Here again, the increase in net foreign assets in China should have resulted in an appreciation of the renminbi. Therefore, it is not surprising that the BEER estimates result in an undervaluation of the renminbi, when they are tested on a panel of countries.

However, the IMF position, as stated in the Article IV Report 2004 on China, considers that there is no misalignment of the exchange rate. This position relies on a study made by Wang (2004), in an IMF occasional paper. The author uses a BEER model, including a Balassa effect, net foreign assets and the degree of openness. The estimation is not done on a panel of countries, like other studies, but on a single country: China. The regression is made on 24 observations (annual data between 1980 and 2003) with 8 explicative variables (the three mentioned above plus a constant, plus 4 dummies). The small size of the sample

compared to the number of regressors makes the fitted value of the regression very close to the observed value. Therefore, it is not surprising that the misalignment, set equal to the residual of the regression, is found close to zero, in this study.

4. CONCLUSION

Various approaches have been used to assess the existence and the size of the renminbi's misalignment. First, several economic indicators tend to show some signs of undervaluation of the real exchange rate of China during the recent years : real effective exchange rate depreciation, surging forex reserves, current account surplus... We have then addressed the issue of the "Balassa effect", in the framework of a BEER approach. The results show a lack of this effect in China, although "Balassa effect" is confirmed in a large sample of countries. To go deeper into the question of undervaluation, we have followed a FEER approach which allows us to calculate the real exchange rate that is consistent with sustainable current accounts. Our results show that China's real exchange rate was highly undervalued in 2002 and 2003 in effective terms and even more against the US dollar. Using the model with different assumptions, we have analysed how the magnitude of currencies misalignments are modified with a lower deficit target for China. As expected, the renminbi's misalignment is less pronounced. Moreover, hard we taken into account the disguised unemployment, undervaluation would have been still weaker. An other interesting result is that the dollar's effective equilibrium exchange rate seems only weakly affected by the renminbi's misalignment. This suggests that a revaluation of the renminbi would have only a small effect on the US external deficit. If the exchange rate was to float now, upward pressures in the forex market would likely produce a nominal appreciation of the renminbi. However, a hasty liberalisation of capital outflows could reverse the market trend.

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APPENDIX 1

Log-linear model of the standard trade block in NIGEM[10]

[A1] Export equation: $xgi_i(t) = s_i(t) + b_{i1}[pxg_i(t) - cpx_i(t)]$

The world demand for exports from country i, $s_i(t)$ is defined as the weighted sum of imports from partner countries[11] as in equation A11. The export price competitiveness is defined as the ratio of the exports of their main competitors (cpx_i) to their export prices (pxg_i).

[A2] Import equation: $mgi_i(t) = c_{i1}tfe_i(t) + c_{i2}[pmg_i(t) - ced_i(t)]$

The demand variable in equations for imports is total final expenditure (tfe_i). Import price competitiveness is defined as the ratio of import prices (pmg_i) to producer prices or consumer prices (ced_i).

[A3] Service exports equation:

$$xser_i(t) = d_{i1}(t)wdmser_i(t) + (1 - d_{i1}(t))mser_i(t) + d_{i2}(t)refex_i(t)$$

Service exports ($xser_i$) are a function of a demand term defined as the service imports of the other countries ($wdmser_i$). The competitiveness indicator ($refex_i$) is the real effective exchange rate deflated by the consumer price index (equation A10).

[A4] Service imports equation: $mser_i(t) + rx_i(t) - ced_i(t) = e_{i1}tfe_i(t) + e_{i2}refex_i(t)$

Service imports ($mser_i$) are determined by a demand term, equal to total final expenditure (tfe_i). The competitiveness indicator ($refex_i$) is identical to the one used for service exports.

[A5] All-goods exports price equation: $pxa_i(t) = f_i(t)pxg_i(t)$

Non-manufactured export and import prices are proxied by international commodities prices (agricultural-foods prices for developed and developing countries; agricultural non-foods prices; metal and mineral prices; oil prices). The all-goods export price is obtained by

[10] This specification is common to all countries except the United States and Japan, whose oil imports are modeled explicitly and China, whose services trade is not modeled.

[11] The weighting, obtained from an all-goods trade matrix, is assumed to be independent of the level of world activity, implying a unit long-term elasticity on the import-demand variable. The long-term world demand elasticity of exports is therefore constrained to unity for all countries.

summing the manufactured export prices and international prices defined earlier, weighted by each sector's share of the national economy. For simplicity's sake, we suppose that international commodities prices are at their equilibrium level, so that the all goods exports price is a function of only export prices for manufactured goods (equation A5). We use the same method to determine the all-goods import price (equation A6).

[A6] All-goods imports price equation:

$$pma_i(t) = f_{i1}(t)[pmg_i(t) - rx_i(t)] + f_{i2}(t)wdpxg_i(t) + rx_i(t)$$

The all-goods imports price is a function of import prices for manufactured goods.

[A7] Manufactured import prices equation: $pmg_i(t) = \sum h_{ij}(t)(pxg_j(t) + rx_i(t))$

Manufactured import prices are calculated as a weighted average of foreign export prices; the weighting h_{ij} reflects the import structure.

[A8] Competitor prices equation: $cpx_i(t) = \sum w_{ij}(t)pxg_j(t)$

The competitor prices are calculated so as to take into account competition in third markets: the weight w_{ij} of each export competitor j in a given country i's competitiveness index depends on the shares of the competitor j's in the country i's export markets.

[A9] Manufactured exports price equation: $pxg_i(t) = -o_{i1}rx_i(t) + o_{i2}cpx_i(t)$

The export prices equation illustrates the margin-adjustment behaviour of local exporters, who set their prices as a weighted average of their domestic prices and their competitors' prices on third-country markets.

[A10] Effective real exchange rate equation: $refex_i(t) = \sum_{j=1}^{5} k_{ij}(t)rx_j(t)$ with $k_{ii} = 1$

This effective real exchange rate is defined in consumer-price terms and explains the services trade. The weights come from the matrix of bilateral trade flows, and they are the sum of services exports from j to i and services imports into j from i divided by the sum of all of j's services exports and imports.

[A11] World demand for manufactured goods equation: $s_i(t) = \sum_{j=1}^{5} l_{ij}(t)mgi_j(t)$

The world demand is defined as the weighted sum of imports from partner countries.

[A12] Total final expenditure equation: $tfe_i(t) = m_i(t)y_i(t) + (1 - m_i(t))mgi_i(t)$

The total final expenditure is obtained by summing domestic GDP (y_i) and domestic imports (mgi_i), weighted by each component's share of final expenditure.

[A13] World demand for services equation: $wdmser_i(t) = \sum_{j=1}^{5} z_{ij} mser_j(t)$

This variable is calculated as the sum of service imports by all partner countries.

[A14] Current account equation:

$$cbv_i(t) = a_{i1}[pxa_i(t) + xgi_i(t)] - a_{i2}[pma_i(t) + mgi_i(t) - rx_i(t)] + a_{i3}(t)xser_i(t) - a_{i4}(t)mser_i(t)$$

with, $cbv_i(t)$ current account in points of nominal GDP.

- *pxa* Prices (in US$) of exports of goods calculated as a weighting of manufactured export prices and commodity prices (exogenous).
- *xgi* Exports of goods in constant U.S. dollars
- *pma* Prices of imports of goods in domestic currency
- *mgi* Imports of goods in constant U.S. dollars
- *rx* Nominal exchange rate against U.S. dollar ($1US\$ = RX$ units of domestic currency)
- *xser* exports of non-factor services (i.e., excluding income), in current U.S. dollars
- *wdmser* total imports of non-factor services (i.e., excluding income), in current U.S. dollars
- *mser* imports of services in current U.S. dollars
- *refex* real exchange rate in consumer-price terms
- *tfe* total final expenditure in constant prices, domestic currency
- *y* domestic GDP in constant prices, domestic currency
- *ced* wholesale prices or consumer expenditure deflator (exogenous)
- *s* trade-weighted world demand for country i 's goods
- *cpx* prices of country i 's competitors on third-country markets (in US$)
- *pxg* manufactured export prices (in US$)
- *pmg* manufactured import prices written as a weighted average of manufactured export prices (the h_{ij} values are the shares of j countries in i 's imports)

APPENDIX 2

A simplified three-country model

The trade between three countries is represented by behavioural equations for imports and exports. The rest of the world is treated as exogenous. In this simplified framework, export prices of country i are assumed to be equal to domestic producer prices P_i and independent of fluctuations in the real exchange rate (there is no price to market behaviour), although it is not the case in the complete model, given in appendix 1.

$$X_i = X_{0i}\left(\prod_{j\neq i} M_j^{\alpha_{ij}}\right)^{\eta_{xi}} Q_i^{-\varepsilon_{xi}} \qquad [B1]$$

$$M_i = M_{0i} Y_i^{\eta_{mi}} Q_i^{\varepsilon_{mi}} \qquad [B2]$$

where Q_i is the real effective exchange rate of country i defined as the ratio of domestic prices to foreign prices in country i (an increase stands for an appreciation); X_i and M_i the quantities exports and imports of i, and Y_i its aggregate demand.

By log-differentiating (B1) and (B2) at the neighbourhood of an equilibrium, we get :

$$x_i = \frac{dX_i}{X_i} = \eta_{xi}\sum_{j\neq i}\alpha_{ij} m_j - \varepsilon_{xi} q_i \qquad [B3]$$

$$m_i = \frac{dM_i}{M_i} = \eta_{mi} og_i + \varepsilon_{mi} q_i \qquad [B4]$$

where $og_i = \frac{Y_i - \overline{Y_i}}{\overline{Y_i}}$ is the output gap and $q_i = \frac{Q_i - \overline{Q_i}}{\overline{Q_i}}$ is the rate of deviation in the real exchange rate relatively to its equilibrium value, $\overline{Q_i}$. In this sense, q_i stands for the misalignment of currency i, which is the difference between country i's real effective exchange rate and its equilibrium level.

The nominal current account CA of country i expressed in local currency can be written as equation (B5):

$$CA_i = P_i X_i - P_i M_i / Q_i - r_i D_i \qquad [B5]$$

where D_i is the net foreign debt of country i and r_i the interest rate paid on this debt.

By differentiating the current account equation in the neighbourhood of the equilibrium, and assuming the factor incomes exogenous, we get:

$$\frac{dCA_i}{P_i M_i / Q_i} = \frac{1}{\mu_i}\left(ca_i - \overline{ca}_i\right) = \tau_i x_i + q_i - m_i \qquad [B6]$$

where ca is the current account expressed in % of GDP and $ca_i - \overline{ca}_i$ the deviation in the current account in % of GDP from its medium-run equilibrium level; $\tau_i = \frac{P_i X_i}{P_i M_i / Q_i}$ is the export-to-import ratio of country i; $\mu_i = \frac{P_i M_i / Q_i}{P_{yi} Y_i}$ is the share of imports in GDP of country i.

By substituting x_i and m_i with their expressions in equations (B3) and (B4), we obtain equation (B7), that can be considered as a three-equation system for $i = 1,2,3$, with three unknowns q_1, q_2, and q_3:

$$q_i\left(\tau_i \varepsilon_{xi} + \varepsilon_{mi} - 1\right) = -\frac{1}{\mu_i}\left(ca_i - \overline{ca}_i\right) + \tau_i \eta_{xi} \sum_{j \neq i} \alpha_{ij}\left(\eta_{mj} og_j + \varepsilon_{mj} q_j\right) - \eta_{mi} og_i \qquad \text{[B7]}$$

By solving this system[12], we can express the misalignment q_i as a function of the gaps of the three economies to their internal and external equilibria :

$$q_i = \sum_{j=1}^{3} \beta_{ij}\left(ca_j - \overline{ca}_j\right) + \sum_{j=1}^{3} \gamma_{ij} og_j \qquad \text{[B8]}$$

which is equivalent to the following formulation:

$$q_i = \sum_{j=1}^{3} \beta_{ij}\left(ca'_j - \overline{ca}_j\right) \qquad \text{[B9]}$$

where ca'_j corresponds to country j's structural current account. The structural current account is the current account position that would result in the present year if output gaps were null and the effects of past exchange rate changes had fully materialised.

If we neglect the lagged effects of real exchange rate changes, the structural current account

12 As there are only ($n-1$) independent bilateral exchange rates, it is not valid to estimate multilateral real exchange rates independently, as in this simplified example. If world trade is fully modelled (i.e. trade weights associated with bilateral exchange rates sum to one), there is a linear constraint across the effective exchange rates. Given any ($n-1$) effective exchange rates, the remaining or redundant rate can be therefore calculated from this relationship (for more details, see Faruqee, 1998). We get around the overdetermination problem by ignoring the rest-of-the-world equation. More precisely, the effective exchange rate for the rest of the world is assumed to ensure global consistency. In other words, "the rest of the world's currency" is assumed to be numeraire ex ante. Consequently, this assumption enables us to derive a set of consistent bilateral exchange rates.

can be written as equation (B10):

$$ca_i' = ca_i + \mu_i \left(\eta_{mi} og_i - \tau_i \eta_{xi} \sum_{j \neq i} \alpha_{ij} \eta_{mj} og_j \right) \quad \text{[B10]}$$

Coming back to equation (B9), the coefficient β_{ij} stands for the elasticity of i 's currency misalignment (q_i) relative to the deviation from country j 's structural current account to external balance target.

The analytical expression of these elasticities β_{ij} is complicated, even in this simplified framework. For example, for country 1, the resolution of the model gives the following values:

$$\beta_{11} = -\frac{1}{\mu_1} \left[\frac{(\tau_2 \varepsilon_{x2} + \varepsilon_{m2} - 1)(\tau_3 \varepsilon_{x3} + \varepsilon_{m3} - 1)}{\Delta} - \frac{(\tau_2 \eta_{x2} \alpha_{23} \varepsilon_{m3})(\tau_3 \eta_{x3} \alpha_{32} \varepsilon_{m2})}{\Delta} \right] \quad \text{[B11]}$$

$$\text{with } \Delta = (\tau_1 \varepsilon_{x1} + \varepsilon_{m1} - 1)(\tau_2 \varepsilon_{x2} + \varepsilon_{m2} - 1)(\tau_3 \varepsilon_{x3} + \varepsilon_{m3} - 1) + \sigma \quad \text{[B12]}$$

where σ are terms of second order (in $\alpha_{ij} \alpha_{k1}$) which can be neglected.

A rough approximation of β_{11} is given by equation (B13):

$$\beta_{11} \approx -\frac{1}{\mu_1 (\tau_1 \varepsilon_{x1} + \varepsilon_{m1} - 1)} \quad \text{[B13]}$$

Under the Marshall-Lerner conditions, and according to the approximation given in equation (B13), the coefficients β_{11} should be negative. Equation (B13) also shows that the magnitude of the coefficient β_{11} is inversely related to the degree of openness μ_i and to the trade price elasticities.

Equation (B14) gives an example of a crossed coefficient β_{ij} and equation (B15) gives approximation:

$$\beta_{12} = \frac{1}{\mu_2} \left[\frac{(\tau_1 \eta_{x1} \alpha_{12} \varepsilon_{m2})(\tau_3 \varepsilon_{x3} + \varepsilon_{m3} - 1) - (\tau_1 \eta_{x1} \alpha_{13} \varepsilon_{m3})(\tau_3 \eta_{x3} \alpha_{32} \varepsilon_{m2})}{\Delta} \right] \quad \text{[B14]}$$

$$\beta_{12} \approx \frac{\alpha_{12}}{\mu_2} \left[\frac{\tau_1 \eta_{x1} \varepsilon_{m2}}{(\tau_1 \varepsilon_{x1} + \varepsilon_{m1} - 1)(\tau_2 \varepsilon_{x2} + \varepsilon_{m2} - 1)} \right] \quad \text{[B15]}$$

According to equation (B15), the crossed coefficients β_{ij} with $j \neq i$, should be positive. They are related to the intensity of trade between the two countries, measured by the

parameters α_{ij}.

If we consider a world with n countries, the expression of the misalignment of currency i can be generalised from the three-country solution given in equation (B9):

$$q_i = \frac{Q_i - \overline{Q_i}}{\overline{Q}} = \sum_{j=1}^{n} \beta_{ij} \left(ca'_j - \overline{ca}_j \right)$$

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