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Real Exchange Rate Misalignment: A Panel Co-Integration and Common Factor Analysis

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Abstract

We combine some newly developed panel co-integration techniques and common factor
analysis to analyze the behavior of the real exchange rate (RER) in a sample of 64
developing countries. We study the dynamic of the RER with its economic fundamentals:
productivity, the terms of trade, openness, and government spending. We derive a number of
common factors that explain the dynamic of the RER in our sample. We find that while some
fundamentals such as productivity, terms of trade, and openness are strongly related to these
common factors in low-income countries, no such link is found for the middle-income
countries. We also derive the misalignment indices, which seem to reproduce recent episodes
of overvaluation and undervaluation in a number of countries.

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I. INTRODUCTION

Research related to exchange rate management still remains of interest to economists, despite a relatively vast literature that exists in the area. The real exchange rate *(RER)*[2] is not only an important relative price, but also signals the competitiveness of a country vis-à-vis the rest of the world. A number of papers have found that the level of the *RER* relative to an equilibrium *RER,* and its stability, importantly influence exports and private investment (e.g., Caballero and Corbo, 1989; Serven and Solimano, 1991). Díaz-Alejandro (1984), drawing from the experience of Latin America, argues that *RER* misalignment and especially overvaluation with respect to the equilibrium *RER* can be detrimental to an export-oriented development strategy.

The measurement of the *RER* misalignment for appropriate policy intervention is then an important issue. However, the literature in this area has not reached a clear consensus. This is because measuring the degree of misalignment is difficult, as it involves measuring an unobserved variable, the *equilibrium RER.* For many years, policymakers have been relying on a misalignment measure based on the so-called purchasing power parity *(PPP)* doctrine. It consists of the choice of a base period in which the economy is thought to have been in equilibrium, and then the *RER* for this year is assumed to be the equilibrium for the rest of the sample period.

This approach is obviously questionable because the equilibrium *RER* is not a static indicator and moves over time as the economy's fundamentals move. As a consequence, and rightly pointed out by Elbadawi (1994), the *PPP* approach runs the risk of identifying as a misalignment what may in fact be an equilibrium movement in the RER.[3]

Given the limitations of the *PPP* approach, the 1980s witnessed the emergence of a new literature that tried to estimate the equilibrium exchange rate. It consists of estimating the equilibrium exchange rate using economy fundamentals. Since most of the macroeconomic variables—especially the real exchange rate—are nonstationary, the estimation requires some time series techniques. As a consequence, most studies estimating the equilibrium exchange rate in the 1980s and 1990s focused on individual countries and time series data (e.g., Williamson, 1994). But most of these studies, especially those concerning developing countries where data availability goes back only to the 1960s or 1970s, have to use short time series data or a small sample for the estimation. The consequence is that most of these estimations run the risk of not being robust, leading to nonreliable measures of misalignment. For example, the situation in the CFA zones prior to the 1994 devaluation illustrates this problem. While most observers agreed that the *RER* in the CFA zones was overvalued, they disagreed on the extent of the overvaluation. This is important, as it determines the degree of policy intervention or devaluation needed. Hence the need to develop empirical models that will deliver reliable measures of misalignment.

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[2] In this paper, we use the real effective exchange rate.

[3] See also Williamson (1994) for a detailed discussion on the *PPP* approach.

Recently, econometric theorists have developed new methods that help to apply some time series techniques to panel data (e.g., Breitung, 2002; Im et al, 2003; Kao and Chiang, 2000). This has reenergized the empirical literature estimating the equilibrium real exchange. As a result, there are some very recent studies estimating the equilibrium *RER* where countries are pooled and time series techniques are applied to panel data (e.g., Calderon, 2002). However, this very recent literature, which uses panel data co-integration techniques, has not included other shocks such as government shocks that generate deviation from the long-run *PPP*. This literature also has not taken advantage of the use of factor analysis that allows us to examine the common factors that explain these deviations.

In this paper, we hope to contribute to this literature by tackling these issues. In particular, we implement an empirical analysis that makes use of the new panel data co-integration techniques and includes government shocks. Most importantly, we improve the evaluation of the real exchange rate deviations from the equilibrium by testing the existence of common factors explaining these deviations.

We follow Edwards (1989), and refer to the equilibrium *RER* as that which prevails when for given sustainable values for other relevant variables, such as terms of trade, capital and aid flows, and technology, the economy achieves both *internal* and *external* equilibrium. For our panel unit root analysis, we use both the panel unit root tests proposed by Im, Pesaran, and Shin (1997), and Hadri and Larsson (2001). We make use of the latter, in addition to the former, because it avoids the lack of power for the test by assuming stationarity under the null hypothesis, and is particularly suitable for panel data series with short time dimension, which is the case in this paper.

Given our panel analysis, we pay special attention to the heterogeneity issue. We show evidence of heterogeneous co-integration relationships by comparing the results from a pooled-based estimator with those obtained with an average-based estimator and also by conducting a common factor analysis. This leads us to conclude that a homogenous equilibrium exchange rate is unlikely to exist in panels of developing countries. This directly implies that calculations of misalignment must be based on the average of the individual exchange rate deviations.

In particular, an in-depth evaluation using our common factor analysis reveals that there exists a relatively low degree of homogeneity with regard to the dynamic of the *RER* in middle-income countries compared to that in low-income countries. Indeed, we find that for the latter there are about 6 or 7 common factors explaining the dynamics of the *RER,* while this number is only about 4 or 5 for the middle-income countries. We analyze whether these common factors are related to the key fundamentals of the *RER*. Our results reveal that while some fundamentals, such as productivity, terms of trade, and openness, are strongly related to our common factors in the low-income countries, no such link is found between fundamentals and common factors in the middle-income countries. In other words, while some fundamentals might account for the joint dynamics of the real exchange rate in low-income countries, the *RER* dynamics in middle-income countries seem to be governed by more heterogeneity.

Based on this analysis, we derive RER misalignments. They show a remarkable success in reproducing the well-known overvaluation and undervaluation episodes in the recent macroeconomic history of a selected number of countries in our sample.

The rest of the paper is organized as follows. The next section specifies the empirical model. Section III describes the data and presents the panel unit root tests. Section IV presents the panel co-integration tests and estimations. Section V lays out the common factor analysis. Section VI analyzes the dynamic of the real exchange rate misalignment. Section VII concludes.

II. SPECIFYING AN EMPIRICAL MODEL

Consider N countries with T observations each, the joint distribution of the *RER,* its fundamentals, and short-run variables can be represented by a vector autoregression *(VAR)* of finite order p, which in turn has an unrestricted vector error-correction representation of the following form.

$$\Delta y_{it} = \alpha_i + \phi_i y_{it-1} + \beta_i' X_{it-1} + \sum_{j=l}^{p} \delta_{ij} \Delta y_{it-j} + \sum_{k=1}^{q} \Upsilon_{ik}' \Delta X_{it-k} + \varepsilon_{it}, \qquad (1)$$

where y is the logarithm of the *RER* and X is the vector of fundamentals and short-run variables which will be described below; $i = 1,..., N$ and t = 1,..., T. This equation says that the *RER* varies with economic fundamentals. Short-run influences are captured by coefficients in the vector γ_{ik}. The real exchange rate's short-term variations can be more or less persistent depending upon the values of the set of parameters δ_{ij}. For instance, if $p = 1$, a value of δ_{i1} near 1 will lead to very persistent adjustment dynamics. It is also important to know whether the exchange rate evolves toward a target value. This target value can be represented as the value compatible with the level of macroeconomic fundamentals in the long run. Since in the long run none of the variables changes, we can put all the variables expressed in variations equal to zero which yields:

$$y_{it} \equiv -(\beta_i' / \phi_i) X_{it} \qquad (2)$$

The double index *ij* refers to a country *i* observed at time t. ε_{it} is a disturbance term distributed as $N(0, \Omega_i)$, where Ω_i is the variance-covariance matrix of the elements of the residuals; γ_i and β_i are $m \times 1$ vectors where *m* is the number of regressors. This equation is the long-run co-integration relationship. A central problem is to obtain estimates of the coefficients that are unbiased and consistent.

A direct application of the OLS estimator indeed yields biased estimates (usually, strong autocorrelations remain in the estimated residuals and further, some bias occurs if some of the regressors are not deterministic). Correction methods are twofold. Some are based on parametric regressions (for instance, Stock and Watson (1993) DOLS estimator can be

transposed to panels), while others uses nonparametric estimators (for instance, a commonly used estimator is the fully modified OLS estimator).

In practice, equation (1) can be estimated using an approach with two steps. In a first step, a long-run (static) equation is estimated by regressing the current values of the *RER* on the contemporaneous values of its fundamentals. In a second step, the residuals of this estimation are introduced in a dynamic short-run equation to form an error-correction model. In this paper, we shall concentrate on the first step given that the aim of the paper is to show evidence of heterogeneous *long-run* relationships between the *RER* and its fundamentals.

The exogenous variables used in this paper include the terms of trade *(TOT),* the degree of openness *(OPEN),* government spending *(GOV),* and productivity *(PROD).* Theoretically, the terms of trade's influence on the *RER* cannot be signed a priori, as this depends on whether income or substitution effects dominate. The former leads to real currency appreciation (increase in *RER)* while the latter to real currency depreciation (decrease in *RER).* An increase in the openness variable is assumed to be arising from a decline in tariff rates, leading to a fall in the domestic prices of importables. This will lead to high demand of foreign currency (to take advantage of cheap imports), and less demand for domestic currency. Hence an increase in the degree of openness is expected to lead to the depreciation of the equilibrium real effective exchange rate. As a result, the openness variable is expected to carry a negative sign.

High government spending is likely to translate into high demand of nontradables, which would lead to a rise in the price of nontradables. According to the definition of *RER* that we use, which is the ratio of the domestic consumer price index (CPI) to the foreign consumer price index, this will lead to a real appreciation. We expect this variable to be positively signed. Similarly high productivity will make the economy stronger leading to an appreciated equilibrium *RER,* hence we expect it to carry a positive sign.

In addition to the fundamentals mentioned above, we also introduce a number of control variables. They include net foreign asset payments *(NFA),* official development assistance *(ODA),* change in the level of reserve *(RESERV),* nominal devaluation *(DEVAL),* and *MACRO,* which is defined as the ratio of the change in domestic credit to lagged money supply. Higher net foreign asset payments from abroad would lead to higher capital inflows with an upward pressure on the exchange rate. We expect this variable to be positively signed. We also expect the *ODA* to influence the exchange rate, as a high level of *ODA* will lead to capital inflows and a high demand of domestic currency leading to an appreciation. Thus, we expect this variable to carry a positive sign. For the same level of money supply, we expect an increase in level of reserve to lead to a currency appreciation. The rate of nominal devaluation is expected to carry a negative sign as it leads to real currency depreciation. Finally, *MACRO* is an indicator of monetary policy. A high level of this ratio strengthens the central bank balance sheet position, and is expected to lead to a real currency appreciation.

III. DATA AND PANEL UNIT ROOT TESTS

A. Data Description

To determine the extent of misalignment, we first need to establish the long-run relationship between the real effective exchange rate and its determinants. To do so, we pool a sample of 64 countries across the world over the period 1979-2000. In what follows, we present the definition and sources of data used in the empirical evaluation.

The dependent variable is the real effective exchange rate. It is the *CPI-based* multilateral real effective exchange rate. The *RER* is defined as the ratio of the domestic consumer price index to the foreign consumer price index. The real effective exchange rate is constructed as the trade-weighted average of the real exchange rate where the weights are generated by the IMF based on both bilateral trade shares and export similarity. According to the definition, an increase in the real exchange rate implies a real appreciation of the domestic currency. Data on this variable are from the IMF.

We follow the literature and use a number of fundamentals for the equilibrium exchange rate. They include the terms of trade, the degree of openness of the economy captured by trade, the productivity, and foreign asset interest payments. In our empirical implementation, the terms of trade is defined as the ratio of export price index to import price index. Data on this variable are drawn from the World Bank database. The second fundamental—the extent of openness—is computed as the ratio of the sum of export and import to the gross domestic product *(GDP).* Data on trade and *GDP* are from the World Bank.

Concerning the relative productivity, we compute the ratio of *GNP* per worker for each country in our sample to the *GNP* per worker in Group of Seven (G-7) countries. To do this, we collect data on labor force and *GNP* for each country in our sample from the *Global Development Finance.* We compute the ratio of *GNP* to labor force to get data on *GNP* per worker. We apply the same method to the G-7 countries to compute their *GNP* per worker. We use these two measures to compute the productivity.

With regard to net foreign assets, we use net income from abroad as a proxy. It would be nicer to use the new and cleaner data on foreign assets computed by Kraay, Loayza, Serven, and Ventura (2000), and data on the international interest rate to compute net foreign assets. However, their data cover only 7 countries out of 64 in our sample, and for the moment, there are no complete data on the intermediate variables we need to construct data on foreign asset using their method. We then simply use data on the net income from abroad *(NFA)* from the World Bank database. It enters as a ratio of *GNP.*

As government shocks can generate deviations from the long-run *PPP,* we are also interested in measuring how government spending will affect the equilibrium real exchange especially in this new empirical implementation. We extract data on government spending from the IMF's *International Financial Statistics (IFS).* It enters in our regression as a ratio of *GNP.* Beyond the determinants described above, we also use other variables related to the capital account such as the official development assistance (as a share of *GNP).* In addition, some monetary policy-related variables— such as the ratio of the change in domestic credit to

lagged money supply *(MACRO)* and nominal devaluation—are also used. The determinants such—as terms of trade, openness, and government spending—enter in our regressions through a logarithmic transformation.

B. Panel Unit Root Tests

A first step before estimating a long-run relationship between the real exchange rate and its determinants is to test for the stationarity of the individual variables. In this paper, we apply two tests proposed respectively by Im, Pesaran, and Shin (1997) (IPS), and Hadri and Larsson (2001) (HL).[4] The results are shown in Tables 1-4. One observes that the IPS statistics lead one to conclude against the presence of a unit root, thereby implying that the variables are, in general, I(0). However, such a conclusion is neither economically meaningful nor statistically reliable. From a statistical viewpoint, we know that tests based on the null of unit root have low power compared to other tests such as mixing tests.

The HL test (which is the panel equivalent of the time series KPSS test) leads to conclusions that are more in line with economic intuition. In tables 1-4, we see that all the variables are at least I (1) and that some variables are even characterized by strong persistence. The I (2) hypothesis characterizes the sluggishness of some structural variables in developing countries (changes in domestic credits, changes in reserves, official development assistance, nominal devaluation), not surprisingly, the "sluggishness" diminishes with the countries' level of development. Indeed, we see that, when the sample is divided in three groups (low-income countries, lower middle-income countries and upper middle-income countries), these variables remain I (2) only for the first group.

The three subgroups of countries are defined as follows:[5]

- *Low-income countries:* Bangladesh, Benin, Burundi, Burkina Faso, Cameroon, Chad, Democratic Republic of Congo, Republic of Congo, Côte d'Ivoire, Ghana, Gambia, Haiti, Indonesia, Kenya, Lesotho, Madagascar, Mali, Mauritania, Malawi, Niger, Nigeria, Nepal, Rwanda, Senegal, Togo, Uganda, Zambia, and Zimbabwe.

- *Lower middle-income countries:* Algeria, Bolivia, Colombia, Dominican Republic, Ecuador, Egypt, Guatemala, Honduras, Islamic Republic of Iran, Jamaica, Morocco, Malaysia, Nicaragua, Peru, Philippines, Papua New Guinea, Paraguay, El Salvador, Syrian Arab Republic, and Tunisia.

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[4] There is extensive on nonstationarity tests for panel data, to which the interested reader may refer. Some papers deal with unit root procedures (see Levin and Lin, 1992, 1993; Quah, 1994; Maddala and Wu, 1999; Harris and Tzavalk, 1999). Others apply the KPSS approach to panel data (see for instance, Hadri, 2000). For a survey and comparisons of methods, see Barnejee (1999), Batalgi and Kao (2000).

[5] This subdivision is based on the World Bank's classification of countries in regard to their GNP per capita: low-income countries ($\leq$ US\$755), lower middle-income countries (US\$756—US\$2,995) and upper middle-income countries (US\$2,996—US\$9,265).

- *Upper middle-income countries:* Brazil, Botswana, Chile, China, Costa Rica, Gabon, India, Israel, Republic of Korea, Mexico, Mauritius, Malaysia, Pakistan, Thailand, Trinidad and Tobago, Uruguay, and Venezuela.

IV. ESTIMATIONS AND PANEL CO-INTEGRATION TESTS

The OLS estimator has shown limitations, especially when applied to finite sample panel data, as it has strong biases. The literature on econometric theory has proposed a number of methods, which not only deal with the endogeneity bias correction, but also accommodate for nuisance parameters and serial correlation in data. Some procedures are based on single equation approaches. These include fully modified OLS estimators (FMOLS) (Pedroni, 1996; Phillips and Moon, 1999), dynamic OLS estimators (DOLS) (Kao and Chiang, 2000), and pooled mean group estimators (PMGE) (Pesaran, Shin, and Smith, 1999). Other approaches are based on vector error-correction representation (Breitung, 2002; Mark and Sul, 2003). In this paper, we use two estimators and compare the results obtained from each of them. The first is the average-based FMOLS estimator proposed by Pedroni (2001). The second is a pooled-based panel co-integration estimator suggested by Breitung (2002). The Pedroni approach is convenient for obtaining robust estimates in situations where long-run co-integration relationships are heterogeneous across countries. Breitung's estimator is used here for the purpose of comparison, to obtain estimates under the assumption of homogenous cointegration relationships. We choose this latter pooled-based estimator since Monte Carlo simulations show that it outperforms the standard pooled-based semiparametric estimators, especially if the number of periods is small.

Once the models are specified, we implement panel co-integration tests (based on demeaned data). We consider two groups of statistics based on Pedroni (1999): Panel ρ, Panel *PP* and Panel *ADF* are computed under the assumption of homogenous coefficients under the null; while Group ρ, Group *PP* and Group *ADF* are computed by assuming slope heterogeneity across countries.

Our estimations are performed by considering different combinations of regressors. The estimation results are reported in Tables 7-l2.[6] Five set of results corresponding to models 1 through 5 are reported. An asterisk in the tables indicates that the exogenous variable is not considered in the regression. Furthermore, for each model, some variables were not statistically significant (these are indicated by NS in the tables). They were accordingly dropped from the regressions and the models were reestimated. All the models include our key macroeconomic fundamentals: *TOT, OPEN, PROD,* and *GOV*. We obtained the five models by altering the variables directly related to monetary policy *(MACRO, DEVAL* and *RESERV)* as well as the foreign aid variable *(ODA)*.

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[6] The tables show the estimates for the samples of respectively, middle-income countries, low-income countries and the full sample. Lower middle-income countries and upper middle-income countries were grouped because they yielded very similar results.

In model 1, we include all the variables except *DEVAL,* and *RESERV.* Model 2 is obtained by dropping *ODA* from model 1. Model 3 includes all the variables except the variables related to capital movement *(NFA* and *ODA).* Model 4 excludes the monetary policy variables as well as *NFA.* Finally, model 5 is obtained from model 4 by introducing the variables *MACRO* and *RESERV.* The models are run for the full sample and two subsamples: one for middle-income countries and the other for low-income countries.[7]

In the regressions based on Pedroni's estimator, all our key fundamentals *(TOT, OPEN, PROD,* and *GOV)* are highly significant with the expected sign. The only exception is government spending, which is not significant in some regressions but only for low-income countries. An analysis of Tables 7, 8, and 9 shows that the terms of trade has a strong and positive effect on real exchange rate. Intuitively, deteriorating terms of trade—as historically observed in low and middle-income countries—is usually associated with an increase in the prices of import goods in comparison with those of export goods. The impact on the demand for domestic goods is twofold. On the one hand, a substitution effect yields an appreciation of the domestic currency if relative price movements induce a shift of the demand in favor of domestic goods. In this case, the sign of the coefficient *TOT* must be negative (since *TOT* and *RER* move in opposite directions). On the other hand, if there is an income effect, a deterioration of the terms of trade can be associated with a decline in the purchasing power, thereby inducing a decrease in the demand of both imported and domestic goods. This will lead to a decline in the price of domestic goods and a depreciation of the domestic currency. In this case, the coefficient of the variable *TOT* is expected to be positive *(TOT* and *RER* move in the same directions). The positive sign obtained here means that the income effect is predominant.

The degree of openness of the economy has a negative and strong effect on real effective exchange rate regardless of the sample. The elasticity in logarithm term is about -0.30 for middle-income countries and -0.25 for low-income countries. This result confirms the earlier finding that a more liberalized and open trade regime requires a more depreciated equilibrium real currency value (e.g., Elbadawi, 1998). This finding is of high importance for policymakers, as it points out that trade liberalization is not sustainable without substantial real currency depreciation. This helps understand at least partially why trade liberalization is so difficult in many developing countries.

Another fundamental of interest for this analysis is productivity. This fundamental has a positive and strong effect with an elasticity in logarithm term fluctuating about 0.40 for middle-income countries and 0.30 for low-income countries. This finding suggests that higher productivity leads to a stronger economy and hence a stronger currency. The implication is that a real appreciation resulting from an improvement of productivity does not require policy intervention.

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[7] The sample of middle-income countries is obtained by pooling the lower middle-income countries and the upper middle-income countries as classified in the panel unit root test section.

Government consumption contributes in logarithmic terms to about 10 percent in explaining the long-run *RER* in middle-income countries. The same is true for low-income countries as long as monetary policy variables as well as net foreign assets are not controlled for. This suggests that government spending exercises an upward pressure on the price of nontradable goods and thus affects the real effective exchange rate. Notice that an examination of the elasticities in Tables 7 and 8 suggests that based on Pedroni's estimator, the impact of key fundamentals analyzed above are stronger for middle-income countries than for low-income countries.

We now turn to our control variables. The results in Tables 7, 8, and 9 reveal that *ODA* does not significantly affect the real effective exchange rate. In our specification section, we conjectured that *ODA* would influence the exchange rate, as a high level of *ODA* will lead to capital inflows and a high demand of domestic currency, leading to the domestic currency appreciation. As the results reveal, this need not be the case necessarily. Indeed, if foreign aid is spent on foreign goods, through higher imports—which is the case for most developing countries— then it will not affect the real exchange rate. Our results suggest that this second effect dominates.

The results concerning *NFA* also confirm our conjecture that higher net foreign asset payments from abroad would lead to higher capital inflows with an upward pressure on the exchange rate as indicated in Tables 7, 8, and 9. Notice, however, that for low-income countries, net foreign asset is not significant in model 2 where we did not control for *ODA*. One justification might be that foreign asset payments are directly used for imports and do not lead to capital inflows.

The results concerning our monetary policy variables are mixed. For example, for middle-income countries (Table 7), the indicator *MACRO* is consistently significant with a positive sign, confirming that a high level of this ratio strengthens the central bank balance sheet position and *is* expected to lead to real currency appreciation. However, for low-income countries (Table 8), the indicator *MACRO* is not always significant; but when significant, it carries a negative sign. This suggests that in low-income countries, a high level of this ratio is an indication of accumulation of high risk bonds or claims in the central bank portfolio. This in turn weakens the central bank's balance sheet position and leads to a depreciated currency. Notice that the other monetary policy variables *(DEVAL* and *RESERV)* perform poorly in affecting the long-run real exchange rate for both the middle and low-income countries.

We wish now to analyze the results based on Breitung's estimator and compare them to those based on Pedroni's estimator. We focus our analysis on the key fundamentals, as they strongly contribute to explaining the variation in the long-run real exchange rate, while our other variables show weaker contributions. The results are shown in Tables 10-12. We observe that in terms of significance and expected sign, the results concerning our key fundamentals *(TOT, OPEN, PROD, GOV)* are overall similar to those obtained with Pedroni's estimator. The exception is found in low-income countries, where productivity loses its significance in models 3, 4, and 5, and where government spending, which was significant in model 4, now loses its significance.

Concerning the other determinants, the results are mixed and sometimes counter-intuitive, suggesting the presence of serious biases when one assumes a homogenous long-run relationship. For example, net foreign assets are significant with an unexpected negative sign (Table 10, models 1 and 2; Table 12, model 1). The same is true for *ODA* (Table 10, model 1; Table l2, model 5). In addition, productivity—which was consistently significant with the expected positive sign—now loses its significance in models 3, 4, and 5 for low-income countries (Table 11).

In comparison with the estimates based on Pedroni's estimator, we see that the assumption of homogenous coefficients in the long run leads one to overestimate the impact of some variables (e.g.; *TOT, OPEN)* and to underestimate others (e.g.; *PROD).* This is further evidence of potential biases.

In summary, we find that estimations based on the assumption of homogenous long-run elasticities can lead to conclusions that differ from those obtained when heterogeneous co-integration relationships are used. This suggests that one needs to be very careful when interpreting the results obtained from pooled-based approaches. Allowing the data to be pooled has the advantage of improving the limitation imposed on short time series data. However, disregarding countries' heterogeneity in terms of long-run relationships can lead to severe biases. Though developing countries may have many similarities, some structural differences may lead to different responses of the real exchange rate to changes in macroeconomic fundamentals. Based on these findings, and contrary to many studies that only use pooled-based approaches, we use average-based elasticities to compute later our misalignment measures.

V.   COMMON FACTOR ANALYSIS

In this section, we provide further evidence of the heterogeneous behavior of the long-run relationship that links the *RER* to its fundamentals, using a common factor analysis. The analysis consists first of identifying some unobservable variables that govern changes in a given variable (here, the dependent variable) regardless of the individual characteristic of this variable. In other words, these variables would account for the joint dynamics of countries' real exchange rates. Since these unobservable variables would affect the variable of interest regardless of country-specific effects, they are referred to as a common factor.

Second, once the common factors are identified, one checks whether each of the key determinants of the dependent variable (here, the *RER)* can be expressed as a linear combination of the common factors. If that is the case, the determinants are considered as a common factor or a combination of common factors and then are supposed to affect the *RER* in the same way regardless of a country's individual effects. In other words, there would be no need for a heterogeneous long-run relationship to account for the impact of the determinants on the dependent variable. A usual pooled-based estimator would be enough. Notice that this approach is not sensitive to any econometric model, ensuring us that the presumed heterogeneity in long-run coefficients is not driven by the choice of econometric or estimation method.

A. The Method

The approach consists of computing the number of common factors in the *RER* and relies on the methodology developed in a growing literature on common factors in nonstationary panels.[8] Let us consider the series $\{y_{it}\}$, $i = 1, .., N$ and $t = 1, ...,T$. A common factor, denoted by F_t, is an unobservable variable that drives the observations in y_{it} together. The common factor model can be written as follows:

$$y_{it} = \sum_{j=1}^{r} \lambda_{ij} F_{jt} + \varepsilon_{it}, \qquad F_{jt} = F_{jt-1} + u_t, \qquad (3)$$

where u_t and ε_{it} are I(0) processes, and λ_{ij} is a factor loading coefficient associated with F_{jt}. We assume that there are r common factors. Two series y_{it} and y_{kt} are correlated because they share the same unobservable common factors. It is further assumed that the nonstationarity of the series y_{it} comes from the fact that the common factors have a unit root (they are common stochastic trends).

Our first interest is to find the number of common factors (that is, to estimate *r)* and then to estimate the parameters λ_{ij} and the common stochastic trend F_{jt}. The approach commonly used to do this is based on principal component analysis. The estimates are obtained by solving the following optimization problem:

$$V(r) = \min_{\Lambda_i, F} (NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \left(y_{it} - \lambda_i' F_t \right)^2 \qquad (4)$$

under the constraint $F'F / T^2 = I_r$ where $\lambda_i' = (\lambda_{i1}, \ \lambda_{i2}, ..., \lambda_{ir})$, $F_t = (F_{1t}, F_{2t}, ..., F_{rt})$, $\Lambda_i = (\lambda_1, \lambda_2, ..., \lambda_N)'$ and F is the common trend matrix. The column components of this matrix are the estimated eigenvectors corresponding to the r largest eigenvalues of the $T \times N$ matrix *YY',* where Y is the matrix of observations $(y_1, y_2, ... y_N)$ and $y_i = (y_{i1}, y_{i2}, ... y_{iT})'$. If we denote $\hat{F}$ the estimated common trend matrix, we have:

$$\Lambda_i' = \hat{F} Y / T^2 \qquad (5)$$

It is easy to see that the optimization solution depends on *r,* for which an optimal value has to be estimated. This can be done by using criteria involving penalty functions, denoted *g(N, T),* which depends on both *N* and *T.* Several penalty functions have been proposed in the

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[8] For an overview of alternative approaches to the study of common factors, the reader may consult—among many others—Forni and others (2000), and Bai and Ng (2002). Notice that when the common factors are unit root processes, they are called "common stochastic trends".

literature. The central point is to choose a penalty function that implies strong consistency, that is:

$$p\lim_{N,T\to\infty}(\hat{r}=r)=1 \tag{6}$$

where $\hat{r}$ is an estimate of r. The criteria used in this paper rely upon Bai and Ng (2002):

$$PC_1(r) = V(r) + r\hat{\sigma}^2\alpha_T\left(\frac{N+T}{NT}\right)ln\left(\frac{NT}{N+T}\right), \tag{7}$$

$$PC_2(r) = V(r) + r\hat{\sigma}^2\alpha_T\left(\frac{N+T}{NT}\right)lnC_{NT}^2, \tag{8}$$

$$PC_3(r) = V(r) + r\hat{\sigma}^2\alpha_T\left(\frac{ln\,C_{NT}^2}{C_{NT}^2}\right), \tag{9}$$

Where $\hat{\sigma}^2$ is a consistent estimate of $(NT)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}E(\varepsilon_{it}^2)$, $C_{NT}=\min\left[\sqrt{N},\sqrt{T}\right]$ and $\alpha_T=T/[4\text{In}T]$.

Once the common factors have been estimated, it remains to examine the relationship between each of the exogenous variables and the common factors. Suppose that $\{x_t\}_{t=1}^{T}$ is the observable series and $\hat{\delta}$ is an OLS estimate of δ in the following regression:

$$x_t = \hat{F}_t'\delta + v_t, \tag{10}$$

Where v_t is an error term. We consider that x_t is one of the common factors or a combination of the latter, if $x_t \in I_{95}$ I_{95} is the 95 percent confidence interval for x_t defined as:

$$\left(\hat{\delta}'\hat{F}_t - 1.96\,S_t\,N^{-1/2}, \hat{\delta}'\hat{F}_t + 1.96\,S_t\,N^{-1/2}\right), \tag{11}$$

where

$$S_t = \left[\hat{\delta}'V_{NT}^{-1}\left(\frac{1}{N}\sum_{i=1}^{N}\hat{\varepsilon}_{it}\hat{\lambda}_i\hat{\lambda}_i'\right)V_{NT}^{-1}\hat{\delta}\right]^{1/2}, \tag{12}$$

V_{NT} is a diagonal matrix consisting of the first r largest eigenvalues of $YY'/(T^2N)$.

B. Application to Our Samples

We estimate the number of factors in the *RER* series using the demeaned data to avoid cross-correlation among countries. Tables 13 and 14 show the values of the three criteria above. The number of common factors (or common stochastic trend) tells us how many potential variables are needed to account for the dynamics of countries' real exchange rates. We find that this number differs according to the subsample. The higher the number of common factors, the higher the degree of homogeneity among countries. This means that if, for a given subsample, countries share a high number of common factors, their exchange rates are likely to respond in a similar way to variations occurring in their determinants. Analyzing the results of our samples, it seems that middle-income countries are characterized by a higher degree of heterogeneity than low-income countries. Indeed, for the former, we find 4 or 5 common trends, whereas for the latter, the number of common stochastic trends equals 6 or 7. If all the countries are considered together, the degree of heterogeneity increases as the number of common factors declines to 3 or 4.

We now move to the second stage of our common factor analysis. Since the common factors are aggregated variables, for the purpose of comparison, we use cross-country means of the independent variables to construct our confidence interval. For instance, to see whether the productivity is one of the common stochastic trends (or a combination of the stochastic trends), we run regression (10) by considering $x_t = PROD_t = (1/N) \sum_{t=1}^{N} PROD_{it}$. To test whether productivity is a true underlying factor, we plot the confidence interval and the mean-average productivity *PROD* in the same figure. We implement the same scenario to other independent variables.

The results for productivity, terms of trade, openness, and the monetary variable *MACRO* are shown in Figures 1 through 8. Analyzing these figures, it appears that for low-income countries, there is a fair number of variables (e.g., *PROD, TOT, OPEN)* that lie within the confidence interval, suggesting that each of these variables is a common factor or a combination of common factors. However, the monetary variable *MACRO* cannot be considered as a common factor or a combination of common factors in low-income countries. Concerning middle-income countries, the picture is a bit different. While *MACRO* can be considered as a common factor or a combination of common factors, other variables such as *PROD, TOT,* and *OPEN* cannot be considered as such, as they do not lie inside the confidence interval.

The findings of this analysis suggest that studies on low-income countries that make use of long-run elasticities estimated from pooled-based estimators can deliver relatively acceptable results. However, studies on middle-income countries or a sample of middle and low-income countries together that simply make use of pooled-based estimators are seriously questionable. Clearly, the average-based estimators would show superior results because of a weak homogeneity in the samples, though the degree of heterogeneity differs.

VI. REAL EXCHANGE RATE EQUILIBRIUM AND MISALIGNMENT

We now proceed to compute indices for the equilibrium real exchange rate using the derived long-run elasticities based on estimates in Tables 7 and 8 (model 1 for the middle-income countries and model 4 for the low-income countries). We compute two indices of equilibrium exchange rate. One is the behavioral equilibrium *(BEER)* computed by using the yearly observed values of fundamentals. The other is the permanent equilibrium exchange rate *(PEER).*[9]

The idea is that the macroeconomic regressors that enter in the *BEER* equation are not necessarily at their equilibrium level, because the fundamentals may fluctuate around their "equilibrium" value. The permanent component is obtained by removing the cyclical components from the estimated *BEER.* Given the short time length of the data, the *PEER* is calculated here using a simple five-year moving average.[10] The choice of a five-year moving average is in accord with the literature, since it reflects the median of the number of years needed to smooth out an exogenous shock.[11] We derived two concepts of misalignment computed as the discrepancy between the actual values of *RER* and each of the equilibrium concepts *(BEER* and *PEER).* We focus on the misalignments based on the *PEER* because this equilibrium concept is based on the sustainable or permanent values of the fundamentals. To be more precise, our misalignment measures are computed as *[(RER - PEER)/PEER] * 100.*

Figures 9-14 show the equilibrium exchange rates and misalignment for selected countries.[12] The Figures show remarkable success in reproducing the well-known overvaluation and undervaluation episodes in the recent macroeconomic history in our selected countries, and the countries in our sample in general.

For example, Figure 9 reveals that Burkina Faso's equilibrium exchange rates were following a decreasing pattern over the period 1979-93, reflecting a structural deterioration of the country's fundamentals. Over the same period, the country witnessed a sustained and substantial real appreciation varying from about 23 percent in 1983 to more than 50 percent in 1987. This real appreciation was brought down from more than 44 percent in 1993 to about 6 percent in 1994. In this same year, the *BEER* and the *PEER* begin to rise. This is apparently the result of the 1994 devaluation of the CFA currency. This structural measure has reduced the degree of the real appreciation not only by bringing down the *RER* but also by raising the *BEER* and the *PEER* through improvement in the fundamentals. The results reveal that though the 1994 devaluation successfully brought the real appreciation down, Burkina Faso still had until 2000 a real appreciation of about 9 percent.

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[9] These concepts were introduced by Clark and MacDonald (1999, 2000).

[10] It is also possible to calculate the *PEER* using a Hodrick-Prescott filter, a Beveridge-Nelson filter, or the Johansen-based method suggested by Gonzalo and Granger (1995).

[11] See Elbadawi (1994) for more details.

[12] Tables containing the misalignment measures are not reported but available upon request to the authors.

The situation in Chad, another CFA-zone country, is similar to that we just described. But the real appreciation was more severe in Chad over the period 1979-93, with an average real appreciation of more than 46 percent compared to 39 percent over the same period in Burkina Faso. However, the dynamics of the *RER,* the *BEER,* and the *PEER* for Senegal, which is also part of the CFA zone, are different. Contrary to the first two countries, the dynamics here are characterized by periods of overvaluation as well as periods of undervaluation. On average, the country witnessed an undervaluation of more than 13 percent over 1979-84. This might have been substantially caused by the steady depreciation of the French franc against the U.S. dollar and other major currencies. This episode was followed by a period of overvaluation running from 1985 to 1993, with an average real appreciation of about 10 percent. The move in the reverse direction by the French franc following 1986 may have contributed to this episode of overvaluation. Indeed, the degree of overvaluation jumps from about 5 percent in 1985 to about 24 percent in 1986. The year 1994 witnessed a sharp depreciation of about 18 percent, which is apparently due to the 1994 devaluation in the CFA zones. This depreciation later shrunk to about 4 percent in 1998 before expanding to a still low percentage of about 9 percent in 2000.

We also look at the dynamics of misalignment in some non-CFA-zone countries. In Ghana for example, the results reveal that the country witnessed substantial overvaluation over 1979-85, with an average of about 54 percent and a peak of about 120 percent in 1982 (see Figure 12). These findings reflect the macroeconomic policies in Ghana. Indeed, 1979-82 was a period of expansive and unsustainable macroeconomic policies that led to substantial real appreciation and deteriorating economic performance in Ghana.[13] In particular, the period 1981-82 witnessed a collapse in cocoa prices, leading to the reversal of earlier policy reforms. This in turns led to the substantial overvaluation mentioned earlier. However, the country managed to bring the real appreciation down in 1986 to just above 3 percent and has kept the *RER* very close to the *BEER* and the *PEER* since then. This is, among others, the result of an aggressive fiscal and monetary stabilization that Ghana undertook during 1983-90.

In Ghana, 1983-90 was a period of profound reforms in which the *RER* was a key instrument. Ghana was successful in eliminating its parallel market for a foreign exchange market and had substantially brought down inflation. The sustained macroeconomic reforms were helpful in eliminating the *RER* misalignment and bringing the *RER* close to the *BEER* and the *PEER*. This in turn helped Ghana to reclaim its international market share in the cocoa sector. Consequently, Ghana was able to reverse the economic decline and achieve sustained growth. The evolution of the *RER* in Ghana is clearly consistent with major shifts in policy regimes over our study period and confirms the robustness of our estimates.

The situation in Nigeria is a bit close to that in Ghana, with the exception that the peak occurred in 1985. Also, Nigeria has not succeeded in bringing the *RER* very close to the *BEER* and the *PEER,* as was the case in Ghana.

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[13] See Elbadawi (1994) for more details.

VII.   CONCLUDING REMARKS

This paper has investigated the stability of the real effective exchange rate using a new approach: the unification of a panel co-integration approach and the common factor analysis. Indeed, the lack of long time series and suitable economic procedures has impeded the evaluation of the long-run *RER*. Taking advantage of these recent techniques for panel data analysis, we addressed these empirical problems. In particular, we pool a heterogeneous panel of data for 64 countries and perform a time-series analysis. The higher number of observations that result from the pooling, increases the power of our econometric analysis. The results are not sensitive to any specific country. Removing one or two countries from the sample does not change the results confirming the robustness of the econometric analysis.

Using the panel unit root approach and the common factor analysis, we have proposed an econometric analysis that links the real effective exchange to a set of fundamentals. A key contribution of this paper is the use of the common factor analysis. This helps us to propose an in-depth analysis of the heterogeneity in our sample and to evaluate the existence of common factors explaining the misalignment of the *RER*. The paper estimates a real effective exchange rate model that accounts for both current account and capital account fundamentals. The results of the estimation strongly corroborate economic intuitions. This estimation allows the derivation of the equilibrium real effective exchange rate for the countries in our sample. In addition, it allows the derivation of a more reliable and key instrument for real exchange rate policy: the real effective exchange misalignment.

Our analysis reveals that there exists a relatively high degree of homogeneity with regard to the dynamics of the real exchange rate in low-income countries compared to that in middle-income countries. Indeed, we find that for low-income countries, there are about 6 or 7 common factors explaining the dynamics of the *RER*. For middle-income countries, we find there are about 4 or 5 common factors. We analyze whether these common factors are related to the key fundamentals of the *RER*. Our results reveal that for low-income countries, the fundamentals such as productivity, term of trade, and openness are strongly related to our common factors. We reach a different conclusion for middle-income countries. In other words, some fundamentals might account for the joint dynamics of the *RER* in low-income countries. For middle-income countries, however, the real exchange rate dynamics seem to be governed by more heterogeneity.

Table 1. Panel Unit Root Tests —All Countries

	IPS*		HL**			
	Level	concl	Level	1st diff	2nd diff	concl
PROD	-3.96	I(0)	8.27	-0.84	-	I(1)
TOT	-7.41	I(0)	8.15	-0.38	-	I(1)
OPEN	-6.71	I(0)	8.14	-0.50	-	I(1)
NFA	-8.36	I(0)	8.68	0.04	-	I(1)
GOV	-7.02	I(0)	9.15	-0.35	-	I(1)
ODA	-3.96	I(0)	10.56	0.93	-	I(1)
MACRO	-19.04	I(0)	5.35	-3.07	-0.41	I(2)
DEVAL	-14.01	I(0)	7.73	-2.81	-0.54	I(2)
RESERV	-22.39	I(0)	5.12	-2.57	-0.43	I(2)
RER	-3.89	I(0)	9.70	-0.54	-	I(1)

* The critical value is -2.46 (model with an intercept and a linear time trend)
at the 5% level of significance (N=21 and T=22).
** Distributed as a standard normal variate.

Table 2. Panel Unit Root Tests—Low-Income Countries

	IPS*		HL**			
	Level	Concl	Level	1st diff	2nd diff	Concl
PROD	-4.00	I(0)	5.35	-0.42	-	I(1)
TOT	-5.00	I(0)	5.46	-0.34	-	I(1)
OPEN	-4.99	I(0)	4.77	-1.27	-	I(1)
NFA	-5.50	I(0)	4.88	-1.29	-	I(1)
GOV	-8.47	I(0)	5.15	-0.72	-	I(1)
ODA	-5.87	I(0)	3.93	-1.98	-1.38	I(2)
MACRO	-14.80	I(0)	3.03	-2.00	-0.99	I(2)
DEVAL	-11.68	I(0)	4.15	-2.30	-1.24	I(2)
RESERV	-14.54	I(0)	3.25	-1.69	-0.45	I(2)
RER	-1.80	I(1)	6.86	-0.59	-	I(1)

* The critical values is -2.55 (model with an intercept and a linear time trend) at the 5% level of
significance (N=16 and T=22). Though not reported, the IPS test on the 1st difference of the
variables PROD and RER yields to reject the null hypothesis of no unit root, thereby implying that
these variables are I(1).
** Distributed as a standard normal variate.

Table 3. Panel Unit Root Tests—Lower Middle-Income Countries

	IPS*		HL**		
	Level	Concl	Level	1st diff	Concl
PROD	-2.86	I(0)	4.24	-0.59	I(1)
TOT	-5.40	I(0)	3.94	-0.02	I(1)
OPEN	-5.09	I(0)	3.98	0.08	I(1)
NFA	-4.77	I(0)	4.85	0.03	I(1)
GOV	-3.56	I(0)	5.96	0.45	I(1)
ODA	-7.17	I(0)	4.56	-0.47	I(1)
MACRO	-14.82	I(0)	2.81	-0.98	I(1)
DEVAL	-7.24	I(0)	3.92	-1.40	I(1)
RESERV	-13.23	I(0)	2.31	-0.61	I(1)
RER	-3.54	I(0)	402	-0.35	I(1)

   * The critical value is -2.46 (model with an intercept and a linear time trend)
    at the 5% level of significance (N=21 and T=22).
  ** Distributed as a standard normal variate.

Table 4. Panel Unit Root Tests—Upper Middle-Income Countries

	IPS*		HL**		
	Level	Concl	Level	1st diff	Concl
PROD	-1.16	I(1)	4.54	-0.84	I(1)
TOT	-2.76	I(0)	3.99	-0.22	I(1)
OPEN	-2.83	I(0)	4.61	-0.40	I(1)
NFA	-3.23	I(0)	3.79	-0.02	I(1)
GOV	-2.53	I(0)	4.83	0.55	I(1)
ODA	-3.02	I(0)	3.51	-0.89	I(1)
MACRO	-11.76	I(0)	3.04	-1.00	I(1)
DEVAL	-7.52	I(0)	4.77	-1.31	I(1)
RESERV	-10.16	I(0)	2.95	-0.79	I(1)
RER	-2.09	I(1)	5.59	-0.37	I(1)

  * The critical value is -2.55 (model with an intercept and a linear time trend)
   at the 5% level of significance (N=16 and T=22). Though not reported, the IPS
   test on the 1st difference of the variables PROD and RER yields to reject the null
   hypothesis of no unit root, thereby implying that these variables are I(1).
  ** Distributed as a standard normal variate.

Table 5. Panel Co-integration Tests—Regressions Based on Breitung's Estimator

	Middle-inc. countries (Model 4)	Low-inc. countries (Model 1)	Full sample (Model 4)
PANEL ρ	1.45	4.79	2.43
PANEL PP	-2.93	2.71	-3.80
PANEL ADF	-1.67	3.87	-1.55

Note: The test is applied on demeaned data and allows individual fixed effects and time trends. All the statistics reported are distributed as standard normal variates. Considering the 5% level of confidence, the null of no co-integration is rejected when the absolute value of the computed statistics are higher than 1.96.

Table 6: Panel Co-integration Tests—Regressions Based on Pedroni's Estimator

	Middle-inc. countries (Model 1)	Low-inc. countries (Model 4)	Low-inc. countries (Model 5)	Low-inc. countries (Model1)
GROUP ρ	5.62	3.34	4.75	7.08
GROUP PP	-3.75	-2.58	0.96	-2.53
GROUP ADF	-3.29	-1.04	0.55	-1.44

Note: See Table 5.

Table 7. Pedroni's Estimator—Middle-Income Countries

	Model1	Model2	Model3	Model4	Model5
TOT	0.12	0.12	0.12	0.12	0.12
	(5.73)	(5.73)	(5.68)	(5.12)	(5.68)
OPEN	−0.31	−0.31	−0.31	−0.32	−0.31
	(−20.03)	(−20.03)	(−19.66)	(−18.53)	(−19.66)
PROD	0.41	0.41	0.45	0.46	0.45
	(22.98)	(22.98)	(22.25)	(23.60)	(22.25)
NFA	0.13	0.13	*	*	*
	(3.92)	(3.92)			
ODA	NS	*	*	NS	NS
MACRO	0.02	0.02	0.03	*	0.03
	(2.99)	(2.99)	(329)		(3.29)
DEVAL	*	*	NS	*	*
RESERV	*	*	NS	*	NS
GOV	0.09	0.09	0.13	0.09	0.13
	(8.19)	(8.19)	(7.11)	(5.48)	(7.11)

Note: An asterisk indicates that the exogenous variable was not included in the regression.
NS refers to an exogenous variable originally introduced in the regression, but not statistically significant.
t-ratios in parentheses.

Table 8. Pedroni's Estimator—Low-Income Countries

	Model 1	Model 2	Model 3	Model4	Model 5
TOT	0.06	0.107	0.06	0.05	0.09
	(6.05)	(5.97)	(6.05)	(5.41)	(6.35)
OPEN	−0.26	−0.27	−0.26	−0.23	−0.26
	(−9.62)	(−11.17)	(−9.62)	(−9.78)	(−9.10)
PROD	0.25	0.34	0.25	0.34	0.29
	(8.21)	(11.04)	(8.21)	(16.0)	(10.07)
NFA	0.17	NS	*	*	*
	(6.18)				
ΔODA	NS	*	*	NS	NS
ΔMACRO	NS	−0.04	NS	*	−0.04
		(−3.02)			(−3.23)
ΔDEVAL	*	*	0.17	*	*
			(6.18)		
ΔRESERV	*	*	NS	*	NS
GOV	NS	NS	NS	0.10	NS
				(2.95)	

Note: See footnote Table 7.

Table 9. Pedroni's Estimator—Full sample

	Model 1	Model 2	Model 3	Model 4	Model 5
TOT	0.03 (3.34)	0.03 (3.34)	0.08 (4.75)	0.06 (4.17)	0.10 (3.76)
OPEN	−0.43 (−19.77)	−0.43 (−19.77)	−0.37 (−18.66)	−0.41 (−19.55)	−0.39 (−19.84)
PROD	0.40 (30.32)	0.40 (30.32)	0.48 (30.02)	0.47 (31.69)	0.47 (32.34)
NFA	0.51 (3.46)	0.50 (3.46)	∗	∗	∗
ΔODA	NS	∗	∗	NS	NS
ΔMACRO	−0.01 (−3.47)	−0.01 (−3.47)	NS	∗	−0.02 (−3.89)
ΔDEVAL	∗	∗	0.06 (5.55)	∗	∗
ΔRESERV	∗	∗	NS	∗	NS
GOV	0.15 (6.00)	0.15 (6.00)	0.19 (7.59)	0.17 (5.97)	0.15 (6.24)

Note: See footnote Table 7.

Table 10. Breitung's Estimator—Middle-Income Countries

	Model 1	Model 2	Model 3	Model 4	Model 5
TOT	0.30 (8.03)	0.27 (7.32)	0.30 (7.63)	0.29 (7.11)	0.31 (7.64)
OPEN	−0.67 (−22.28)	−0.67 (−22.50)	−0.65 (−19.65)	−0.62 (−18.30)	−0.65 (−19.85
PROD	0.29 (9.47)	0.35 (11.64)	0.27 (8.83)	0.28 (9.15)	0.27 (8.83)
NFA	−1.07 (−6.97)	−0.94 (−6.22)	∗	∗	∗
ODA	−0.458 (−2.14)	∗	∗	NS	NS
MACRO	−0.11 (−4.81)	−0.13 (−5.83)	NS	∗	∗
DEVAL	∗	∗	NS	∗	NS
RESERV	∗	∗	−0.14 (−5.43)	∗	−0.14 (−5.42)
GOV	0.08 (2.45)	0.07 (2.10)	0.14 (3.78)	0.13 (3.69)	0.14 (3.78)

Note: See footnote Table 7

Table 11. Breitung's Estimator—Low-Income countries

	Model 1	Model 2	Model 3	Model 4	Model 5
TOT	0.19 (4.08)	0.19 (4.08)	0.24 (4.58)	0.27 (4.09)	0.26 (4.29)
OPEN	−0.71 (−18.38)	−0.71 (−18.38)	−0.63 (−14.54)	−0.58 (−10.99)	−0.59 (−11.88)
PROD	0.12 (2.78)	0.12 (2.78)	NS	NS	NS
NFA	−1.01 (−5.78)	−1.01 (−5.78)	∗	∗	∗
ΔODA	NS	∗	∗	NS	NS
ΔMACRO	−0.15 (−4.28)	−0.15 (−4.28)	0.57 (5.34)	∗	∗
ΔDEVAL	∗	∗	NS	∗	NS
ΔRESERV	∗	∗	NS	∗	−0.13 (−2.82)
GOV	NS	NS	NS	NS	NS

Note: see footnote table 7.

Table 12. Breitung's Estimator—Full sample

	Model 1	Model 2	Model 3	Model 4	Model 5
TOT	0.40 (6.32)	0.40 (5.74)	0.39 (6.04)	0.42 (6.44)	0.40 (6.33)
OPEN	−0.91 (−16.31)	−0.93 (−15.21)	−0.93 (−16.10)	−0.91 (−16.10)	−0.91 (−16.31)
PROD	0.48 (11.16)	0.48 (9.51)	0.46 (10.35)	0.45 (10.15)	0.48 (11.16)
NFA	−1.97 (−3.79)	0.81 (2.53)	∗	∗	∗
ΔODA	NS	∗	∗	NS	−1.97 (−3.79)
ΔMACRO	0.10 (3.06)	0.08 (2.18)	0.41 (2.88)	∗	∗
ΔDEVAL	∗	∗	−1.90 (−3.39)	∗	NS
ΔRESERV	∗	∗	0.21 (5.51)	∗	0.10 (3.6)
GOV	0.14 (2.58)	0.12 (2.01)	0.18 (3.13)	0.15 (2.56)	0.14 (2.58)

Note: See footnote Table 7

Table 13. Common Stochastic Trends—Low and Middle-Income Countries

	Low-inc. Countries			Middle-inc. Countries		
	$PC_1(r)$	$PC_2(r)$	$PC_3(r)$	$PC_1(r)$	$PC_2(r)$	$PC_3(r)$
r =1	0.0220	0.022	0.0218	10.82	10.84	10.79
r =2	0.0173	0.0179	0.0164	4.19	4.23	4.14
r =3	0.0146	0.0155	0.0133	1.64	1.70	1.55
r =4	0.0128	0.0141	0.0112	0.84	0.92	0.73
r =5	0.0122	0.0137	0.0101	0.86	0.95	0.71
r =6	0.0118	0.0137	0.0093	0.91	1.02	0.73
r =7	0.0118	0.0139	0.0089	0.96	1.10	0.76
r =8	0.0123	0.0147	0.0090	1.03	1.18	0.80
r	6 or 7	5 or 6	7	4	4	5

Table 14. Common Stochastic Trends—Full sample

	$PC_1(r)$	$PC_2(r)$	$PC_3(r)$
r =1	0.117	0.118	0.115
r =2	0.098	0.100	0.090
r =3	0.090	0.094	0.084
r =4	0.092	0.097	0.084
r =5	0.095	0.101	0.085
r =6	0.100	0.107	0.087
r =7	0.106	0.114	0.091
r =8	0.113	0.123	0.096
r	3	3	3 or 4

Figure 1. Common factor - Confidence interval - Variable TOT - Middle-Income countries
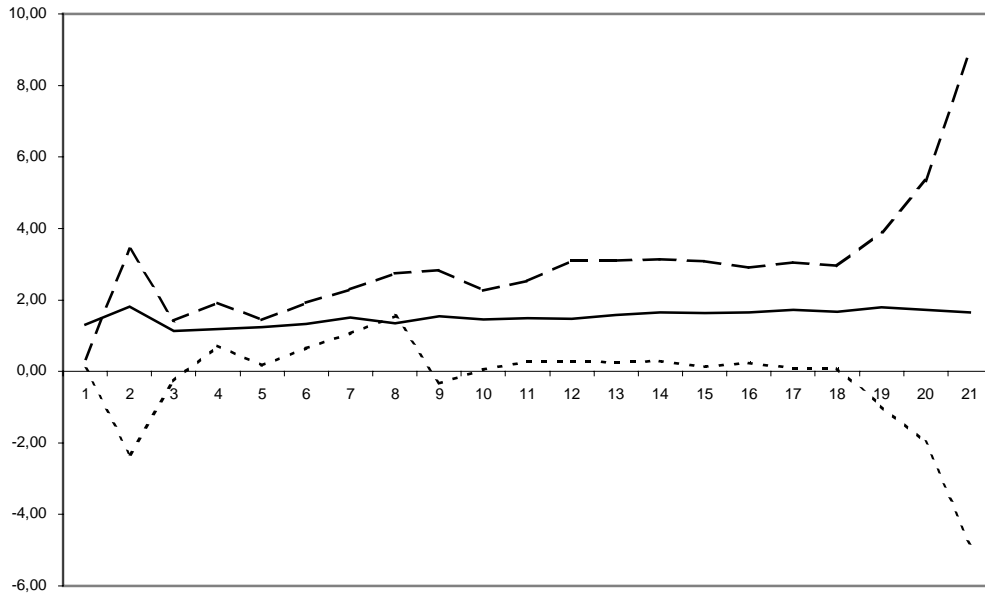
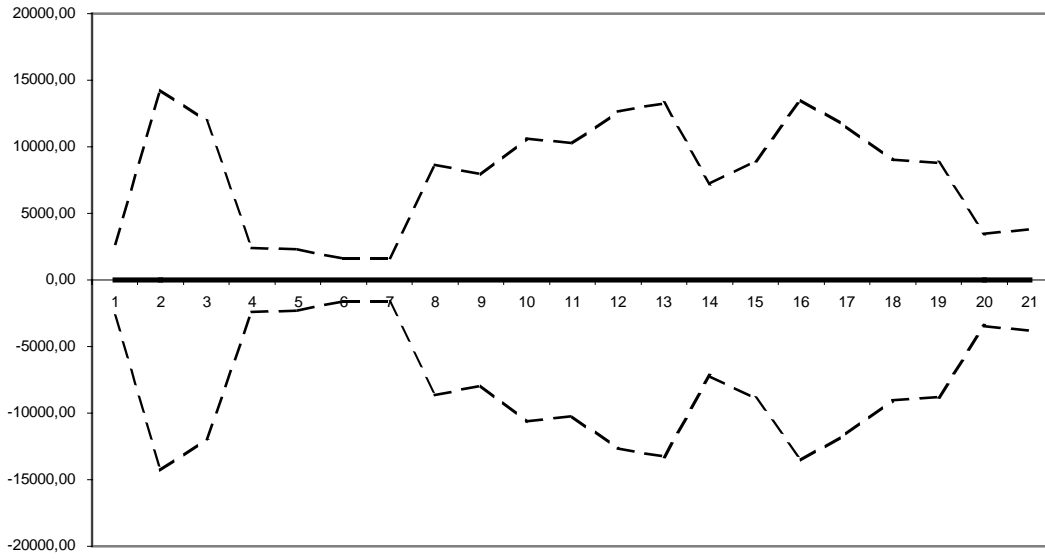**Figure 2. Common factor - Confidence interval - Variable : PROD - Middle-Income countries**
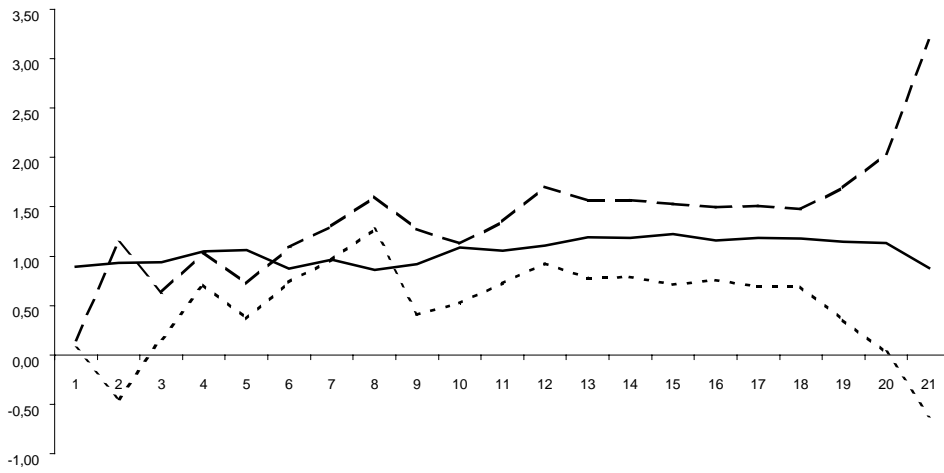
Figure 3. Common factor - Confidence interval - Variable : OPEN - Middle-Income countries
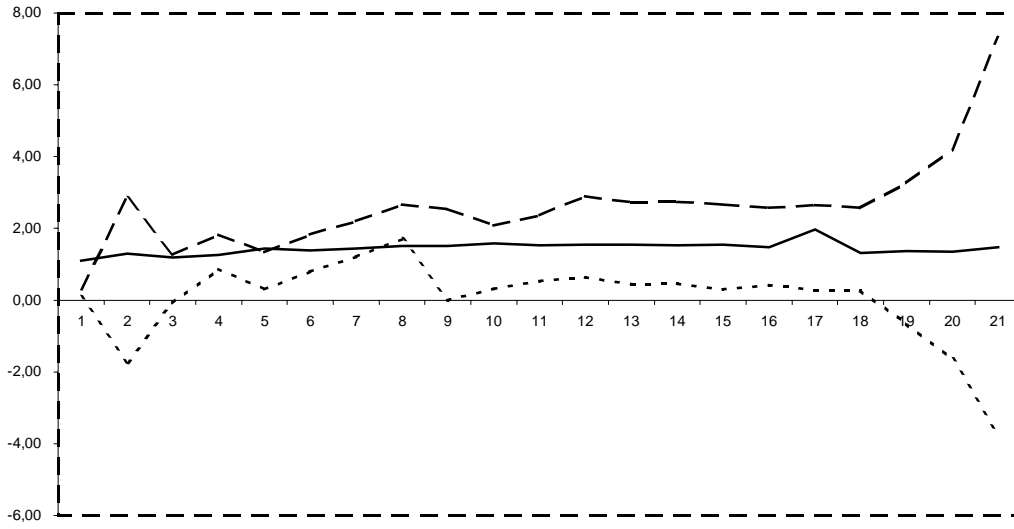
Figure 4. Common factor - Confidence interval - Variable : MACRO - Middle-Income countries
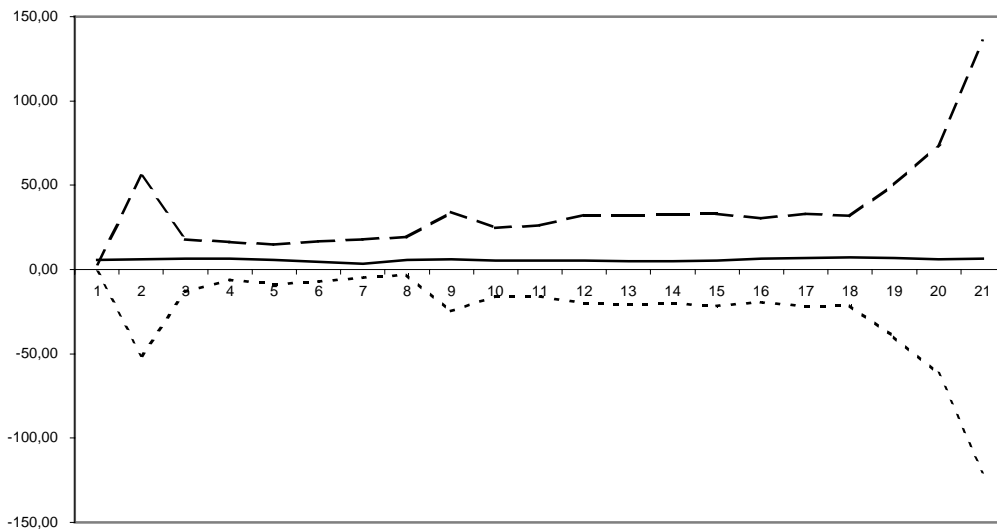
Figure 5. Common factor - Confidence interval - Variable : TOT - Low-Income countries
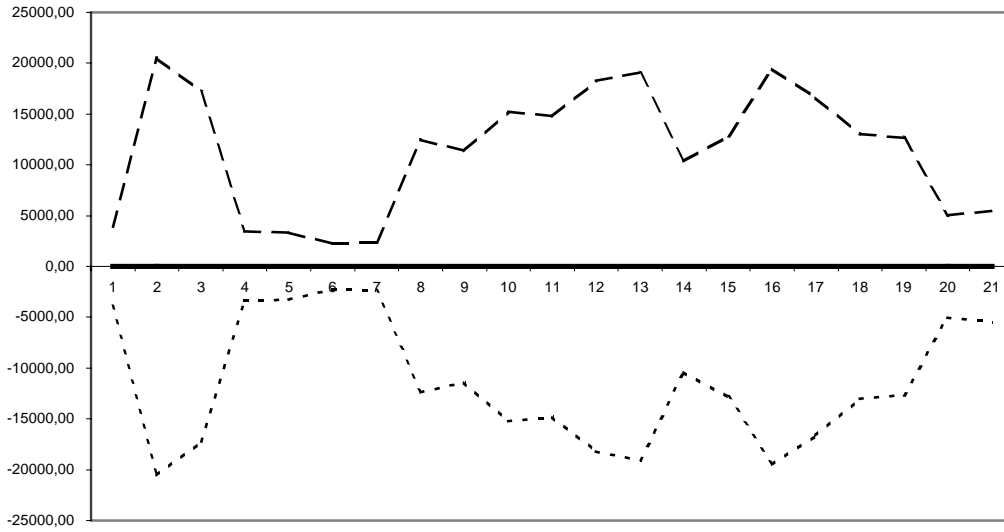
Figure 6. Common factor - Confidence interval - Variable PROD - Low-Income countries
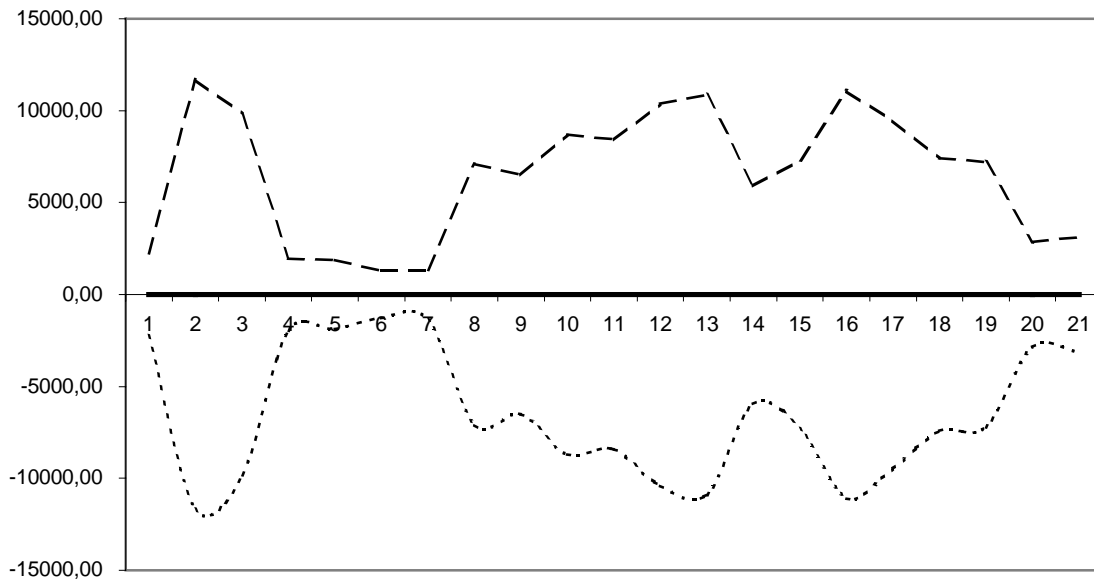
Figure 7. Common factor - Confidence interval - Variable : TRADE - Low-Income countries

Figure 8. Common factor - Confidence interval - Variable : MACRO - Low-Income countries
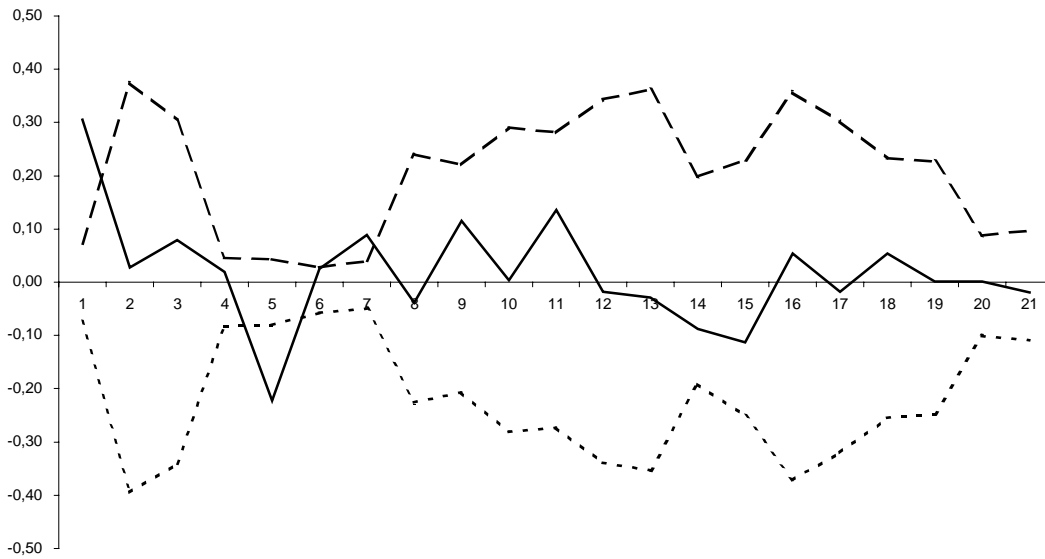
Figure 9. RER Equilibrium and Misalignment - Burkina Faso

RER, BEER, PEER - Burkina Faso
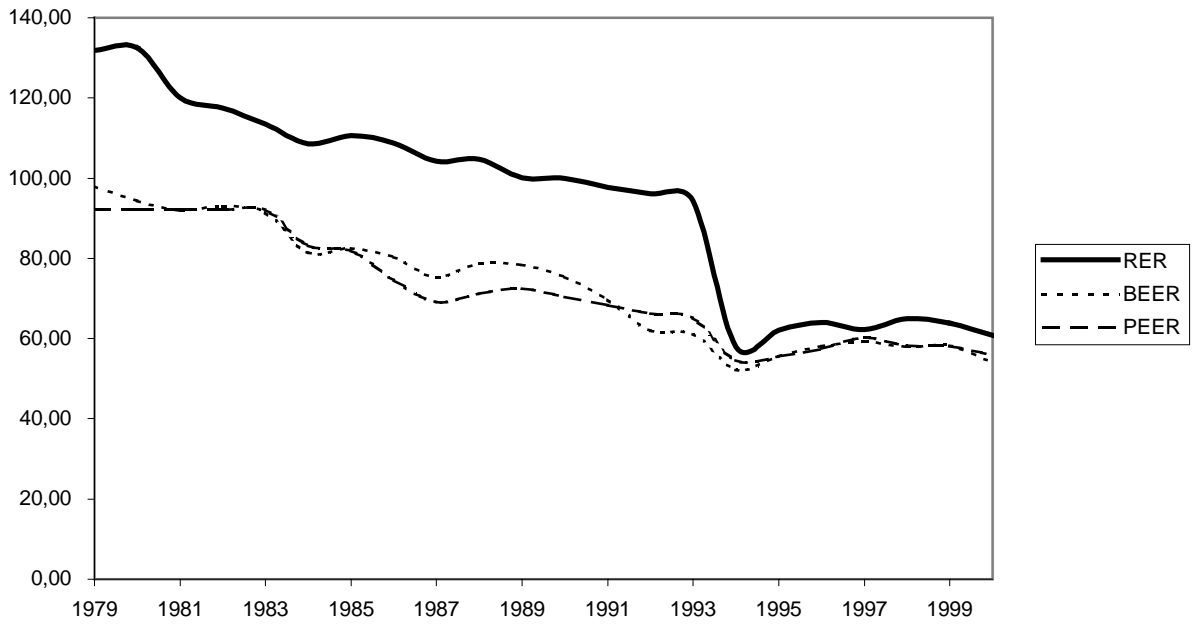
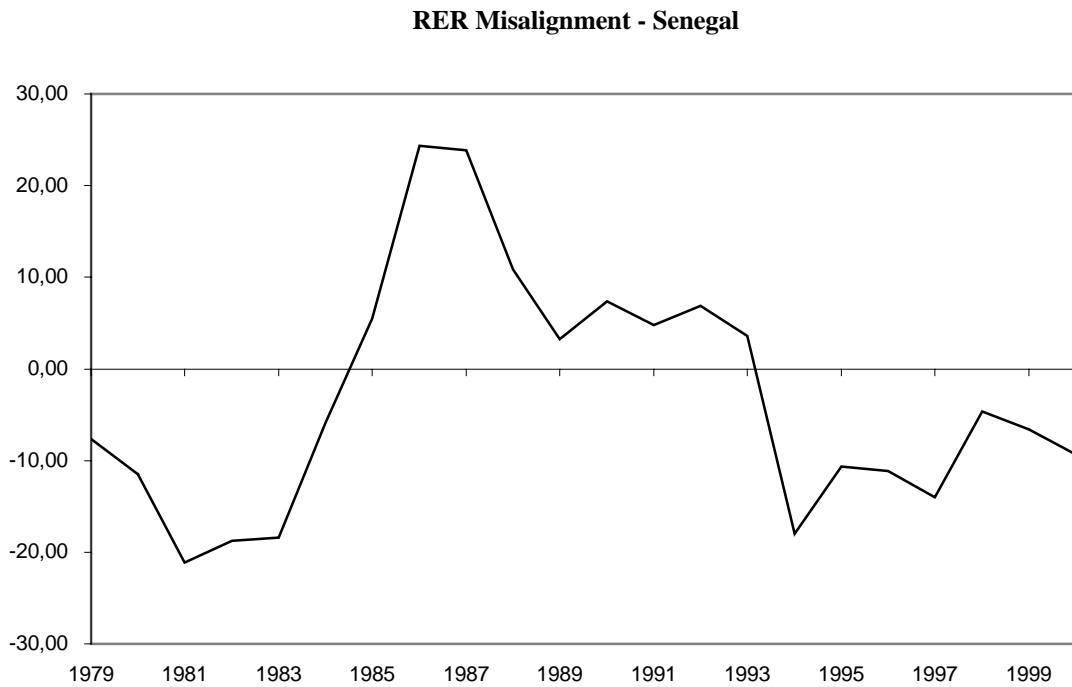
RER Misalignment - Burkina Faso
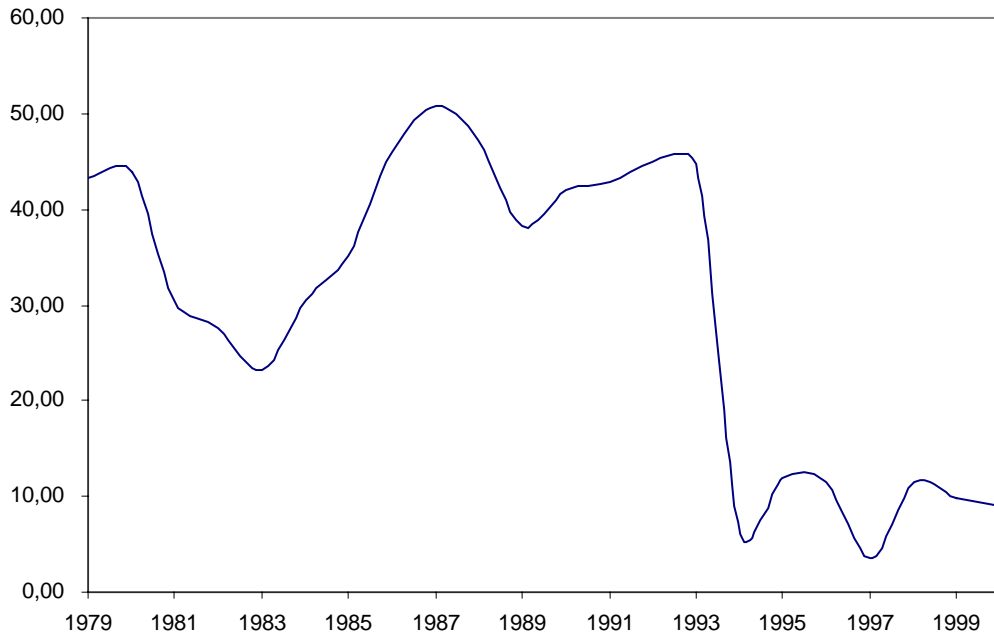
Figure 10. RER Equilibrium and Misalignment - Chad

RER, BEER, PEER - CHAD
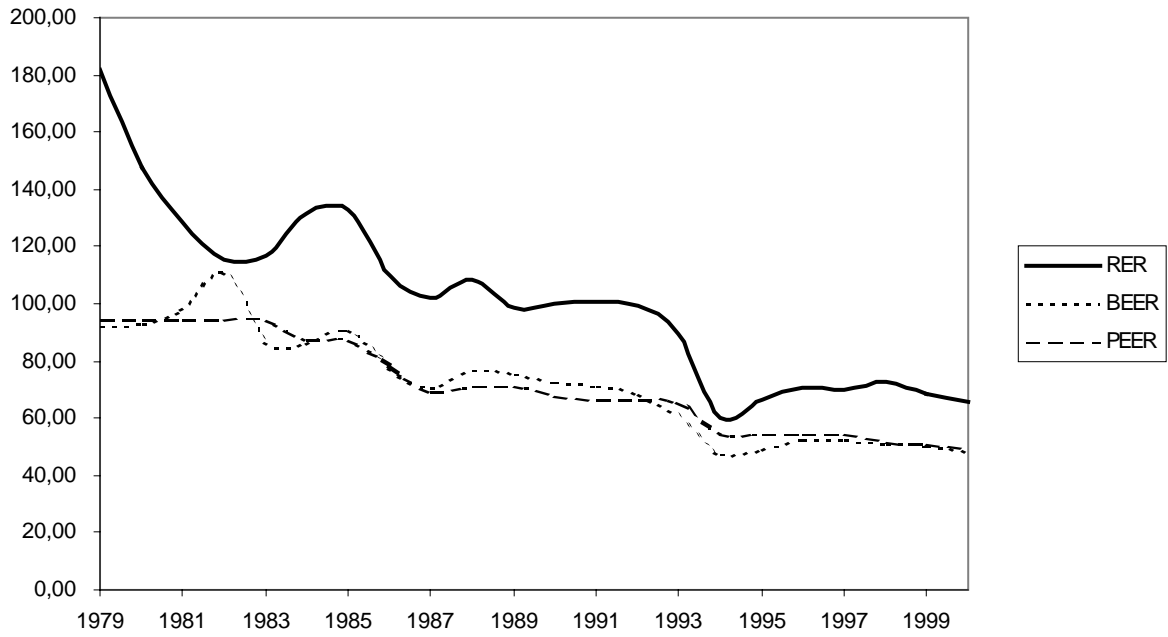
RER Misalignment - CHAD
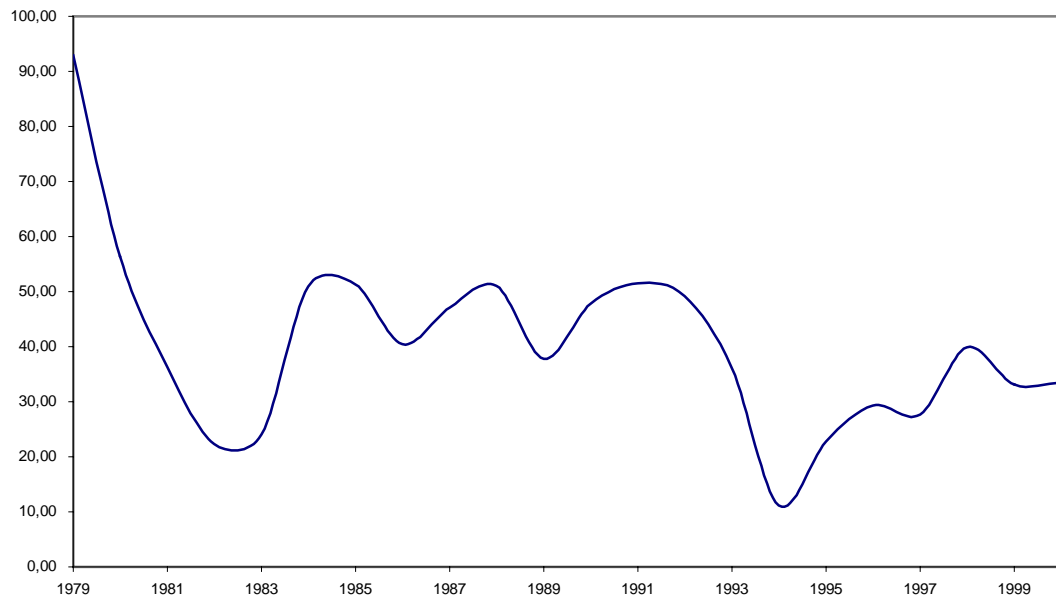
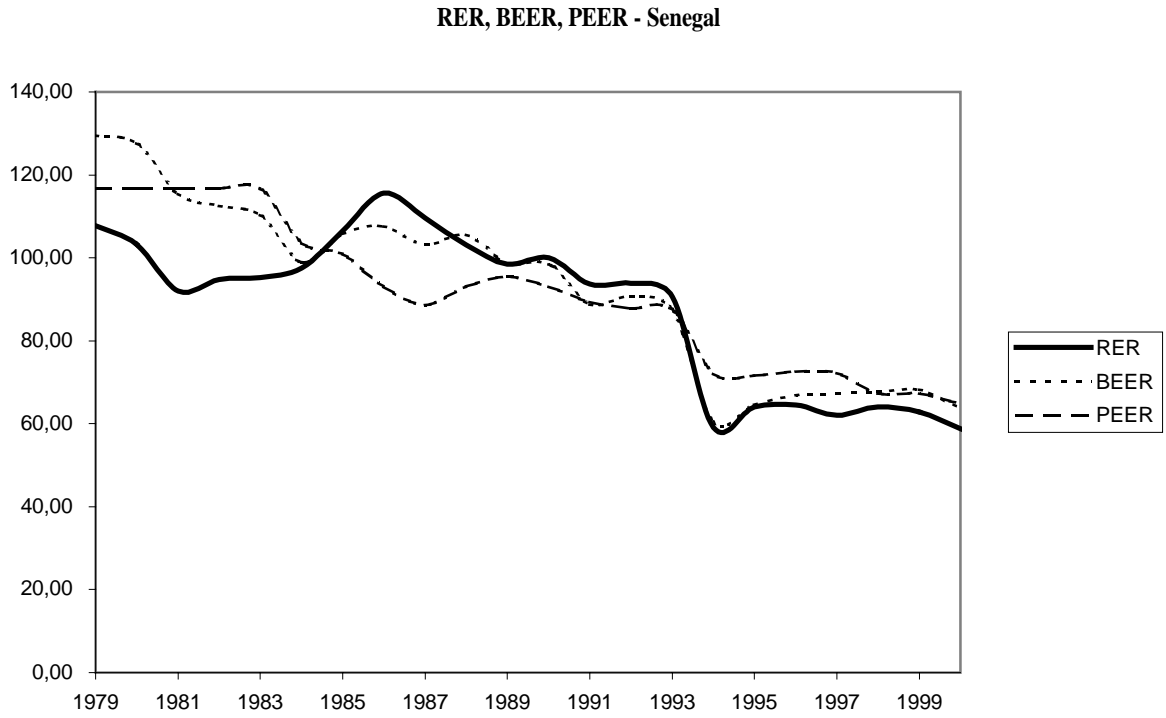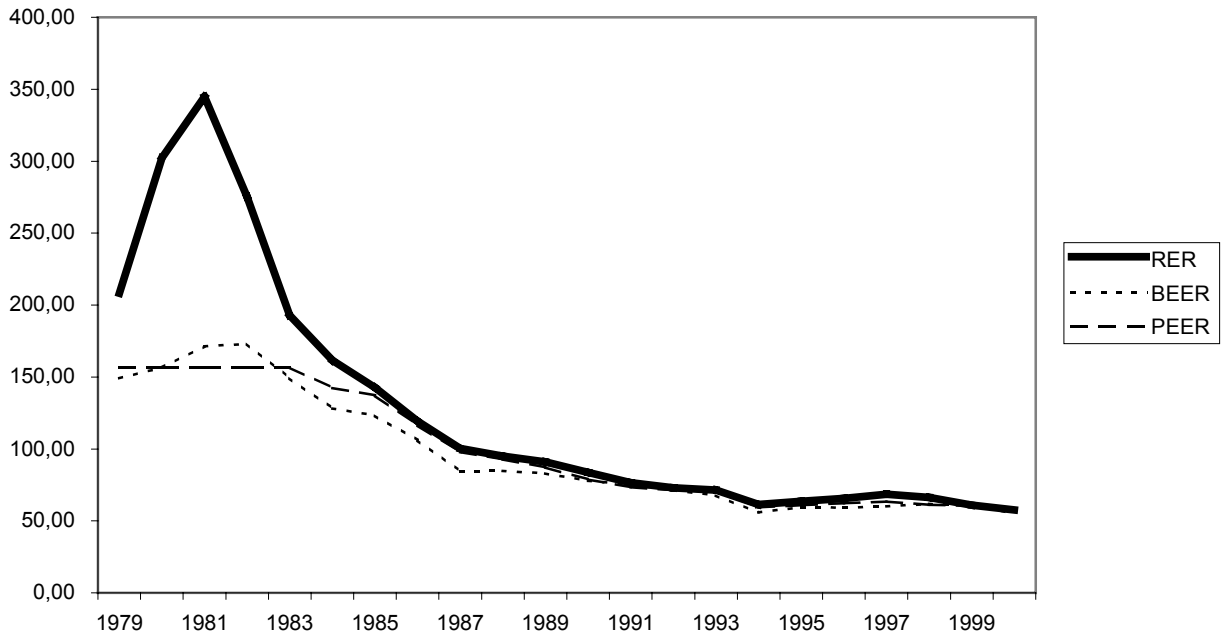**Figure 11. RER Equilibrium and Misalignment - Senegal**

RER, BEER, PEER - Senegal

RER Misalignment - Senegal

Figure 12. RER Equilibrium and Misalignment – Ghana

RER, BEER, PEER - Ghana
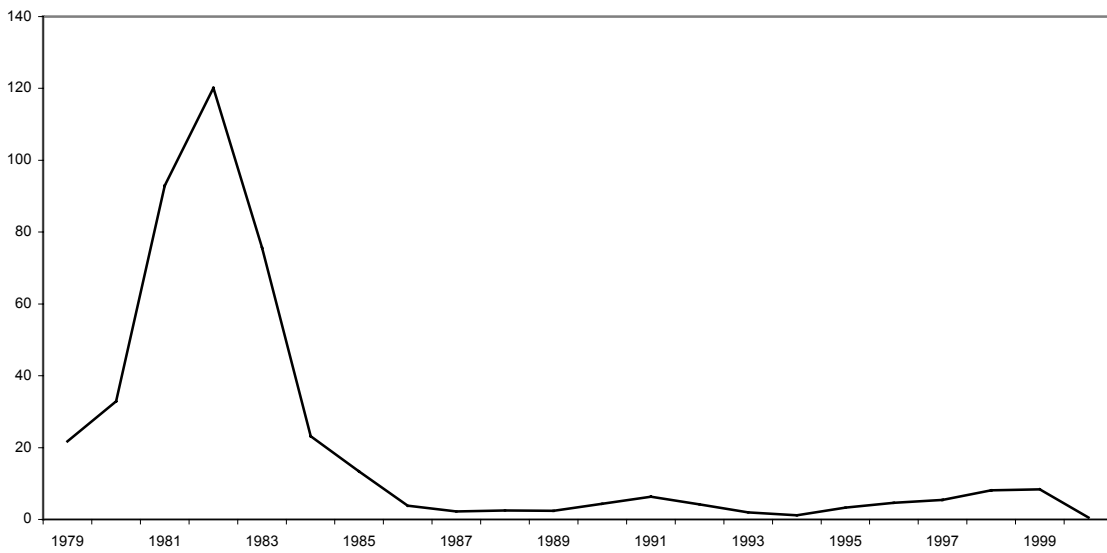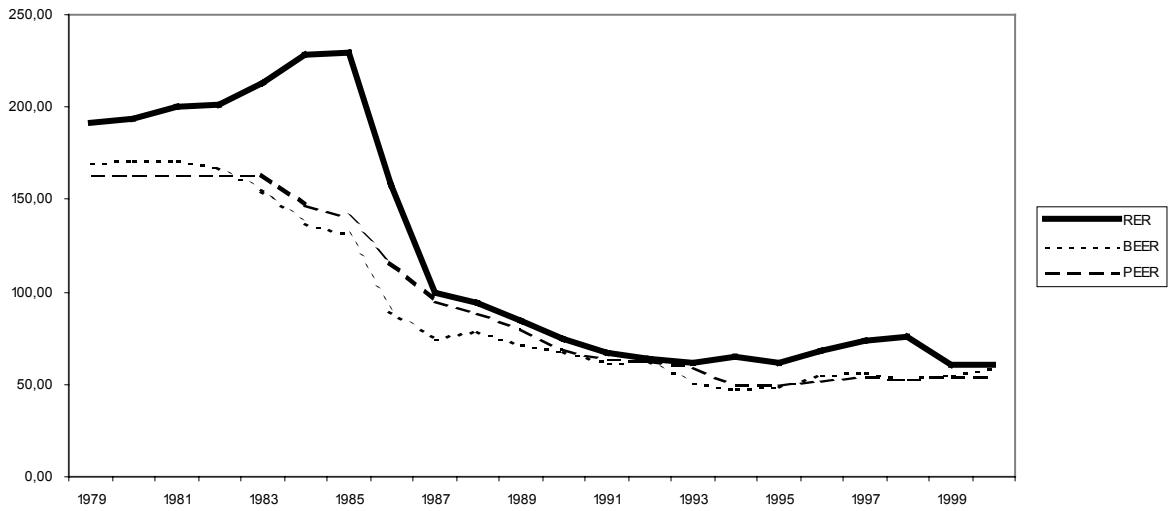

RER Misalignment - Ghana

Figure 13. RER Equilibrium and Misalignment – Nigeria

RER, BEER, PEER - Nigeria

RER Misalignment - Nigeria

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