UCL Université catholique de Louvain

LOUVAIN School of Management

Louvain School of Management

Analysis of the convergence in West and Central Africa: Cluster analysis of the economic performance.

Mémoire recherche réalisé par

Gilchrist Hounhanou

en vue de l'obtention du titre de

Master 120 crédits en sciences de gestion, à finalité spécialisée

Promoteur(s)

Sophie Béreau

Année académique 2016-2017

Acknowledgement:

First of all, I would like to express my gratitude to my supervisor Sophie Béreau for the support she provided for this thesis.

Then, I would like to thank everyone that contributed to the realisation of this thesis.

Finally, my gratitude goes to anyone that has been by my side during my master program.

Director: Thomas Périlleux

Contents

Introduction

During the past few months, debates about the controversial currency unions in west and central Africa have taken place. Due to its origin and many pan African movements, the monetary system in place in the CFA franc region has come under criticism. The CFA franc is considered by its opponents as a currency that undermines the development of countries in the region. The argument often cited by those opposed to the CFA franc is the currency reserves held at the French Treasury. Indeed, the agreement made by France and the CFA franc countries states that at least twenty percent of sight liability of each central bank must be covered by foreign exchange reserves; and fifty percent of that foreign exchange reserves must be held in an operating account at the French Treasury (Banque de France, 2002). These reserves represent an opportunity cost that could be used to finance the development of countries in the region. Paradoxically, the ratio of domestic credit to the GDP is very low for most countries in the region[1].

This growing concern has triggered the desire to dedicate my thesis to the analysis of the two currency unions in Africa to gain further knowledge of the mechanism in place and its performance over time.

A currency union has obvious benefit but its benefit should outweigh its cost if it is to be profitable for the countries in the union. Although this condition is simple, it is difficult to control because the cost and benefit of a currency union are not quantifiable. Therefore, the analysis will should be based on the factors that either mitigate or exacerbate the cost or magnify the benefit of a currency union.

Currency unions have the advantage of reducing transactional costs and reducing exchange rate risks. Additionally, currency unions can potentially increase competitivity due to better price comparison. These positive effects should promote intra-regional trade among countries in the union. Much literature has tried to quantify the effect that a common currency can have on trade. Although an obvious consensus about the positive sign of the effect has emerged, the magnitude of the effect is still debatable. Indeed, Rose (2000) in his empirical analysis finds that sharing a common currency (the euro) increases trade by 200 percent, and his

[1] See annexes II Domestic credit to private sector

results overcome some sensitive analysis. However, Baldwin (2006) highlights the different flaws in the methodology employed by Rose (2000). He estimates that the impact of the euro on trade is much lower, around three per cent. Limited literature deals with the effect that the two monetary unions in Africa has on trade. The estimation of the effect is out of the scope of this thesis. Only a literature review and the methodology behind the gravity model will be presented. Nevertheless, it should be highlight that although trade statistics are available for most African nations, they are likely to be an understatement of the real trade activity in those countries. Informal trade represents an important part of the total trade for most African countries. Because only formal trade is recorded in the data available online, the official trade statistics are likely to be inaccurate (Amin & Hoppe, 2013).

Factors that will mitigate the cost of maintaining a common currency are found in the idea behind the optimal currency theory initiated by Mundell (1960). Mundell's theory called the "Optimum currency area" highlights the factors that could mitigate or exacerbate the cost of maintaining a monetary union. A key factor that significantly affects the cost of maintaining a currency union is the concept of "asymmetric shocks". A shock in the economy makes interventions of central institutions in the economy more or less difficult depending on the asymmetry of the shock. In case of dissymmetric shock, a common policy won't be effective to eliminate the shock out the entire economy because it will result in different outcomes in different regions of the union. In order to mitigate the risk associated with shock asymmetry, economic integration should be promoted. Therefore, fiscal and monetary disciplines should be imposed on every member of the union.

The two monetary unions in Africa has set convergence criteria in their respective union. Moreover, regional integration has been further promoted all over Africa via the different economic unions that have been created. The convergence criteria reflect the will of West and Central African countries to strengthen the credibility of their union and to reduce the cost linked to the maintaining the union by becoming more homogenous.

Different methodologies have been developed to measure the convergence between a group of countries. A common yet simple methodology consists in measuring the Pearson's correlation of the business correlations between countries in a union. An alternative and more advanced method consists in decomposing shocks into supply and demand component by employing a vector of auto-regression. This method initially developed by Blanchard and Quah (1989) has been employed in different literatures. For example, Bayoumi and

Eichengreen (1996), estimate the supply and demand shock for the core European group and estimate the correlation of the shocks between Germany and the other European countries from 1987 to 1995. Their results show a high correlation between Germany and the core-European countries[2]. More recent literatures go a step further by employing a dynamic model to estimate the evolution of convergence between countries through time. This method consists in employing a Kalman filter to the shocks estimated. The Kalman filter allows to estimate time-varying parameters. Another alternative method, called cluster analysis, consists in measuring similarities and dissimilarities through a specific set of economic data and to used algorithms to form groups of countries that presents a certain level of homogeneity.

In this thesis, we will use cluster analysis to analyse the extent to which CEMAC (Central African Economic and Monetary Community) and WAEMU (West African Economic and Monetary Union) countries cluster with each other. Additionally, we include WAMZ (West African Monetary zone) countries in our analysis to check whether the extension of the actual currency union to other West African countries would result in an excessive cost due to their heterogeneity with CFA franc countries.

This thesis is divided in five sections. The first section makes a summary of the literature about the different exchange rate regimes and their economic performance. In the second and third section, we analysis the effect that currency unions can have on trade and on FDI (Foreign direct investment). The gravity model is explained and the different methodology errors, that could bias the estimates, are given. The fourth section is dedicated to the empirical analysis of the CFA region, its performances from its creation to the 21th century. Finally, in the last section a cluster analysis is run to assess the homogeneity between CFA countries and WAMZ countries.

[2] Austria, France, Denmark, Belgium, Netherland and Luxembourg

The exchange rate regimes and their economic performance

I) The exchange rates regimes and their trade-offs.

When considering a currency policy, policy-makers have to come up with two decisions that are not without consequences. Each decision implies trade-offs between two packages of value i.e. flexibility on one hand, and on the other hand stability and credibility. An economy cannot fully benefit from both packages at the same time. The choice of one package implies the loss of the other package. Additionally, the choice of the exchange rate regime is not only driven by welfare objectives but it is also influenced by other stakeholders.

The first decision consists in determining the regime by which the currency will be managed. A fixed rate or a floating rate is the options available to politicians. A fixed exchange rate has the advantage of reducing volatility and lowering transaction cost. Volatility adds risk premium to the costs of goods and assets. A fixed rate helps to stabilize the currency, enhances the credibility of monetary policy and gives more incentive to investors. By anchoring the value of the domestic currency to a low-inflation currency, monetary officials are constrained to follow a time-consistent path of low inflation. In that situation of low inflation, a fixed exchange rate provides an observable nominal anchor which in turn helps international trade and investment, and disciplines monetary policy (Canavan & Tommasi, 1997; Giavazzi & Pagano, 1988). Nevertheless, a fixed rate implies a loss of the monetary sovereignty. For the fixed rate to be credible, monetary policies must be line with the exchange rate and the balance of payment. Thus, in case of shock, monetary policy would not be considered as a tool that can be used to stabilize the economy.

On the opposite, a floating exchange rate provides more room to accommodate to foreign and domestic shock. For instance, governments can modify the domestic interest rate to make domestic currency less attractive, thus depreciating the value of the domestic products. This would make domestic products more attractive compare to foreign products. Imports should therefore decrease and exports should rise. This monetary sovereignty is valuable for countries in which the cost of fixing the exchange rate is a too big sacrifice.

The second decision that has to be made is to determine the level of the exchange rate. Here again policy-makers has to make a trade-off between two values. A strong currency gives to national consumers greater purchasing power compare to a weak currency. When a currency

is strong, the relative price of foreign products is lower and local consumers gain more purchasing power. On the other hand, local producers are affected because they face more competition from abroad. A weak currency, on the opposite, makes local products more competitive, the relative price of foreign products is greater. Local producers benefit from a strong currency on the behalf of local consumers who see their purchasing power reduced. Thus, an appreciation of the local currency benefits local consumers at the expense of local producers by respectively rising their purchasing power and lowering their competitiveness; while a depreciation is at the disadvantage of the local consumers and at the advantage of the local consumers by reducing their purchasing power and improving their competitiveness. Policy-makers please either local producers by appreciating the currency or local producers by depreciating the currency.

Because policy makers make decisions about the exchange rate and that decisions will have distributional consequences, governments face pressures from different stakeholders that have interest in different exchange rate regimes at both the international and national level (Frieden, 2007)

At the international level, nation-states are decision-making units and they deal with coordination and cooperation problems. In the international monetary relations, coordination entails interaction among governments to converge on a focal point, and cooperation involves the adjustment of national policies to support the regime. A fixed rate system has important characteristics as a focal point around which national choices can be coordinated (Frieden, 2007). A coordinated, fixed-rate system is self-reinforcing: the more membership it counts, the more attractive it is. As an example, the European monetary integration started with the Benelux, Germany and Austria and attracted more members over time. However, the opposite is also true. If an increase in the number of members strengthens the attractiveness of the system, a decrease in the number of members has the opposite effect of reducing its attractiveness. The departure of the most important members may give incentive to other members to leave the system as well, eventually leading to its collapse. In order to move closer to that focal point, cooperation among the members of the system is required. A strong cooperation is crucial to the durability of the system. According to Eichengreen (1992) the classical gold standard was sustained by strong cooperation among participants in the system, and its collapse was due to their lack of cooperation.

Although international factors play important roles in the international monetary cooperation and coordination, they rest on the foundation of national currency which are subject to several political and economic pressures. Nationally, international coordination and cooperation may not be accepted within the nation because it does not get enough supports from national stakeholders. First, its distributional consequences may be detrimental to some stakeholders that are enough powerful to block the taking part in the international system. Then, politician may manipulate the exchange rate to win the election[3].

Frieden (1991) clusters national stakeholders in groups according to their benefit in an exchange rate regime and the level of the exchange rate. With regard to the level of the exchange rate, stakeholders that operate at the international level (foreign trade and investment) such as international banks, investors or exporters should favour fixed rate system because exchange rate stability promotes trade and investment. On the opposite, stakeholders whose activities are confined to the national level such as the non-tradable producers or the import-competing sectors should prefer a floating regime because the government is able to stabilize domestic economic conditions. Moreover, Bernhard and Leblang (2003) emphasized that regime choice has electoral implication which vary with the structure of political institutions. It is possible to imagine a situation in which politician are reluctant to join a fixed-rate international regime because it would mean a giving-up on tools that could influence favourably the economy for electoral purpose. Politicians may prefer a floating regime when the stacks in election are high because they can use the monetary policy to gain support before the elections[1]. On the other hand, when elections are not that decisive, fixed rate is more likely to be chosen.

In conclusion, the exchange rate regime has significant impacts on the macroeconomic fundamental and its choice is not only driven by some welfare purpose but also by some political factor within the independent states.

[3] See annexe VII currency manipulation

II) Literatures review of the exchange rate regimes and their economic performances

After the Asian crisis in late 1990s, a big flow of literatures about the consequence of the exchange regime on macro-economic performance has emerged. Flexible exchange regime offers a protection against external shocks, but it comes at the expense of instability in investments that could adversely impact growth. The consequence of the exchange rate regime on growth is thus not straightforward. Empirical studies result in diverging results due to differences in the econometric decisions e.g. classification of exchange rate arrangement, cross-country or time-series data sample, model specification or estimation methodology.

First overall, we should emphasize the difference that exists between the actual practice of exchange rate policy and the public commitment that central governments make regarding their exchange rate regime. Countries may make a public commitment about their exchange rate regime (de jure regime) but their monetary policies actually induce a different type of exchange rate regime (de facto regime). Because there exists a discrepancy between the exchange rate stated policy that a government announced to follow and the actual decisions they take, Reinhart and Rogoff (2004) have created a classification of the different exchange rate regime based on their monetary policies and the behaviours of their nominal exchange rate. Many studies use the de jure/de facto classification to test for the relation between exchange rate regime and macroeconomic performances.

Gosh et al (1995) find no systemic difference in the output growth across regimes. Their study shows that fixed exchange regimes are associated with low and less volatility in inflation while flexible exchange rate regimes are associated with lower volatility in output growth. Nevertheless, they find no significant different between exchange rate regime with regard to output growth. Levy-Yeyati and Sturzenegger (2003) demonstrate that hard pegs (currency boards) produce lower inflation and slower growth in developing countries but he also observed no effect in industrialized countries. Additionally, they find that countries with short pegs under-perform floats because they grow slower and have no benefit from lower inflation. Husain, Mody, and Rogoff (2005) argue that the effect of different exchange rate regime on the economy depends on the level of economic and institutional level. Their results show that greater exchange rate flexibility improves growth, but no effect on inflation is observed for advanced economies. As for developing countries, flexible rate reduces growth and increase inflation.

Regarding trade performance, there is a consensual view for which pegging is associated with lower transactional cost and uncertainty. Nevertheless, to be optimal, the choice of the pegging and the base to which a country pegs its currency is important. All the literatures about the effect of exchange rate on bilateral trades point to the conclusion that a fixed exchange rate promotes bilateral trade. Lee and Shin (2010) investigated how exchange rate regimes influence bilateral trade, output co-movement and financial integration. They conclude that currency unions have the greatest effect on trade; pegged regimes also significantly affect trade but to a lesser degree. Their results also suggest that currency union leads to higher industry specialization and better risk sharing opportunities than other pegged regimes. Klein and Shambaugh (2006) classify fixed regimes into three categories i.e. direct peg, indirect peg and currency union. They show that currency union and direct peg have significant positive impacts on bilateral trade while indirect peg have negative and insignificant impact on trade.

Although fixing the exchange rate benefits bilateral trade, it should be weighed against the cost of fixing the rate. Pegging to another currency may be an alternative for country that are willing to expand their trade and avoid all the burdens embedded with the taking part to a currency union. However, maintaining a peg could be burdensome due to market pressure. A currency union has the power of reducing this pressure by signalling a long-term commitment to the market.

The cost of joining a currency union depends on the members in the union. A currency union will be less costly if there is high level of labour mobility and flexible wage and price that would facilitate full employment and reduce the need for active policy. Moreover, the cost of joining a union will be reduced if public or private mechanisms are available to smooth out shocks through regional transfers (Kenen, 1969). The capital market integration also contributes to the reduction of the cost by smoothing consumption when facing idiosyncratic shocks (Mundell, 1961). A currency union will also tend to be less costly for a country with a high degree of sectoral diversification, as this will provide insulation against a variety of shocks, avoiding the need for changes in the exchange rates regime (Kenen, 1969). On a different line, joining a currency union may also be less costly for small, open (price-taking) economies for which the prices of tradeable goods (both imports and exports) are flexible because nominal exchange rates, in this case, become an ineffective mechanism to affect terms of trade, hence to restore external balance (McKinnon, 1988)

Currency unions and trade performance

Globally, there exists four monetary unions, two of them are located in Africa. While the European monetary union, EMU, is commonly known to the general public, the remaining three currency unions are less famous. Namely, they are the Central African Economic and Monetary Community (CEMAC), the West African Economic and Monetary Union (WAEMU) and the Eastern Caribbean Currency Union (ECCU). The main characteristic of a monetary union is the issuance of a common currency by a central bank and a common monetary policy jointly conducted by the members of the union. Dollarization is an alternative to currency union for countries that are willing to make exchange rate arrangement. In the case of dollarization, monetary policy is single-handily conducted by the country that issues the currency and there is no common monetary institution.

I) The Rose's effect

Currency union are credited for increasing trade by reducing volatility and transaction cost. However, nowadays countries, that have access to derivative market, can hedge against exchange rate volatility. Additionally, no empirical research evidences the negative impacts of exchange rate volatility on trade. Consequently, it is reasonable to question whether the currency union effect on trade comes through the channel of low exchange rate volatility. Rose (2000) published a famous literature to evidence the pro-trade effect of stable exchange rates and common currencies. In his literature, he uses a gravity model and dummy variables to measure the effect of currency union on bilateral trade. He finds that countries that share a common currency trade three times as much as countries that do not share the same currency. Moreover, he argues that reducing volatility to zero increases bilateral trade by 13%, which is not substantial in comparison with the effect of currency union. Following literatures of Rose and his peers (Frankel and Rose (2002), Rose and van Wincoop (2001), Glick and Rose (2002)) supported the view that the benefit of currency union come mainly through increased bilateral trade and not through reduced exchange rate volatility. National currency is a barrier to trade but not the most important.

Glick and Rose (2002) evidence that joining/leaving a currency union nearly doubles/ halves bilateral trades. However, Thom and Walsh (2002) analyse Ireland change of exchange rate regime (from the UK-Sterling to the EMU pegging) and they conclud that the change of exchange rate regime did not significantly change the bilateral trade between the UK and

Ireland. These findings are not in line with the result of Roses and they spotlight the different biases around the methodology used by Rose (2000).

Baldwin (2006) emphasizes the different mistakes that could undermine the gravity model. He labels them as the gold, silver and bronze medal errors. Baldwin estimates the effect of the euro zone on trade after controlling for the different medal errors. He concluded that the Rose's effect is much smaller and is about 2 percent. In addition to the medal error emphasised by Baldwin, zero-trade data also undermine the estimation of the currency union effect on trade. Additionally, a large part of bilateral trade date can contain zero observation. When zero observations represent a substantial part of the data, a consistent methodology should be applied to take into account this specificity. First the model has to be adjusted to accommodate zero observations, then estimations should be revised to avoid inconsistency. This issue appears even more important when we deal with small open economies. Santos, Silva and Tenreyro propose the using of a Poisson pseudo-maximum likelihood method to address the problem of zero in the bilateral trade observations.

II) The gravity model for bilateral trade

Despite the success encountered by Rose's finding, his methodology is embedded with flaws that seriously affect his estimation of the effect that currency unions have on trade. In order to understand the different flaws in Rose's methodology, we will develop the foundation behind the gravity model and the way a theory was derived from physic to a trade theory.

In physics, the gravity model describes the force of gravity between two objects as proportional to the product of their mass divided by the square of the distance between them. A straightforward but naive derivation of the physics model to a bilateral trade model between two countries would consist in replacing their mass by their GDP:

$$bilateral\ trade = G\frac{GDP_1 GDP_2}{dist^2{}_{12}}.$$

This equation states that bilateral trades between two countries depend on a constant G, that is equivalent to the gravitational constant in the physic model, the distance between them and the product of their GDP.

The main problem with this naïve derivation is the gravitational constant term, G. An OLS regression of the bilateral trade using this model will return a good but misleading fit, R^2. The estimated coefficient in the regression will be biased. The bias stems from the fact that G should not be constant in the gravity equation, it should vary over time and between trade partners. Furthermore, and above all, it is correlated with the other variables in the model that will create a bias in the coefficient.

The derivation of a structural trade gravity model starts with the hypothesis of a homogenous and frictionless world. Under this assumption, the same good has the same price everywhere. The natural benchmark prediction is $\frac{X_{od}}{E_d} = \frac{Y_o}{Y}$ (1), the proportion of spending by *d* (d for destination) on goods from *o* (o for origin) is equal to the global proportion of spending on goods from *o* and Y stands for the world spending.

Let us introduce the following constraints:

- The sum of sales to all destinations must equal Y_o, the total sale by origin o.
- The sum of purchases from all origins must equal E_d, the total expenditure for each destination *d*.
- Total sales and expenditure must be equal $\sum_o Y_o = Y = \sum_d E_d$

From the benchmark prediction and the restrictions made above, the observed trades between two nations is determine by $X_{od} = \frac{Y_o\, E_d}{Y}$. Most common models use aggregated goods but the derivation is straightforward if we use the index k, $X_{od}^k = \frac{Y_o^k\, E_d^k}{Y^k}$.

The economic foundation of the gravity model is based on a Constant Elasticity of Substitution function. Under the CES case the expenditure share is given by:

$$\frac{X_{ij}}{E_j} = \left(\frac{p_{od}}{p_d}\right)^{1-\sigma} \quad (2)$$

The price, in nation d, of a good made in the nation o depend on p_o, the producer price in nation-o, μ bilateral cost-price mark-up and τ_{od} represents all trade cost e.g.: distance, currency union, free-trade agreement (FTA). However, for simplicity purpose μ is kept equal to 1.

$$p_{od} = \mu\, p_o \tau_{od}$$

To get the total bilateral trade exports from nation-o to nation-d, which is expressed as an expenditure V_{od}, we multiply (1) by the number of variety, n_o, that nation-o sell to nation-d:

$$V_{od} = n_o (p_o \tau_{od})^{1-\sigma} \frac{E_d}{P_d^{1-\sigma}} \quad (3)$$

The price of the exporting nations, p_o, is still unknown. To get around this problem, we will use the equilibrium price condition i.e. the price that will clear the market; the price for which the exporting nation will sell all its outputs, Y_o.

$$Y_o = n_o p_o^{1-\sigma} \sum_{d=1}^{R} \left(\tau_{od}^{1-\sigma} \frac{E_d}{P_d^{1-\sigma}}\right)$$

Solving for $n_o p_o^{1-\sigma}$:

$$n_o p_o^{1-\sigma} = \frac{Y_o}{\Omega_o} \quad (4), \text{ where } \Omega_o = \sum_{d=1}^{R} \left(\tau_{od}^{1-\sigma} \frac{E_d}{P_d^{1-\sigma}}\right)$$

Ω_o measure the openness of the world to a nation exports, it also refers to as the inward multilateral resistance.

Substituting 4 into 3 we get the gravity equation of bilateral trade.

$$V_{od} = (\tau_{od})^{1-\sigma} \frac{Y_o E_d}{\Omega_o P_d^{1-\sigma}} \quad (5)$$

Finally, we can proxy the Y_o with the GDP of the origin nation and E_d with the GDP of the destination nation. Anderson (2011) criticized the common practice of using the GDPs as the proxies for origin and destination mass variable. He argues that it is conceptually misappropriate and leads to inaccurate modelling unless the ratio of gross shipments to GDP is constant. For simplicity purpose, we will make the bilateral trade gravity model looks like the physical model by assuming that bilateral trade cost only depends on the distance between the two nations.

$$bilateral\ trade_{od,t} = G_{od,t} \frac{GDP_{o,t} GDP_{d,t}}{(dist_{od,t})^{\sigma-1}}, \quad G = \frac{1}{\Omega_o} \frac{1}{P_d^{1-\sigma}}$$

The important point here is to notice that G is not constant anymore, it depends on the trading partners and it varies over time.

III) The medal errors

Baldwin (2006) emphasizes the different mistakes that could undermine the model. He labels them as the gold, silver and bronze medal errors.

- The gold medal error: The gold medal error refers to the omission of the gravity un-constant term, G. Its omission affects the estimates that currency unions have on bilateral trade. Since the omitted variables will be captured by the residuals, the gold error medal results in a correlation between the independent variables in the model and the residuals. Baldwin (2006) further illustrates this problem by analysing the methodology employed by Rose (2000). In his literature, Rose (2000), try to estimate the trade effect of currency union by using the gravity model and a dummy variable, CU_{od}, to measure the effect of a currency union on bilateral trade. The currency union dummy takes the value of 1 when the two partner belong to the same currency union and 0 otherwise. Rose (2000) uses a simple OLS regression of the gravity model.

$$y = \beta_0 + \beta_1 x_1 + u_t$$

The model used by Rose (2000) omits the gravitational un-constant terms. Since the model employs by Rose (2000) does not specify the un-constant term, it will be capture by the error term. Because the un-constant gravitational term depends on the bilateral trade costs, the currency union dummy variable is thus correlated with the errors term. The 200-percent effect of currency union on trade drawn by Rose (2000) is thus biased. Depending on the correlation between the omitted variables and the currency union dummy variable, the estimated coefficient of the currency union dummy variable will be biased upward or downward.

- The silver medal error: Theoretically, the gravity model explains the value of spending by one nation on the goods produced by another nation. Thus, the gravity model deals with unidirectional trade. In much literatures; they average the inflows and the outflows of goods and services form the origin country to the destination country and vice versa e.g. the average of the exports from Belgium to France with the exports from France to Belgium. The silver medal mistake occurs when the average is wrongly calculated. The theory behind the gravity model implies that we should use the average of the log instead of the log of the average. Nevertheless, the last could be used as an approximation of the former when the trades are balanced between countries. When trades are unbalanced, the greater the divergence between the two flows of export, the worst the approximation will be (Baldwin

2006). It can be shown that the bias in the bilateral trade estimation resulting from a wrong averaging are positive, meaning that bilateral trade data will be overestimated.

Consequence of the silver medal error could be double. First, if the measurement error in the bilateral trade has a mean different from zero, the estimation of the intercept, β_0, will be affected. Secondly, the measurement error could be correlated with some variables included in the gravity model. This in turn could bias the estimates in the model.

- The bronze medal error: the bronze medal error refers to the deflation of trade flows with a price index. In most literature, the US CPI is commonly used as a deflator. The use of a deflator creates a price illusion (trend effect) that will bias the estimates. Thankfully, the bronze medal mistake is often eliminated by the inclusion of time dummies.

Acknowledging the gold medal mistake, Rose and Van Wincoop (2001) include countries dummy variable to correct for the mistake. The Rose's effect was substantially reduced to 58 percent. Another solution to correct for the gold medal is to include country pair-specific variables as in Rose and Glick (2002). The country pair specific variable reduces the currency-union effect from 3.7 to 1.9. Nonetheless, these two solutions only address the time-invariant omitted variable. Some omitted variable may vary over time and be correlated with the variable in the model.

Baldwin and Taglioni (2006) estimated the size of all the 3 medal errors by reproducing the work of Micco, Stein, and Ordoñez (2003). They tested euro's currency-union effect on trade. Their data contain trades between the EU15 plus their major trading partners i.e. Australia, Canada, Japan, Norway, New Zealand and the USA. Baldwin and Taglioni (2006) included different dummies in addition to the variables of interest to test for the size of the medal errors. Exclusive inclusion of the time dummies corrects the bronze medal mistake i.e. the incorrect deflation of bilateral trade. Estimations show a strong effect of the euro on trade. To check for the robustness of the bronze medal mistake, they compare the estimates when the bilateral trades are correctly deflated with those that are wrongly deflated but with time dummy variables. Both methods resulted in the same estimate.

The second testing method consists in including time and pair dummies. The time dummies completely correct the bronze medal mistake while the pair dummies partially reduce the gold mistake i.e. omission of the gravity un-constant term. In line with the theory, inclusion of the pair dummies reduced the estimated impact of the euro from 0.17 to 0.1. However, inclusion of the pair dummies significantly affects the EU membership coefficient. In

comparison with the model that only include time dummies, the EU membership is significantly reduced and become statistically insignificant. This is cause by little change in the EU membership over the tie period of the data. The pair dummies will remove all the effect of the EU membership effect.

The last testing method consists in including nation and times dummies. The nation dummies also control for the correlation between the omitted variables and the included variables but here the likelihood of reverse causality has to be taken into account. Nations may form a currency union because they trade more with members in the union than they do with non-member of the union. Currency union formation may be due to different factors that intensify trade, and these factors are unobservable to econometricians. Baldwin and Taglioni (2006) argue that euro-effect coefficient is surely biased upward. On the other hand, because the EU membership should have a big impact on trade flow, the estimate fit better expectations when nation dummies are used. The estimate increases from 0.03 to 0.21.

Baldwin and Taglioni (2006) also estimate the size of the silver medal. The silver medal error consists in a wrong measurement of the bilateral trade. Because the gravity model is naturally multiplicative, the averaging of trade flows should be done via a geometric averaging instead of an arithmetic averaging. They concluded that the silver medal mistake overestimates the coefficient of the euro effect on trade. When the silver medal mistake is not handled, the euro has a strong and significant impact on trade. A correction of the mistake results in a small and insignificant effect of the euro on trade. In order to strengthen their conclusion, they also investigate whether bilateral trade data are balanced in their sample. They conclude that bilateral trades data are imbalanced and they are not randomly distributed. Thus, they conclude that some of the variations in the trade effect of the common-currency coefficient are due to varying severity of the silver medal mistake.

IV) The zero-trade flows issue

Because all country pairs do not conduct trade with each other or they only trade in one direction, a substantial part of trade data exhibit zero. When zero-trade data represent a substantial part of the sample, a consistent methodology should be applied to take into account this specificity. First the model has to be adjusted to accommodate zero-trade data, and then the method of estimations should be revised to avoid inconsistency when the dependent variable frequently includes zero-observations.

A first and simple approach to adjust the model for the inclusion of zeros is to assume that zeros are simply data recording issues i.e. zeros are only statistical zeros due to rounding or declaration threshold e.g. if we assume that bilateral trades are measured in thousand, a bilateral trade value of 450 will be rounded to zero. A second approach would be to explain zeros by fixed costs of exporting a positive amount. In the model develops by Eaton, Kortum and Sotelo (2012), if the most productive firm in country, i, cannot export profitably to another country, j, there will be no trade between i and j, yielding zero-trade data. This model implies that the more the likelihood of low bilateral trade, the more likely zeros will be observed. If one takes the log of trade, as it is the case in the gravity model, zero observations should be removed which will create a selection bias. It is therefore important to determine an estimator that will deliver good result when zeros are endogenous component of the data generating process.

Common practice consists in adding one to observed data and then taking the log of observed data. Tobit model can then be used since we have a lower limit of zero. Although this practice is simple, it presents a drawback because it makes the results depend on the unit of measurement (Head & Mayer, 2014). Head and Mayer (2014) show that a change in the unit of measurement from million to billion make estimates change from negative and insignificant to positive and significant.

Eaton and Tamura (1994) propose an alternative model of ln ($a + X_{ni}$). Instead of setting arbitrary a equal to one, a represents a parameter to be estimated. Unfortunate, this methodology has no structural interpretation.

Santos Silva and Tenreyro (2011) propose the using of a Poisson pseudo-maximum likelihood (PPML) method to address the problem of zeros in the bilateral trade observations. Under the assumption that the conditional mean is proportional to the conditional variance, they perform a Monte Carlos simulation and they tested the robustness of the PPML to different pattern of heteroscedasticity. Their results show that PPML is robust to the presence of heteroscedasticity and provide a natural way to deal with zero observation in trade data.

V) Literatures review of the effect of common currencies on bilateral trade in Africa

Most literature about the effect of currency union on bilateral trade deals with the euro-zone. Little literature deals with developing countries such as sub-Saharan countries. Masson (2008) analyses whether the formation of a currency union in West Africa can be justified by positive trade effect between nations within the region. He finds that the low intra-regional trade, the asymmetry of the shock and lack of fiscal convergence suggest that currency union formation would be sub-optimal in term of welfare. He added that an improvement of the infrastructure, political stability would have a better effect on trade.

Tsangarides et al. (2008) employ an augmented version of the gravity model to estimate the effect of currency union on trade in Africa. They find that sharing a common currency in Africa doubles trade and the rise in trade does not come with trade diversion from members that do not belong to the currency union. Further, they observe that the longer the membership in the union the greater the trade effect. Finally, they show that a currency union is associated with lower trade volatility, increased price co-movement and does not affect output co-movement.

Frankel 2008 employs an OLS-model to determine the effect on trade of the fixed exchange rate between the CFA franc zone and the Eurozone. His model only includes year fixed effect. He observed that the EMU formation has led to an increase of 76 percent of trade between the CFA zone and the Eurozone. Moreover, he shows that bilateral trade is reduced by 50 percent when both countries belong to the CFA region.

Currency union and foreign investments

Along with trades, currency unions facilitate movements of capitals between members by boosting financial integration which facilitate foreign investments. In this section, we attempt to determine the effect that currency unions have on foreign investments.

VI) Greenfield investment and M&A

Oversea expansions of businesses can be done via two vectors. Companies can either create subsidiaries i.e. greenfield investments, or they can simply purchase an existing company via an acquisition i.e. mergers and acquisitions (M&As). The difference between greenfield investments and FDIs (foreign direct investment) rests in the way they are implemented. M&As expand the internal organization of firm through the external market. Greenfield will use the internal capability of the firm organizations and resources to acquire new production capacities by purchasing new lands, machines and workforces. M&A implementation generates a great amount of market transaction costs while implementation of greenfield investments generates internal management costs. The difference between the internal organization management cost and market transaction cost is determined by the capacity and resource of the company.

As with international trade, the choice of foreign investments over national investments is motivated by technological and factor endowment difference, scale economies and imperfect competition. To be worthwhile, foreign investments should give a competitive advantage to the firm over its foreign competitors. The choice of expansion method will influence the competitive advantage gained from the foreign investment. A market of low competition is often characterised by high profits. When few companies operate in the market, a greenfield investment would help the company to get a place in the market, from which it can gain its competitive advantage. Due to the market prospect, the existing firm in the market will see their values surge, the cost of acquisition for investors willing to enter the market will be very high. In this condition, investors will favour greenfield investments over M&A. On the other hand, when the market is becoming saturated M&A should be favour by investors. When the supply is relatively high, in order to survive, incumbents have to cut their price for market share. M&As result in gain of market share and reduce cost by increasing production capacity.

Competitive advantages drive FDIs but these competitive advantages often involve intangible asset such as know-how, technology, patents or organisational networks. FDIs are also about

corporate control, yet there is no straight definition of control and it can take many forms. Consequently, FDI is less well-defined concept compare to trade.

VII) FDI measurement

There exist two approaches to measure FDIs, the central bankers approach and the economic ministers' approach. Central banker considers FDIs as part of the capital account of balance of payments. They are interested in the link between FDI activity, stock market development and financial deepening. The economics ministry approach looks at the impact of inward FDIs on job creations and estimate the potential knowledge transfers and access to international sale networks or management expertise. With this approach, outward FDIs are about allowing domestic firms to better exploit their advantage in the wider world. The economics ministry approach would be the most suitable when one wants to look at the effect of currency union on FDIs. However due to confidentiality requirements, data are difficult to access. Even when they are accessible they only concern one nation and their aggregation is difficult due to their incompatibility. On the opposite, capital account data are easily accessible but they are only indirectly related to economic activity.

FDI flow is said to occur when a firm from a country creates a subsidiary or takes control of another firm in another country. Some capitals are often required to cross the border but it is not always the case. The subsidiary can borrow locally or from another country to finance its investments. Even when capitals cross the border, the size of the flow can differ from its impact on the real economy. The capital flow can be associated with the creation of a subsidiary fully funded by the mother company or it can be associated with a 10 percent equity stake.

VIII) Literature review of the effect of common currencies on investments

Most literature on the impact of currency union on FDIs deal with the euro. The first set of literatures look at unconditional evidence of the euro effect on FDIs. They try to find evidence that suggest that intra-FDI inflows exceed extra-FDI inflows i.e. inflow originated from outside the euro-zone.

Taylor (2008) analyses the growth in FDI flows for all OECD nations between 1994 and 2003. To account for the euro effect, he divides his timeline into two sub-periods and looks at the variation of FDIs between the two sub-periods. They find that the euro made the euro area attractive to foreign investments from both inside and outside the euro area. However, when

they control for potential problem[4], the euro effect is substantially reduced. This suggests that other factors may be behind the increase attractiveness of the euro area as a place to invest via FDIs.

Coeurdacier, De Santis, and Aviat (2009) provided evidence in favour to the pro-FDI hypothesis in the manufacturing sector. They used data of cross-border M&As and distinguished between manufacturing and service sector because they followed different development. They analysed the difference in the growth of M&A between from 1993 to 1998 with the period from 1999 to 2004. For the manufacturing sector, they observed a higher growth in the later period for M&A in the euro area and M&A in the EU15[5], but the growth was higher in the euro area. They also showed that M&A from the rest of the world to the euro area and the EU15 has experienced a higher growth during the later period. When looking at the data of cross-border M&A in service, the growth of cross-border M&A in the EU has not change across the two periods. Moreover, the growth of the rest of the world M&A in the euro area is higher during the period after the euro introduction. A possible explanation, developed by the author, for this finding is that non-euro nations wanted to enter the financial sector of the euro area via M&A.

The second set of papers use econometric approaches to evidence the pro-FDI effect of the common euro usage. The first group of literatures are based on the "knowledge capital model" developed by Markusen and Venables (1998). According to the model, FDI involve two trade-offs. The first trade-off is between scale economies (production units are concentrated in a specific location) and transport-cost savings that stem from the spatial allocation of production units to be as much close as possible to their customers; firms set up production units to avoid trade cost. These trade-offs imply that the euro should promote FDIs from the non-Eurozone nation into the Eurozone. However, since the euro reduces transaction costs, firms in the Eurozone have less incentive to invest in the Eurozone. The second trade-off concerns vertical FDIs. Firms have to choose between concentration and cost-efficient spatial allocation of their stages of production. By facilitating trade, the euro should encourage vertical FDIs.

Helpman, Merltiz and Yeaple (2003) developed an advanced version of the knowledge capital model to allow for the heterogeneous firms. Their model considers firms with

[4] In the data Luxembourg are linked with 76 percent of all the intra-FDI flows between 1999 and 2003.
[5] Belgium (BE), Denmark (DK), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES) and United Kingdom (UK), Austria (AT), Finland (FI) and Sweden (SE)

different productivity and fixed costs of establishing "beachhead" in various countries. The euro should have double impacts on the profit of firms and the impact will depend on the competitiveness of firms. First, the euro should lower marginal trade costs, which will increase the competitiveness of each firm. But because we are dealing with marginal trade cost, firms that are the most competitive will benefit the more. Their sale and profit will rise the most. Then, the euro should lower the fixed cost of establishing beachhead e.g. fixed cost due to the foreign currency management.

Carr, Markusen and Markus (2001), from Monte Carlos simulations of their theoretical model, find that horizontal FDIs is associated with a positive coefficient on the sum of GDP of both nations, a negative coefficient on the GDP difference and a negative coefficient on the host trade cost variable. They also find that vertical FDIs should have a positive coefficient for the skill difference variable. Their results show evidence supporting the knowledge capital model. Nevertheless, Blonige, Davies and Head (2003) outlines the econometric problems in their studies. Once the different problems were solved, the results no longer supported the vertical FDI motivation of the model.

The second empirical approach consists in using the gravity FDI model. All models have been developed to take into account the distance between two countries as a variable that influences the FDI activities. The general FDI-gravity model is like

$$FDI_{od,t} = \propto_1 D_d + \propto_2 D_t + \propto_3 D_o + \propto_4 X_{od,t} + \varepsilon_{od,t}$$

Where the subscripts o,d and t stand for respectively the origin, destination countries and time. Ds are dummies (fixed effects) and X is the vector of variable that may affect FDIs. Literature on the euro effect on FDIs uses the additional dummy EZ11 that turns to 1 when both the origin and destination nation are part of the Eurozone.

Peutrolus (2007) uses panel data of 18 developed countries during 1992-2001. He finds that the euro promoted inward trades in the euro area, and the effect is almost double for members of the European Union.

Coeurdacier, De Santis and Aviat (2008) uses panel data of 21 developed countries as source countries and a list of 31 host countries, which are composed of 20 developed countries and 11 developing countries. They used cross-border M&A flows as data for their analysis. Since their data contain a significant part of zero data, they use Poisson Maximum likelihood estimator. They find that the euro increased cross-border M&A inside the euro area by 300

percent and about half of the effect could be attributed to the euro area formation. With regard to the EU effect, they found that euro increased cross-border M&A inside the EU by 340 percent and about 50 percent of the effect can be imputed to the Eurozone formation. They also made the distinction between horizontal M&A (M&A within the same sector) and vertical M&A (M&A across sector; conglomerate formation). They find that cross-border M&A is sector specific, the euro effect on cross border M&A within the same sector is about 300 percent. Additionally, they argue that the rest of the world seeks both horizontal and vertical M&A in the euro area. In order to control for any unobservable variables that could promote FDIs and could increase the likelihood of forming a currency union at the same, they included country-pair dummies in their model. This does not change the estimates.

Russ (2007) uses a model with upfront sunk costs, heterogeneous firms and endogenous exchange rate to analyse the impact of interest rate volatility (endogeneity of exchange rate) on national and cross-border M&A. His results confirmed the pro-FDI effect of the euro but the magnitudes of the effect were different. The euro increased the level of M&A activity by 20 percent with OLS estimator and by 1 percent with the FGLS (Feasible General Least Square) estimator. The estimates were quite similar for veteran and first timers.

In conclusion, the effect that currency unions have on trade and FDI is positive. However, estimation of the magnitude of the effect is significantly impacted by the econometric methodology. Application of the gravity model to estimate the effect of currency unions is a challenging task. First the data are difficult to find and their aggregation may be daunting. Secondly, the gravity model requires sound knowledge of the economic theory behind the model. A naïve application of the model will create biased estimates of the effect of currency union on trade and FDIs.

Analysis of the CFA franc zone.

IX) The CFA franc creation

Although CEMAC and WAEMU have their distinct currency, they form a monetary alliance called the CFA franc zone. The agreement dates from the colonial time and it was originally created by the French government for its colonies in Africa. Its purpose was to eliminate the cost of carrying the money from France to its colony. The monetary policy was entirely handled by the French government via two issuance houses that were located in Paris. In the process of independence, African nations jointly with the French government set up monetary cooperation which led to the creation of two institutions i.e. "Banque Centrale des Etats de l'Afrique de l'Ouest" (BCEAO) and "Banque Centrale des Etats de l'Afrique Centrale et du Cameroun" (BCEAC). They were in charge of the issuance of money and the management of the monetary policy. However, the monetary policy of the former colonies was still mainly led by their former colonial power. In 1972 and 1973, after update of the structure and the membership of these two institutions, efforts were invested to put in place a pan-African leadership in the two institutions and to reduce the influence of the former colonial power in the monetary affairs of the African nations. In late seventies, the BEAC (Banque des Etats de l'Afrique Centrale), former BCEAC, and the BCEAO are relocated respectively in Yaoundé, Cameroon and Dakar, Senegal. Both banks conduct monetary policies in their respective region and monitor the banking system at regional level.

Nowadays the CFA franc zone has 14 members, and the group can be divided into 2 sub-groups which found their roots in two African economic and monetary unions. Both unions have their respective issuance house – the Central African Economic and Monetary Community whose central bank is the BEAC and the West African Economic and Monetary Union whose central bank is the BCEAO. Each central bank issues its own currency that can be converted into euro at a fixed rate of 655.957 per euro. Even if both CFA francs are converted at the same rate into the euro, they are independent and not convertible into each other.

Despite the step back of the French government in the monetary affairs of both institutions, it still plays a key role in the currency issuance of the CFA zone. Indeed, it guaranties the peg of the CFA franc to the euro by providing an operation account in the French Treasury for the two central banks. Provided one of the central bank has a deficit in its reserve, it may draw a

theoretical unlimited overdraft. However, some limitations were set to make sure that the arrangement was viable. Among these limitations, three of the most important are[6]:

- At least twenty percent of sight liabilitie of each central bank must be covered by foreign exchange reserves.
- At least fifty percent of foreign exchange reserve must be held in the operation account.
- Increasing interest rate penalties is applied if there is an overdraft
- France is represented on the board of both institutions.

[6] See Banque de France.(2002). *The franc zone*.

X) DEVALUATION

In 1994, both francs were devaluated by 50 percent due to the loss of competitiveness. The appreciation of the French franc against its major trading partners mixed with internal and external adjustment problems impacted the terms of trade of both regions. The consequences of this shock on the fundamentals were amplified by a poorly managed banking system. Because of eroding tax base and increased demand for fiscal transfer, government deficits deteriorated impacting the banking system further.

The overvaluation of the CFA franc was first analysed by the IFM and the World Bank, and the devaluation was finalized in 1994. The policy reforms were implemented in most country of the franc with the help of the IMF and the World Banks. Economically, the devaluation has been beneficial in restoring the external and internal balance, and a strong economic growth. However, the positive trend reversed in 1992. Weak growth rate, fiscal and external deficit are observed for several countries. Loss in competitiveness is observed due to the appreciation of the dollar against the euro and domestic wage development. Moreover, for many CEMAC countries, their GDP relies heavily on their oil revenue, the plummet of the oil price has heavily impacted GDP growth.

XI) The European monetary union

The introduction of the single European currency (euro) also represents a potential threat to the competitiveness of the CFA zone. Trades between the euroland and the CFA zone represent 40 to 50 percent of total trade for countries belonging to the zone. Consequently, the introduction of the euro induced uncertainty for the CFA franc zone.

On one hand the introduction of the euro could create a boom in the euroland, boosting the production and demand for imports. This would be beneficial for the euroland trading partners. CFA countries would benefit from the shift in the currency peg to euro which means lower transaction cost. Moreover, greater inflows of investment from the euroland countries could be expected. On the other hand, the introduction of the euro would undermine growth in the euroland, shrinking the GDP growth of its trading partners. Furthermore, the obligation embedded in the euro convergence criteria could adversely impact some sectors and/or economies in Europe which could slow exports growth for members of the zone.

With regard to the financial market, several negative outcomes could occur. First, easier access to European financial market could result in a flight of capital from the CFA franc

zone to the euro zone which would stall the development of the zone. Secondly, provided a boom in the productivity and growth of the euroland, the relative attractiveness of Europeans assets could increase, which would make the cost of borrowing for CFA countries more expensive. Finally, a strong or volatile euro poses a risk of competitiveness for the CFA zone. A strong euro against other currencies would make exportations more expensive, competitiveness would fall and further devaluation would be necessary to restore competitiveness in the region

XII) 21th century economic analysis

a. CEMAC

Oil revenue account for a significant part of the GDP for all CEMAC's members expect for Central African Republic which draws most of its revenue from the production of diamonds. The economic development of the zone depends mainly on the development of the oil market. On average, the real GDP growth rate was around 5 % from 2004 to 2010 and it declined to 3.67 % from 2010 to 2016. This reduction is mainly explained by the drop in the oil price since 2013. In terms of stability and credibility, the good performance of the community had been stalled by the financial crisis. Before 2008, figures of price inflation, external current account and reserve coverage were better and stable. These past and positive performances were mainly due to the surge in oil price between 1994 and 2006. It led to an increase in fiscal revenues, export and reserve. During the 2008-2009 global recession, most of the macroeconomic indicators turned abruptly downward. Current account fell into the negative zone, the total debt to GDP ratio has significantly increased and the part of government expenditure has been shrunk.

In terms of financial sector integration, the ratio of private credit to GDP is growing year over year, but the ratio remains low. A.Alter and B.Yontcheva(2015), in their analysis of the financial integration of the SSA (Sub-Saharan African) region, show that macroeconomic stability is a prerequisite for a sound financial integration. Inflation, income and natural resources explain most of the private credit to GDP ratio which is the proxy they use to measure financial integration. They also determine the factors that explain the financial development gap in Africa. Inflation, technology and operational cost are the factors that explain most of the gap. Against expectation, their result also show that income does not explain the gap: richer and poorer countries may be equally far from their expected financial development levels.

The high dependence of the region on the oil revenue presents a risk for the region. Julius Agbor Agbor (2012) conducts a risk analysis of the region, and he highlights the risks factor to which the region is exposed. First, the exchange rate reserve is mainly funded by the oil export revenue. Oil accounts for a significant part of export and GDP. The scarcity of the resource would pose a threat to the reserve. Derivative products, monetary tightening and capital controls could be a solution in case of depletion of the resources, but these solutions are cost-ineffective or unavailable to CEMAC economy (Agbor Agbor 2012). Thus, apart from new oil discoveries and subsequent exploitation, the future of the regime is not assured. Secondly, increased volatility in export revenue, compels CEMAC countries to build increasingly higher coverage. Because the volatility in the export revenue implies more volatility in the foreign reserve, there are risks of currency speculation and currency crisis. Gulde & Tsangarides (2008) estimate that one standard deviation fall in oil price leads to a loss in reserves of about two months of import coverage in 2006. Moreover, there is an opportunity cost of holding higher foreign reserve because the reserve could be used for investments and promote growth.

b. WAEMU

WAEMU exports are mainly agricultural products such as cottons, bananas, cacao and fishes. Niger and Mali are respectively uranium and gold exporter while Togo is a cement exporter. Ivory Coast is the only country in WAEMU to produce oil but it also exports cacao and coffee. Commodities such as cotton and cacao have suffered a sharp price cut at the beginning of the decade. This explains the difference in the fiscal performance between CEMAC and WAEMU from 2004 to 2010. While CEMAC benefited from the boom of oil price to amass its fiscal surplus, WAEMU countries had to cope with the commodity price drop which hampered its fiscal performance. After 2010, WAEMU had strong growth, supported by the GDP growth of Ivory Coast and investments in public infrastructures. Growth rate was on average at 6 percent. CPI has been more stable. However, the situation is more severe when we observe the other macroeconomic indicators. Fiscal deficit as a percentage of the GDP has gone deeper into the negative territory since 2010 due to the fact that government spending and capital expenditure have significantly increased while fiscal revenue have slightly increased from 15 percent to 20 percent. Based on IMF data, total debts to GDP should remain stable at a rate of 40 percent until 2019.

WAEMU countries have set convergence criteria in order to strengthen their union. The convergence criteria have been modified in 2015 due to the lack of compliance of the deficit criterion, the complexity of the criteria and the lack of incentive and sanctions. While rules increase credibility, and can act as a shock-smoothing mechanism in the region, their compliance can be difficult for countries in period of downturn. In case of downturn, compliance of the rule can have countercyclical effects that can further aggravate the situation. Thus, in order to meet their development needs, WAEMU countries may be compelled to overlook the convergence criteria. Olumuyiwa and Williams (2007) state that the fiscal convergence criteria should be evaluated with regard to their exposure to external shock. This point is even more important since CFA economy relies on a limited number of commodities. The assessment of fiscal performance should not be based on adjusted balance but rather on statistics and methodology. Moreover, the criteria should give flexibility to accommodate to short-term development.

Table 1

First-order criteria	2011	2012	2013	2014	2015
Overall Balance/GDP (≥ - 3 percent)	4	4	2	3	2
Average consumer price inflation (≤ 3 percent)	5	3	0	0	0
Total debt/GDP (≤ 70 percent)	0	0	0	0	0

Source: author ‘s calculation

Table 1 shows the convergence criteria that have been set by the WAEMU Heads of States in 2015. The convergence criteria are composed of two set of criteria i.e. the first-order and the second-order criteria. The second order criteria state that the ratio of wages and salaries to tax revenue should not exceed 35 percent; and the ratio of tax revenue to GDP should be great than 20. Table 1 shows that the level of debt and the inflation criteria were met by every country since 2013 but the overall balance criterion was only met by most countries.

Convergence analysis among Central and West African countries

XIII) Mundell and optimum currency area theory.

Mundell (1960) developed the theory of optimal currency area (OAC). In his theory, he develops four criteria that are necessary for a region to be recognised as an optimal currency area.

- Great labour mobility: Free movement of labour into the area which is entailed with a lack of cultural barrier such as different languages and government benefit policies.
- Capital mobility, price and wage flexibility: Trade is made easier and economy is boosted when countries tend to trade with each other's. Money can be easily allocated where it is the most needed and active policies are less frequently required.
- A currency risk-sharing across countries: When some members is in difficulty, other members with surplus should give up their revenue in order to support them. Mundell (1960) insisted that the currency risk-sharing mechanism is not only crucial but vital for the currency area.
- Similar business cycle: Business cycle should be similar so that policies of the central bank are more efficient in the entire area. When countries in the area are affected by negative shocks, the shocks will be symmetric if their business cycles are similar. Thus, a common policy (e.g. depreciation/appreciation of the currency, expansionary/ restrictive monetary policy) will be optimal in the entire area. However, when the business cycles are not similar, the shocks will be asymmetric. A common policy will not be optimal because it will result in different outcomes in distinct parts of the area depending on the sign of the shock in the part of the area.

In order to investigate whether the CFA franc zone is an optimal currency area we will use these four criteria and run a cluster analysis to analyse the extent to which the CEMAC and WAEMU countries cluster with each other. Additionally, we include WAMZ countries in our analysis to check whether the extension of the actual currency union to other West African countries would result in an excessive cost due to their heterogeneity with CFA franc countries. Cluster analysis enable us to group objects (countries) into groups (clusters) based on their homogeneities. These homogeneities will be assessed via multiple variables that find their root in the OCA theory.

XIV) Theory of cluster analysis

Cluster analysis methods can be divided into two groups: hard (or exclusive) and soft (fuzzy) clustering. In hard clustering, each observation is assigned to a unique cluster. On the opposite, in soft clustering, each observation can be assigned to various clusters with a membership coefficient varying between 0 and 1. The membership coefficients measure the degree of belonging of each member to each cluster.

c. Hard clustering

Many clustering algorithms have been developed to form clusters from set of variables, but two methods are most commonly used, the K-mean methodology and the hierarchical methodology. K-mean clustering consists in generating a pre-specified number of clusters from the set of variables. Hierarchical clustering will consist in generating a set of partitions which range from a single clustering containing all the objects to N partitions in which each object belongs to a cluster.

In this analysis, we will only use the agglomerative hierarchical clustering which is the most commonly used. This method consists in forming a first partition of N clusters and forming successive partition by merging the clusters until a partition composed of a unique cluster, that encompassed all the objects, is created.

The first step in performing an agglomerative hierarchical clustering consist in determining the way two objects are considered similar or dissimilar. Similarity or dissimilarity can be measured using the distance between the objects. Most cluster methods use the distance matrix to determine the similarity or dissimilarity between pairs of objects.

The distance between two objects is measured as follow:

$$d(x_i, x_j) = \left(\left|x_{i1} - x_{j1}\right|^g + \left|x_{i2} - x_{j2}\right|^g + \ldots + \left|x_{1n} - x_{2n}\right|^g\right)^{1/g}$$

Where x_i and x_j are the vector of observation of object i and j respectively for each variable. Conventionally, g is fixed to 2 which corresponds to the Euclidean distance metric. Another alternative is to fix g to 1 in which case the sum of absolute distance is employed i.e: Manhattan metric.

Euclidean distance is heavily affected by the variable with large size and dispersion difference. In case the variables used in the analysis have different variances, the Euclidean

distance will produce inaccurate data. In order to cope with this problem, data should be standardized first (Tan, Steinbach and Kumar, 2006).

Alternatively, one can use the Pearson correlation to measure the similarity between two objects. It measures as follow:

$$s(x_i, x_j) = \frac{(x_i - \bar{x}_i)^T . (x_j - \bar{x}_j)}{\|x_i - \bar{x}_i\| \times \|x_j - \bar{x}_j\|}$$

In this analysis, we will use the Euclidean distance instead of the Pearson correlation because we are more interested in the relative magnitude of the variable across objects (Tan, Steinbach and Kumar, 2006).

Once the similarity or dissimilarity is calculated the second step consists in determining how the cluster will be formed. Many algorithms have been developed and they differ by the way they define the distance between clusters or objects. The commonly used algorithms are the single linkage, complete linkage, average linkage and centroid algorithm.

Single linkage determines the distance between two clusters as the minimum distance between the different pair of members from two different clusters. On the opposite, the complete linkage determines the distance between two clusters as the longest distance between the different pair of members from two different clusters. In the average linkage, the distance is measured as the average distance between all pairs of members in the two clusters. Centroid method only considers the distance from the centre of a cluster to the centre of another cluster as the distance between two clusters.[7]

The choice of the appropriate linkage algorithm will depend on the cophenetic correlation coefficient (CPCC). The CPCC measure the correlation between the cophenetic distance matrix and the similarity/dissimilarity matrix. Elements of the cophenetic matrix are the cophenetic distance between each pair of object. The cophenetic distance between two points is defined “as the proximity at which an agglomerative hierarchical clustering technique assigns an object to a unique cluster” (Tan, Steinbach and Kumar, 2006, p.544). Thus, the cophenetic distance matrix depends on the linkage algorithm employed. The linkage algorithm that exhibits the highest CPCC should be the one to be considered. The CPCC measures the degree at which the hierarchical clustering fits the actual representation of the

[7] See reference VI Linkage Algorithm

data. Thus, a CPCC coefficient close to 1 implies that our hierarchical cluster fits well the actual representation.

The final step is to determine the optimal number of cluster that should be used. When dealing with hierarchical clustering, little guidance is available to make this decision. One can look at the dendrogram to determine the optimal number of cluster. The optimal number of cluster should be set so that the creation of an additional combination of cluster or objects will lead a substantial change in the fusion level (vertical axis of the dendrogram). An alternative solution is to calculate the variance ratio criterion developed by Calinsky and Harabasz (1974). This ratio is defined as:

$$VRC_k = (SS_B/(k-1))/(SS_W/(n-k))$$

Where SS_B stands for the sum of square between the segment, SS_W for the sum of square within the segments, k for the number of segments and n the number of objects (Tan, Steinbach and Kumar, 2006). SS_w measure the compactness of the cluster, while SS_B measures how well the cluster are separate from each other. High value for the ratio indicates a great partitioning thus a good clustering.

d. Fuzzy clustering

Fuzzy clustering allows an object to belong to several clusters with a membership coeficcients assigned to each object. Fuzzy clustering has a main benefit over hard clustering in the sense that it does not force objects that are on the boundaries between several clusters to belong to a specific cluster. Instead it assings a membership coefficients, raging from 0 to 1, to indicate their partial membership. A high membership coefficent indicates that the object is similar to the other objects in the cluster while a low coefficent indicates that the object is dissimilar the to the other objects in the cluster.

As for hard clustering the creation of the partition are based on algorithms. Most fuzzy clustering algorithm are derived from the fuzzy c-mean. The c-means algorithm aims at minimizing the the following function

$$J(Z;U,V) = \sum_{i=1}^{c} \sum_{k=1}^{N} (\mu_{ik})^m \, \|x_k - v_i\|_A^2$$

Where μ_{ik} stands for the membership coefficient, x_i for the vector of object and v_i the vector of clusters'centre which has to be determined.

The number of clusters c must be specify aposteriory. This could pose a problem when we have no a priori information about the structure of the data. Since the number of clusters has a lot of influences on the partition, one should be cautious that the resulting partiton is a good reprentation of the original data. In order to validate the number of cluster, three index are usually used, the Dunn's partition coefficient, the Xie and Beni's Index and the silhouette plot. Each coefficient has its own interpretation and limitation. The Dunn's partition and the silhouette index range between 0 and 1, a value close to 1 means less fuzziness in the partition.so we look for the number of clusters that has an index close to 1. On the other hand, when using the Xie and Beni's index we look for the number of clusters that minimizes the index.[8]

[8] For further information see Liu, Y., Li, Z., Xiong, H., Gao, X., & Wu, J. (2010). Understanding of Internal Clustering Validation Measures. 2010 IEEE International Conference on Data Mining. doi:10.1109/icdm.2010.35

XV) The data

The choice of the variable that will be used is based on the OCA theory. Our goal consists in looking for any convergence between the three unions by analysing the degree at which West and Central African countries cluster with each other. We will use the same procedure as Tsangardide and Querish (2006) to construct our variable. The period of analysis is from 2004 to 2015. The variable included in the analysis are the following:

- Business cycle correlation

In order to compare the businnes cycle correlation between the CFA countries, a benchmark is required. Because the EU is a majors trading partner of every sub-saharan African countries, we will calculate and compare the bussiness cycle correlation between the Euro area and the CFA countries. The business cycle series are extracted from Real GDP series from which the Hodrick-Prescot filer is apllied. Following De Jong and Sakarya (2016), we set the smoothing parameter to 6.45. and we extract the cyclical compenent of the GDP data. Similar correlation coefficients implie that the business cycle in CFA zone follow the same patern.

- Term of trade synchronisation

As with the business cycle correlation we choose the Euro area as an anchor. The correlation is measured using the first difference of the term of trade index. The term of trade is an important indicator for the CFA zone since their economy relies heavily on commodoties. A shock in the term of trade can have important consequences on economic performance, espacially on fiscal performance. Because the exchange rate is not a monetary tool available to smooth the shock, it is important to observe a correlation in the term of trade in the CFA zone. Correlated term of trade increases the effectiveness of a regional monetary policy in the whole region.

- Real exchange rate variability

A flexible exchange rate system is a powerful monetary tool to absorb supply and demand shock in the economy. A monetery union prevent economies to use this tool as a shock absorder, this can be consider as a loss for the economy in the union. Weak variability in the real exchange rate make the loss less costly. The variability of the real echange rate is measured as the standard deviation of the log difference.

- Regional trade intensity

The regional trade intensity measures the degree at which a county trades with other countries in the same region. In our analysis we will consider a region composed of 3 regional agreement i.e. WAMZ, WAEMU and CEMAC. Together they emcompass most of the central and west african countries. The regional trade intensity of a country is measure as the ratio of the sum of its exports and imports to the sum of its total export and import.

$$(Xi, region + Mi, region)/(Xi + Mi)$$

where X stands for the exports and M for imports. Countries that tend to trade a lot with the partners in the currency union have more to gain from joigning the currency union than countries that do not trade much.

- Inflation

One of the convergence criteria of the CFA community is to keep the annual inflation rate below 3 percent. The inflation rate is measured as the log difference of the consumer price index.

- Government balance

The convergence criteria also requires a ratio of budget deficit to gdp less than 3 percent. This variable is defined as the ratio of the net lending/borrowing excluding grants of the central government to GDP.

- Total debt.

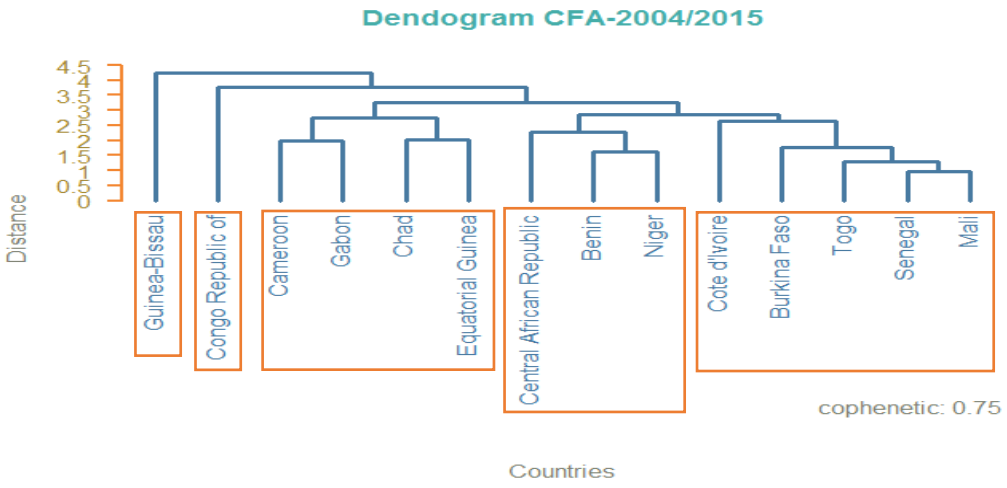
Another convergence criterion limits the total outstanding domestic and foreign debt to 70 percent of the GDP. Olumuyiwa and Oral (2007) found that the debt to gdp ratio has a significant and positive effect on fiscal performance for the CFA countries. They find that to ratio of debt at time t-1 to GDP has a significant effect on current year fiscal perfomace for both CEMAC and WAEMU countries. When countries experience a high level of debt stocks they may be tempted to either increase the money supply or they repay their debt with more debt. Both solutions may be be unsustainbale and may have adverse impact on the economy on the long run. It is thus important to control the debt level by building primary budget surpluses.

The data were extracted from the IMF's Regional Economic Outlook 2015, the direction of trade statistics and the World Bank Data base.

XVI) The results

a. Hierarchical clustering

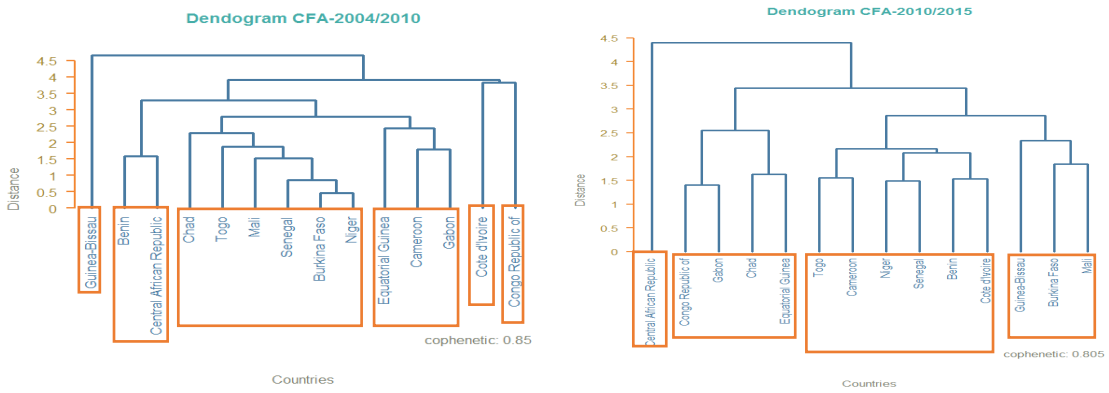
The linkage algorithm that exhibits the highest cophonetic coefficient is the average linkage, with a cophenetic value of 0.73. The plot of the Calinsky and Harabasz's value does not indicate a unique solution for the number of clusters that should be used. At first, the line decreases before it increases at a decreasing marginal rate. We set the number of cluster to five[9] because the marginal increase is significantly reduced for any numbers of cluster greater than five. The partition shows that WAEMU countries are more homogenous than CEMAC. WAEMU countries are grouped together by two clusters, only Guinea-Bissau is not part of any of the two clusters since it forms a singleton. However, Central African Republic is group with WAEMU countries. Regarding WAEMU countries, two groups of countries are linked at a relatively small distance (Mali, Senegal and Togo, Benin and Niger). Cote d'Ivoire joins the group at a higher distance. CEMAC countries show less homogeneity than WAEMU countries do. Cameroon and Gabon, Chad and Equatorial Guinea form two clusters while Congo Republic forms a cluster alone. The distance (vertical axis), at which CEMAC countries forms a single cluster, is relatively higher than the distance at which WAEMU countries group together.



When analysing the clustering for the two different sub-periods, we observe an evolution of the partition before and after the financial crisis. For the 2004/2010 period, we set the number of clusters to six[10]. The marginal increase of the C-H's index value is the highest from five to

[1] See annexe IX "Hierarchical clustering" for further details about the optimal number of clusters.

six clusters. After that point, the plot only increases smoothly. Three clusters are singleton, Guinea-Bissau, Côte d'Ivoire and Congo Republic. WAEMU countries belong to the same cluster except for Benin that forms a cluster with the Central African Republic. The last cluster is composed of three CEMAC countries, Equatorial Guinea, Cameroon and Gabon. Altough some WAEMU contries are linked at a short distance, the result of this clustering is not in line with the actual CEMAC-WAEMU partition. Côte d'Ivoire and Benin are far from the main WAEMU cluster while Chad is close to that cluster. The period 2010/2015 exhibits less discrepency with the actual CEMAC-WAEMU partition. The optimal number of clusters is set to four. The plot of the C-H's index value is cubersome. Although the highest index is reached for a value of eight, this number of clusters is too high when taking into account the number of countries in our sample. Thus we choose the number that exhibits the second highest value i.e.four clusters. WAEMU and CEMAC countries respectly are split into two clusters. Only the Central african Republic forms a singleton and it joins the other clusters at high distance. The clustering is more in line with the actual CEMAC-WAEMU partition. WAEMU countries are split into two clusters but they eventually form a unique cluster. Cameroon is the only CEMAC country that belongs to a cluster mainly composed of WEAMU country. Apart from Cameroon and the Central African Republic, all CEMAC countries group together at a distance (vertical axis) that is relatively the same as WAEMU countries do.

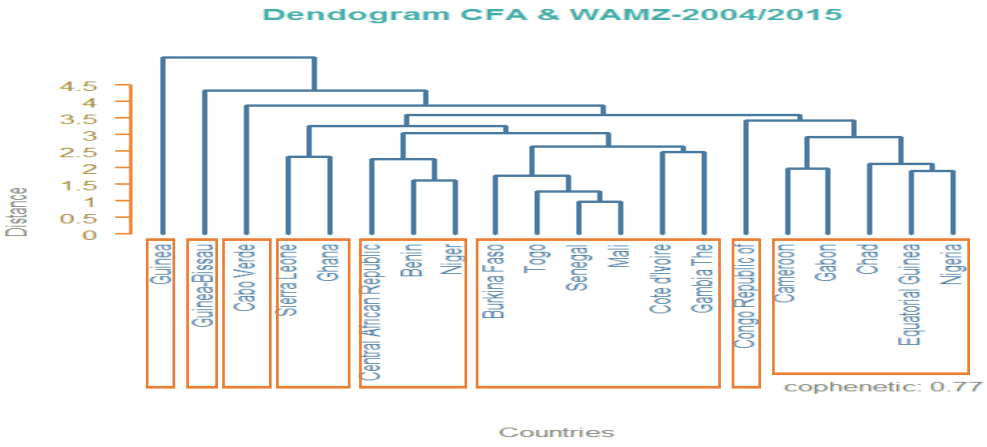


Source: Author's production

The second set of analysis consists in adding the WAMZ counties in our group of observation. This action is motivated by the willing of promoting futher economic intergration in the the ECOWAS (Economic Community of West African State) by expanding the CFA franc in West Africa to the other WAMZ countries. The ECOWAS is composed of WAEMU

countries and WAMZ countries and it has been created in 1975 with the goal of promoting economic cooperation and regional integration.

The linkage algoritm that exhibits the highest CHI is the average method , and the optimal number of clusters is set to eight. Four counties form singleton, Guinea ,Guinea-Bissau, Cabo Verde and Congo Republic. They join other clusters at a high distance, that shows the dissimilarity between these countries and the reamining countries in the analysis. Most of WAEMU countries belongs to the same clusters with two CEMAC countries, Central African Republic and the Gambia.WAEMU countries cluster with each other at a short distance with the exception of Cote d'Ivoire that joins the group at a higher distance. Sierra Leone and Ghana join group the WEAMU group a higher distance. Moreover, Five CEMAC countries form a group with Nigeria, Congo Republic completes the group at a higher distance, all of them are oil-producers.

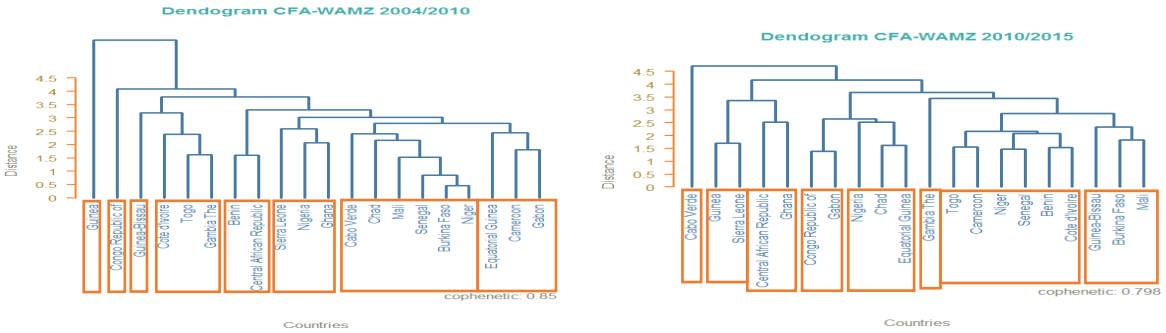


Source: Author's production

The 2004/2010 sub-period shows eight clusters from which three are singletons (Guinea, Guinea Bissau, Congo Republic). With regard to WAEMU countries, Niger, Burkina Faso , Senegal and Mali are linked together at small distance and they are part of a cluster that includes Cabo Verde and Chad. Three WAMZ countries (Nigeria, Ghana and Sierra Leone) show similarity and cluster with WAEMU countries at a higher distance. The third main cluster is composed of three CEMAC countries (Equatorial Guinea, Gabon and Cameroon) and they join a bigger cluster composed of WAEMU countries at a higher distance. The remaining countries shows big disimilarity with countries in the three main clusters since they merge at a relatively high distance.

For the 2010/2015-period, the number of cluster is set to eight. Two clusters are singletons (Cabo Verde and Gambia). The first cluster is composed of all WAEMU countries with

Cameroon and Gambia that join the goup at a higher distance. This shows the homogeneity of the WAEMU countries during this period. The second cluster is composed of CEMAC countries and Nigeria. In this cluster CEMAC countries cluster at a smaller distance with each other and Nigeria joins the cluster at a higher distance; all countries in this cluster are oil-producers. The last cluster is composed of three WAMZ coutries and Central African Republic. Clusters for this period is more in line with the actual CEMAC-WAMZ-WAEMU partition. Moreover, we observe that WAEMU countries are more similar to CEMAC countries and Nigeria than it is to the WAMZ countries.



Source: Author's production

In conclusion, among the three community, the WAEMU is the community that exhibits the greatest homogeneity since they link at much lower distance than the two other communities. The partition CEMAC-WAMZ-WAEMU is better observeved when clustering during the 2010/2015 period, even if the observed partition could be deemed as oil-exporters, WEAMU and WAMZ excluded Nigeria. Finally, Central African Reuplic, Guinea Bissau and Guinea exhibit the greatest dissimilarity among all the countries in the sample. Central African Republic has gone through many civil wars during the analysed period and Guinea was striked by the ebola virus in the last period 2010/2015.

b. Fuzzy clustering

The validity tests for the optimal number of clusters for the period 2004/2015 are diverging. The statistic indeces (Dunn's partition coefficient, silouhette index and Xie and Beni' s index) give different values for the optimal number of clusters. Therefore, the number of clusters is fixed at three, which is the optimal number of clusters for the Silhouette's index[11]. Those countries that have a membership coefficient lower than 60 percent will be considered as lying on the bonder between two clusters which highlights a lack of homogeneity with the other countries in the group.

The results show a good clustering because the average membership coefficient for each cluster is greater than 60 percent, only cluster one has 3 unclear assigments (countries with a membership coefficient lower than 0.5). Cluster one and cluster two are composed of WAEMU countries. Two contries are associated to WAEMU countries while they are actually CEMAC countries (Central African Repubic and Cameroon). In cluster one, two countries (Cote d'Ivoire and Guinea Bissau) lie on the border between cluster one and cluster two. Mali, Togo and Senegal are the three WAEMU countries that show the greatest homogeneity in the group, they all exhibit low business cycle correlation and low term of trade correlation. Central African Republic and Cameroon are the only CEMAC countries that are clustered with WAEMU country. Central African Republis has a high membership coefficient in cluster two and Cameroon lies on the border between a WEAMU cluster and a CEMAC cluster. The last cluster, cluster three, is composed of CEMAC countries. It has two countries that lie on the border of the cluster but their membership coefficients for the other clusters are relatively low.

The WAMZ countries are now included in the analysis. Here again, the number of cluster is set to three . The results show fuziness in the partition. Six countries have a membership coefficient lower than 0.5. Cluster one has six countries with a membership coefficient greater 0.5, and all of them are WAEMU countries. Apart from Benin, all countries in the cluster have relatively low membership coefficient in other clusters. Benin has low membership coefficient in cluster one and it lies on the border between cluster one and cluster three (WAMZ countries). Gambia is the only WAMZ country that has its highest membership coefficient with WEAMU contries, it also lies on the border between a cluster composed of WAMZ contries and a cluster composed of WEAMU countries.In cluster two, five countries have a membership coefficent greater than 0.5 and most of them are CEMAC

[11] See Annexes V "Fuzzy clustering"

countries. Equatorial Guinea has the highest membership coefficient in the cluster at 0.70. Nigeria, a WAMZ country, has its highest membership coefficient with cluster two. Cameroon lies on the border between cluster one (WEAMU cluster) and cluster two (WEAMU cluster). Cluster three has all its members with a membership coefficient greater than 0.5, three out of four countries are WAMZ countries with Central african Republic ,the only CEMAC country, that has a membership coefficient of 0.63. Cabo Verde has a low membrship coefficent will all the three clusters.

In conclusion for the period 2004/2015, the result of the fuzzy clustering show convergence among WAEMU countries even if some members such as Benin, Guine-Bissau and Cote d'Ivoire still lie on the bonder of the cluster. Additionally, we observe very little convergence among the WAMZ countries. Cabo Verde has membership coefficients that are almost evenly distributed between the three clusters. Nigeria is an outlier in the group, it is closer to the CEMAC cluster than it is to the WAMZ cluster. That is in line with the study of Masson and Patillo (2004) that consider Nigeria as a difficult member for the ECOWAS.

For the period 2004/2010, the Dunn's partition (PC) and the Xie and Beni's index (BX) indicate that five is the optimal number of clusters. The Dunn'partition coefficient (PC) is equal to 0.6. As in the hierarchical clustering, with a membership coefficeint of 1 and 0.97 respectively, Guinea Bissau and Cote d'Ivoire form a singleton (cluster two and cluster three). Cluster one is composed of seven countries, most of them are WAEMU countries. Niger, Senegal, Burkina Faso are the countries that have the highest membership coefficient. They have similar business cycle and terms of trade correlation, low inflation and low debt level. Mali belongs to cluster one, but it is distant from the other members in the cluster. It had business cycle and terms of trade correlation lower than other members in cluster one, but it has similar low inflation, low level of debt. Altough Togo has it highest membership coefficient with cluster one, it lies on the bonder between cluster one and cluster three (Côte d'Ivoire). Cameroon and Chad also have their highest membership coefficient with cluster one, they are the only CEMAC countries in cluster one, but their ceofficient are low (0,46 and 0,36 respectively). Cluster four is composed of Benin and Central African Republic, their membership coefficient is high for this cluster. They exhibit similar business cycle and term of trade correlation, low inflation and low real effective exchange rate. The last cluster is composed of Equatorial Guinea and Gabon, they have high membership coefficient for this cluster.

The inclusion of the WAMZ countries in the analysis also results in a number of optimal cluster equal to five according to the Xie and Beni‘s index. Three clusters do not change their composition, cluster one, cluster three and cluster four. Ghana and Gambia now have the highest membership coefficient for cluster two and cluster five. Cote d’Ivoire and Guinea Bissau have experienced a substantial decrease in their membership coefficient. Their highest membership coefficient is associated with cluster two. Nigeria, Cabo Verde and Sierra Leon has low membership coefficient for each cluster.

The conclusion for this period is in line with the result obtained from the hierachical clustering,WAEMU countries are split into three sub-groups. Niger, Mali Senegal and Burkina Faso cluster well with each other, and other WAEMU country are distant from each other. WAMZ countries do not show similarity with the WAEMU countries. Apart from Equatorial Guinea and Gabon, CEMAC do not really cluster with each other.

The analysis of the last period, 2010/2015, for the CFA franc countries poses one more time the problem of determining the optimal number of clusters. The indices diverge in their optimal number of clusters, therefore we set the number of clusters to five which is the optimal number based on the Silhouette’s index. WAEMU countries have been split into two clusters.Three contries lie on the border of their cluster (Senegal, Mali and Niger). However Niger and Mali have a low membership coefficient in the other clusters. Senegal has its highest membership coefficients in two clusters (cluster one and cluster two). Burkina Faso is the only WAEMU country that has low membership coefficient in the two WEAMU clusters.CEMAC countries are split into three clusters, one cluster is a singleton (Central African Republic). Cameroon lies on the border of cluster three but it has a significant value in cluster one, a WAEMU cluster. Apart from Cameroon in cluster three, no countrie in these three clusters has a membership coefficient below sixty percent. For this period, the clustering is in line with the actual partition, apart from Cameroon no country lies on the border between the two regions.

The WAMZ countries are now included in the sample for the sub-period 2010/2014, we also set the number of cluster to three based on the Silhouette’s index. Cluster one is composed of WAEMU countries, Niger has the highest membership coefficient in the group. WAEMU countries have relatively high membership coefficient in the group and they do not lie at the border between any of the two remaining clusters. Cameroon and Gambia have also their highest membership coefficient in this group. Both of them lie on the bondary between the

WAEMU cluster and the two remaining clusters (WAMZ cluster for Gambia and CEMAC cluster for Cameroon). Cluster two has its highest membership coefficient with CEMAC countries. Although they are not CEMAC countries, Nigeria, Mali and Burkina Faso has their highest membership coefficient in this cluster.Nevertheless Mali and Burkina Faso lie on the bonder between the WAEMU cluster and the CEMAC cluster. The last cluster is composed of WAMZ countries, with Guinea, Sierra Leone and Ghana. Central African Republic has its highest membership coefficient in the WAMZ cluster but its membership coefficient in the other two clusters is quite small and equivalent. Finally, although Cabo Verde has its highest membership coefficient with the WAMZ cluster, its membership coefficients with all three clusters are almost equivalent.

To summurise the results of our fuzzy clustering, WAEMU countries exhibit the biggest homogeneity than the three communities espeacially during the period 2010/2014, this may highlight the effectiveness of the pact of convergence set by the BCEAO. Cameroon, and Central African Republic show heterogeneity with other CEMAC countries. Cameroon lies on the bonder between CEMAC and WEAMU. Central African Republic is an outlier in the CEMAC group, it either forms a singleton or it is cluster with WAMZ countries. Its terms of trade and business circle correlation is very different for the other CEMAC countries. This may be explained by the fact that it is the only CEMAC country which economy is not mainly based on oil production. WAMZ countries show little homogeneity between each other. Nigeria, the biggest oil producer in Africa, shows more homogeneity with CEMAC countries than it does with WAMZ countries.

CFA COUNTRIES FUZZY CLUSTERING

2004/2010

Countries	Clust 1	Clust 2	Clust 3
Benin	0.19	0.68	0.12
Burkina Faso	0.6	0.21	0.2
Cote d'Ivoire	0.45	0.37	0.17
Guinea-Bissau	0.43	0.4	0.17
Niger	0.15	0.8	0.05
Togo	0.82	0.12	0.06
Senegal	0.82	0.15	0.04
Mali	0.73	0.13	0.14
Cameroon	0.41	0.22	0.38
Central African Republic	0.23	0.61	0.15
Chad	0.28	0.2	0.52
Congo Republic of	0.25	0.22	0.53
Equatorial Guinea	0.1	0.08	0.82
Gabon	0.19	0.15	0.66

2004/2015

Countries	Clust 1	Clust 2	Clust 3	Clust 4	Clust 5
Benin	0.06	0.02	0.03	0.86	0.04
Burkina Faso	0.86	0.02	0.03	0.05	0.04
Cote d'Ivoire	0.01	0.01	0.97	0.01	0.01
Guinea-Bissau	0.00	1.00	0.00	0.00	0.00
Niger	0.92	0.01	0.02	0.03	0.03
Togo	0.39	0.14	0.21	0.15	0.11
Senegal	0.94	0.01	0.02	0.02	0.02
Mali	0.58	0.05	0.15	0.09	0.13
Cameroon	0.46	0.05	0.07	0.18	0.24
Central African Republic	0.07	0.05	0.04	0.80	0.05
Chad	0.36	0.06	0.13	0.16	0.29
Congo Republic of	0.14	0.10	0.21	0.21	0.34
Equatorial Guinea	0.06	0.02	0.04	0.04	0.85
Gabon	0.17	0.04	0.05	0.10	0.63

2010/2015

Countries	Clust 1	Clust 2	Clust 3	Clust 4	Clust 5
Benin	0.64	0.1	0.15	0.06	0.06
Burkina Faso	0.21	0.31	0.27	0.07	0.14
Cote d'Ivoire	0.65	0.14	0.1	0.05	0.06
Guinea-Bissau	0.09	0.78	0.05	0.04	0.04
Niger	0.58	0.17	0.15	0.05	0.05
Togo	0.68	0.11	0.13	0.04	0.04
Senegal	0.31	0.49	0.09	0.06	0.05
Mali	0.12	0.58	0.12	0.05	0.13
Cameroon	0.33	0.11	0.41	0.04	0.11
Central African Republic	0	0	0	1	0
Chad	0.09	0.07	0.59	0.05	0.21
Congo Republic of	0.03	0.04	0.07	0.02	0.84
Equatorial Guinea	0.07	0.04	0.79	0.03	0.07
Gabon	0.03	0.03	0.07	0.02	0.86

CFA & WAMZ FUZZY CLUSTERING

2004/2015

Countries	Clust 1	Clust 2	Clust 3
Benin	0.39	0.27	0.34
Burkina Faso	0.5	0.29	0.21
Cote d'Ivoire	0.53	0.23	0.24
Guinea-Bissau	0.47	0.21	0.32
Niger	0.50	0.19	0.31
Togo	0.80	0.11	0.10
Senegal	0.87	0.07	0.06
Mali	0.60	0.29	0.11
Cameroon	0.36	0.47	0.17
Central African Republic	0.21	0.16	0.63
Chad	0.21	0.6	0.19
Congo Republic of	0.28	0.48	0.24
Equatorial Guinea	0.16	0.7	0.13
Gabon	0.23	0.58	0.18
Nigeria	0.20	0.54	0.26
Gambia The	0.47	0.23	0.3
Guinea	0.24	0.24	0.53
Sierra Leone	0.23	0.21	0.56
Ghana	0.18	0.15	0.67
Cabo Verde	0.35	0.34	0.31

2004/2010

Countries	Clust 1	Clust 2	Clust 3	Clust 4	Clust 5
Benin	0.09	0.07	0.70	0.07	0.08
Burkina Faso	0.81	0.05	0.04	0.03	0.07
Cote d'Ivoire	0.16	0.47	0.12	0.13	0.12
Guinea-Bissau	0.17	0.42	0.17	0.09	0.14
Niger	0.90	0.02	0.02	0.02	0.04
Togo	0.24	0.47	0.11	0.08	0.10
Senegal	0.85	0.04	0.03	0.04	0.04
Mali	0.49	0.14	0.09	0.14	0.14
Cameroon	0.39	0.09	0.16	0.22	0.14
Central African Republic	0.07	0.07	0.73	0.05	0.08
Chad	0.27	0.12	0.13	0.26	0.21
Congo Republic of	0.13	0.18	0.20	0.34	0.15
Equatorial Guinea	0.07	0.04	0.05	0.77	0.06
Gabon	0.18	0.07	0.11	0.53	0.11
Nigeria	0.16	0.09	0.10	0.28	0.36
Gambia The	0.03	0.88	0.03	0.02	0.04
Guinea	0.16	0.19	0.20	0.15	0.30
Sierra Leone	0.14	0.11	0.25	0.10	0.39
Ghana	0.09	0.05	0.05	0.04	0.77
Cabo Verde	0.34	0.10	0.20	0.16	0.21

2010/2015

Countries	Clust 1	Clust 2	Clust 3
Benin	0.59	0.22	0.19
Burkina Faso	0.42	0.42	0.17
Cote d'Ivoire	0.67	0.16	0.17
Guinea-Bissau	0.55	0.25	0.21
Niger	0.78	0.11	0.11
Togo	0.74	0.13	0.12
Senegal	0.76	0.12	0.12
Mali	0.42	0.43	0.15
Cameroon	0.46	0.38	0.16
Central African Republic	0.28	0.27	0.45
Chad	0.1	0.81	0.09
Congo Republic of	0.18	0.67	0.15
Equatorial Guinea	0.23	0.54	0.23
Gabon	0.15	0.73	0.12
Nigeria	0.19	0.54	0.27
Gambia The	0.4	0.24	0.35
Guinea	0.14	0.12	0.74
Sierra Leone	0.15	0.16	0.69
Ghana	0.16	0.16	0.68
Cabo Verde	0.32	0.32	0.36

Source: Author's production

Conclusion

The exchange rate can have important consequences on the growth of an economy. The link between the different exchange rate regime is not straightfoward and there is not a perfect exchange rate regim as such. A flexible regime provides a powerful tool to deal with external shocks but it poses the thread of excessive volatility in investments and production outputs. On the other hand, a fixed exchange rate promotes stability and credibility but it results in the loss of monetary sovereignty and more exposure to external shocks. The exchange rate regim has also distributional consequences. A weak currency improves the competitivity of the local producers but it reduces the purchasing power of the consumers in the econmy; a strong currency strenghten the purchasing power of the consumers and reduced the competitivity of the producers in the economy. Additionaly, producers that operate at the national level should favor a flexible exchange rate because the government has the possibility to stabilise the economy through monetary policy while those producers that operate at the international level will favor a fixed regim because stability promotes trade and investments. Because the exchange rate regim has consequences on many stackeholder in the economy, the choice of the regim is not only driven by economic factors but by political factors as well.

The CFA Franc zone is credited for its stability in term of inflation and macroeconomic performance, however there are costs embeded with the maintenance of the currecy union and these costs have significant consequences on the growth of the region. In order to reduce these costs, regional integration has been promoted in the zone. WAEMU has set different convergence criteria in order to strenghten their monetary union and economic unions has been developed in West and Central Africa to futher develop regional trade and to improve the financial integration in the region.

Results of our cluster analysis show that WAEMU countries show the highest convergence among the three regions. The convergence criteria are reflected in our results. Senegal, Mali, Togo and Burkina Faso show particuliar homogeneity in the WEAMU group. CEMAC countries do not group well together, some CEMAC countries were located in the WAEMU cluster meaning that they show a greater similarity with WEAMU countries than they do with CEMAC countries. Ghana, Sierra Leone and Guinea group well together and show little similarity with WAEMU countries. Gambia shares similarity with WEAMU contries while Nigeria shows similarity with CEMAC countries.

The convergence among WAEMU countries are promosing for the future and the different economic agreements show a will to converge toward an optimal currency union. Enlargement of actual monetary union may result in greater benefit and further regional integration through the positive effect that currency union has on trade and investment. However, the current situation is such that cost for the economic agents in the CFA zone is currently high and difficult to bear. Even if they are increasing over years, the loans to the private sector are very low and have negative consequences on growth. Provided enlargment of the actual monetary zone results in further restriction on the flow of money in the economy, the situation may become unbearable for the economic agents in the zone. This situation would pose the risk of social protests that may ultimately threat the fondation of the CFA franc zone.

References

Alter, A., & Yontcheva, B. (2015). Financial Inclusion and Development in the CEMAC. *IMF Working Papers,* 15(235), 1. doi:10.5089/9781484317556.001

Amin,M., & Hopp,M. (2013). Where Informal Procedures are Quasi-Formal: CrossBorder Trade between West and Central Africa. *World Bank Africa Trade Policy Notes*, No. 37

Anne, G., & Charalambos, T. (2008). The CFA Franc Zone : Common Currency, Uncommon Challenges. USA: 'IMF eLibrary '.

Banque de France.(2002). *The franc zone*. Retrieved from https://www.banque-france.fr/fileadmin/user_upload/banque_de_france/Eurosysteme_et_international/zonefr/i127gb.pdf

Baldwin, R., & Taglioni,D. (2007). "Trade effects of the euro: a comparison of estimators.", *Journal of Economic Integration*, Vol. 22, No. 4, 2007.

Bernhard, W., & Leblang, D. (2003). Democratic Institutions and Exchange-rate Commitments. *International Organization, 53*(1), 71-97. doi:10.1162/002081899550814

Broz, J. L., & Frieden, J. A. (2001). THE POLITICAL ECONOMY OF INTERNATIONAL MONETARY RELATIONS. *Annual Review of Political Science, 4*(1), 317-343. doi:10.1146/annurev.polisci.4.1.317

Carr, D. L., Markusen, J. R., & Maskus, K. E. (2001). Estimating the Knowledge-Capital Model of the Multinational Enterprise. *American Economic Review, 91*(3), 693-708.

Coeurdacier, N., De Santis, R. A., & Aviat, A. (2009). Cross-border mergers and acquisitions and European integration. *Economic Policy, 24*(57), 56-106. doi:10.1111/j.1468-0327.2009.00218.x

Eaton, J., & Tamura, A. (1994). Bilateralism and Regionalism in Japanese and U.S. Trade and Direct Foreign Investment Patterns. *Journal of the Japanese and International Economies, 8*(4), 478-510. doi:http://dx.doi.org/10.1006/jjie.1994.1025

Eaton, J., Kortum, S., & Sotelo, S. (2012). International Trade: Linking Micro and Macro. doi:10.3386/w17864

Frankel, J. (2008). The Estimated Effects of the Euro on Trade: Why Are They Below Historical Effects of Monetary Unions Among Smaller Countries? doi:10.3386/w14542

Frankel, J., & Rose, A. (2000). Estimating the Effect of Currency Unions on Trade and Output. doi:10.3386/w7857

Frankel, J., The Estimated Effects of the Euro on Trade: Why are They Below Historical Effects of Monetary Unions Among Smaller Countries? (December 2, 2008). *HKS Working Paper* No. RWP08-076. Available at SSRN: https://ssrn.com/abstract=1314434 or http://dx.doi.org/10.2139/ssrn.1314434

Frieden, J. (2007). Globalization and exchange rate policy *The Future of Globalization* (pp. 344-357): Routledge.

Ghosh, A., Gulde, A.-M., Ostry, J., & Wolf, H. (1995). Does the Nominal Exchange Rate Regime Matter? *IMF Working Papers*, 95(121), 1. doi:10.5089/9781451854329.001.

Giavazzi, F., & Pagano, M. (1988). The advantage of tying one's hands. *European Economic Review, 32*(5), 1055-1075. doi:http://dx.doi.org/10.1016/0014-2921(88)90065-7

Glick, R., & Rose, A. K. (2002). Does a currency union affect trade? The time-series evidence. *European Economic Review, 46*(6), 1125-1151. doi:http://doi.org/10.1016/S0014-2921(01)00202-1

Head, K., & Mayer, T. (2014). Chapter 3 - Gravity Equations: Workhorse,Toolkit, and Cookbook. In E. H. Gita Gopinath & R. Kenneth (Eds.), *Handbook of International Economics* (Vol. Volume 4, pp. 131-195): Elsevier.

Helpman, E., Melitz, M. J., & Yeaple, S. R. (n.d.). Export versus FDI. doi:10.2139/ssrn.386924

Husain, A. M., Mody, A., & Rogoff, K. S. (2005). Exchange rate regime durability and performance in developing versus advanced economies. *Journal of Monetary Economics, 52*(1), 35-64. doi:http://doi.org/10.1016/j.jmoneco.2004.07.001

Kenen, P (1969), "The Theory of Optimum Currency Areas: An Eclectic View," in Robert Mundell and Alexander Swoboda (eds), *Monetary Problems of the International Economy*, Chicago: University of Chicago Press (1969), pp.41-60.

Klein, M., & Shambaugh, J. (2006). The Nature of Exchange Rate Regimes. doi:10.3386/w12729.

Lee, J.-W., & Shin, K. (2010). Exchange Rate Regimes and Economic Linkages. *International Economic Journal, 24*(1), 1-23. doi:10.1080/10168731003589741

Levy-Yeyati, E., & Sturzenegger, F. (2003). To Float or to Fix: Evidence on the Impact of Exchange Rate Regimes on Growth. *American Economic Review, 93*(4), 1173-1193.

Markusen, J. R., & Venables, A. J. (1998). Multinational firms and the new trade theory. *Journal of International Economics, 46*(2), 183-203. doi:http://doi.org/10.1016/S0022-1996(97)00052-4

McKinnon, R. I. (1988). Monetary and Exchange Rate Policies for International Financial Stability: A Proposal. *Journal of Economic Perspectives, 2*(1), 83-103.

Micco, A., Stein, E., & Ordoñez, G. (2003). The currency union effect on trade: early evidence from EMU. *Economic Policy, 18*(37), 315-356. doi:10.1111/1468-0327.00109_1

Mundell, R. A. (1961). A Theory of Optimum Currency Areas. *The American Economic Review, 51*(4), 657-665.

Reinhart, C. M., & Rogoff, K. S. (2004). The Modern History of Exchange Rate Arrangements: A Reinterpretation*. *The Quarterly Journal of Economics*, *119*(1), 1-48. doi:10.1162/003355304772839515

Rose, A. K. (2000). One money, one market: the effect of common currencies on trade. *Economic Policy, 15*(30), 08-45. doi:10.1111/1468-0327.00056

Rose, A. K., & van Wincoop, E. (2001). National Money as a Barrier to International Trade: The Real Case for Currency Union. *American Economic Review, 91*(2), 386-390.

Russ, K. N. (2007). The endogeneity of the exchange rate as a determinant of FDI: A model of entry and multinational firms. *Journal of International Economics*, *71*(2), 344-372. doi:http://doi.org/10.1016/j.jinteco.2006.04.004

Santos Silva, J. M. C., & Tenreyro, S. (2011). Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Economics Letters*, *112*(2), 220-222. doi:http://doi.org/10.1016/j.econlet.2011.05.008

Tan, P.-N., Steinbach, M., & Kumar, V. (2014). *Introduction to data mining*.(1st Ed.) Noida, India: Pearson.

Taylor, C. (2008). Foreign direct investment and the euro: the first five years. *Cambridge Journal of Economics, 32*(1), 1-28. doi:10.1093/cje/bel044

Thom, R., & Walsh, B. (2002). The effect of a currency union on trade: Lessons from the Irish experience. *European Economic Review, 46*(6), 1111-1123. doi:http://doi.org/10.1016/S0014-2921(01)00203-3

Tsangarides, C. G. & Qureshi, M.S., What is Fuzzy About Clustering in West Africa? . *IMF Working Paper*, Vol. , pp. 1-45, 2006.

Tsangarides, C.G., Ewenczyk, P. & Hulej, M., 2006. Stylized Facts on Bilateral Trade and Currency Unions : Implications for Africa. *IMF Working Paper*, (WP/06/31). doi:10.5089/9781451862911.001

Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve, Belgique **www.uclouvain.be/lsm**