

On the Adequacy of Monetary Arrangements in Sub-Saharan Africa

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Preliminary, comments welcome

Abstract:

We examine the economic rationale for monetary union(s) in Sub-Saharan Africa through the use of cluster analysis on a sample of 17 countries. The variables used stem from the theory of optimum currency areas and from the fear-of-floating literature. It is found that the existing CFA franc zone cannot be viewed as an optimum currency area: CEMAC and UEMOA countries do not belong to the same clusters, and a “core” of the UEMOA can be defined on economic grounds. The results support the inclusion of the Gambia, Ghana and Sierra Leone in an extended UEMOA arrangement, or the creation of a separate monetary union with the “core” of the UEMOA and the Gambia, rather than the creation of a monetary union around Nigeria. Finally, the creation of the West African Monetary Zone (WAMZ) around Nigeria is not supported by the data.

Keywords: monetary unions, CFA franc zone, West African Monetary Union, ECOWAS, optimum currency areas, cluster analysis.

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1. Introduction

Existing monetary arrangements in Sub-Saharan Africa are the result of different choices made after the colonial era. As a general rule, former British colonies moved from their currency boards to flexible exchange rates after their independence¹, whereas a monetary agreement was reached between francophone former colonies and France, in the form of the CFA franc zone.² The latter comprises two monetary unions: UEMOA (*Union Économique et Monétaire Ouest Africaine*) comprising Benin, Burkina Faso, Côte d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo; and CEMAC (*Communauté Économique et Monétaire d'Afrique Centrale*) comprising Cameroon, Chad, Republic of Congo, Central African Republic, Equatorial Guinea and Gabon.³ Each union has a single central bank which creates money along to some constraints in terms of official reserves and monetisation of public deficit (see, for instance, Hadjimichael and Galy, 1997). The French Treasury is committed to providing the required amount of foreign devices in order to fill any balance of payment deficit provided the rules are followed.⁴ Since the rules are similar across the two central banks, and because the CFA franc is pegged to the euro with institutional guarantee by the French Treasury, the CFA franc zone can be viewed today as an area with a hard peg against the euro.

Whether the CFA arrangement has been beneficial or detrimental over the past is debated (see Devarajan and Rodrik, 1991; Guillaumont and Guillaumont-Jeanneney, 1995; Elbadawi and Madj, 1996; Honohan and O'Connell, 1997; Dordundo, 2000; Fouda and Stasavage, 2000; Masson and Pattillo, 2001a). It is generally concluded that the arrangement was successful from the early 1950s to the mid-1980s, in terms of lower inflation and higher GDP growth (compared with other sub-Saharan countries). Conversely, during the 1986-1993 period, the zone suffered from a cumulative deterioration of the terms of trade combined with growing external debt in line with fiscal indiscipline, and a bank crisis stemming from generous lending to public enterprises, although the zone still displayed lower inflation than non-CFA countries. The devaluation of the CFA franc by 50% in January 1994 seems to have been relatively successful. It has been supported by bank restructuring and debt relief. On the whole, it is often pointed out that UEMOA has been more successful than CEMAC; but that, if any, the success of the CFA essentially comes from higher credibility related to

¹ A monetary arrangement was maintained between Kenya, Uganda and Tanzania (the East African Community) until 1977. This regional arrangement was revived in January 2001, with a long-run objective of monetary unification. In South Africa, the Rand monetary area was formally established in 1974 and accommodated in 1986 and 1992. In practice, Lesotho, Namibia and Swaziland function as currency boards, the circulation of the rand is free, and it is legal tender in Lesotho and Namibia (Ogunkola, 2002).

² CFA stands for *Colonies Françaises d'Afrique*. The CFA franc was introduced by France after World War II, hence before political independence. Equatorial Guinea and Guinea Bissau, which are not former French colonies, joined the CFA zone in 1985 and 1997 respectively.

³ The Comoros is also a member of the CFA franc zone, but with its own central bank. The Comorian franc, introduced in 1981, was devalued against the French franc in January 1994, but only by 33% compared to 50% for the CFA franc.

⁴ Cape Verde has a similar arrangement with the support of Portugal. The rules for convertibility have been strengthened over time in order to cope with the failure of the system to ensure fiscal discipline. See Hadjimichael and Galy, 1997.

the specific arrangement with the French Treasury (Guillaumont and Guillaumont-Jeanneney, 1989; Collier, 1991).

In 2000, six non-CFA countries of West-Africa⁵ declared their intention to proceed to monetary union by 2003 and to extend this so-called “second monetary union” to UEMOA countries by 2004 in order to match the frontiers of the regional economic grouping ECOWAS (Economic Community of West African States), as illustrated in Figure 1.⁶ Convergence criteria were defined, covering inflation (single digit by 2000 and no more than 5% by 2003), official reserves (gross reserves covering at least six months of imports by 2002), monetisation of public deficit (less than 10% of tax revenues of the preceding year), and public deficit (no more than 5% of GDP in 2001 and no more than 4% in 2002). Additional criteria include tax revenues of at least 20% of GDP, public employment expenses not exceeding 35% of public receipts, public investment of at least 20% of public receipts, real exchange rate stability and a positive real interest rate. A West African Monetary Institute was created in Accra (Ghana) in December 2000, in the spirit of the former European Monetary Institute, in order to supervise compliance with the convergence criteria (in particular through the building of harmonized statistics), organize macroeconomic surveillance within the group and prepare monetary unification. In April 2002, the West African Monetary Zone (WAMZ) was created comprising five countries (the Gambia, Ghana, Guinea, Nigeria and Sierra Leone) with an exchange-rate mechanism allowing each member’s currency to fluctuate within a +/- 15% band against the US dollar. The name *Eco* was suggested for the future WAMZ single currency.⁷ In late 2002, the relatively poor achievements of the convergence process lead the members of the monetary zone to postpone monetary union to 2005.⁸

⁵ Ghana, Guinea, Liberia, Nigeria, Sierra Leone, The Gambia.

⁶ CEDEAO (*Communauté Économique Des États d’Afrique de l’Ouest*) in French. ECOWAS was settled in 1975 amongst 15 West African countries; Cape Verde joined soon after. Hence, ECOWAS comprises 16 states: the eight UEMOA members plus Cape Verde, Gambia, Ghana, Guinea, Liberia, Mauritania, Nigeria and Sierra Leone. The initial objective of ECOWAS was to remove barriers to trade and factor mobility and promote economic, social and cultural cooperation. The success of ECOWAS to promote intra-regional trade is a matter of discussion (see, for instance, Hanink and Owusu, 1998). The west-African monetary union is sometimes viewed as one step towards some single Panafrikan currency.

⁷ See, *WAMI News*, April 2002, www.ecowas.int/wami-ima/.

⁸ *WAMI News*, December 2002.

Figure 1. Existing groupings in Sub-Saharan Africa

CEDEAO (ECOWAS)			
CEMAC	UEMOA	WAMZ	OTHER
Cameroon Chad Congo (Rep. Of) Central Afr. Rep. Equatorial Guinea Gabon	Benin Burkina Faso Côte d'Ivoire Guinea Bissau Mali Niger Senegal Togo	Gambia Ghana Guinea Nigeria Sierra Leone	Cape Verde Liberia

Notes: CEMAC = Communauté Économique des États d'Afrique Centrale
 UEMOA = Union Économique et Monétaire Ouest Africaine
 WAMZ = West-African Monetary Zone
 CEDEAO = Communauté Économique Des États d'Afrique de l'Ouest
 ECOWAS = Economic Community Of West-African States.

From the beginning, the timing of this project has been viewed as somewhat unrealistic, both by international experts and by economists from the sub-region.⁹ Indeed, only the Gambia and Nigeria were close to meeting the official reserve criterion in 2002, only Nigeria met the fiscal deficit criterion in 2001 (although Guinea and Ghana would also have met it on the basis of the UEMOA methodology which excludes foreign financed investment expenditure).¹⁰ Finally, inflation peaked 40% in 2000 for Ghana, and the so-called “secondary” criteria were not well disposed in a number of countries either (Ogunkola, 2002). However the convergence and surveillance process has been launched for WAMZ countries, and there seems to be some political will to go ahead, at least for WAMZ countries. UEMOA countries already have some experience of multilateral surveillance which was put in place by the UEMOA Treaty in 1994 (changing the UMOA into the UEMOA). In 1999, fiscal surveillance was enhanced by the Convergence, Stability, Growth and Solidarity Pact.¹¹

Hence, although the single currency per se should maybe not be put at the top of the priorities in West Africa, the project can be viewed as a way to commit the various countries to better macroeconomic management. In addition, monetary unification may help economic integration, especially since most ECOWAS currencies (apart from the CFA franc) are not convertible presently, which necessitates using foreign devices for intra-regional trade (see Asante and Masson, 2001). However several

⁹ See Masson and Pattillo (2001a and b) and, for instance, the speech given in March 2001 by Mr Apea, the former Deputy Director of the central bank of Ghana, WAMI news, April 2002. The merger of WAMZ and UEMOA appears even more remote (Asante and Masson, 2001).

¹⁰ See *WAMI News*, August 2002.

¹¹ See <http://www.uemoa.int/actes/dec99/AA0499.htm>

geographical boundaries are possible for a monetary union, and we try here to assess their relative relevance. In this paper, we use cluster analysis to provide an assessment of the economic adequacy of CEMAC, UEMOA, WAMZ and ECOWAS as the boundaries of monetary area(s) in Sub-Saharan Africa (SSA). Section 2 provides a first outlook of the SSA region regarding optimum currency areas criteria. The methodology used in this paper is presented in Section 3. Section 4 describes the data set. The results of the cluster analysis are commented in Section 5. Section 6 concludes.

2. Optimum currency areas in Sub-Saharan Africa

The standard tool to evaluate the adequacy of a currency union is the theory of optimum currency areas (Mundell, 1961; McKinnon, 1963; Kenen, 1969). This theory compares the advantages of a currency union in terms of reduced transaction costs, to its drawbacks in terms of the loss of a policy instrument. Still, this theory has been designed for developed economies. In low developed countries, it is not possible to disentangle the choice of countries to be included in a regional monetary union from the choice of the single exchange-rate regime. For instance, the CFA franc zone is both a regional monetary union and a area with a hard peg on the euro. The latter feature may well be more important than the former for individual members of the monetary area. In the following, we try to adapt the theory of optimum currency areas to this specificity of developing countries.

The still low level of intra-regional trade in Sub-saharian Africa limits the scope for reduced transaction costs stemming from a regional monetary union. Indeed, intra-regional trade accounted for only 8.4% of ECOWAS exports and 13.1% of ECOWAS imports in 1997-1998 (Masson and Pattillo, 2001a). This share was higher for UEMOA countries than for non-UEMOA ones. Including non-recorded trade would raise this figure, but the final share would unlikely compete with the 42-43% of trade carried out with the European Union. Hence, a single currency would significantly reduce transaction costs only to the extent that the single regional currency is merged (through euroization), or at least pegged on the euro, as it is the case for the CFA zone. Consistently, Masson and Pattillo (2001a) argue that genuine trade liberalization would be one precondition for successful monetary unification with an independent single currency.¹² However it should also be kept in mind that the scope for intra-regional trade is limited due to low market potential, high transportation costs, similar factor endowments (high labour availability, low capital), and political unrest (Hanink and Owusun 1998, Yeats, 1999).

Simultaneously, the high specialization of most countries in a few number of commodities (often different from one country to another, see Table 1) yields a high cost of abandoning independent monetary policies. Indeed, Masson and Pattillo (2001a) show that the correlation of changes in terms

of trade is generally small between each country and the ECOWAS or UEMOA grouping. A fall in the terms of trade in one country could be adjusted for by a currency depreciation that raises export revenues in domestic currency, because the price of commodities is set in foreign currencies. This is no longer the case if the domestic currency is pegged or merged into a single currency. The WAMZ project includes the creation of a fund in order to help individual countries to buffer adverse temporary shocks. But the limited size of this fund would provide only limited support to smaller countries, and it would be almost useless for a large country like Nigeria. Although labor mobility amongst neighboring countries can be viewed as relatively high traditionally, it is reduced by administrative difficulties and military conflicts. Hence, asymmetric shocks stemming from high specialization can be viewed as the main risk for the second monetary union (see Asante and Masson, 2001). However it should also be stressed that the high dependence on primary products also raises the costs of nominal exchange rate volatility against hard currencies, since it directly transmits into unstable export income in local currency.

Table 1. SSA countries main exports, 2001 (in %)

Benin	Cotton (65)	Ghana	Cocoa (30), aluminum (15)
Burkina Faso	Cotton (53)	Guinea Bissau	Oil (49), nuts (45)
Cameroon	Oil (46), wood (13)	Mali	Cotton (54), electronic circuits (19)
Central Af. Rep.	Wood (38), cotton (19), diamonds (19)	Niger	Uranium (56), live sheep (15)
Chad	Cotton (69), natural gums and resins (25)	Nigeria	Oil (87)
Congo	Oil (74)	Senegal	Refined oil (16), crustaceans (10), groundnut oil (10)
Côte d'Ivoire	Cocoa (39)	Sierra Leone	Seats (29), diamonds (26)
Gabon	Oil (77)	Togo	Cements (30), calcium and phosphates (20)
Gambia	Groundnuts (34), crustaceans (13)		

Note: commodities with 10% or more of total exports.

Source: United Nations, Comtrade database.

In SSA countries, dropping the nominal exchange rate as a policy instrument may show up less costly than claimed by the OCA theory: SSA countries which have retained monetary independence have generally failed to build monetary credibility, which reduces the scope for macroeconomic stabilization through monetary instruments, whereas the CFA franc zone has been viewed as an “external agency of restraint” (Collier, 1991). In this respect, a supra-national central bank could be a

¹² See also Guillaumont and Guillaumont-Jeanneney (1993). Akanni-Honvo (2003) shows that ECOWAS countries fall well behind UEMOA ones as far as trade integration is concerned, although a regional single

way of overcoming national credibility problems: its independence from national fiscal authorities could be easier to establish than in the case of a national central bank.¹³ This is a case where a regional “corner solution” (a regional monetary union) may reconcile the needs for both flexibility (against the rest of the world) and credibility. Such regional solution is to be valued against the alternative of a unilateral hard peg in the form of the CFA arrangement, which is likely more credible at the expense of flexibility (it should be noted however that the CFA arrangement could hardly be adopted by former British colonies given the strong involvement of the French Treasury). Indeed, UEMOA countries will likely be very careful before giving up the CFA franc which has proved efficient in bringing in monetary stability. Perhaps their willingness to join the second monetary union could be enhanced should WAMZ countries build credible monetary institutions and adopt a peg against the euro.

The theory of optimum currency areas (OCA) cannot tell what is the most appropriate exchange-rate regime for a country or a group of countries, which refers to the huge literature on the choice of an exchange rate regime (see Frankel, 1999, or Mussa et al., 2000, who mention the specificity of SSA countries in their still low integration into in the world capital market). Its role is more to point out the more appropriate country groupings in the region while keeping in mind that most SSA countries will likely need some exchange-rate stability against hard currencies, at least before their monetary institutions prove to be truly independent and credible.

In the 1990s, a large number of empirical studies were carried out to determine whether Europe or a sub-group of European countries would form an OCA. One popular approach consisted in looking at the correlation of business cycles or at the volatility of bilateral real exchange rates between each pair of countries, in order to find out whether the shocks to the various economies were mainly symmetric or asymmetric (de Grauwe and Vanhaverbeke, 1991). There were two problems with this approach. First, it did not assess the degree of symmetry of the shocks, but rather the degree of asymmetry of the results of the shocks, including economic policy reaction (and perhaps nominal exchange rate adjustment). For instance, a positive correlation of business cycles between two countries could stem from appropriate contra-cyclical monetary policies in the face of asymmetric shocks. Similarly, low real exchange-rate volatility could be the result of an existing exchange rate arrangement rather than the outcome of symmetric shocks. To solve this problem, Bayoumi and Eichengreen (1993) proposed a VAR methodology based on the Blanchard-Quah decomposition of shocks between supply side and

market is hardly conceivable without Nigeria.

¹³ See de Melo et al. (1993), Cobham and Robson (1994). However Fouda and Stasavage (2000) argue that “The two CFA central banks have enjoyed far less independence from member governments in practice than has often been assumed, despite that they are supranational” (p. 225). Indeed, the monetary policy of the BCEAO is decided by a board of finance ministers where the President of the bank only has a consultative voice. Furthermore, the theoretical dilution of lobbies at the supranational level has been encountered by the similarity of the lobbies across SSA countries (Guillaumont-Jeanneney, 2002; Akanni-Honvo, 2003). Consistently, Masson and Pattillo (2001b) show that multilateral currency unions tend to display higher public debt ratios, and Honohan and Lane (2000) detail how the rules of the CFA zone were not well designed to prevent fiscal indiscipline.

demand side. The second problem was how to aggregate the various sources of information related to the optimality of one possible monetary union. To solve this second problem, Artis and Zhang (1997) carried out cluster analysis which allows to draw country groupings by using an aggregate measure of economic distance.

Ogunkola (2002) has studied bilateral real exchange-rate volatility in SSA countries. He finds conditional volatility to be lower for intra-CFA real exchange rates than for non-CFA ones; outside the CFA zone, Nigeria seems to display the highest conditional volatility.

The VAR approach has been used by Bayoumi and Ostry (1997), Hoffmaister et al. (1998) and Fielding and Shields (2001). Bayoumi and Ostry actually work on an AR model of the growth of real output per capita. They find real disturbances to be little correlated across countries, with no special effect of CFA zone membership. Hoffmaister et al. show that external shocks are a prominent source of macroeconomic fluctuations in SSA and that they are more detrimental to CFA countries than to non-CFA ones, supposedly due to the fixed peg. Fielding and Shields find high correlation between inflation shocks among CFA members, but they distinguish two CFA sub-groups as far as output growth shocks are concerned. Since the two sub-groups do not coincide with the existing monetary unions, they conclude that “there may be a reason to redraw the internal boundaries of the Franc Zone, if the policymaker is particularly concerned about output growth shocks” (p. 221).

To our knowledge, cluster analysis has not yet been applied to Sub-Saharan African countries. One sizeable advantage of this approach is that it allows to account for variables that are not in the traditional OCA literature but have been put at the forefront recently, like indebtedness which can lead to “fear of floating” when the debt is invoiced in foreign devices as it is the case in low developed countries (Bénassy-Quéré, 1999; Calvo and Reinhart, 2000). In addition, this methodology is relatively well disposed towards those countries for which consistent time-series data is relatively scarce.

3. The variables

Cluster analysis offers a numerical method for sequentially aggregating objects according to some metric (see Kaufman and Rousseeuw, 1990). Artis and Zhang (1997) used such analysis to sequentially aggregate European countries according to their “economic distance” to Germany which at that time was viewed as the core of a possible European monetary union. “Economic distance” was calculated as the Euclidean distance between vectors characterizing each country (except Germany). Each vector comprised five variables, namely: the correlation of the business cycle with that of Germany, the volatility of the real exchange rate against Germany, the correlation of the real interest rate cycle with that of Germany, the correlation of the export cycle with the German import cycle, the correlation of

the import cycle with the German export cycle. This allowed Artis and Zhang to point out a core of “close” countries gathering France, Austria, Netherlands, Belgium around Germany.

Here we use a similar methodology to delimit groupings of SSA countries. However the methodology needs to be adapted for several reasons:

- (i) As demonstrated by the breakdown of the Bretton Woods system and by European monetary integration, *real exchange rate volatility is highly dependent on nominal exchange-rate volatility, hence on the exchange rate regime*. Since SSA countries include both CFA countries and countries using flexible exchange-rate regimes, the volatility of the real exchange rate over the past cannot be used as a criterion for designing an OCA. To a lesser extent, real interest rates display the same caveat since both nominal interest rates and inflation rates are likely to be more correlated to foreign rates in the case of a hard peg (ie for the CFA area).
- (ii) Contrasting with the anchor role of Germany in the European monetary integration process, *there is no evident leader amongst the countries under review*. For sure, Nigeria is by far the largest country. However due to poor political and monetary track record, and high dependence on oil exports, it cannot be viewed as the *alter ego* of Germany. One consequence is that the correlation of business cycles cannot be calculated with one SSA country, or even with one immutable country grouping: it has to be calculated with one foreign area. Given the historic background, the present CFA arrangement and the country breakdown of trade, the Eurozone is the natural reference area. Indeed, it has been shown by Guillaumont and Guillaumont-Jeanneney (1989), Guillaumont-Jeanneney and Paraire (1991), and Honohan and Lane (2000) that the euro would be the most suited candidate as an external monetary anchor for most SSA countries (and the suitability of the euro for Anglophone countries would be enhanced should the United Kingdom join EMU).
- (iii) The limited development of the statistical system also implies *data limitations*: only annual data are available, and they are subject to missing values and/or large fluctuations in relation with political developments. Hence we use several structural variables that appear little dependent on a specific time span.
- (iv) The theory of OCAs is mainly designed for industrial countries. As it has been highlighted by the recent literature on the exchange-rate regime choice, *high indebtedness and pass-through may twist the choice towards pegs on international currencies*. This argument needs to be included here especially since UEMOA countries would have to choose between staying pegged to the euro and moving to a truly regional arrangement.

Several authors have contrasted the success of the CFA area in the 1970s and early 1980s with its poor performance afterwards. Consistently, we concentrate on the post 1985 period. Five variables are first introduced in the cluster analysis (data sources are provided in Appendix 1):

1. *The correlation of GDP with the euro area (CORR)*. Annual real GDP in domestic currency is filtered through a Hodrick-Prescott filter over the 1975-1999 period. Then, the correlation of filtered GDP with the euro area is calculated separately for the two sub-periods. CORR is supposed to be higher the more symmetric shocks between each country and the euro area. Hence, two SSA countries with high CORR values will exhibit similar business cycles: they will face an incentive both to form a monetary union and to choose the euro rather than another foreign currency as a monetary anchor, as CFA countries are doing. Conversely, two SSA countries with negative CORR values will share a low incentive to use the euro as a monetary anchor while still exhibiting relatively parallel business cycles among themselves. Finally, a CORR value close to zero will entail low incentive to both form a monetary union and peg to the euro.
2. *The export-to-GDP ratio (OPEN)* measures the scope for foreign demand shocks (which would ask for exchange-rate adjustment in order to isolate the domestic economy) and pass-through (in the form of imported inputs and/or foreign-currency denomination of exports). As Bénassy-Quéré and Coeuré (2002) have shown that the latter effect dominates, we expect large openness to be an argument against exchange-rate flexibility (because in this case the real exchange rate is little sensitive to the nominal exchange rate). Exports and GDPs are in current dollars, and we use the average ratio over 1986-1999.
3. *The share of the European Union in total exports (XEU)*: as argued previously, in SSA countries it is not easy to separate the design of monetary frontiers from the choice of an external anchor. We consider a high reliance on the EU for exports as an incentive to use the euro as an anchor, or at least as an incentive to follow similar exchange-rate policies against the European currency. The ratio is averaged over 1986-1999.
4. *The share of the primary sector in GDP (PRIM)*: this ratio is taken as a rough measure of low product diversification. It follows Kenen's criterion of an OCA saying that low-diversified economies are more likely to suffer from specific shocks, which makes a monetary union more costly. Since the price of primary products is set in foreign currencies (generally in dollars), a high share of primary goods in output also means that nominal exchange rate volatility will generate some instability in export revenues, raising the costs of a flexible exchange-rate regime. The ratio is averaged over 1986-1999.
5. *The share of the first exported commodity in total exports (FIRST)*: this ratio is complementary to the PRIM variable. Two countries with similar reliance on the primary sector may exhibit different vulnerability to specific sector shocks depending on their reliance on one single commodity. This

feature is especially important for SSA countries, as illustrated in Table 1. We alternatively use the share of the three first commodities in total exports (*THREE*). The two ratios are calculated in 2001.

6. *The share of oil in exports (OIL)*: two countries with high reliance on one single commodity will face similar terms of trade shocks provided the commodity in question is the same. Due to the variety of commodities exported by SSA countries, it is not possible to account for each of them. Since half of the countries in our sample are concerned by oil exports, for sometimes a very high share, the share of oil in total exports is used to refine the measurement of specialization. The ratio is averaged over 1986-1999 for all countries but Chad where the 1975-1985 average is retained due to data limitations.
7. *The debt service ratio (DEBT)*: the higher the debt service, the lower the incentive to devalue, because the debt service is denominated in hard currencies. Hence, countries with high debt service ratio are expected to be more willing to peg and possibly to form a monetary union with a peg on a foreign device. The total debt service ratio is calculated as a percentage of exports of goods and services and averaged over 1986-1999.

Our sample consists of five CEMAC countries (all but Equatorial Guinea), eight UEMOA countries (all of them) and four ECOWAS, non UEMOA countries (all but Liberia); hence a total of 17 countries. The database is displayed in Appendix.

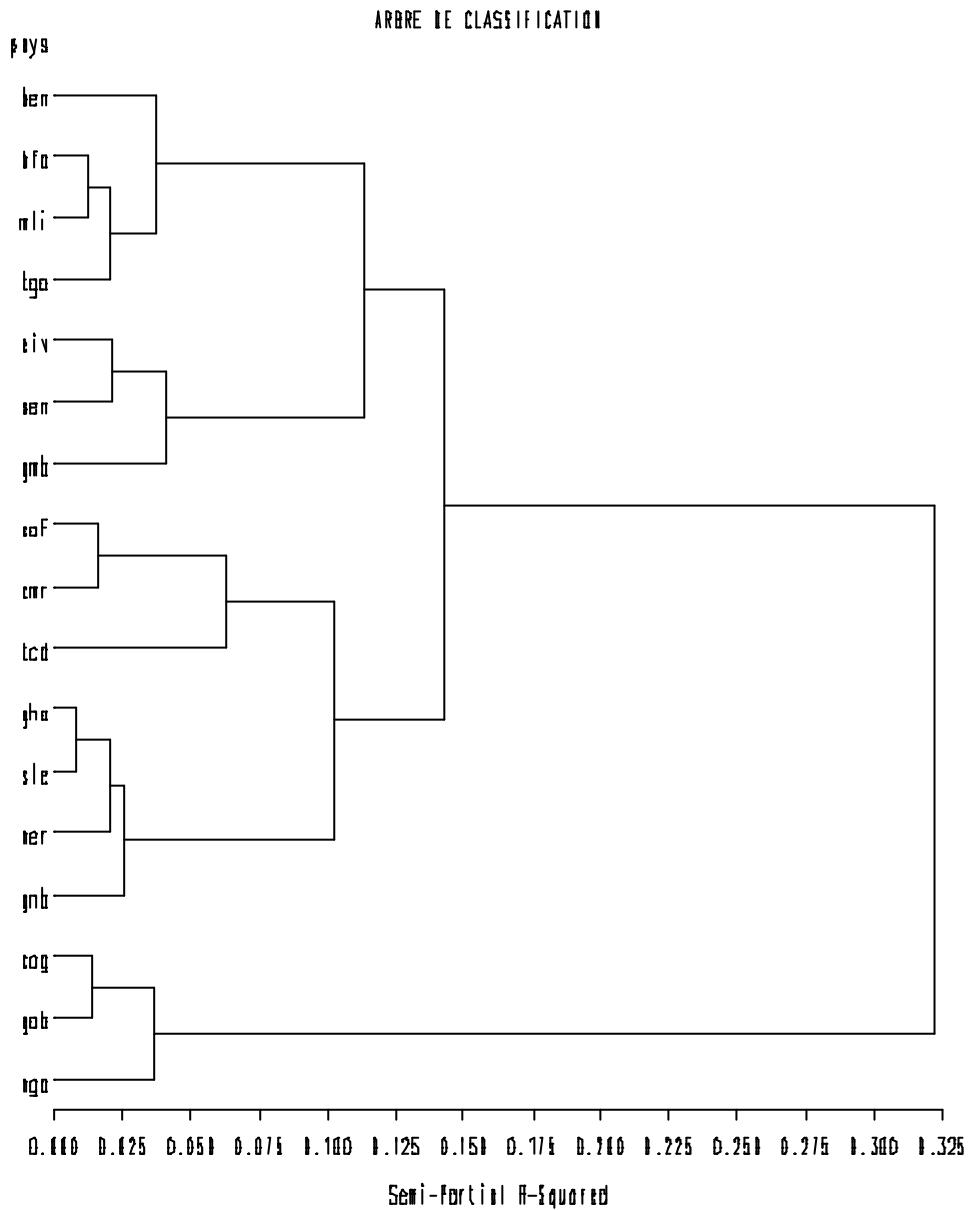
It should be kept in mind that economic analysis is only part of the story. Even in the case of European Monetary Union, it has often been suggested that political motivation had dominated economic analysis. This is likely to be the same in other regions in the world. Nevertheless we believe economic analysis to be useful as a background for discussion.

5. The Results

We start with the baseline analysis, where countries are grouped according to all seven variables: the correlation of output cycles (CORR), the openness ratio (OPEN), the share of the EU in exports (XEU), the share of the primary sector in output (PRIM), the share of the first exported commodity in exports (FIRST), the share of oil in exports (OIL) and the debt service to exports ratio (DEBT). In order for each of the variables to enter the aggregation criterion with equal weight, we work on centered-reduced variables. Three aggregation algorithms have sequentially been used: the average, centroid and Ward methods (see Appendix 2). The number of groups retained is based on the loss of inter-class inertia when merging two clusters: the merging process is stopped when less groups no longer provides a substantial drop in inter-class inertia (see Appendix 3).

Along these lines, the Ward methodology leads to five country groupings (Figure 2).

Figure 2. Baseline results (Ward method)



Source: cluster analysis. Country codes: see Appendix 1.

As shown in Appendix 4, the average methodology leads to the same classification, except for Cluster 4 (Cameroon, Central African Republic and Chad), which is dissolved into different groups. The centroid methodology leads to very confuse results, with one huge country grouping (which covers almost all countries outside the group of countries relying heavily on oil exports), and two singletons. Note however that the centroid classification is consistent with the Ward one. Here we concentrate on those obtained with the Ward method while keeping in mind the fragility of Cluster 4.

Table 2 provides the mean and standard deviation of each economic variable for each country grouping. In addition, we test whether each variable is significantly different in one cluster compared with the sample mean (Student test), and whether a given variable is significantly different in one cluster (Fisher test). The five clusters are displayed the same way as in Figure 1 in order to facilitate the reading.

Table 2. Mean variables in each cluster (Ward method)

Clusters		CORR	OPEN	XEU	PRIM	FIRST	OIL	DEBT
	All	19.0 (35.7)	27.3*** (13.8)	50.1*** (13.5)	47.8** (11.0)	49.8*** (19.3)	21.7*** (33.1)	19.3** (9.3)
2	Benin, Burkina Faso, Mali, Togo	6.9 (33.6)	20.2 (8.4)	35.3** (1.4)	46.3 (6.2)	50.6 (13.0)	0.9 (1.4)	10.9** (2.4)
5	Côte d'Ivoire, Gambia, Senegal	16.8 (30.7)	39.4 (9.9)	51.0 (6.4)	32.1*** (4.5)	29.6* (10.0)	10.0 (7.1)	22.5 (6.8)
4	Cameroon, Central African Rep., Chad	-4.2 (43.3)	17.8 (2.5)	73.3*** (1.5)	47.0 (7.8)	51.1 (13.2)	19.3 (13.5)	13.7 (6.7)
1	Ghana, Guinea Bissau, Niger, Sierra Leone	24.5 (20.3)	17.8 (3.8)	54.5 (2.3)	56.8* (5.7)	41.0 (12.0)	1.8 (3.1)	30.4*** (6.9)
3	Congo, Gabon, Nigeria	53.0* (20.8)	46.9*** (7.3)	39.6 (2.4)	54.6 (10.4)	79.3*** (5.4)	90.3*** (4.2)	18.4 (5.4)

Source: cluster analysis.

Notes: intra-class standard deviations in brackets. *** means that the corresponding variable is significantly different across the five classes (Fisher test) or that it is significantly different in the corresponding class compared to the sample mean (Student test), at the 1% level. ** and * have the same meaning with a 5% and 10% significance threshold respectively.

The first country grouping in Table 2 (Cluster 2), comprising Benin, Burkina Faso, Mali and Togo, all being UEMOA members, displays relatively low reliance on EU markets and low debt service ratio (DEBT). The second grouping (Cluster 5), made of Côte d'Ivoire, the Gambia and Senegal, enjoys relatively high output diversification, in terms of relatively low share of primary sectors (PRIM) and of the relatively low share of the first item in exports (FIRST). Credibility problems aside, the main features of these two clusters would make them relatively good candidates for moving towards a common, independent currency.

The third grouping (Cluster 4), with Cameroon, Central African Republic and Chad, displays very high reliance on EU markets (XEU). The countries in this cluster all belong to the CEMAC. The fourth grouping (Cluster 1), which brings together Ghana, Guinea Bissau, Niger and Sierra Leone, relies heavily on primary goods (PRIM) and suffers from high debt service (DEBT). Finally, the last grouping (Cluster 3) consists in oil exporting countries (Congo, Gabon, Nigeria) which are very open (OPEN) and rely heavily on a single good for exports (FIRST). Hence, clusters 4, 1 and 3 all display fear-of-floating features which would favor pegs against the euro and/or the dollar.

As summarized in Table 3, there is no coincidence between the country groupings stemming from the cluster analysis and the existing or projected monetary arrangements in the sub-continent. Indeed, CEMAC, UEMOA and ECOWAS groups are disseminated in four different clusters each. Strikingly, though, CEMAC and UEMOA countries never show up in the same cluster. In fact, CEMAC countries display very low diversification in terms of products (oil exporting countries) or geographically (other countries, which heavily rely on EU markets). In terms of monetary arrangements, these features are consistent with the CFA arrangement for Cluster 4, whereas they would seem to ask for a type of peg on the dollar for Cluster 3.

Table 3. Country groupings with the Ward method, baseline analysis

Nb	CEMAC	UEMOA	Other ECOWAS	Main features
2		Benin Burkina Faso Mali Togo		Low reliance on EU markets, low debt service
5		Côte d'Ivoire Senegal	Gambia	Low share of primary sectors, low share of first item in exports
4	Cameroon Centr. Afr. R. Chad			High reliance on EU markets
1		Guinea Bissau Niger	Ghana Sierra Leone	High reliance on primary products, high debt service
3	Congo Gabon		Nigeria	High openness, high correlation with the EU, high reliance on one product (oil)

Source: Table 2.

Non-CFA ECOWAS countries do not form a comprehensive cluster: the Gambia, Ghana and Sierra Leone are grouped with UEMOA countries (albeit in different clusters), whereas Nigeria is grouped with two CEMAC countries. Hence our cluster analysis supports the WAMZ project in the limited sense that Ghana, the Gambia and Sierra Leone could be grouped with UEMOA countries, within the CFA arrangement or within a new monetary arrangement. However Nigeria would better not be part of this arrangement.¹⁴

Finally, our analysis suggests that the “core” of UEMOA, in the sense given by the OCA literature, is formed by Benin, Burkina Faso, Mali and Togo. Côte d'Ivoire and Senegal are close to this core (see Figure 1), and could be joined by the Gambia. This grouped formed by Clusters 2 and 5 could perhaps move towards a monetary union with single independent currency. Conversely, Guinea Bissau and

¹⁴ This conclusion is all the more important that Nigeria is by far the largest country in Western Africa: as noted by Debrun et al. (2002), a single West-African monetary policy would likely be very dependent on the economic outcome of this single country.

Niger are relatively far from this core due to low diversification and high indebtedness; they are closer to Ghana and Sierra Leone, which are not in the UEMOA. Note that the classification obtained with the average methodology (see Appendix 4) puts Cameroon and Chad, two CEMAC countries, in Cluster 1, hence closer to non-CFA countries than to the UEMOA “core”. On the whole, should the UEMOA arrangement remain unchanged, Ghana and Sierra Leone could feel the same incentive as the Gambia to join it; but the analysis shows that Cluster 1 would perhaps need to stay away from the creation of an independent, regional monetary union.

According to Cohen (2003), the sustainability of a monetary union depends either on the existence of a “locally dominant country” (a leader), or on the existence of “a genuine sense of community”, taking the form of “a developed set of institutional connections and reflects”. Within this taxonomy, the second monetary union in Africa could be organized around Nigeria (the leader) or around UEMOA (the existing set of institutional connections). Our results would seem to favor the second option, although it should be reminded that the sense of community could well be weakened by the inclusion of former British colonies in a French-speaking, long-lived area. However, non-UEMOA countries would unlikely be able to get the French Treasury guarantee, the system would then have to evolve either towards a more standard hard peg (eg a currency board) or to a more flexible regime. On the whole, there could be some asymmetry in the incentives to form a large second monetary union, UEMOA countries feeling much less willing than non-UEMOA ones.

5. Robustness analysis

One weakness of cluster analysis is that it does not rely on statistical tests and could perhaps lead to a different conclusion depending on the methodology employed and on the variables included in the analysis in Section 4. We have already checked that the results are robust to the choice of the aggregation algorithm, whether centroid, Ward or average. Here we further test for robustness through replacing or removing some of the variables included in the cluster analysis sequentially.

More specifically, we perform four exercises:

- *CORR removed*: the interpretation of the correlations may be difficult in countries where some fluctuations of output may have been related to geo-political events which may not re-iterate in the future. In addition, CORR is the only variable which fails to pass the Fisher test in Table 2: it is the only variable that does not significantly discriminate between the five clusters. Hence we re-run the clustering analysis while simply dropping the CORR variable.
- *The share of the three first commodities (THREE)*: some countries (like Nigeria, Gabon or Benin) rely on one single commodity, whereas others (like Cote d’Ivoire, Ghana or Senegal) rely on a

small number of commodities, with still low diversification. In order to account for this phenomenon, we re-run the cluster analysis while substituting THREE for FIRST.

- *The share of agriculture (AGRI)*: in the baseline, we use the share of primary sectors in GDP as a proxy for the degree of diversification. It can be argued however that a large share of agriculture is often a feature of traditional economies, whereas the mining sector by nature is foreign-oriented. As a robustness check, we substitute the share of agriculture (AGRI) for the share of primary sectors (PRIM) in the analysis.
- *OIL removed*: the baseline analysis underlines the specificity of countries with high reliance on oil exports. In order to measure the robustness of other groupings to this criterion, we re-run the analysis while dropping the OIL variable.

The results with these successive changes are summarized in Table 4. They are almost unchanged. Substituting the share of the three first items in exports to the share of the first one leads to exactly the same classification. Removing CORR from the analysis makes Niger move from Cluster 1 (Ghana, Guinea Bissau, Sierra Leone) to Cluster 4 (Cameroon, Central African republic, Chad). Niger shares with the latter countries a high reliance on EU markets, but its positive correlation with EU GDP prevents it from being in Cluster 4 in the baseline, because Cluster 4 displays a negative correlation. The rest of the classification is unchanged compared to the baseline. Finally, substituting the share of agriculture (AGRI) for the share of primary goods (PRIM) in total production leads to two changes. In Côte d'Ivoire, the share of agriculture (30%) is close to those of countries in Cluster 1, but the share of primary goods is not much higher (33.5%) which makes Côte d'Ivoire closer to Senegal and the Gambia in the baseline. Côte d'Ivoire is replaced by Togo in Cluster 5. Due to the production of phosphates, the share of primary sectors in Togo (49.4%) is much higher than the share of agriculture (36.8%). Hence, Togo is symmetric to Côte d'Ivoire, and moves to a cluster with low agriculture share when this variable is used.

Last but not least, dropping the OIL variable from the analysis leads to the same classification as in the baseline. This is because countries relying heavily on oil (Cluster 3, gathering Congo, Gabon and Nigeria) are those where the share of the first commodity in exports is highest (see Table 2). Hence, our results are robust to successive robustness checks.

Table 4. Robustness check (Ward method)

Baseline		CORR removed		THREE for FIRST		AGRI for PRIM		OIL removed	
2	Benin	2	Benin	2	Benin	2	Benin	2	Benin
2	Burkina Faso	2	Burkina Faso	2	Burkina Faso	2	Burkina Faso	2	Burkina Faso
2	Mali	2	Mali	2	Mali	2	Mali	2	Mali
2	Togo	2	Togo	2	Togo	5	Togo	2	Togo
5	Senegal	5	Senegal	5	Senegal	5	Senegal	5	Senegal
5	Côte d'Ivoire	5	Côte d'Ivoire	5	Côte d'Ivoire	1	Côte d'Ivoire	5	Côte d'Ivoire
5	Gambia	5	Gambia	5	Gambia	5	Gambia	5	Gambia
4	Cameroon	4	Cameroon	4	Cameroon	4	Cameroon	4	Cameroon
4	Central Afr R.	4	Central Afr R.	4	Central Afr R.	4	Central Afr R.	4	Central Afr R.
4	Chad	4	Chad	4	Chad	4	Chad	4	Chad
1	Ghana	1	Ghana	1	Ghana	1	Ghana	1	Ghana
1	Guinea Bissau	1	Guinea Bissau	1	Guinea Bissau	1	Guinea Bissau	1	Guinea Bissau
1	Niger	4	Niger	1	Niger	1	Niger	1	Niger
1	Sierra Leone	1	Sierra Leone	1	Sierra Leone	1	Sierra Leone	1	Sierra Leone
3	Congo	3	Congo	3	Congo	3	Congo	3	Congo
3	Gabon	3	Gabon	3	Gabon	3	Gabon	3	Gabon
3	Nigeria	3	Nigeria	3	Nigeria	3	Nigeria	3	Nigeria

Source: cluster analysis. In grey: countries outside the clusters considered.

On the whole, the results tend to support the inclusion of the Gambia, Ghana and Sierra Leone in an extended UEMOA arrangement, or the creation of a separate monetary union with the core of the UEMOA and the Gambia, rather than the creation of a monetary union around Nigeria. In any case, the recent move of WAMZ countries to a pegged regime on the US dollar is not supported by the data, except for Nigeria. Finally, the analysis shows that splitting the CFA zone along the lines of the two existing monetary areas would make sense since UEMOA countries seem to be closer to other ECOWAS ones than to the CEMAC.

4. Conclusion

In this paper, cluster analysis has been carried out to shed some light on the desirability of moving from existing monetary arrangements in Sub-Saharan Africa (i.e. the CFA arrangement in the one hand, a group of floating currencies in the other hand) to another arrangement consisting in one genuine monetary union whose boundaries would fit the ECOWAS grouping, the CFA zone being then reduced to the CEMAC. It is found that the existing CFA franc zone cannot be viewed as an optimum currency area: CEMAC and UEMOA countries do not belong to the same clusters, and a “core” of the UEMOA can be defined on economic grounds. Furthermore, the results tend to support the inclusion of the Gambia, Ghana and Sierra Leone in an extended UEMOA arrangement, or the creation of a separate monetary union with the “core” of the UEMOA and the Gambia, rather than the creation of a monetary union around Nigeria. Hence, the creation of the West African Monetary Zone (WAMZ) with a regional monetary arrangement makes sense in the limited sense of a connecting the

Gambia, Ghana and Sierra Leone to the UEMOA. Including Nigeria in this zone is not supported by the analysis, neither does creating a separate WAMZ monetary union.

Of course, one should be careful with conclusions stemming from cluster analysis which is little more than sophisticated descriptive statistics. However we believe this analysis to be valuable in that it provides multi-criteria arguments. This is especially useful since the relative scarcity of the data limits econometric investigations for SSA countries. Hence, our results should be viewed as one building block in the debate which of course will involve strong political arguments.

References

Akanni-Honvo, A., 2003, L'UMOA et la CEDEAO: intégration à géométrie variable ou fusion?, in Ph. Hugon ed., *Les Economies en Développement à l'Heure de la Régionalisation*, Karthala.

Artis, M.J. and W. Zhang, 1997, On identifying the core of EMU: an exploration of some empirical criteria, CEPR discussion paper 1689, August.

Asante, R.D. and P.R. Masson, 2001, The pros and cons of expanded monetary union in west Africa, *Finance and Development*, 38 (1), March, available at www.imf.org/external/pubs/fin/2001/03/

Bayoumi, T. and J. Ostry, 1997, Macroeconomic shocks and trade flows within sub-saharian Africa: implications for optimum currency areas, *Journal of African Economies*, 6 (October) (also IMF WP 95/142).

Bénassy-Quéré, A., 1999, Optimal pegs for East Asian currencies, *Journal of the Japanese and International Economies*, 13, 44-60.

Boughton, J.M., 1991, The CFA franc zone: currency union and monetary standard, IMF working paper 91/133.

Calvo, G., and C. Reinhart, 2000, Fear of floating, NBER working paper 7993.

Cobham, D. and P. Robson, 1994, Monetary integration in Africa: a deliberately European perspective, *World Development* 22 (3), 285-299.

Cohen, B., 2003, Are Monetary Unions Inevitable?, *International Studies Perspectives*.

Collier P., 1991, Africa's external economic relations 1960-1990, *African Affairs* 90, 339-56.

Deaton, A., 1999, Commodity prices and growth in Africa, *Journal of Economic Perspectives*, 13 (3), 23-40.

Debrun, X., Masson, P. and C. Pattillo, 2002, Monetary union in West Africa: who might gain, who might lose, and why?, IMF working paper 02/226, December.

De Grauwe, P. and W. Vanhaverbeke, 1991, Is Europe and optimum currency area? Evidence from regional data, CEPR discussion paper 555.

Devarajan, S. and D. Rodrik, 1991, Do the benefits of fixed exchange rates outweigh their costs? The franc zone in Africa, NBER working paper 3727, June.

Dordundo, C.K., 2000, Growth, inflation and foreign exchange regimes in Sub-Saharan Africa (CFA and non-CFA zones), Project LINK fall meeting, Oslo, October 2-6.

Elbadawi, I. and N. Madj, 1996, Adjustment and economic performance under a fixed exchange rate: a comparative analysis of the CFA zone, *World Development*, 24 (5), 939-951.

Fielding, D. and K. Shields, 2001, Modelling macroeconomic shocks in the CFA franc zone, *Journal of Development Economics* 66, 199-223.

Fouda, S.M., and D. Stasavage, 2000, The CFA franc zone after EMU: Status quo, reform or dissolution?, *World Economy* 23 (2), pp. 221-33.

Frankel, J., 1999, No single currency regime is right for all countries at all times, *Essays in International Finance*, 215, Princeton University.

Guillaume, D.M., and D. Stasavage, 2000, Improving policy credibility: is there a case for African monetary unions?, *World Development* 28 (8), 1391-1407.

Guillaumont-Jeanneney, S., 2002, Bilan de l'intégration monétaire dans l'UMOA, Symposium du quarantième anniversaire de l'UMOA, mai.

Guillaumont, P. and S. Guillaumont-Jeanneney, 1989, The implications of the European monetary union for African countries, *Journal of Common Market Studies*, 28 (2), 139-253.

Guillaumont-Jeanneney, S. and J.L. Paraire, La variabilité des taux de change et le rattachement optimal des monnaies des pays en voie de développement, *Revue d'Économie Politique* 101 (3), 438-462.

Guillaumont, P. and S. Guillaumont-Jeanneney, 1989, The implications of the European Monetary Unification for African countries, *Journal of Common Market Studies*, 28 (2), 139-53.

Guillaumont, P. and S. Guillaumont-Jeanneney, 1993, L'intégration économique: un nouvel enjeu pour la zone franc, *Revue d'Économie du Développement*, 2, 83-112.

Guillaumont, P. and S. Guillaumont-Jeanneney, 1995, Ébranlement et consolidation des fondements des francs CFA, *Revue d'Économie du Développement*, 9 (3), 87-111 .

Hadjimichael, M.T. and M. Galy, 1997, The CFA franc zone and the EMU, IMF working paper 97/156, November.

- Hanink, D.M. and J.H. Owusu, 1998, Has ECOWAS promoted trade among its members?, *Journal of African Economies*, 7 (3), 363-383.
- Hernandez-Cata, E. et al., 1998, The West African economic and monetary union, IMF occasional paper 170.
- Hoffmaister, A.W., Roldos, J. and P. Wickham, 1998, Macroeconomic fluctuations in Sub-Saharan Africa, *IMF Staff Papers*, 45 (1), 132-160.
- Honohan, P. and P.R. Lane, 2000, Will the euro trigger more monetary unions in Africa?, mimeo
- Honohan, P. and S.A. O'Connell, 1997, Contrasting monetary regimes in Africa, IMF working paper 97/64, May.
- Hugon, Ph., 1999, *La Zone Franc à l'Heure de l'Euro*, Karthala, Paris.
- Kaufman, L., and P.J. Rousseuw, 1990, *An Introduction to Cluster Analysis*, J. Wiley & Son Inc.
- Laporte, B., 1996, L'intégration monétaire avant l'intégration commerciale: le cas e l'Afrique de l'ouest, *Revue d'Économie du Développement* 3 (9), 95-114.
- Masson, P. and C. Pattillo, 2001a, Monetary union in West Africa (ECOWAS): is it desirable and how could it be achieved?, IMF Occasional Paper 204.
- Masson, P. and C. Pattillo, 2001b, Monetary union in west Africa: an agency of restraint for fiscal policies?, mimeo IMF, December.
- Melo (de), J., Panagariya, A., and D. Rodrick, 1993, The new regionalism: a country perspective, in J. de Melo and A. Panagariya eds., *New Dimensions in Regional Integration*, Cambridge University Press.
- Mussa, M., Masson, P., Swoboda, A., Jadresic, E., Mauro, P. and A. Berg, 2000, Exchange rate regimes in an increasingly integrated world economy, IMF Occasional Paper, 193.
- Ogunkola, E.O., 2002, The second monetary zone in West Africa and the future of a single monetary zone in sub-Saharan Africa, mimeo, National University of Lesotho.
- Savvides, A., 1996, CFA franc zone membership and exchange rate variability, *Journal of African Economies*, 5 (March), 52-69.
- Yeats, A.S, 1999, What can be expected from African regional trade arrangements? Some empirical evidence, World Bank policy research working paper 2004.

Appendix 1: the data

Data sources

- CORR (correlation of output with the euro area): annual GDP in constant domestic currency is from the World Bank Development Indicators; it is filtered through Eviews software.
- OPEN (exports to GDP ratio): exports and GDPs in current dollars are from the World Bank Development Indicators.
- PRIM (share of the primary sector in total exports in %): this ratio is calculated as the complement to the share of manufacturing and services in GDP. Source: World Bank Development Indicators.
- OIL (share of oil in total exports in %): oil exports and total exports are in current dollars. Source: World Bank Development Indicators.
- DEBT (debt service over exports in %): the ratio is from World Bank Development Indicators.
- XEU (share of the European Union as a destination for exports, in %): all exports are in current dollars. Source: IMF, Direction of Trade.
- FIRST (share of the first exported product in total exports of goods, in %): SITC, Rev.3 classification of exports is taken from United Nations, COMTRADE database.
- THREE (share of the three first exported products in total exports of goods, in %): SITC, Rev.3 classification of exports is taken from United Nations, COMTRADE database.

Database

COUNTRY	CORR	OPEN	XEU	PRIM	AGRI	FIRST	THREE	OIL	DEBT
Benin	-0.47	16.8	28.9	41.2	35.8	65.2	77.0	3.2	7.6
Burkina	0.18	9.7	34.7	39.6	33.1	53.2	64.3	0.0	10.2
Cameroon	-0.46	27.8	73.8	45.9	32.3	46.3	65.4	26.8	22.8
Chad	0.55	15.0	68.7	37.8	34.9	69.1	95.6	30.8	6.6
CAF	-0.21	23.1	70.2	57.3	48.3	37.9	75.6	0.3	11.7
Côte d'Ivoire	-0.14	38.9	56.0	33.5	30.2	38.9	50.2	13.0	31.6
Congo	0.55	51.2	40.9	44.5	11.2	74.2	84.7	88.6	24.7
Gabon	0.26	58.1	31.8	48.2	8.3	76.9	95.5	86.2	11.6
Ghana	0.54	9.6	54.2	53.6	42.2	29.9	52.5	7.1	32.3
Gambia	0.59	42.5	53.3	36.7	29.8	34.2	54.9	0.2	15.3
Guinea B	-0.03	9.0	41.8	61.3	55.6	49.2	96.3	0.0	40.5
Mali	0.45	13.7	35.2	55.5	46.2	54.0	75.8	0.0	14.2
Niger	0.20	22.4	57.4	49.4	38.1	56.3	74.8	0.0	22.1
Nigeria	0.77	19.9	35.1	70.0	32.5	86.7	94.6	96.1	18.8
Senegal	0.05	32.8	42.8	26.2	19.7	15.6	34.8	16.9	20.7
Siera Leone	0.26	20.8	55.6	63.7	45.3	28.9	58.1	0.0	26.6
Togo	0.12	49.0	30.6	49.4	36.8	29.7	58.1	0.2	11.5

Country codes (Figures)

BEN	Benin	CPV	Cape Verde	NER	Niger
BFA	Burkina Faso	GAB	Gabon	NGA	Nigeria
CAF	Central African Rep.	GHA	Ghana	SEN	Senegal
CIV	Côte d'Ivoire	GMB	Gambia (the)	SLE	Sierra Leone
CMR	Cameroon	GNB	Guinea Bissau	TCD	Chad
COG	Congo (Rep. of)	MLI	Mali	TGO	Togo

Appendix 2: the aggregation algorithms

Let x_i^l be variable l ($l=1$ to 7) for country i , and x_i the 7 variables vector. The Euclidian distance between two countries i and j is:

$$d^2(i, j) = \sum_{l=1}^7 (x_i^l - x_j^l)^2 = (x_i - x_j)'(x_i - x_j)$$

Three aggregation algorithms are sequentially used. At each stage, the algorithm selects the couple of objects A and B (either countries or previous groupings) that should be grouped together.

- *Average method*: A and B are merged if the average distance between any member of cluster A and any member of cluster B is minimum:

$$d^2(A, B) = \frac{1}{N_A N_B} \sum_{i \in A} \sum_{j \in B} d^2(i, j) \text{ minimum}$$

where N_A (N_B) is the number of countries in cluster A (B resp.).

- *Centroid method*: A and B are merged if the distance between the centroid of A , $c(A)$, and the centroid of B , $c(B)$, is minimum:

$$d^2(c(A), c(B)) \text{ minimum with } c(A) = \frac{1}{N_A} \sum_{i \in A} x_i \text{ and } c(B) = \frac{1}{N_B} \sum_{j \in B} x_j$$

- *Ward method*: A and B are merged if the loss of inter-class inertia is minimum:

$$I(A) + I(B) - I(A \cup B) \text{ is minimum, with } I(A) = N_A d^2(c(A), c), I(B) = N_B d^2(c(B), c),$$

$$I(A \cup B) = (N_A + N_B) d^2(c(A \cup B), c) \text{ and } c \text{ is the centroid of the whole sample of countries.}$$

The latter method is the most popular because it generally produces relatively net groupings. However it is important to check the robustness of the analysis by comparing with other aggregation methods.

Appendix 3: clustering thresholds

Loss of inter-class inertia (Baseline, Ward method):

Number of clusters	Loss of inter-class inertia 0/00	Cumulated loss of inter-class inertia
2 → 1	322	322
3 → 2	143	465
4 → 3	113	578
5 → 4	103	681
6 → 5	64	745
7 → 6	41	786
8 → 7	37	824
9 → 8	36	860
10 → 9	26	886
11 → 10	22	908
12 → 11	21	928
13 → 12	21	949
14 → 13	16	966
15 → 14	13	979
16 → 15	13	992
17 → 16	8	1000

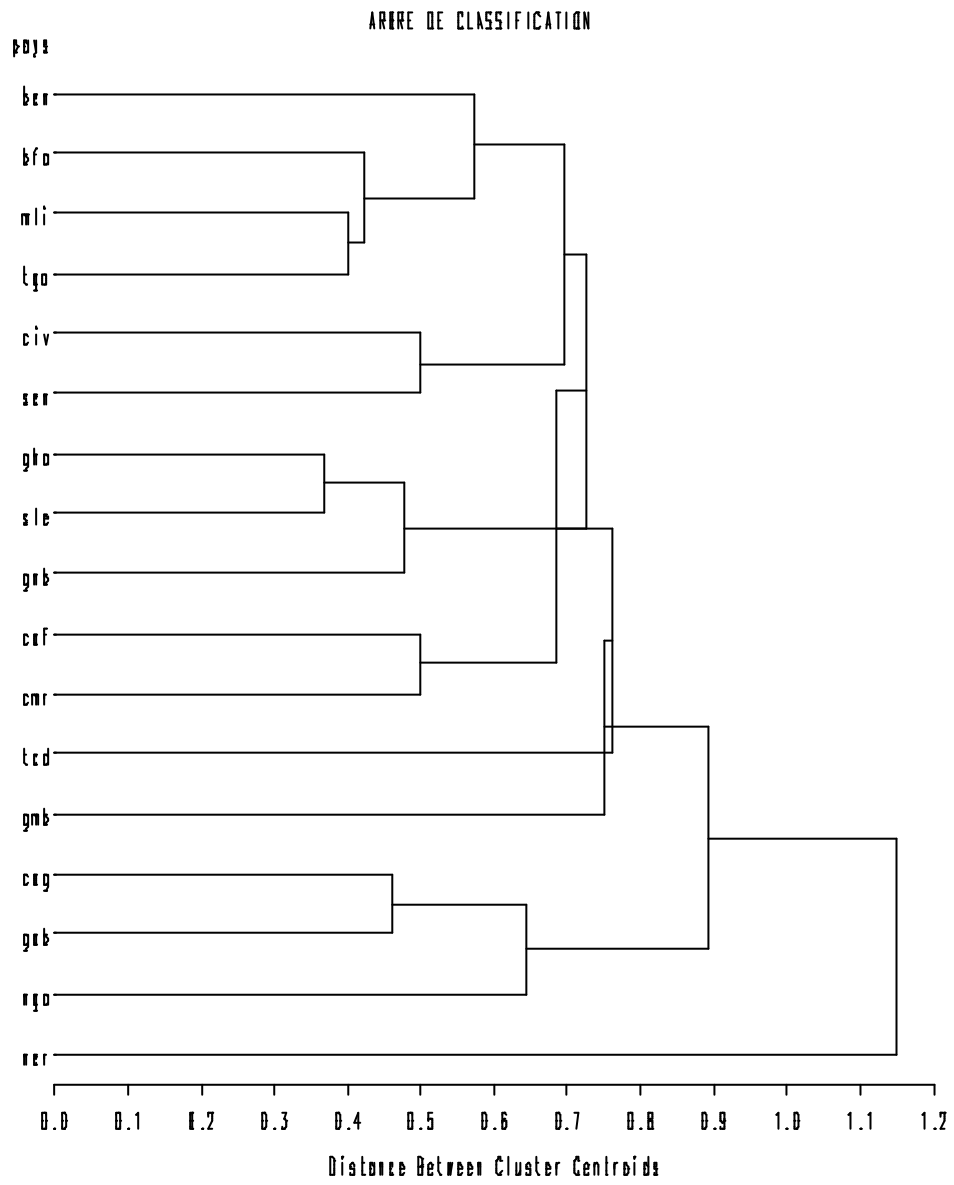
Appendix 4: the results with alternative aggregation methodologies

Baseline case

Ward		Centroid		Average	
2	Benin	2	Benin	2	Benin
2	Burkina Faso	2	Burkina Faso	2	Burkina Faso
2	Mali	2	Mali	2	Mali
2	Togo	2	Togo	2	Togo
5	Senegal	2	Senegal	5	Senegal
5	Côte d'Ivoire	2	Côte d'Ivoire	5	Côte d'Ivoire
5	Gambia	2	Gambia	5	Gambia
4	Cameroon	2	Cameroon	1	Cameroon
4	Central Afr R.	2	Central Afr R.	4	Central Afr R.
4	Chad	4	Chad	1	Chad
1	Ghana	2	Ghana	1	Ghana
1	Guinea Bissau	2	Guinea Bissau	1	Guinea Bissau
1	Niger	1	Niger	1	Niger
1	Sierra Leone	2	Sierra Leone	1	Sierra Leone
3	Congo	3	Congo	3	Congo
3	Gabon	3	Gabon	3	Gabon
3	Nigeria	3	Nigeria	3	Nigeria

Source: cluster analysis.

Merging tree (Centroid method)



Merging tree (average method)

