Real exchange rate misalignment in Senegal: effect on growth

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22 December 2017

ECONOMIC NOTE

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Summary

Is there an overvaluation of the real exchange rate? What is the effect of devaluation on economic growth? This empirical study attempts to answer these two important questions in the economic context of Senegal, using 1980 - 2014 data. To answer the first question, we used the BEER (Behavioral Equilibrium Exchange Rate)[2] approach and Rodrik's approach. As for the second question, we used the ARDL (AutoRegressive Distributed Lag) cointegration model.

Our results show that since 2008, there has been a trend towards the overvaluation of the CFAF in Senegal. Senegal, for example, recorded an overvaluation of the real exchange rate estimated at between 10% and 35% in 2013 and 2014. In addition, our results show that misalignment has a positive impact on long-term economic growth, in particular devaluation in situations of overvaluation. In addition, a devaluation of 10% leads to an increase in economic growth of 0.64 percentage points. Our results are based on all the robustness tests performed.

[2] Using the Fully Modified OLS model by applying the Christiano and Fitzgerald filter to the variables

Introduction

Several studies have shown the importance of the exchange rate regime in an economy and its implications for growth [Dollar (1992); Sachs and Warner (1995); Rodriguez and Rodrik (2001)]. Since 1962, Senegal has been part of the WAMU (West African Monetary Union) zone and shares with its seven other members (Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger and Togo) a single currency, the CFA Franc, managed by the Central Bank of West African States (BCEAO). France guarantees the unlimited convertibility of the CFA Franc[3], which is set at a fixed exchange rate against the Euro. In nominal terms, the exchange rate of the CFA franc changed only once in 1994, following a devaluation of 50% (from 50 CFA francs to 100 CFA francs per French franc, since converted to 655.957 CFA francs per Euro).

Following this devaluation, which was accompanied by some stabilization policies (such as restrictive fiscal policy and structural reforms for private sector development), some macroeconomic indicators improved markedly in the medium term. Thus, the effect of this devaluation, combined with the reforms that accompanied it, led to a rebound in economic growth in Senegal. The average growth rate for the five-year period after devaluation is 4.6%, almost three times the average growth rate (i.e. 1.7%) for the five years preceding the devaluation.

Despite this good economic performance, growth thereafter (i.e. from 2000 onwards) was volatile with a low level until 2014. Assuming that the 1994 devaluation had a positive effect on economic growth in subsequent years, this positive impact may not have lasted long. One might wonder: two decades after the 1994 devaluation, is Senegal's real effective exchange rate not overvalued? Given that overvaluation hinders growth and that under fixed exchange rate regimes (as is the case for Senegal), there is more evidence of real overvaluation of the exchange rate [Coudert and Coharde (2008); Nabli, Keller and Veganzones (2004)], the question is fully justified.

The Government of Senegal, through the Senegal Plan Senegal Emergent (PSE), has demonstrated its ambition to achieve good economic performance in the medium term. Indeed, through the PSE, strong and sustained growth of around 7% and 8% is expected. In order to maintain strong growth over the medium term, it is necessary to check whether there is a risk of an overvaluation of the currency that could hamper economic performance. With this in mind, this study aims to measure the misalignment of the REER and assess its impact on economic growth.

[3] To do this, BCEAO maintains at least 50% of its Reserves in a French Treasury account.

This study has two objectives: it first measures the misalignment of Senegal's real exchange rate and then, it assesses its impact on growth.

With regard to the degree of misalignment, two approaches have been applied. First, an econometric analysis was done to estimate the equilibrium REER using the economic fundamentals approach (the BEER approach). Second, we estimated the misalignment of the exchange rate using Rodrik's approach[4].

Regarding the economic performance impact that would be caused by the misalignment of the exchange rate, we have applied an Autoregressive Distributed Lag (ARDL) econometric model, the results of which have been confirmed by a Vector AutoRegressive (VAR) co-integration model and the Fully Modified OLS (FMOLS).

In both parts of the analysis, data covering the 1980-2014 period was used.

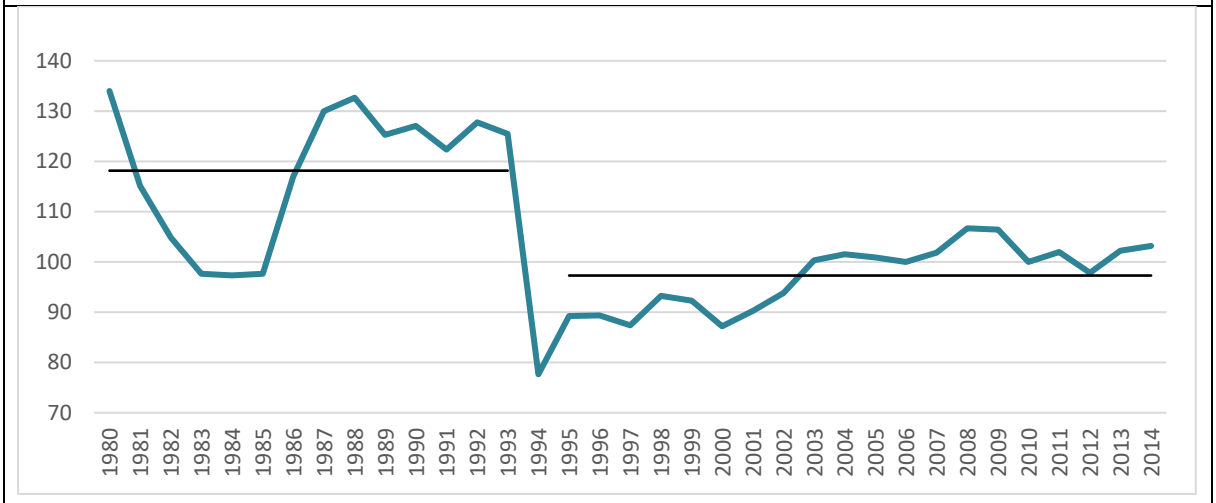
Overall, the results show that there has been an overvaluation of the real effective exchange rate in recent years and that a devaluation of the exchange rate would have a positive impact on economic growth.

This work is divided into four parts. The first one gives a brief presentation of the literature on the subject. The second part of the paper discusses the measurement of misalignment by outlining the empirical methodology and results. The third part concerns the measurement of misalignment with growth -the methodology used and the results obtained-. The last part presents the robustness tests and the conclusion.

[4] These approaches are developed later in the document.

Some stylized facts on the macroeconomic context of Senegal since 1980.

Graph 1: Evolution of the real effective exchange rate from 1980 to 2014



Source: WDI, World Bank

Senegal has experienced a period of high variability in the real effective exchange rate from 1980 to 1993, with a lackluster picture of macroeconomic indicators.

During the pre-devaluation period (1980-1993), the average economic growth rate is 2%, the population growth rate is 3%, the average current account deficit is 9.1% of GDP; the average inflation rate is 4.8 and the budget deficit is 3.1% of GDP, while the external debt amounts to 78% of GDP on average over this period. Moreover, it was also a period of internal and external macroeconomic instability, which required the initiation of several economic programs with a view to restructuring and guiding economic policies. Thus, the 1980-1985 Medium-Term Economic and Financial Recovery Plan (PREF) aimed at restoring the major macro-financial balances by promoting a limitation of external debt through a strong mobilization of domestic savings and a reduction in imports generated by a depreciation of the currency. As the PREF did not meet expectations regarding external imbalances, it was followed by the Medium and Long Term Adjustment Program (PAMLT) over the 1985-1992 period. The PAMLT objectives were to restore internal and external financial equilibrium, adjust supply to demand and stimulate domestic savings.

From 1995 to 2014, the macroeconomic framework improves and there is a lower variability in the real effective exchange rate.

Over the post-devaluation period, 1995-2014, economic performance improved, with an average growth rate of 4.2% and a population growth rate of 2.7%. The current account is at its average deficit level of 7.3% of GDP; while inflation is 2%, the budget deficit as a percentage of GDP is 2.8% and the external debt at about 50% of GDP. During this period, there have been several economic reforms - restrictive fiscal policy, deepening of structural policies and private sector development - that have accompanied the devaluation in order to improve the competitiveness of the economy and allow for sustained growth.

Table 1: Some macroeconomic indicators

	Average for the 1980-1993 period	Average for the 1994-2014 period
Real GDP growth	2	4.2
Current account balance (% GDP)	9.1	7.3
Inflation (%)	4.8	2
Fiscal deficit (% GDP)	3.1	2.8
External debt (% GDP)	78	50
Population growth rate	3	2.7

Sources: WDI, BCEAO

I- Brief literature review and data

1- Brief literature review

The following is a very brief summary of the various studies that have examined the misalignment of the exchange rate and its relationship to growth.

The misalignment of the real exchange rate is more likely under a fixed exchange rate regime.

Regarding the risk of misalignment, the literature has not been able to establish what the best regime would be, because each regime has its advantages and disadvantages. However, some authors have measured the risk of overvaluation under the exchange rate regime. Under the fixed exchange rate regime, there is more evidence of real overvaluation of the exchange rate than under the flexible exchange rate regime [Coudert and Coharde (2008); Nabli, Keller and Veganzones (2004)]. Indeed, Goldfajn and Valdes (1999) find that the probability of an

actual overvaluation is very high (>65%) in fixed exchange rate systems. However, this probability is significantly lower (<30%) in flexible regimes and is even lower in flotation systems where the probability remains lower than 7%.

Nguyen (2013) finds, using Rodrik's approach, that there is an overvaluation of the exchange rate of 78% in Senegal in 2011. Karl Grekou (2014) in his study on the CFA Franc zone shows, using the BEER (Behavioral Equilibrium Exchange Rate) approach, that in 2011 there was an overvaluation of about 11% of the real effective exchange rate in Senegal. It is important to note that Rodrik's approach measures the misalignment of the real exchange rate, while BEER's measures the misalignment of the *real effective exchange rate*.

Overvaluation hinders the economic performance of developing countries.

Moreover, some authors have shown that misalignment has a significant influence on economic growth: (Aguirre and Calderon, (2005); Gala and Lucinda, (2006); Audrey Sallenave, (2010) for G20 countries; MacDonald and Vieira, (2010); Béreau et al. (2012), then Elbadawi et al. (2012) etc). Cottani, Cavallo and Kahn (1990) have shown a significant negative relationship between overvaluation and economic growth in sub-Saharan Africa. They found that countries with overvalued currencies are generally low labor productivity economies in which capital is not well allocated to sectors, hindering economic performance. Furthermore, Bleaney and Greenaway (2000), in their study on the Sub-Saharan Africa economies, showed that the currency's overvaluation negatively affects economic growth through its impact on exports and investment. Indeed, these authors find that overvaluation is a brake on total investment, especially foreign investment, and at the same time does not encourage trade - since the competitiveness of the economy is declining - and thus hinders exports. This same result was found by Ghura and Grennes (1993), which confirms the thesis of Cottani et al (1990). Razin and Collins (1997) have shown that misalignment has asymmetrical and non-linear effects on growth. Indeed, a strong overvaluation has a negative impact on growth, while a slight overvaluation has no significant effect on growth. On the other hand, an undervaluation, whether small or large, has a positive influence on economic performance. Béreau et al (2009) found this same result. Aghion, Bacchetta, Ranciere, Rogoff (2009) focused on the impact of exchange rate misalignment on growth - using the Rodrik's approach to measure misalignment. They have found that overvaluation negatively affects economic growth, especially in the poorest countries.

There is a positive relationship between devaluation and economic growth.

Rodrik (2008) shows that undervaluation of the exchange rate has a positive impact on growth, especially in developing countries despite the poor quality of institutions. According to the author, while currency devaluation stimulates economic growth, this effect varies according to the size of tradable sectors. Indeed, the larger the tradable sectors, the better devaluation will be for economic growth. Sallenave (2010) found evidence of a negative effect of misalignment on the macroeconomic performance of G20 countries between 1980 and 2006. His analysis shows that a good exchange rate policy that keeps the REER close to its equilibrium level would lead to an increase in GDP per capita in emerging economies. Ibrahim Elbadawi et al (2012), in their study of sub-Saharan African countries, find that in countries dependent on Official Development Assistance (ODA) - as is the case for several African countries - ODA leads to overvaluation. In this context, devaluation undermines the overvaluation effect of ODA and thus positively influences growth. Mbaye Samba (2012) analyses the link between misalignment and growth and finds that devaluation positively influences growth and that much of this effect is channeled through the productivity improvement channel to meet stronger foreign demand. Also, Nabil Aflouk and Mazier (2013) found a similar result and also identified a devaluation threshold beyond which devaluation is detrimental to growth. Indeed, a sharp devaluation leads to a distortion in the distribution of income, which could lead to high inflation and subsequently a recession due to the decline in real income.

Similarly, Calderon and Aguirre (2005), using the method of generalized moments on panel data, found a non-linear relationship between devaluation and growth - that is, devaluation does not have an indefinite positive impact on growth because at a very high level of devaluation its effect on growth can be negative. This was also proven by Carl Grekou (2015) in his study on the CFA zone over the 1985-2011 period, where he adds that devaluation helps growth through improved competitiveness. In his study, Carl Grekou finds that there is an overvaluation of about 10% in Senegal in 2011 and that overvaluation leads to a drop in economic performance while a devaluation of 10% leads to an increase in GDP growth per capita of 0.32 point.

Our study is equivalent to an update of Carl Grekou's (2015) study, in the sense that even though we are focusing on Senegal, we are applying the same BEER approach to the measurement of misalignment, but our study period extends to 2014.

2- Data

Despite the identical method of calculating REER, the composition of the basket of trading partners differs from one source to another, which implies a divergence in the evolution of Senegal's REER.

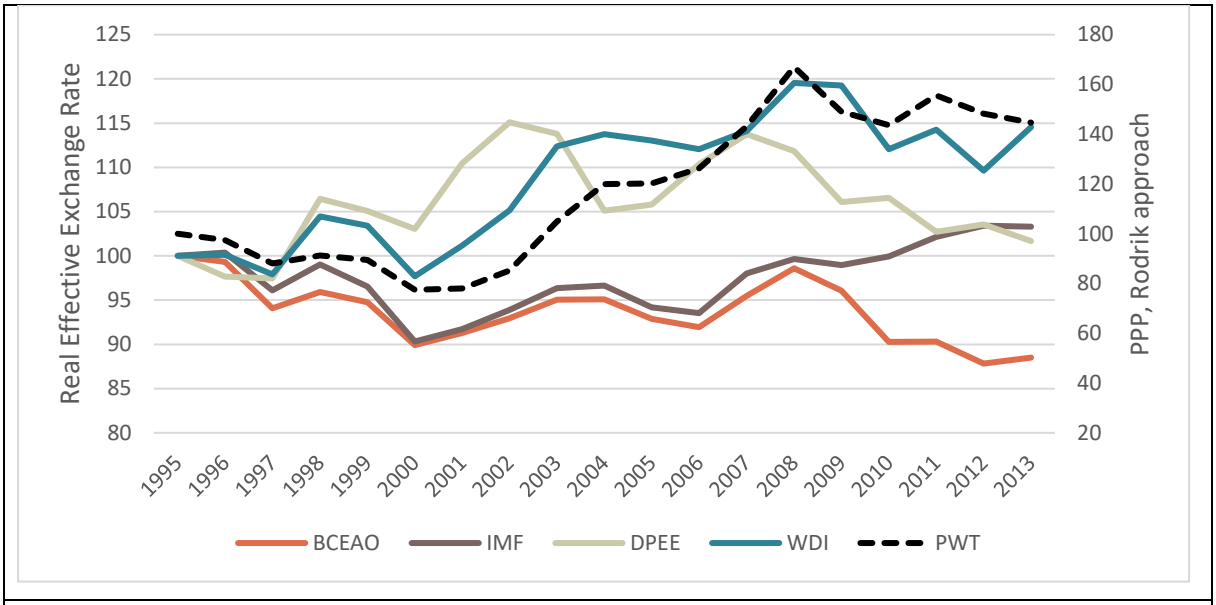
- ✓ REER calculation method

Suppose that the Senegalese economy exchanges with n countries, that these n countries constitute the geographical area of reference. Each of these n countries has a "weight" in the international trade of the Senegalese economy. This weight can be measured by its share in Senegal's exports or imports; an average of the two criteria can also be used.

There are often differences between data sources related mainly to the trade partners considered and weights applied. Thus, over the 1995-2014 period (*Chart 2*), there is a discrepancy between the evolution of Senegal's REER based on data sources and the definition of the REER.

It is also very likely that the REERs are sensitive to the choice of the base year, as Senegal's trade has changed over time with the improvement of trade relations with WAEMU (West African Economic and Monetary Union), other African countries, and China at the expense of the European Union.

Graph 2 Changes in the real effective exchange rate (standardized at 100 in 1995) according to the various data sources, and in the real exchange rate according to the Rodrik approach (PWT).



Sources: BCEAO; IMF (WEO); WDI (World Bank); DPEE; PWT

For this study, several data sources were used, mainly DPEE (Directorate of Economic Forecasting and Studies), ANSD (National Agency for Statistics and Demography) and the World Bank's WDI (World Development Indicators). The choice of these sources is motivated by the availability of data over our entire study period (1980-2014). With regard specifically to REER data, we use the data from the World Bank's WDI, since it is the most complete series over the study period (the primary source of this series is the International Monetary Fund (IMF) International Financial Statistics (IFS) which uses a double weighting in the calculation of the REER, associating the weight of suppliers in imports with the weight of competitors on the export market). In addition, both the WDI REER series and the Penn World Table RER series are highly correlated with the USD/Euro exchange rate [0.96 and 0.92 respectively, compared to 0.24 for the DPEE series]. Although Senegal's trade exchanges are concentrated in the CFA zone and the euro zone, these markets compete rather with third countries in the dollar zone. Therefore, it seems more relevant to use real exchange rate measures that reflect more closely this reality.

II- Measurement of misalignment

1- Methodology

There are several methods of measuring REER misalignment. The oldest is the Purchasing Power Parity (PPP)[5], followed by the Fundamental Equilibrium Exchange Rate (FEER)[6] of J. Williamson (1985, 1994) and the Natural Real Exchange Rate (NATREX)[7] of J. Stein (1994). We can also add the Behavioral Equilibrium Exchange Rate (BEER) method of Mc Donald Clark and Mc Donald (1998), as well as Rodrik's approach, which is a modified form of the BEER method.

Despite extensive literature on exchange rate misalignment, there is no consensus on the best way to measure it (see Edwards and Savastano, 2000; Driver and Westaway, 2004). Nevertheless, to be linked with empirical studies carried out in developing countries (Abdih and Tsangarides 2006; Saxegaard et al 2007; Elbadawi and Soto 2008; DPEE 2010; Couharde et al 2011 etc.), the BEER method and Rodrik's method will be used in this study to measure the misalignment of the exchange rate in Senegal.

a) BEER Approach

The equilibrium real exchange rate is measured using the BEER estimation method.

The BEER method consists of estimating the equilibrium exchange rate on the basis of the long-run relationship between the real exchange rate and the various macroeconomic variables that influence internal and external equilibria.

In order to measure the long-term equilibrium exchange rate, we have broken down economic fundamentals into transitory and permanent components (using the Hodrick Prescott filter, and Christiano and Fitzgerald filters). Permanent components provide another measure of the equilibrium real exchange rate, also known as the permanent equilibrium exchange rate

[5] The PPP method is the real equilibrium exchange rate obtained by equalizing the prices of goods between a domestic and foreign country. The equilibrium real exchange rate is then equal to the unit or constant.

[6] The FEER method allows the estimation of the long-term relationship between the equilibrium exchange rate and its fundamentals. Indeed, the equilibrium real exchange rate is the one that corresponds to the desirable and sustainable level of the capital account balance.

[7] The NATREX method consists of evaluating the long-term relationship between the exchange rate, the preference for the present and the technical progress

by some authors. Thus, only the permanent component of the explanatory variables was used in the estimates.

The empirical model is as follows:

$$\mathbf{Ln(E_t) = \alpha_0 + \alpha_1 Ln(Terme_t) + \alpha_2 Ln(Absorption_t) + \alpha_3 Ln(Open_t) + \alpha_4 Ln(Prod_t) + \varepsilon_t} \quad (1)$$

Terme = Terms of trade

Absorption = consumption and investment as a percentage of GDP

Open = Trade openness, which is the sum of imports and exports as a percentage of GDP

Prod = The ratio of tradable sector labor productivity and non-tradable sector labor productivity.

The fundamentals used in equation (1) are taken from the literature on measuring misalignment in developing countries [Combes and Plane (2007), Bamba and Niang (2010), A. Berg and Y. Miao (2010), and Couharde et al. (2011)].

The negative sign on the exchange rate is expected from the effect of the terms of trade, absorption and trade opening while a positive sign is expected from the effect of the productivity ratio. Indeed,

- Trade restrictions negatively affect the REER, implying a negative sign of the trade opening coefficient.
- An increase in the terms of trade should lead to an appreciation of the REER as it improves the trade balance. The coefficient should therefore be negative.
- A high absorption level is an indicator of overheating of the economy leading to higher domestic prices relative to partner country prices, leading to an appreciation of the REER. Thus, the coefficient should be negative.
- An increase in productivity in the tradable sector leads to an improvement in competitiveness and a depreciation of the REER. Therefore, the positive sign is expected.

Estimates are made using Hansen's (1992) Fully Modified Ordinary Least Square (FMOLS) estimation method to account for the cointegrating relationship between variables. However, the use of the Hodrick Prescott filter introduces border effects[8] (the last points of the sample can be problematic for the estimates), which is why we use the Christiano and Fitzgerald filter.

[8] Border effect result from the fact that the calculation of the filtered variable at a certain date requires knowledge of the variable to be filtered at the dates immediately after that date, which implicitly requires a projection to extend the medium-term series for the calculation of the filtered variable for the last points of the sample.

The misalignment of the REER with respect to its equilibrium position is measured by its deviation from the equilibrium rate, as follows:

$$\boldsymbol{MIS_t} = \frac{\boldsymbol{E_t} - \boldsymbol{E_t^{Equilibre}}}{\boldsymbol{E_t}} \quad (2)$$

MIS_t = Exchange rate misalignment

E_t =REER

$E_t^{Equilibre}$: Equilibrium REER (calculated by the model explained).

MISt ≥ 0 means overvaluation of the REER

MIS_t < 0 means REER undervaluation

An alternative way to measure misalignment: Rodrik's methodology.

b) Rodrik's approach

This approach consists of measuring the misalignment of the exchange rate using the level of domestic prices adjusted by the Balassa-Samuelson effect[9]. Rodrik's misalignment is defined as the difference between the real exchange rate and the value of its purchasing power (PPP[10]), adjusted for the effects of per capita income on the real exchange rate. To implement this Rodrik method, use was made of data from the Penn World Tables (PWT) version 9.0 (the most recent version).

For this method, the regression of the PPP (which is used as the real exchange rate) on GDP per capita (which captures the Balassa-Samuelson effect) is carried out by introducing the country fixed effect, without including the constant so that the misalignment equals the residual. This is an estimate in panel data (consisting of 182 countries studied from 1960 to 2014 with reference to PWT database data). The misalignment of Senegal is then deduced as the residual of the estimation of the following equation.

$$\ln RER_{i,t} = \alpha \ln GDPpercapita_{i,t} + f_i + u_{i,t} \quad (3)$$

The misalignment of the exchange rate is deduced from the estimate as follows:

[9]The Balassa-Samuelson effect states that improved productivity in the tradable goods sector increases wages, which increase demand for non-tradable goods, which appreciates the real exchange rate.

[10] The PPP value of the exchange rate is that value that would yield the same price level as in the reference country (the United States) when expressed in a common currency.

$$Mis_{it} = \ln(RER_{it}) - \ln(\hat{RER}_{it}) = u_{it} \quad (4)$$

RER = Real Exchange Rate

GDPpercapita = GDP per capita

f_i represents the country fixed effect and u_{it} represents the remainder of the estimate.

It should be noted that Rodrik's approach allows for the measurement of real exchange rate misalignment, while BEER's approach allows for the measurement of real effective exchange rate misalignment.

2- Result of the misalignment measurement

- **The results of the equilibrium REER estimation for the determination of misalignment**

The CFA Franc experienced episodes of overvaluation and great devaluation between 1980 and 2014.

The evolution of the misalignment indicator is compared to the zero value. Indeed, when the curve is above zero, it is overvaluation and if not, it is undervaluation. The degree of misalignment, as measured by the two approaches (explained above), shows a relatively similar pattern of evolution. Between 1993 and 1994, following the devaluation of 50% of the CFA Franc, according to the BEER approach, the CFA Franc went from 23% overvaluation to 19% undervaluation, while according to Rodrik's approach, the CFA Franc left an overvaluation level of 17% to reach an undervaluation level of 23%. Between 1999 and 2000, due to the changeover from the French Franc to the Euro, according to the BEER approach, the CFA franc fell from 5% to 13% in terms of undervaluation, while according to Rodrik's approach, the CFA franc left a undervaluation level of 16% to reach 28%. Since then, there has been a steady trend towards overvaluation, regardless of the approach. The Senegalese economy has been overvalued since 2008 according to the BEER approach, and since 2004 according to Rodrik's approach.

The magnitude of misalignment differs significantly between the two approaches, especially after 2003. Several reasons may explain this difference:

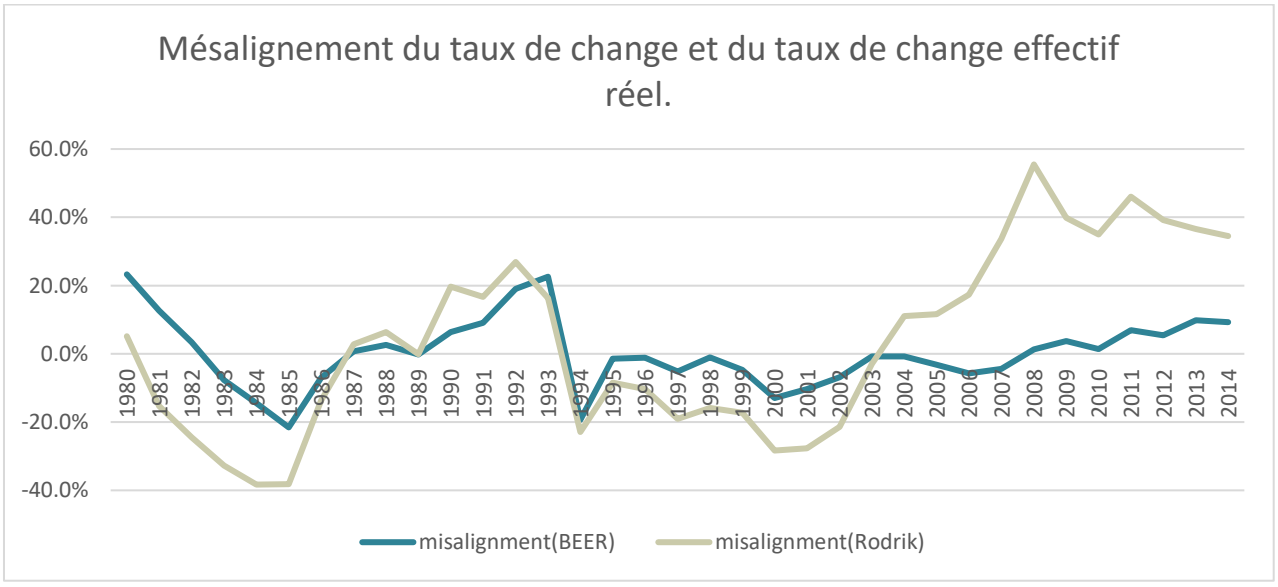
1) If the BEER approach measures misalignment of the real effective exchange rate, Rodrik's approach measures misalignment of the real effective exchange rate.

2) Rodrik's approach measures the misalignment of the real exchange rate by assuming that the purchasing power parity of the local currency against the dollar is the real exchange rate.
3) The difference in the amplitude of misalignment could also be due to the fact that Rodrik's methodology is based on cross-country analysis - more precisely, the Balassa-Samuelson effect is calculated using data from 182 countries - while the other alternative method (BEER) is an analysis based on a single country.

4) Rodrik misalignment is an index of improved PPP undervaluation which is the difference between the observed value of the real exchange rate and the equilibrium value adjusted by the Balassa-Samuelson effect. Thus, the real exchange rate is considered overvalued when the domestic price level is higher than expected by the purchasing power parity. This definition is also based on the intuition that non-tradable goods are cheap in the poorest countries (according to Balassa-Samuelson).

All of the above may justify the difference in the amplitude of misalignment observed from Graph 3.

Graph 3 REER and exchange rate misalignment



Source: Authors' estimates

III- Link between growth and REER misalignment

1- Methodology

The ARDL model is the best way to measure the misalignment effect on long-term economic growth in Senegal.

To assess the effect of exchange rate misalignment on Senegal's economic performance, we estimate the real GDP growth equation explained by misalignment (measured by the BEER and Rodrik approaches), controlling for lagged real GDP; cyclical component of GDP and its lagged value; private investment; inflation and trade openness. The choice of control variables is made by following the literature [Elbadawi (2012), Rodrik (2008b) and Nabil Aflouk and Mazier (2013)].

The growth equation is as follows:

$$Ln(GDPGDPGDP_t) = \alpha_0 Ln(MIS_t) + \alpha_1 Ln(GDPGDPGDP_{t-1}) + \alpha_2 Ln(GDPGDPGDPycle_t) + \alpha_3 Ln(GDPGDPGDPcycle_{t-1}) + \alpha_4 Ln(InvPri_t) + \alpha_5 Ln(INF_t) + \alpha_6 Ln(Open_t) + \varepsilon_t \quad (3)$$

To estimate the long-term relationship between growth and exchange rate misalignment while taking into account possible endogeneity problems, we use the ARDL (AutoRegressive Distributed Lag) model developed by Pesaran and Shin (1995, 1999). Indeed, from the stationarity tests [(Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)] the variables are either I (0) or I (1) and Johansen's cointegration test reveals that the series are wedged from row 1. In this case, the traditional cointegration approach (Engle and Granger (1987)) is limited because of the need for integrated series of the same order, I (0) or I (1). We use here the ARDL[11] model proposed by Pesaran et al (1999), which defines long-term relationships between variables I (0) and I (1) and has the advantage of providing robust estimates for long-term relationships in the presence of the lagged explained variable. Johansen's VAR (Vector AutoRegressive) cointegration model was used in terms of robustness check to verify the level of sensitivity of our results with the model used, which confirms that the ARDL model is appropriate.

[11] More details about the rationale of the ARDL model are available in the Annex

2- Presentation of the results

$$Ln(GDP_t) = \alpha_0 Ln(MIS_t) + \alpha_1 Ln(PGDP_{t-1}) + \alpha_2 Ln(GDPcycle_t) + \alpha_3 Ln(GDPcycle_{t-1}) + \alpha_4 Ln(InvPri_t) + \alpha_5 Ln(INF_t) + \alpha_6 Ln(OPEN_t) + \varepsilon_t$$

Table 1: ARDL estimation results

VARIABLES	(1)	(2)	(3)	(4)
Misalignment (according to BEER)	-0.0466**	-0.0383**	-0.0670***	-0.0635***
	(0.0193)	(0.0159)	(0.0168)	(0.0163)
GDP (Lagged)	1.004***	0.991***	0.994***	0.984***
	(0.00164)	(0.00342)	(0.00312)	(0.00621)
GDP Cyclical component	1.206***	1.128***	1.161***	1.209***
	(0.132)	(0.109)	(0.0969)	(0.0968)
GDP Cyclical component (Lagged)	-0.909***	-0.991***	-0.973***	-0.966***
	(0.123)	(0.103)	(0.0904)	(0.0870)
Private investment		0.0120***	0.00986***	0.0149***
		(0.00302)	(0.00275)	(0.00383)
Inflation			-0.000693***	-0.000923***
			(0.000225)	(0.000251)
Trade openness				0.0392*
				(0.0216)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1				

Source: Authors' estimates

The effect of misalignment on economic growth increases as the control variables are integrated into the econometric model.

The results of the selected model are presented in the table above. Validity tests were performed for all models, which confirms that our estimates are good with the expected regressors. An estimate with the initial GDP control variables and the cyclical component of GDP (Column 1) indicates an elasticity of 0.047 for misalignment. The introduction of the "private investment" variable slightly reduces the elasticity of misalignment. On the other hand, the introduction of the inflation variable (*Column 3*) indicates a significant increase in the elasticity of misalignment (from 0.038 to 0.067), which explains why a large variability in economic growth is attributable to the value of the currency in relation to those of trading partners, and to the general level of prices. The introduction of the trade openness variable slightly reduces this effect of misalignment on growth (from 0.067 to 0.064).

The devaluation of the CFA franc leads to an improvement in Senegal's economic performance, contrary to the overvaluation that moderates growth.

The devaluation of the currency has a positive effect on economic growth. The results are consistent with those of authors such as Dani Rodrik (2008), Sallenave (2010) and Elbadawi (2012). Indeed, a devaluation of the CFA franc by 10% leads to an improvement in Senegal's economic growth of 0.64%. As Rodrik (2008) has already shown, the countries that have maintained an undervalued currency have been responsible for strong growth, thanks to the benefits it provides for the expansion of the industrial sector. Grekou Karl, had already found that a devaluation of 10% would imply an increase in growth of 0.32 for the countries of the CFA zone. Our results show that this is double the effect of the devaluation of REER on economic growth found by Grekou (2015). Also, our results do not deviate too much from those of Rodrik (2008) with his effect of around 0.03 for developing countries and Elbadawi (2012) who found 0.04 for sub-Saharan Africa, as well as those of A. Berg and Y. Miao (2010) who found a positive impact of around 0.03 of the misalignment on growth.

With devaluation, there is a revival of exports of goods and services, and a reduction in imports, which leads to a significant improvement in competitiveness, and thus encourages domestic private investment, and attracts foreign investment and aid. In a word it strengthens international development financing, restores external and internal balances, can increase productivity in tradable and even non-tradable sectors, and supports job creation, which would then improve household living conditions. It should also be made clear that this devaluation cannot be done indefinitely, as it may generate inflation and therefore generate counter-effects.

Devaluation improves revenue mobilization as profits from tradable sectors increase in terms of consumption expenditure, while the Senegalese economy's increasing participation in the international transactions market will boost new investments to meet foreign demand.

The non-linear relationship between misalignment and growth

By introducing the interaction variable (misalignment*Dummy_undervaluation) in equation (3), we have:

$$Ln(GDP_t) = \alpha_0 Ln(MIS_t) + \beta_0 Ln(MIS_t{*}D_{undervaluation}) + \alpha_1 Ln(GDP_{t-1}) + \alpha_2 Ln(GDPcycle_t) + \alpha_3 Ln(GDPcycle_{t-1}) + \alpha_4 Ln(InvPri_t) + \alpha_5 Ln(INF_t) + \alpha_6 Ln(OPEN_t) + \varepsilon_t \quad \textbf{(4)}$$

The results of the estimation of equation (4) (see annex) show that when the economy is overvalued, a devaluation of the real effective exchange rate of 10% leads to an increase in growth of 1.0 percentage points, whereas if the economy is undervalued, a devaluation of 10% leads to an increase in economic growth of 0.1 percentage point. Devaluation encourages growth in situations of overvaluation [as is the case for Senegal] rather than undervaluation. This confirms the view that overvaluation does not promote long-term economic growth while undervaluation is good for economic growth. Since, according to our analysis, Senegal is in a situation of overvaluation in recent years, a devaluation in this margin would lead to a gain in long-term economic growth.

IV- Robustness of results

In this section, we will conduct some robustness tests to analyze the sensitivity of the results to the methods and data used.

Calculating misalignment

The first test is the Hodrick Prescott (HP) filter parameter. We have used the HP filter with parameter λ=6.25 following Ravn and Uhlig (2002) which have shown that using this parameter on annual data reduces the border effect problem. The results (see annex) show that the elasticities of the explanatory variables on the REER have the same significance and influence the REER in the same direction.

The second test concerns the use of the HP filter. A possible criticism of using the HP filter is that it introduces the border effect regardless of the parameter λ. To circumvent this, the use of Christiano and Fitzgerald's filter - which is not exposed to the border effect (Christiano and Fitzgerald, (2003)) - was made. From the results, it is inferred that the equilibrium REER estimate is not affected by the border effect. Consequently, we have chosen for the remainder of the analysis the misalignment estimate obtained using REER from the WDI, for which Christiano and Fitzgerald (2003) applied the filter to economic fundamentals.

Evaluation of the impact on growth

We then tested the type of model used to estimate the effect of misalignment on long-term growth. One possible criticism of using the ARDL model is that it gives estimates that have asymptotic properties similar to those of Hansen's Fully Modified OLS model (1992). Pesaran and Shin 1997 have already shown that the ARDL model presents more robust estimates than the Fully Modified OLS (FMOLS) especially in the case of small samples (as in

our case). However, to make matters clear, we have restated our estimates with FMOLS, which confirms the robustness of our results, as the results are essentially identical (*see Annex*).

On the other hand, to verify the robustness of the results of the growth equation obtained by ARDL and FMOLS, we used the VAR (Vector AutoRegressive) estimation method, which is a multiple equation method in contrast to the ARDL and FMOLS models. Indeed, even if the ARDL and FMOLS methods take into account the cointegrating relationship, one might wonder whether the results would not change significantly if a multi-equation method such as Johansen's VAR instead of ARDL and FMOLS (which are single-equation models) were used. The results of the VAR model demonstrate the robustness of our estimates, as the results are likely to be identical (*see Annex*).

We then measured the effect of exchange rate misalignment (Rodrik's approach) on growth. In order to do this, we replace the misalignment of the BEER approach with the Rodrik approach in the various models; the results are roughly comparable, even if the magnitude of the impact of exchange rate misalignment on long-term growth is smaller than the effect of real effective exchange rate misalignment on long-term economic growth (*see Table 2*).

Finally, we carry out the Granger causality test (Granger C. W. 1969), which confirms that the misalignment of the real effective exchange rate causes economic growth and there is no evidence of reverse causality.

Conclusion

This study contributes to the debate on the fundamental role of the exchange rate for growth. This note first measured the misalignment of the exchange rate in Senegal using different approaches, and our results are robust to data and estimation methods. Second, this work assessed the effects of misalignment on economic growth.

Our analysis of the misalignment of Senegal's real effective exchange rate shows that, since 2008, there has been a trend towards the overvaluation of the CFAF. Senegal has recorded an overvaluation of the REER estimated at 10% in 2013 and 2014. This situation reflects the deterioration in Senegal's trade balance and other fundamentals. Thus, the situation of overvaluation is somehow an obstacle to Senegal's trade and consequently to economic growth - despite the good performance of the last two years [which are not in the sample].

In addition, our study clearly illustrates that overvaluation has a cost in terms of economic performance. Our results also confirm the importance of good policy for the development of poor countries such as Senegal. Our results fully corroborate those of Balassa (1990), Cottani et al (1990) and Rodrik (2008) on the strong link between growth and devaluation.

This study once again shows that exchange rate policy plays a vital role in economic growth, and good exchange rate policy should seek to avoid overvaluation of the REER in favor of undervaluation.

The main conclusion is that, while overvaluation discourages growth, devaluation favors performance, which confirms the assertion[12] that "*Not only overvaluation is bad for growth, but undervaluation is good for this latter*".

One possible way of extending this study would be to carry out panel data analysis of FCA zone economies in order to control for omitted variables that are invariant over time and use an identification strategy to better address the endogeneity problem.

[12] See Andrew Berg & Yanliang Miao (2010).

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Annexes

- ✓ Justification of the ARDL model

There are advantages of using ARDL framework instead of the conventional Johansen procedures as noted by Duasa (2007). The conventional cointegration method estimates the long run relationships within a context of a system of equations, the ARDL method employs only a single reduced form equation (Pesaran & Shin, 1995). The ARDL method yields consistent and robust results both for the long-run and short-run relationship between growth and real exchange rate misalignment. The ARDL approach does not involve pre-testing variables, which means that the test for the existence of relationship between variables in levels is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1) or mixture of both. This feature alone, given the characteristics of the cyclical components of the data, makes the standard of cointegration technique unsuitable and even the existing unit root tests to identify the order of integration are still highly questionable. Duasa (2007) further established that with the ARDL, it is possible that different variables have different optimal lags, which is impossible with the standard cointegration test. Most importantly, the model could be used with limited sample data (30 observations to 80 observations) in which the set of critical values were developed originally by Narayan (2004).

- ✓ Unit Root Test

To avoid a fallacious regression, we studied the stationarity of variables. The Augmented Dickey-Fuller test (ADF) [the most commonly used test in the literature to verify the stationarity of time series] whose null hypothesis is the presence of unit root was used. The results are summarized in the table below.

Variables	REER	OPEN	ABS	PROD	TERME	GDP	INF	INVPri
Order of Integration	I(1)	I(0)	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)

- ✓ Cointegration test

Johansen's cointegrating test reveals that there is a rank 1 cointegrating relationship between the variables.

✓ Comparison of misalignment using the BEER approach (HP filter parameter 6.25 versus Christiano & Fitzgerald filter)

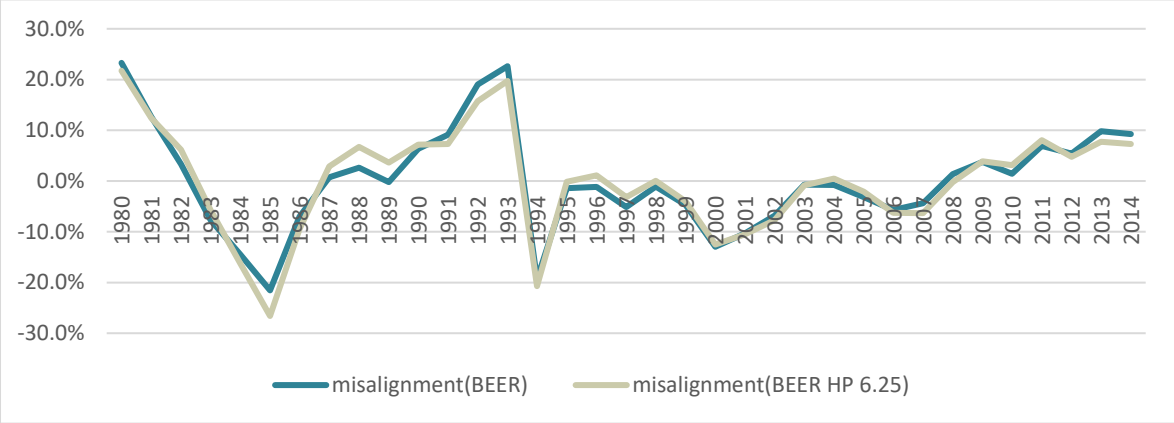

Table 2: ARDL estimation results: Rodrik versus BEER

VARIABLES	Rodrik	BEER
Misalignment	-0.0293***	-0.0635***
	(0.00509)	(0.0163)
GDP (lagged)	0.977***	0.984***
	(0.00499)	(0.00621)
GDP Cyclical component	1.162***	1.209***
	(0.0768)	(0.0968)
GDP Cyclical component (lagged)	-0.962***	-0.966***
	(0.0724)	(0.0870)
Private investment	0.0244***	0.0149***
	(0.00307)	(0.00383)
Inflation	-0.000689***	-0.000923***
	(0.000192)	(0.000251)
Trade openness	0.0225	0.0392*
	(0.0191)	(0.0216)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		

Source: Authors' estimates

✓ **Results of growth and misalignment relationship estimates with VAR**

VARIABLES	Rodrik	BEER
Misalignment	-0.0257***	-0.0615***
	(0.00524)	(0.0150)
GDP (lagged)	0.980***	0.982***
	(0.00515)	(0.00607)
GDP Cyclical component	1.130***	1.217***
	(0.0798)	(0.0880)
GDP Cyclical component (lagged)	-0.975***	-0.962***

	(0.0741)	(0.0784)
Private investment	0.0208***	0.0159***
	(0.00319)	(0.00377)
Inflation	-0.000714***	-0.000950***
	(0.000199)	(0.000230)
Trade openness	0.0218	0.0442**
	(0.0191)	(0.0209)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		

- ✓ **Results of growth and misalignment relationship estimates with FMOLS**

VARIABLES	Rodrik	BEER
Misalignment	-0.0293***	-0.0980***
	(0.00509)	(0.0151)
GDP (lagged)	0.977***	0.990***
	(0.00499)	(0.00306)
GDP Cyclical component	1.162***	1.227***
	(0.0768)	(0.0862)
GDP Cyclical component (lagged)	-0.962***	-0.946***
	(0.0724)	(0.0788)
Private investment	0.0244***	0.0137***
	(0.00307)	(0.00264)
Inflation	-0.000689***	-0.00102***
	(0.000192)	(0.000217)
Trade openness	0.0225	0.000327
	(0.0191)	(0.000300)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1		

- ✓ **Granger Causality Test**

Equation	Excluded	Prob(Chi2)	Conclusion
GDP growth	Misalignment	0.000	Misalignment causes growth
Misalignment	GDP growth	0.314	Growth does not cause misalignment

- ✓ **Correlation of real exchange rates with the euro/dollar exchange rate**

	Correlation with Euro/USD exchange rate
BCEAO	0.11
DPEE	0.24
IMF	0.74
WDI	0.92
PWT	0.94

- ✓ **Non-linearity of the misalignment-growth relationship: Regression with misalignment according to BEER approach**

$$Ln(GDP_t) = \alpha_0 Ln(MIS_t) + \beta_0 Ln(MIS_t * D_{undervaluation}) + \alpha_1 Ln(GDP_{t-1}) + \alpha_2 Ln(PGDPcycle_t) + \alpha_3 Ln(GDPcycle_{t-1}) + \alpha_4 Ln(InvPri_t) + \alpha_5 Ln(INF_t) + \alpha_6 Ln(OPEN_t) + \varepsilon_t$$

α_0 = effet de la dévaluation en situation de surévaluation du taux de change réel.

$\alpha_0 + \beta_0$ = the effect of devaluation in a situation of undervaluation of the real exchange rate.

	ARDL	VAR	FMOLS
VARIABLES			
GDP (lagged)	0.984***	0.984***	0.990***
	(0.00589)	(0.00571)	(0.00281)
Misalignment	-0.0988***	-0.0972***	-0.131***
	(0.0234)	(0.0216)	(0.0203)
Misalignment#Undervaluation	0.0877*	0.0857**	0.0897**
	(0.0437)	(0.0394)	(0.0372)
GDP Cyclical component	1.153***	1.158***	1.164***
	(0.0958)	(0.0867)	(0.0823)
GDP Cyclical component (lagged)	-0.980***	-0.979***	-0.960***
	(0.0829)	(0.0737)	(0.0724)
Private investment	0.0140***	0.0144***	0.0129***
	(0.00366)	(0.00360)	(0.00244)
Inflation	-0.000724***	-0.000740***	-0.000778***
	(0.000258)	(0.000236)	(0.000215)
Trade openness	0.0383*	0.0403**	0.000306
	(0.0205)	(0.0196)	(0.000275)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1			

- ✓ **Non-linearity of the misalignment-growth relationship: Regression with misalignment using the Rodrik approach**

	ARDL	VAR	FMOLS
VARIABLES			
GDP (lagged)	0.977***	0.975***	0.979***
	(0.00592)	(0.00556)	(0.00290)
Misalignment	-0.0404***	-0.0397***	-0.0451***
	(0.0103)	(0.00909)	(0.00876)
Misalignment#Undervaluation	0.0387*	0.0386*	0.0395**
	(0.0225)	(0.0198)	(0.0191)
GDP Cyclical component	1.107***	1.119***	1.148***
	(0.0874)	(0.0785)	(0.0741)
GDP Cyclical component (lagged)	-0.970***	-0.966***	-0.955***
	(0.0803)	(0.0709)	(0.0691)
Private investment	0.0233***	0.0241***	0.0249***
	(0.00374)	(0.00348)	(0.00267)
Inflation	-0.000591**	-0.000629***	-0.000556***
	(0.000227)	(0.000206)	(0.000187)
Trade openness	0.0293	0.0349*	0.000526*
	(0.0212)	(0.0201)	(0.000275)
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1			