Exchange Rate Misalignments and Economic Growth
Non-linear Models Based Study

Nabil Aflouk† and Jacques Mazier‡

ABSTRACT - This study deals with the link between exchange rate misalignments (ERM) and economic growth for a large sample of advanced and emerging economies on the period 1982-2010. The estimation of equilibrium exchange rate (EER) are based on a FEER approach (Jeong and al. (2010) and Aflouk and al. (2010) and are extended to a larger panel. The relationship "misalignments-growth" is estimated using a PSTR (Panel Smooth Transition Regression) and GMM models. Our main results show that the impact of ERM on economic growth is nonlinear and positive. An overvaluation has a negative impact on growth while an undervaluation sustains growth until an estimated threshold (15.5% for emerging countries and 9% for developed countries). The coefficient is weaker for emerging countries (0.02) than for developed countries (0.08). Due to non linearity and coefficient’s value, the undervaluation has a positive effect on growth even beyond the threshold. We also demonstrate that the impact of ERM on growth is positive only in the case of small undervaluation for emerging countries. However, concerning developed countries, the undervaluation have a positive effect on growth even beyond the estimated threshold. Nevertheless, overvaluation seems to have a negative effect on economic growth. Some specific results can be underlined. The negative impact of overvaluation of the euro for south Europeans countries appears clearly only during the 2000’s, while German growth is supported by the undervaluation of German euro. Similarly, undervaluation of dollar has strongly supported US growth at the end of 1980’s and beginning of 1990’s. Japanese growth has also been supported during the 1980’s and 2000’s by yen undervaluation. For emerging countries, the support of undervaluation for growth seems more limited (China specially) but the overvaluation of the Argentina peso during 1990’s , of the Indian rupees during the 2000’s, of the Brazilian real at the end mi 1990’s and of the 2000’s appear clearly significant.

Classification JEL : F31, F43, C23, O47

Keywords: Growth, exchange rate misalignments, non linearity, PSTR model

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1. Introduction

The poor economic performance in some developed countries versus remarkable results observed in other areas of the developing world raises several issues about the reasons of these differences. This heterogeneity further questions the theoretical and empirical determinants of economic growth. Some studies have emphasized the importance of exchange rate policy as a determinant of the “awesome” performance, in recent years, of some Asian countries. Furthermore, the exchange rate policy is the subject of considerable attention in recent debates of policy decision-makers, particularly during recent meetings of G20. This policy is considered as an important source of macroeconomic imbalances. It is equally a crucial condition for leveling up economic performance.

Several econometric studies carried out on developed and developing countries have attempted to identify the relationship between economic growth and the change rate dynamics. Many studies have measured the effects of the overvalued exchange rate on the growth rate (Razin and Collins, 1997, Easterly, 2001, Loayza and al, 2004; Magyar, 2008; Béreau and al. 2009). Others have studied the role of exchange rate policies in the development strategy of Asian countries. Most of them came out with significant correlations between exchange rate misalignments and growth. Indeed, Bresser-Pereira (2004) and Dooley and al. (2005) have shown that competitive currencies of Asian countries have stimulated investment and consequently the regional growth rates. Frenkel (2004) noticed that the overvaluation of the exchange rate is among the cardinal causes of crises and stagnation of growth in Latin America during the 1980s and 1990s. This result implies the existence of a significant relationship between economic growth and the real level of exchange rate.

The exchange rate misalignment, a concept that refers to an equilibrium exchange rate level, is one of the major pillars of the exchange rate policy. The approach of how to assess exchange rate misalignments is still a very controversial issue in economic literature. Purchasing Power Parity (PPP) remains the reference theory for determining the equilibrium exchange rate. However, several alternative approaches have been developed recently. The so-called exchange rate fundamental equilibrium (FEER) is focused on the simultaneous attainment of internal and external equilibrium (Williamson, 1985 and 1994). Other studies calculate the equilibrium exchange rates using reduced equations. They are based on long-run relationships between the real exchange rate and its fundamental determining factors. In this respect, we may mention the work of Stein and Allen (1997) who have developed the theory of Natural Real Exchange Rate (NATREX). On the other hand, Clark and MacDonald (1997) have proposed a purely econometric model called Behavioral Equilibrium Exchange Rate (BEER).

In order to investigate the "misalignments-growth" relationship, several studies are based on calculations of the PPP to measure exchange misalignments (Easterly, 2001, Chadha and Prasad, 1997, Hausman and al. 2004; Rodrik, 2008). Other studies are more based on the general equilibrium models (Loayza and al., 2004, Aguirre and Calderón, 2005). Nonetheless, Magyari (2008) revealed some major drawbacks for these approaches. The approach of the PPP does not take into account the structural characteristics of developing countries. The general equilibrium model is a complex approach that involves modeling the whole economy. Most recent studies on this issue are based on (BEER) approach to estimate exchange rate misalignments (Magyari (2008); Béreau and al, 2009; Sallenave, 2010). However, FEER approaches could be also used as they can better ensure the coherence and consistency of exchange rate misalignments when dealing with different countries using a worldwide trade model. Williamson (1990) has shown that the differences with respect to the equilibrium level have a negative impact on the growth. On the one hand, the overvaluation
implies external imbalances whilst undervaluation means an internal imbalance and excessive inflation. Undervaluation, although it is beneficial for the growth, may have some negative effect on the economy fundamentals. The analysis of the "misalignments-growth" relationship by means of the FEER approach seems more appropriate to discern the pitfalls throughout the growth models adopted by each country.

Most previous works have used the ordinary least square, the triple ordinary least square and the generalized moment’s dynamic method as techniques to assess the link between exchange rate misalignments and economic growth. Our work is based on a new econometric technique, namely the PSTR (Panel Smooth Transition Regression) model, used by Béreau and al. (2009) in the same context with a BEER approach. These models are an attractive solution to meet the new challenges induced by the use of macroeconomic panel data. The use of regime-changing models in panel data allows both to combine the benefits of working on panel data and solve simultaneously the problems of nonlinearity, heterogeneity and time instability of the relationship (Colletaz and Hurlin, 2006; Bessec and Fouquau, 2008). For comparison, we study the relationship based on the Generalized Method of Moments (GMM) developed by Arellano and Bover (1995).

This article is presented as follows. A first part is devoted to the literature review on the impact of misalignments on growth. The second part describes the adopted methodological. A third section examines the empirical link between economic growth and misalignments. A forth part displays the results obtained at the end of these estimates. A final section identifies key finding and draws conclusions

2. Literature Review

Very few theoretical works have addressed the issue of exchange rate misalignment as a determinant factor of economic growth. Many empirical studies conducted in recent years reflect the fundamental role of the exchange rate behavior in economic performance, essentially in emerging countries. Developing countries are still in the stage of seeking an appropriate model growth to help them to initiate their catching-up process.

Based on the PPP method to measure misalignments of the real exchange rate, Benaroya and Janci (1999), Easterly (2001), Fajnzylber and al. (2002), Rodrik (2008) and Berg and Miao (2010) studied the relationship between exchange rate misalignments and economic growth. Benaroya Janci (1999) found significant correlation between different levels of exchange rate and the growth rate. According to these authors, the countries with an exchange rate undervaluation tend to benefit of increased exports and higher growth rate per capita. Easterly (2001) analyzed the growth of developing countries from 1980 to 1998. He found out that despite the reforms of the 1980s and 1990s, the observed growth rates were still relatively low. In that analysis, he used several traditional variables such as initial GDP per capita, schooling, infrastructure and price stability. The results tend to confirm that better education and infrastructure boosts growth. Conversely, high inflation rates tend to deter growth. Easterly also found out a negative correlation between the exchange rate overvaluation and the economic growth rate.

Fajnzylber and al. (2002) found similar results by comparing the growth in the economies of Latin America and other countries during the period 1960-1999. Based on the measurements of the PPP built by Easterly (2001), these economists concluded that the overvalued exchange rate has a significant negative impact on growth. As an explanation of these empirical findings, they highlighted the increasing likelihood of payments balance crises due to overvalued exchange rates.
Rodrik (2008) revived the approach of the PPP adjusted from the Balassa-Samuelson effect to calculate the exchange rate misalignments. He demonstrated empirically that the increase in the undervaluation as well as the reduction of overvaluation was beneficial for the growth of developing countries. Once extending his analysis over periods of five years, he also noted that the periods of undervaluation are followed by higher economic growth ones. Among the theoretical arguments addressed by the author, we could mention: the dynamism of the tradable sector and the importance of positive externalities provided by the exports for economic growth. Rodrik added that the undervaluation might compensate the institutional weaknesses within developing countries and boost development growth.

Berg and Miao (2010) resumed the work of Rodrik (2008) by measuring the impact of exchange rate misalignments on growth. They estimated measures of misalignments based on PPP increased by fundamental variables, such as exchange terms and the investment rate as a % of GDP. Their results suggested firstly that the differences in the exchange rate with respect to equilibrium, obtained with their methodology, are higher than those calculated from the simple PPP. On the other hand, the overvaluation resulting from an exterior imbalance may generate a lower growth rate. The undervaluation can lead to "overheating" and to an excessive inflation that can have a negative impact on the medium-run growth.

Razin and Collins (1997) have elaborated an indicator of misalignment of the real exchange rate based on a set of behavioral equations. The model is based on the IS-LM standard model for a small open economy that produces a single tradable good. Aggregate demand depends on the real exchange rate and the real interest rate. The exchange rate equilibrium is determined simultaneously with respect to the goods market as well as the currency market. Then they study the impact of misalignments on growth. The authors highlight two ways through which exchange rate misalignments can affect the economic growth of a given country. On the one hand, they could act through domestic and foreign investment, influencing the process of capital accumulation, whose role is paramount for growth. On the other hand, misalignments could affect the competitiveness of the tradable sector with respect to the rest of the world. Based on panel data and a large sample of 93 countries (developed and developing), the authors introduced two exchange misalignments indicators, one to estimate the undervaluation, the other to assess the overvaluation. They found that only a very high overvaluation has a negative and statistically significant impact on growth. No significant relationship between economic growth and undervalued exchange rates was noticed. Nonetheless, a negative impact was detected regarding the exchange rate misalignments volatility on economic growth.

Based on a reduced version of the general equilibrium model of Obsteld-Rogoff increased by an equation of public expenses, Aguirre and Calderón (2005) calculated the misalignments of real exchange rate. Then, they assessed the impact of exchange rate misalignments and volatility on economic growth. Based on a sample of 60 countries over the period 1965-2003, the two authors came out with two findings: an important undervaluation has a negative impact on the growth of developing countries, while an average overvaluation (up to 12%) increases growth by 3 to 11% yearly. They equally noticed that an important overvaluation have an adverse effect on growth. In addition, they showed that the impact on growth of exchange rate misalignments is always negative and significant. That impact is remarkable particularly during periods of currency crises.

Popov and Polterovich (2005) focused their efforts on detecting the possible effects of the exchange rate undervaluation (not the overvaluation) on growth in the long run. The authors worked on a sample of 100 developed and developing countries over the period 1960-1999. They applied the accumulation of reserves as an indicator to measure the undervaluation situations with respect to the real exchange rate. The policy of accumulating reserves maintains the currency competitiveness for long periods. By comparing the levels of

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3 A similar version of this model, without government spending, is presented by Lane and Milesi-Ferretti (2004)
reserves with the growth rate per capita, they found a positive correlation for developing countries. These results show that the continuing undervaluation of the exchange rate may increase growth. In models of growth driven by exports, the accumulation of foreign exchange reserves reflects successive devaluations that increase aggregate demand in the short term and stimulate technological innovation in the long term. Devaluations increase the competitiveness of the tradable sector, stimulating, thereby, investment and economic development.

Magyari (2008), Béreau and al. (2009) and Sallenave (2010) studied the impact of the real exchange rate misalignment on the economic growth based on a BEER approach. Magyari (2008) studied the "misalignment-growth" relationship among 4 countries of Central Europe and Eastern Europe using the GMM estimation technique, using an analysis of data panel. He found out that 1% increment of the real exchange rate misalignment reduces the economic growth by 0.017%. By separating the periods depending on the nature of misalignment (over or undervaluation), the results remain significant in the sense that an important overvaluation slows economic growth. On the contrary, the undervaluation seems to have no significant impact on growth, a confirmation of the previous finding by Razin and Collins (1997).

Béreau and al (2009) attempted to assess the impact of exchange rate misalignments on growth by using the PSTR (Panel Smooth Transition Regression) model for a large number of developed and developing countries. This model showed non-linear and asymmetric relation between misalignments and economic growth. Indeed, they noted the existence of a significant and positive correlation between the change misalignment and the economic growth when money is undervalued (or slightly overvalued), while significant overvaluation seems to have no important impact on economic growth. The undervaluation’s related to competitive devaluation might lead to an exchange level which fosters exportations and boosts growth. On the contrary, overvaluation seems not to have specific impact on economic growth.

Sallenave (2010) studied the impact of exchange rate misalignment on economic growth by using techniques of dynamic panel data (GMM). According to the author, this technique allows both to take into account the specific effects at each country and to remedy of endogeneity-related possible problems. The results highlight the negative and significant link between the growth and the exchange rate misalignments. The author equally demonstrates that countries pursuing certain policies to reduce exchange rate misalignments are very likely to have some gain in economic growth.

Following these studies, we will study the relationship between economic growth and misalignments based on the FEER approach, to estimate the misalignments of exchange. The relation "misalignments-growth" will be studied by referring to the PSTR model used by Béreau and al. (2009) and the specification of the GMM.

3. Methodology

3.1. Equilibrium Exchange Rate Model

In this paper, we use the Fundamental Equilibrium Exchange Rate model (FEER). In this approach, the real exchange rate equilibrium corresponds to the real effective exchange rate enabling the economies to achieve their internal and external balances in the medium run.

The equilibrium exchange rates of the main countries or regions (USA, China, Euro Zone, Japan, and United Kingdom) are computed using a multinational model describing the foreign trade of these countries and of the rest of the world (Jeong and al. 2010). To estimate the equilibrium exchange rate of the less developed and emerging countries, a simplified model is used to describe the foreign trade of small countries while
assuming that the global demand and prices are exogenous (Jeong and al. 2010; Aflouk and al. 2010). In order to obtain the misalignment in terms of bilateral exchange rates, the results in terms of real effective exchange rates of small countries issued from the national model are articulated with those of the multinational model.

As defined previously, internal imbalances are measured by the difference in potential production with respect to the observed one. External imbalances are obtained by the difference between the observed and the equilibrium current account. This latter is estimated by taking into account the most important structural factors proposed in the literature, inspired from the work of Chin and Ito (2005) and Lee and al. (2008).

Once the reduced equation (1) is solved, this provides us evaluations of the real exchange rate misalignments. The misalignments with respect to the real equilibrium effective exchange rates \(r_i = (R_i - R^e_i) / R^e_i\) and to the bilateral nominal one \(e = d \log E = dE / E = (E - E^o) / E^o\) are computed based on the deviations with respect to the internal and external equilibriums, enabling consequently to assess the real and nominal undervaluation \((r_i > 0\) and \(e > 0\)) and overvaluation \((r_i < 0\) and \(e < 0\)) situations of the different currencies.

\[
\begin{align*}
    r_i &= \left[ \frac{((b_i / \mu_i)^T (1 - \sigma_{petx} - \sigma_{xi})) + \eta_d d_i - \eta x d_i \gamma}{((1 - \alpha x_i) \gamma))} \right] \\
    e &= \left[ \frac{((b_i / \mu_i)^T (1 - \sigma_{petx} - \sigma_{xi})) + \eta_d d_i - \eta x d_i \gamma}{((1 - \alpha x_i) \gamma))} \right]
\end{align*}
\]

Where \(b\) = difference between the observed and equilibrium current account balances as % of GDP, \(\sigma_{petx} = EP_{pet} M_{pet}/PXX\) :ratio of net oil imports with respect to non-oil exports, \(\sigma_x = dE/PXX = \text{ratio of external debt service on non-oil exports}\), \(X\) = net exports of oil in quantity, \(\alpha = \text{world demand in quantity}\), \(\gamma = \text{internal demand in quantity in logarithmic differential with respect to the equilibrium level}\), \(E = \text{nominal bilateral exchange rate against the dollar}\), \(i = \text{interest rate of foreign debt}\), \(F = \text{net foreign debt}\), \(\gamma = \text{oil price}\), \(\mu = \text{consumer price}\).

Equations 2 and 3 compute \(e\), which reflects the misalignment in bilateral and nominal term, and \(rc\) the misalignment in effective real term based on the consumption price.

\[
\begin{align*}
    e_i &= r_i + \sum_{j \neq i} \lambda_{ij} (px_j - e_j) \\
    rc_i &= (1 - \alpha m_i \mu_i) r_i + \sum_{j \neq i} \nu_{ij} (pd_j - e_j) - \sum_{j \neq i} \lambda_{ij} (px_j - e_j)
\end{align*}
\]

Where \(px\) is the export world price and \(pd\) is the consumer price.

### 3.2. GROWTH MODEL

Since the mid-1980s with the emergence of endogenous growth models, economic growth is no longer the result of demography and technological progress (Romer, 1986; Lucas, 1988 and Rebelo, 1991). The exogeneity of technical progress has been questioned and people can deliberately choose to accumulate knowledge and thus impact positively growth. Moreover, these models incorporate, in their formalization,
several growth factors, such as investment in physical capital, human capital, public capital, research and development, etc. Economic and social policies can also impact the level of growth rate.

Technical progress is made endogenous by human capital investment (Lucas, 1988). Differences in educational levels of countries labor force at the initial period cause differences in the level of growth rates. More educated people are expected to generate higher growth rate in terms of total product, as well as product per capita. Theoretically, it is expected that each level of scholarization generates a higher growth rate. Nonetheless, several studies have shown that the level of elementary education was negatively linked to economic growth. For that reason, this study uses instead the level of secondary education, as a variable designed to capture the impact of human capital.

Among the factors related to economic policy and expected to influence economic performance, we might mention in priority two, the inflation rate and the ratio of government consumption to GDP. In developing countries, when inflation is important, it can lead to a slowdown in economic growth, in overall product as well as employment collapse. A higher domestic inflation than abroad reduces the attractiveness of the economy and competitiveness of domestic firms and requires monetary adjustments. An increase in inflation reduces the real interest rate (ie interest rate of borrowers) but leads banks to raise their nominal interest rates (1980 and 1990), thus penalizing investment. Public expenses, when not being excessive, exert a positive externality on economic growth. Following the Keynesian view, the regulation of economic activity by public authorities should be ensured through counter-cyclical actions. This perspective leads governments to actively support this approach when agents demand collapse and to slow it down when the boom raises fears of internal and external imbalances. Thus, in the short term, public expenses can be used to stimulate global demand and boost economic growth. The argument in favor of public expenses considers that public investment in roads, electricity, transportation, telecommunications, education and health, generates externalities that enhance private factors productivity and can thus support economic growth (Aschauer, 1989, Tanzi and Zee, 1997).

In summary, the retained explanatory variables are lagged real GDP by capita, the inflation rate, investment share in the GDP (in %), the Human Development Index, the degree of openness, foreign direct investment in GDP (in %), Government expenses and our variable of interest, the exchange rate misalignments.

3.3. Econometric model

González and al. (2005) have proposed an extension of the PTR model (Panel Transition Regression) with abrupt transition, developed by Hansen (1999). PSTR models (Panel Smooth Transition Regression models) are characterized by a smooth transition passage.

Definition: the process satisfies a PSTR representation with two regimes, if and only if:

\[ y_{it} = \mu_i + \alpha_i X_{it} + \beta_0 r_{c_{it}} + \beta_1 r_{c_{it}} G(r_{c_{it}}; \gamma, c) + \epsilon_{it} \]  \[ [4] \]

Where \( \mu_i \) is the vector of individual fixed effects and \( G(r_{c_{it}}; \gamma, c) \) is the transition function associated to a transition variable \( r_{c_{it}} \). \( c \) is the threshold parameter, \( \gamma \) determines the slope of the transition function. \( X_{it} = (X_{1it}, \ldots, X_{kit}) \) is the matrix for interpreting variables, \( r_{c_{it}} \) describes the real effective exchange rate misalignment and where \( \epsilon_{it} \) is iid \((0; \sigma^2)\).

The indicator function of PTR models is replaced by a continuous transition function \( G(r_{c_{it}}; \gamma, c) \). González and al. (2005) proposed to work with a logistic transition function of order \( m \)
\[ G(rc_{it}; \gamma, c) = \left[ 1 + \exp\left(-\gamma \prod_{j=1}^{m}(rc_{it} - c_j)\right)\right]^{-1}, \gamma > 0, c1 < \ldots < cm \]

Where \( c = (c_1, \ldots, c_m) \) is a vector of dimension \((1, m)\) containing the thresholds parameters and \( \gamma \) is the smoothing parameter supposedly positive. The order of the transition function has a direct impact on the transitional dynamics between extreme regimes. Empirically, González and al. (2005) indicate that it is usually sufficient to consider \( m = 1 \) or \( m = 2 \).

PSTR modeling has the advantage of generating less extreme relations than PTR models (Colletaz and Hurlin, 2006; Besssec and Fouquau, 2008). It is considered as a model with regime infinity having two extreme regimes as its interval endpoints. It therefore could be considered as a linear and heterogeneous model for panel data where coefficients may vary depending on the individual and time period chosen. The second solution is to interpret the PSTR model as a nonlinear one where the system gradually moves through between two extreme linear and homogeneous regimes.

The values generally enable required changes of the slopes coefficients in order to take into account the non-linearity majority cases due to changes in regimes. Indeed, it was noticed that the higher is the smoothing parameter, the more abrupt is the transition between the two regimes. In the PSTR models, the elasticity’s value for a given country and at a given date might differ from the value of the estimated parameters of the two extreme regimes (\( \beta_0 \) and \( \beta_1 \)). The parameter \( \beta_0 \) is the elasticity when the transition function \( G(rc_{it}; \gamma, c) \) tends to 0. The sum of the parameters \( \beta_0 \) and \( \beta_1 \) corresponds to the elasticity when the transition function \( G(rc_{it}; \gamma, c) \) tends to 1. Between the two extreme regimes, the elasticity is defined as a weighted average of parameters \( \beta_0 \) and \( \beta_1 \) obtained in the extreme regimes (see equation 6 below).

In particular, when \( \gamma \) tends to infinity, the transition function tends to an indicator function, the PSTR model then has the same transition mechanism as a two-regime PTR model. However, the transition function becomes constant when \( \gamma \) tends to 0, thus the PSTR model becomes a linear panel with homogeneous coefficients and individual fixed effects. In the interim situation where \( \gamma \) does not tend to zero or to infinity, the series dynamics can be described by the slopes coefficients of one or the extreme regimes, or from a combination of the coefficients of the two extreme regimes.

Whatever the choice of transition function, PSTR models have a high capacity to enable parameters variation in function of misalignments \((rc)\) and of the concerned country. More specifically, the elasticity is defined as the weighted sum of \( \beta_0 \) and \( \beta_1 \)

\[ e_{it}^{rc} = \frac{\partial y_{it}}{\partial rc_{it}} = \beta_0 + \beta_1 G(rc_{it}; \gamma, c) \forall i, \forall t \]

According Gonzalez and al. (2005) the application of PSTR models requires a three-step procedure:

- **The specification:** The goal of this stage is to test homogeneity versus PSTR alternative. For this reason, we use the \( LM^5 \) and Fisher tests \( LF^6 \) provided by Gonzalez et al. (2005). This test defines the appropriate transition variable which minimizes the associated p-value, as well as the appropriate transition function order \( m^7c \) (i.e. the threshold) becomes a "kind" of misalignment reference value.

\[ LM = TN(SSR0 - SSR1)/SSR0 \text{ (Where SCR0 is the sum of squared residuals of a linear model with individual effects and SCR1 the sum of squared residuals of the auxiliary equation. Under the null hypothesis, the LM statistic is distributed according to a } \chi^2 \text{ with } mk \text{ degrees of freedom where } k \text{ is the number of explanatory variables).} \]

\[ F = (SSR0 - SSR1)/mk/SSR1/(TN - N - mk) \]

\( PSTR \) which reduces the standard deviations for the threshold parameters and smoothing.
However, it is not arbitrarily determined, but estimated so as to minimize the sum of squared residuals of the model.

- **The estimation:** The non-linear least squares are used to estimate the parameters

- **The evaluation and the selection of the regime number:** The test for nonlinearity (No. Remaining Heterogeneity) enables to test the number of regimes or equivalently the number of transition functions required to determine data heterogeneity and nonlinearity. González and al. (2005) propose to apply constancy tests on the used parameters by Eitrheim and Teräsvirta (1996) in the context of time series.

We introduce an estimation based on GMM, which can be used solely for comparative basis. This methodology is based on a dynamic model incorporating with panel data (i.e the set of interpreting variables including a lagged dependent one). As noted out by Arellano and Bover (1995) and Arellano and Bond (1991), the advantage of this method is to take into account country-specific effects and overcome endogeneity bias.

The regression estimation equation in its dynamic form is provided as follows:

\[
y_{it} = \alpha y_{it-1} + \beta t + \delta r_{it} + \mu + vt + \varepsilon_{it}
\]  

Where \( y \) represents the growth rate of real GDP per capita, \( X \) is the logarithm of initial real GDP per capita, \( r_{it} \) represents the misalignments of the real effective exchange rate, with control variables such as the secondary enrollment rate (HDI), trade openness (OPEN), government spending (GOV) and inflation (INF), \( \mu \) is the country specific effect, \( v \) is the specific temporal effect and \( \varepsilon \) is the error term, \( i \) and \( t \) represents respectively the country and time indices.

### 4. Data and estimation process

In this study, we considered a panel of 25 emerging countries (Argentina, Bolivia, Brazil, Chili, China, Colombia, Ecuador, Egypt, India, Indonesia, Malaysia, Mexico, Morocco, Pakistan, Paraguay, Peru, Philippines, Singapore, Sri Lanka, Thailand, Tunisia, Turkey, Uruguay, Venezuela and Vietnam) and 13 OCDE countries (Germany, Austria, South Korea, USA, Finland, France, Ireland, Italy, Japan, Netherlands, Portugal and United Kingdom) over the period 1982-2010, based on annual data. The data are from the CEPII database (CHELEM), the World Bank and IMF. The results of estimates of exchange equilibrium rates are based on the FEER model provided by the work of Jeong and al. (2010) and Aflouk and al. (2010). These works were taken and extended to a larger sample (Bolivia, Ecuador, Egypt, Morocco, Pakistan, Paraguay, Peru, Singapore, Sri Lanka, Tunisia, Turkey, Venezuela and Vietnam), keeping the same approach. The HDI are obtained from the database of Barro and Lee (2010).

We propose to reexamine the relationship between misalignments of the real effective exchange rate and economic performance based on an econometric study incorporating other explanatory variables of growth that have become standard in the literature. We apply a PSTR specification and the GMM dynamic (equation 7).

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* For the industrial economies, We use a shorter sample for the series of misalignments (1982-2009) ( Jeong and al. (2010).
We initially regressed on the entire sample, the real GDP growth per capita by the lagged real GDP per capita; the human development index (HDI) and the inflation rate calculated from the consumer price indices; the investment rate(I/Y); the degree of foreign trade openness (OPEN) and foreign direct investment(FDI). Government expenses(GOV), as an approximation of the fiscal impulse, were introduced separately, in order to distinguish their possible effects.

The first of these variables is the lagged income per capita; its coefficient represents the convergence effect, which would be negative according to neoclassical theory. On the contrary and according to the theory of endogenous growth, this coefficient would be zero. The convergence effect is zero and the economies do not deviate from their permanent growth regime. The second variable is a measure of human capital stock. Both theories predict that the coefficient of the stock of human capital should be positive, since countries with more human capital should have higher growth.

Other control variables include the investment rate, the public sector consumer expenses, the degree of openness to trade and international capital flows. The expected sign of the coefficient of the investment rate is positive, because the accumulation of capital is supposed to favor the growth of the real GDP per capita. As Aschauer (1989) and Tanzi and Zee (1997) have pointed out, the public sector consumption aims to represent public expenses that can generate positive externalities which would enhance private factors productivity. The coefficient for this variable would therefore be positive. Regarding the expected impact of foreign trade, it still remains ambiguous in economic theory (Hadjimichael and al.1997). The expected effects of international capital flows on economic growth are expected positive.

Regarding the misalignments exchange variable, most studies demonstrated two important impacts of this latter: an overvaluation tends to slow growth, while an undervaluation increases the exportation competitiveness which generates positive externalities for growth.

5. Results and interpretation

We first test the linearity⁹ and determine the number of regimes necessary to capture the non-linearity and/or individual heterogeneity and temporal instability of the slopes coefficients. In the second phase, we estimate the threshold-based model parameters in order to deduce the elasticity between economic growth and misalignments, but also we’ll assess the growth with respect to a given exchange misalignment. Estimates for the PSTR models, with a logistic function, are made from Hurlin and Colletaz codes.

We consider, in turn, three panels composed of different countries, namely: the entire sample, the emerging markets and ultimately, the developed countries. The applied approach is traditional. In a first step, we test the non-linearity of our growth function using threshold-based specification. If linearity hypothesis is rejected, we must then determine the optimal number of transition functions to capture all the non-linearity. For each specification, we have reported, in Table 1, the calculation of LM test statistics as well as Fisher test. These values are given to the first non-rejection of H0. However, we limit our analysis to a model with a logistic transition function (m = 1).

⁹ The linearity test against a PSTR alternative is to test H0: θ₁ = 0 in equation (4) for the specification with a logistic transition function, and H0: θ₁ = θ₂ = 0 for the logistic function.
Table 1: Linearity tests versus the PSTR alternative

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<tr>
<td>H0 : r = 0 vs</td>
<td>40.79</td>
<td>6.77</td>
<td>56.95</td>
</tr>
<tr>
<td>H1 : r = 1</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>H0 : r = 1 vs</td>
<td>9.74</td>
<td>1.55</td>
<td>1.96</td>
</tr>
<tr>
<td>H1 : r = 2</td>
<td>(0.13)</td>
<td>(0.15)</td>
<td>(0.92)</td>
</tr>
</tbody>
</table>

(Source: authors’ estimates). The test procedure is as follows. First, the linear model \( (r = 0) \) is tested with respect to a model with a threshold \( (r = 1) \). If the null hypothesis is rejected, the model is tested with respect to a double threshold model. The procedure continues until the additional threshold hypothesis is rejected. The corresponding LM and LMF statistics follow an asymptotic distribution of \( \chi^2 \) (1) for a logistic function under the null hypothesis. The \( p \)-corresponding values are shown in parentheses.

Apparently and regardless the statistics taken or the sample selected, the linearity test clearly rejects the null hypothesis of existence of a linear relationship between economic growth and exchange rate misalignment.

The estimated slopes coefficients for the PSTR model, the smoothing parameters and thresholds parameters and the GMM model results are illustrated in Tables 2, 3 and 4. We consider LPSTR models with \( m = 1 \), the coefficients have the expected signs: \( \beta_0 \) is always positive, while \( \beta_1 \) is negative. The values of the estimated smoothing parameters \( \gamma \) are relatively small. This confirms the impossibility to use an abrupt transition model to describe the nonlinear relationship between economic growth and change rate misalignments. The results prove that the exchange rate misalignment impact differently economic growth, depending on the adopted models (PSTR, GMM) or the selected sample.

We first pay more attention to the set of control factors for the three considered samples. All explanatory variables have expected signs, regardless of the retained specification (PSTR, GMM).

The regressions show a very negative significant effect of lagged real GDP per capita. This result supports the hypothesis of the convergence effect mentioned in the literature review. The investment rate seems to play a greater role in the case of developed countries. In most emerging countries, this could be tributary to the fact that investment is sometimes oriented towards unproductive projects (real estate, oversized projects, etc ....). The variables that reflect the external relations of the countries raise some questions. Contrarily to FDI which produced an expected effect for the various specifications, the unexpected effect of trade openness for developed countries according to the PSTR model, would rather mean that the significant levels of trade openness that have marked these economies have not promoted economic growth. Such an effect can be explained inter alia, by the application of growth models that are more fueled by domestic demand. On the other hand, the HDI (Human Development Index), despite its positive sign for the different specifications seems to have a more significant impact on growth in emerging countries. The impact of inflation is predicted with a negative and very significant impact on growth. The public expenses variable was discarded from the regressions models given the limited availability of data and / or even if they existed, they were only part of public expenditures (public administrations expenses). These difficulties prevented us from accurately interpreting the expected impact of this variable.

Regarding the effect of exchange rates misalignments on economic growth, the PSTR model results appear relatively consistent throughout the three samples. Moreover, we found out that the threshold parameter value (TPV) differs from one sample to another. According to our estimates, we obtained misalignments TPV of 15.8% for the total sample, 15.5% for emerging countries sample and 9% for developed countries sample. These results are relatively significant and may reflect the level of development of each region.
Consider first the total sample (table 2). For PSTR results, the threshold estimated for the misalignment is 15.8%. Indeed in the first regime, the coefficient is 0.029. Our results confirm the negative impact of the overvaluation \( r<0 \) on growth, regardless of its value. Furthermore, an average underestimation \( r>0 \) till about 16% may be favorable to economic growth. This finding is consistent with the results of Aguirre and Calderón (2005) and Berg and Miao (2010). However, in the second regime, misalignments appear to act differently on growth. The impact of relatively high level of undervaluation on growth is negative and significant in the case of the extreme regime. Beyond 15.8%, an increase of the undervaluation of 1% contributes to a reduction of the GDP per capita of 2.1%\(^{10}\), Aguirre and Calderón (2005) showed that the impact on growth is positive only for the undervaluation of small size (up to 12%). Our results seem not to be consistent with those of Béreau and al. (2009). Indeed, the authors showed that the undervaluation, irrespectively of how big it is, has a positive impact on growth. Conversely, they concluded that large overvaluations do not seem to have important effects on economic growth.

In theory, industrialization can be accomplished through real undervaluation by generating profits in the tradable sector. However, some difficulties could be encountered. A much undervalued currency implies deterioration in income distribution and an intensive use of natural resources. Devaluations can lead to excessive undervaluation. This phenomenon often results into an inflation and a recession, by increasing the prices of production goods. This would lead to an inflation-devaluation spiral, causing a serious delay in the economic development (Dervis and Petri, 1987; Isard, Symansky and Ito, 1997).

In the GMM econometric models (Table 2), misalignment of the real effective exchange rates has little influence on countries growth as a whole. Despite their expected signs, the exchange rate misalignments do not seem to play an important role in the economic performance of the studied countries. This finding may be explained, on the one hand, by the different levels of development of these countries and, on the other hand, by the significant misalignments volatility, especially in emerging economies.

---

**Table 2: Growth determining variables: PSTR and GMM; All the sample**

<table>
<thead>
<tr>
<th>Variable</th>
<th>PSTR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff</td>
<td>T-Stat</td>
</tr>
<tr>
<td>initial GDP per capita in log</td>
<td>-0.028</td>
<td>-4.940</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.001</td>
<td>-4.526</td>
</tr>
<tr>
<td>Investment/PIB</td>
<td>0.043</td>
<td>2.240</td>
</tr>
<tr>
<td>HDI</td>
<td>0.002</td>
<td>1.012</td>
</tr>
<tr>
<td>Openness level</td>
<td>0.065</td>
<td>4.046</td>
</tr>
<tr>
<td>FDI/GDP</td>
<td>0.220</td>
<td>5.194</td>
</tr>
<tr>
<td>Misalignments</td>
<td>0.029</td>
<td>4.162</td>
</tr>
<tr>
<td>Misalignments * ( G(r_{ct};\gamma, c) )</td>
<td>-0.050</td>
<td>-3.920</td>
</tr>
<tr>
<td>( c )</td>
<td></td>
<td>0.158</td>
</tr>
<tr>
<td>( \gamma )</td>
<td></td>
<td>5.000</td>
</tr>
</tbody>
</table>

Source: Authors estimates

\(^{10}\) The coefficient in the second regime = \( \beta_0 + \beta_1: (0.029-0.05=-0.021) \)
Table 3: Growth determining variables: PSTR and GMM; Emerging Countries

<table>
<thead>
<tr>
<th>Variable</th>
<th>PSTR Coeff</th>
<th>PSTR T-Stat</th>
<th>GMM Coeff</th>
<th>GMM T-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial GDP per capita in log</td>
<td>-0.053</td>
<td>-6.674</td>
<td>-0.053</td>
<td>-6.699</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.001</td>
<td>-3.653</td>
<td>-0.001</td>
<td>-3.614</td>
</tr>
<tr>
<td>Investment/PIB</td>
<td>0.032</td>
<td>1.467</td>
<td>0.032</td>
<td>1.440</td>
</tr>
<tr>
<td>HDI</td>
<td>0.023</td>
<td>4.619</td>
<td>0.025</td>
<td>5.291</td>
</tr>
<tr>
<td>Openness level</td>
<td>0.052</td>
<td>2.738</td>
<td>0.058</td>
<td>3.000</td>
</tr>
<tr>
<td>FDI/GDP</td>
<td>0.280</td>
<td>3.748</td>
<td>0.280</td>
<td>3.667</td>
</tr>
<tr>
<td>Misalignments</td>
<td>0.022</td>
<td>2.549</td>
<td>0.009</td>
<td>1.538</td>
</tr>
<tr>
<td>Misalignments * G(rc_it; γ, c)</td>
<td>-0.031</td>
<td>-2.022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>0.155</td>
<td></td>
<td></td>
</tr>
<tr>
<td>γ</td>
<td></td>
<td>5.000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors estimates

Taking into account the disparities in development levels between countries, we proceed to estimate the misalignment-growth relationship in two sub-samples. The results depicted in Tables 3 and 4 show some differences. First, the estimated threshold varies between the two groups of countries: only 9% for developed countries versus 15.5% for emerging countries. This difference can be explained by the fact that exchange rate misalignments are generally higher in emerging countries than in the developed ones. We can note that emerging economies are experiencing an economic “catch-up”. These countries attempt to pursue the best strategies to maintain the competitiveness of their exportations. An undervalued currency may boost exports significantly, thus raising significant growth.

Figure1: Exchange rate misalignment in % impact on Growth in % in Argentina, Brazil, Bolivia, China, India, Morocco, Thailand and Tunisia
Second, the PSTR model results show that the undervaluation has a negative significant impact on growth in emerging countries, when the undervaluation exceeds the estimated threshold of 15.5%. On the contrary and for developed countries, even beyond the threshold of 9%, the undervaluation has a significant and positive impact amounting to 0.028. This could be explained by the better control of the exchange rate misalignments volatility in developed countries than in emerging countries. This finding highlights the positive effects of monetary policy adopted by developed economies. This policy promotes price stability and consequently the stability of the real exchange rate within developed economies. In addition, the flexible exchange rate regime adopted by these countries induces stability of the exchange rate by allowing an automatic adjustment.
Table 4: Growth determining variables: PSTR and GMM; Developed Countries

<table>
<thead>
<tr>
<th>Variable</th>
<th>PSTR</th>
<th>GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
<td>T-Stat</td>
</tr>
<tr>
<td>initial GDP per capita in log</td>
<td>-0.048</td>
<td>-6.954</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.228</td>
<td>-5.422</td>
</tr>
<tr>
<td>Inversement/PIB</td>
<td>0.466</td>
<td>8.137</td>
</tr>
<tr>
<td>HDI</td>
<td>0.002</td>
<td>1.218</td>
</tr>
<tr>
<td>Openness</td>
<td>-0.036</td>
<td>-1.337</td>
</tr>
<tr>
<td>FDI/GDP</td>
<td>0.158</td>
<td>4.844</td>
</tr>
<tr>
<td>Misalignments</td>
<td>0.076</td>
<td>5.325</td>
</tr>
<tr>
<td>Misalignments * (G(r\gamma; \gamma, c))</td>
<td>-0.048</td>
<td>-1.988</td>
</tr>
</tbody>
</table>

Source: Authors estimates

Third, the results obtained by the GMM estimates from the two sub-samples support the findings demonstrated beforehand. The misalignments with a positive coefficient but not significant (Table 3) do not appear as a growth determinant factor for emerging economies.

Figure 2: Exchange rate misalignment in % impact on Growth in % in United States, Japan, France, Germany, Spain and Portugal
According to the results of estimates of equilibrium exchange rate, it was found out that the exchange rate misalignments for emerging markets are higher and less stable than those in developed countries. This finding can be partially explained by inappropriate macroeconomic policies (commercial and exchange rates) (Ghura and Grens, 1993). The high degree of misalignments and their persistence turned out to be significant factors for slowing down growth, especially in emerging countries, as shown in Table C (appendix C). Indeed, Sallenave (2010) concluded that the adjustment of the exchange rate towards the equilibrium levels seems to be more feasible in developed countries rather than in emerging ones. Thus, it sets evidence that countries pursuing appropriate reforms to reduce exchange rate misalignments are more prone to achieve some gain in terms of growth.

6. Conclusion

The main objective of this article was to study the impact of misalignments of real effective exchange rate on economic growth. We have considered equilibrium exchange rates estimated by the FEER approach in the works of Jeong and al. (2010) and Aflouk and al. (2010). In this paper, we expanded the sample by adding other countries but pursuing the same methodological approach. For that scope, we used the GMM specification and the PSTR model, combined with a logistic transition function in order to characterize the relationship between exchange rate misalignments and economic growth.

Our study was carried out on a sample of 25 emerging countries and 13 developed countries for the timeframe 1982-2010. It has confirmed the presence of nonlinearity and asymmetry in this relation between misalignment and growth. Besides, the use of threshold-based specifications with a logistic transition function has characterized in a better way misalignments-growth relationship for the three samples.

The control explanatory variables are significant and of expected sign. The obtained results for the misalignment variables show that for values below the estimated thresholds overvaluations have a negative impact on growth. On the contrary, under the estimated thresholds undervaluation has invariably a positive impact on growth.

However, working with sub-samples of countries enabled to notice that the threshold value varies from developed countries to emerging ones: a threshold of 9% for industrialized economies versus 15.5% for developing ones. The initial level of development, as well as misalignments generally higher in emerging countries than in advanced ones, can explain the different values of the threshold between both classes of economies.
We concluded that the effect of misalignments on growth depends on the size of these misalignments in the case of undervaluation. The effect on growth is negative; whatever how large is the overvaluation. The impact on growth is positive in the case of slight undervaluation (up to 15.5%) and negative in the case of significant undervaluation for emerging countries. In developed countries the undervaluation seems to have a positive impact, even beyond the estimated threshold.

Some specific results can be underlined. The negative impact of overvaluation of the euro for south Europeans countries appears clearly only during the 2000’s, while German growth is supported by the undervaluation of German euro. Similarly, undervaluation of dollar has strongly supported US growth at the end of 1980’s and beginning of 1990’s. Japanese growth has also been supported during the 1980’s and 2000’s by yen undervaluation. For emerging countries, the support of undervaluation for growth seems more limited (China specially) but the overvaluation of the Argentina peso during 1990’s, of the Indian rupees during the 2000’s, of the Brazilian real at the end mi 1990’s and of the 2000’s appear clearly significant.

The conduction of an analysis based on GMM model led to conclusions that can be used solely for comparison. In that respect, the findings showed variation in the exchange rate inter-countries and not intra-country. The GMM results showed that exchange rate misalignments, even if they have an expected sign, did not seem to be a determining factor on the economic performance of emerging countries.
Bibliographie


Appendix A: Multinational model in differential logarithmic

Multinational model in logarithmic differentials \( x = dX / X = (X - X^*) / X^* \) is transformed into:

\[
x_i = \eta x_i \sum_{j \neq i} \alpha_{ij} m_j + \varepsilon x_i \left( px_i - px^*_i \right) \tag{A.1}
\]

\[
px_i = \sum_{j \neq i} \alpha_{ij} \left( px_j - e_j \right) + e_i
\]

\[
m_i = \eta m_i di + \varepsilon m_i \left( pd_i - pm_i \right) \tag{A.2}
\]

\[
pmm_i = \sum_{j \neq i} \mu_{ij} \left( px_j - e_j \right) + e_i
\]

\[
\sum_i wx_i \left( x_i + px_i - e_i \right) = \sum_i vm_i \left( m_i + pm_i - e_i \right) \tag{A.3}
\]

\[
\sum_i wx_i x_i = \sum_i wm m_i \tag{A.4}
\]

\[
px_i = \alpha x_i pxm_i + \left( 1 - \alpha x_i \right) p_i \tag{A.5}
\]

\[
pm_i = \alpha m_pmum_i + \left( 1 - \alpha m_i \right) pd_i \tag{A.6}
\]

\[
pd_i = a_i pm_i + \left( 1 - a_i \right) p_i \tag{A.7}
\]

\[
r_i = e_i - pd_i + \sum_{j \neq i} \left( pd_j - e_j \right) \tag{A.8}
\]

\[
b_i = \mu_i T_i (1 - \sigma_{pex_i} - \sigma_{x_i}) (px_i + x_i - pm_i - m_i) \tag{A.9}
\]

With \( wx, wm, vx, vm \) = the shares of each country in the world exports in volume, the world imports in volume, the world exports in value and the world imports in value, respectively; \( T = PXX / PMM \) = ratio of exportation to importation; \( \mu = PMM / PY \) = openness ratio; \( F \) = net external position in dollars; \( i \) = interest rates; \( \sigma_i = iEF/PXX \) = ratio of external debt services to exports and \( \sigma_{pex} = EP_{petMpet}/PXX \) = ratio of net oil imports on non-oil exports.

The way the equation [A.9] is derived should be explained:

\[
b_i = \frac{B_i}{P_i Y_i} - \frac{B_i^e}{P_i^e Y_i} = d \left( \frac{B_i}{P_i Y_i} \right) = \mu_i d \left( \frac{B_i}{P_i Y_i} \right)
\]

\[
b_i = \mu_i d \left( \frac{PX_i X_i}{PM_i M_i} - 1 - \left( \frac{EP_{petMpet}}{PX_i X_i} \right) - \left( \frac{i_i E_i F_i}{PX_i X_i} \right) \right)
\]

\[
b_i = \mu_i T_i (1 - \sigma_{pex_i} - \sigma_{x_i}) (px_i + x_i - pm_i - m_i)
\]

\[
b_i = \mu_i dT_i (1 - \sigma_{pex_i} - \sigma_{x_i})
\]

\[\lambda_{ij} = \frac{X_{i, x+}}{X_i} ; \mu_{ij} = \frac{M_{i, x+}}{M_i} ; \alpha_{ij} = \frac{X_{i, x+} + M_{i, x+}}{M_i} ; \nu_{ij} = \left( \frac{X_{i, x+} + M_{i, x+}}{X_i + M_i} \right) \] (Source: authors’ calculations, CHELEM, CEPII’s database). Here, we use natural logarithms in order to simplify calculations. This approximation is acceptable at first order and in the vicinity of equilibrium.
Appendix B: National model in differential logarithmic

National model in logarithmic differentials \((x = dX / X = (X - X^\star) / X^\star)\) is transformed into:

\[
x_i = \eta x_i d_i^\star + (1 - \alpha x_i)x_i r_i
\]

\[
m_i = \eta m_i d_i - (\alpha m_i) m_i r_i
\]

\[
px_i = \alpha x_i r_i + p_i
\]

\[
pm_i = \alpha m_i r_i + p_i
\]

\[
b_i = \mu T_i \left(1 - \sigma_{petx_i} - \sigma_{x_i}\right)(px_i + x_i - pm_i - m_i)
\]

We can compute \(r\) (equation [1]), the misalignment in real effective terms \((r = dLogR = dR / R = (R - R^\star) / R^\star)\):

\[
\frac{dT_i}{T_i} = px_i + x_i - pm_i - m_i
\]

\[
\frac{dT_i}{T_i} = (\eta x_i d_i^\star - \eta m_i d_i) + \left[(1 - \alpha x_i x_i) + \varepsilon m_i \alpha m_i + \alpha x_i - \alpha m_i\right] r_i
\]

\[
b_i = \mu dT_i \left(1 - \sigma_{petx_i} - \sigma_{x_i}\right)
\]

\[
\frac{dT_i}{T_i} = \frac{b_i}{\mu T_i \left(1 - \sigma_{petx_i} - \sigma_{x_i}\right)}
\]

\[
r_i = \frac{\left[\left(\frac{b_i}{\mu T_i \left(1 - \sigma_{petx_i} - \sigma_{x_i}\right)}\right) + \eta m_i d_i - \eta x_i d_i^\star\right]}{(1 - \alpha x_i) \varepsilon x_i + \varepsilon m_i \alpha m_i + \alpha x_i - \alpha m_i)}
\]

By using the equation of the real effective exchange rate, we can find out \(e\), the degree of misalignment in bilateral nominal terms (equation[2]); the partner countries’ misalignments are given by the previous multinational model:

\[
r_i = e_i + px_i^\star - p_i
\]

Like in the multinational model, we suppose that \(p_i = \left(\frac{P_i - P_i^\star}{P_i^\star}\right) = 0\)

\[
e_i = r_i + \sum_{j \neq i} \lambda_{ij} \left(px_j^\star - e_j\right)
\]
We can also compute the effective ERM based on consumer prices (PD) (equation [3]):

\[ RC_i = \frac{E_i PD_i^*}{PD_i} \]

\[ rc_i = e_i + pd_i^* - pd_i \]

\[ pd_i^* = \sum_{j\neq i} V_{ij} (pd_j - e_j) \]

\[ pd_i = \mu_i pm_i + (1-\mu_i) p_i \]

\[ pm_i = \alpha m_i (e_i + pm_i^*) + (1-\alpha m_i) p_i \]

\[ pd_i = \alpha m_i e_i + pm_i^* \]

\[ rc_i = (1-\alpha m_i \mu_i) r_i + pd_i^* - px_j^* \]

\[ rc_i = (1-\alpha m_i \mu_i) r_i + \sum_{j\neq i} V_{ij} (pd_j - e_j) - \sum_{j\neq i} \lambda_{ij} (px_j - e_j) \]

\[ (pd_j, e_j, px_j) \text{ obtained thanks to the multinational model} \]

Appendix C

Table C.1 : Misalignments in absolute value and economic growth estimates in GMM

<table>
<thead>
<tr>
<th>Variable</th>
<th>All countries</th>
<th>Emerging countries</th>
<th>Developed countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coeff</td>
<td>T-Stat</td>
<td>Coeff</td>
</tr>
<tr>
<td>initial GDP per capita in log</td>
<td>-0,036</td>
<td>-6,390</td>
<td>-0,052</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0,001</td>
<td>-4,551</td>
<td>-0,001</td>
</tr>
<tr>
<td>Investment/PIB</td>
<td>0,031</td>
<td>1,625</td>
<td>0,028</td>
</tr>
<tr>
<td>HDI</td>
<td>0,002</td>
<td>1,002</td>
<td>0,022</td>
</tr>
<tr>
<td>Openness level</td>
<td>0,052</td>
<td>3,248</td>
<td>0,053</td>
</tr>
<tr>
<td>FDI/GDP</td>
<td>0,208</td>
<td>4,947</td>
<td>0,271</td>
</tr>
<tr>
<td>Misalignments in absolute value</td>
<td>-0,029</td>
<td>-3,614</td>
<td>-0,018</td>
</tr>
</tbody>
</table>

Source : Authors estimates
Table C.2: Misalignments of the real effective exchange rate: Bolivia, Paraguay, Peru, Singapore, Ecuador, Egypt, Morocco, Pakistan, Sri Lanka, Tunisia, Turkey, Venezuela and Vietnam.

<table>
<thead>
<tr>
<th></th>
<th>BOL</th>
<th>PRY</th>
<th>PER</th>
<th>SGP</th>
<th>ECU</th>
<th>EGY</th>
<th>M0R</th>
<th>PAK</th>
<th>LKA</th>
<th>TUN</th>
<th>TUR</th>
<th>VEN</th>
<th>VNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>82</td>
<td>0.01</td>
<td>-0.51</td>
<td>-0.46</td>
<td>0.47</td>
<td>-0.14</td>
<td>-0.18</td>
<td>0.27</td>
<td>0.50</td>
<td>-0.27</td>
<td>-0.30</td>
<td>0.48</td>
<td>-0.34</td>
<td>na</td>
</tr>
<tr>
<td>83</td>
<td>0.02</td>
<td>-0.37</td>
<td>-0.25</td>
<td>0.31</td>
<td>0.07</td>
<td>-0.08</td>
<td>-0.04</td>
<td>0.16</td>
<td>-0.17</td>
<td>-0.21</td>
<td>0.63</td>
<td>0.16</td>
<td>na</td>
</tr>
<tr>
<td>84</td>
<td>0.14</td>
<td>-0.55</td>
<td>0.23</td>
<td>0.09</td>
<td>0.05</td>
<td>-0.32</td>
<td>0.04</td>
<td>-0.19</td>
<td>0.29</td>
<td>-0.38</td>
<td>0.66</td>
<td>0.21</td>
<td>na</td>
</tr>
<tr>
<td>85</td>
<td>-0.35</td>
<td>-0.42</td>
<td>0.34</td>
<td>0.14</td>
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Source: Authors estimates