CHAPTER 4

Euro-dollar Exchange Rate and Developing Country Trade Balances: An Empirical Investigation

4.1 Introduction

The European Monetary Union (EMU) formation process was completed several years ago. Many studies were devoted to external consequences of the newly born EMU on various areas outside the union[1] but only a little amount of literature is devoted to the possible implications of the euro advent on the economies of Sub-Saharan Africa (SSA) (see Konate (2001) and Nyembwe (2003)). However, it seems that one of the great challenges many countries of this region could face is to manage the external effects of the EMU policies. Such effects, if they exist, cannot be avoided but they have to be managed. Hence, developing country (DC) policymakers could base themselves on a better knowledge of the current bipolar international monetary system implications to improve economic policy implementation and management. The possible impact of the euro-dollar exchange rate (ER) on DCs is the external effect in which we are interested in.

The behavior of the euro was treated in the prospective literature much before

[1]For example, Benassy-Quéré (1996) and Benassy-Quéré and Larèche-Révil (2000) deal with the anchorage of the Central and Eastern European Countries currencies to the euro while Levy Yeyati and Sturzenegger (2000), Verner (2000) and Miotti et al. (2002) treat of the EMU advent implications for Latin America. Even if Northern Africa countries are also concerned in some analyses like in Ruhashyankiko (1999), the Sub-Saharan Africa is ignored.

its advent. Invoking the *reciprocal benign neglect* argument, Benassy-Quéré et al. (1997) and Cohen (1997) argued that the euro-dollar ER should be more volatile than the ante-EMU European currencies or a basket of these currencies' ER vis-à-vis the dollar. Nevertheless, other studies (Martin, 1998; Benassy-Quéré and Mojon, 2000) concluded that the euro that was to come should be less volatile than the preceding European currencies. This inconclusive investigation raises an interesting issue for African Economies: Will the increased (decreased) volatility of the euro matter for African countries? Answering this question would require understanding the mechanism through which the euro-dollar ER variations can affect these economies.

The theory of trade invoicing and practices in international trade allow us to link the euro-dollar ER to African economies. As the *Grassman's law* states that trade in manufactured goods between developed countries is generally executed in the exporter's currency, it is observed on one hand that trade between developed and developing countries is invoiced either in the currency of the developed country or in dollar, and on the other hand that the dollar is the main currency in which trade in primary goods is denominated (ECU Institute, 1995, and references therein). Theoretical and empirical studies argue that the use frequency of the exporter's currency to invoice trade is positively related to the market share, the product differentiation and the country size (see for example Bacchetta and van Wincoop, 2002; Donnenfeld and Haug, 2003). As for SSA's countries, they are small compared to their trading partners of the industrialized world and they mainly export primary goods of which the degree of differentiation is low. That is why African exports and imports are not invoiced in domestic currencies. We postulate that SSA's imports are mostly invoiced in euro (formerly in European currencies) because the European Union appears to be their main trading partner while their exports are invoiced in dollar which is the main currency of price expression on the international commodity stock exchange.

Thus, the African countries trade balances (TBs) are likely to be directly affected by changes in the euro-dollar ER. An increase or a decrease of the volatility of the euro could then have a direct impact on the nominal African TBs. The more volatile the euro-dollar currency, the more volatile the African TB's will be. The aim of this study is to investigate the invoked possible channel by looking for a theoretical and empirical link between the African TBs and the euro-dollar ER.

A reason why only few studies focus on African countries is the scarcity and the doubtful quality of data which make empirical investigations difficult. This is an additional challenge for us as we can follow Hoffmaister et al. (1998a) by tackling this problem and attempting to draw any interesting information from existing data. More-

over, when it is necessary, we build relevant data from the existing ones in order to be consistent with the theoretical framework assumptions.

Section two will be devoted to an analytical framework of our typical SSA's country TB. We will suggest a definition of Sub-Saharan African country TB that gives channels through which the expected behavior of the euro could be influential for the economies of developing country.

In Section three, we will perform an empirical investigation through crude stylized facts on which the theoretical framework is based.

Finally, we will discuss, in Section four, the methodology and data we use before undertaking our formal econometric bivariate analysis of the possible impact of the euro-dollar ER to African TBs. Time series methodology will be used, especially the transfer function model's estimation. We simply intend to test the extent to which euro-dollar ER movements contribute to the changes in the TBs of countries under study. A three variable multivariate analysis is performed to check the robustness of our results. A concluding section will highlight our findings.

4.2 Theoretical Framework

Here we discuss the theoretical framework on which we build our empirical investigations. There are at least two channels through which the advent of euro could entail external effects on DCs, especially the sub-Saharan countries in Africa. On the one hand, there are trade links between European countries and many of these African countries. The euro behavior matters because the euro is one of the currencies used in the trading partnerships. On the other hand, we can invoke financial interactions through which changes in the euro ER could be dramatic for many African economies. The fact is that their debt service can be affected by euro value changes because the European Union is a major creditor and the euro is poised to be a money of debt labeling. This framework deals with the trade flows channel but also highlights what is different if a country pegs its currency on the euro or not.

4.2.1 Direct Price Effect and the Expected Behavior of the Euro-dollar Exchange Rate

This analysis focuses first on the implications of having the newly born monetary union as the main trading partner in a bipolar international monetary system in which the euro and the dollar are the most used currencies. We use a simple trade balance model — an approximation of the current account — for the purpose of illustrating the

intuitive reasoning. An index is used in place of a usual additive equation in order to easily derive the euro-dollar exchange rate (ER)[2]. We recall first that exports in many developing countries are mostly composed of raw materials and commodities that are usually invoiced in dollar. Then, taking into account the fact of having European countries as the main import provider — imports being invoiced in the major trading partner, the following small country trade balance expression can be retained:

$$TB = \frac{P_x.X}{P_m.M} \tag{4.2}$$

where $P_x = P_{\$}.E_{\$}$ and $P_m = P_{€}.E_{€}$

P_x and P_m are respectively the export and import prices in the domestic currency while $P_{\$}$ and $P_{€}$ are the prices of exports and imports respectively invoiced in dollar and in euro. We assume that they are fixed as we are interested in highlighting the impact of ER movements[3]. $E_{\$}$ and $E_{€}$ are respectively domestic currency ER vis-à-vis the dollar and the euro. Replacing P_x and P_m by the definitions given above and transforming in logarithm form, we get:

$$tb = (x - m + p_{\$} - p_{€}) + (e_{\$} - e_{€}) \tag{4.3}$$

where tb, x, m represent respectively trade balance, exports and imports of the DC while $p_{\$}$ and $p_{€}$ are the export and the import prices in the foreign currencies. $(e_{us} - e_{€})$ is the euro-dollar ER since $e_{€}$ and e_{us} are respectively the euro and the dollar ER in the small country currency. All variables are deviations from equilibrium values and are expressed in logarithm. This equation is the expression of a typical African country TB after the completion of the EMU formation process. It is noticeable that a change in the euro-dollar ER $(e_{\$} - e_{€})$ has a direct effect through price changes on a typical small African country TB. More precisely, it can be expected that a percent change in the TB of such a country is likely to be originated by a percent change in the euro-dollar ER. Because of this relation, the debate on the behavior of the euro turns out to be interesting.

Whether the euro will be a more volatile currency — vis-à-vis the dollar — than the former European currencies is discussed in the literature without a clearcut consensus. Although, whether the greater volatility and the appreciation of euro will occur or not is a debate beyond the scope of this chapter. We merely note that DCs are likely

[2] $TB > 1$ and $TB < 1$ mean respectively that the trade balance is positive and negative.

[3] This is consistent with the traditional J-curve small country case (see for example Lindert, 1991).

to be affected by the actual euro movements. The invoked *benign neglect* approach (see for example Benassy-Quéré et al., 1997), the strong depreciation of the euro after two years of official existence [4] and its sharp appreciation from the second semester of 2003 suggest that swings of the euro have to be expected. From a relatively realistic prospective view, it can be argued that movements of a volatile euro is likely to entail dramatic changes in some critical developing countries economic values, e.g. trade revenues, debt service or international reserves.

Proposition 1 *For African countries whose exports are mainly invoiced in dollar while their imports are invoiced in euro, a volatile euro against the dollar is expected to transmit its volatility to the nominal TB.*

4.2.2 Global Euro-dollar Exchange Rate Effect When the Euro Depreciates

The direct price effect analyzed above is only a partial outcome of the euro-dollar ER. According to the traditional literature on the implications of a devaluation on TBs, an additional volume effect is likely to be observed in the aftermath of an early nominal effect (price effect). Equation (4.3) can be extended as a particular expression of the traditional trade balance. Consider the following equation:

$$tb = x(y_{€}, p_x) - m(y, p_m) + (p_{\$} + e_{\$}) - (p_{€} + e_{€}) \tag{4.4}$$

Exports(x) and imports(m) are now expressed as functions of the EMU real revenue ($y_{€}$), domestic real revenue (y), and prices (p_x and p_m). Notice that the export price (p_x) is equal to ($p_{\$}+e_{\$}$) while the import price (p_m) is equal to ($p_{€}+e_{€}$). We also recall that, since the euro-dollar ER is equal to ($e_{\$} - e_{€}$), its change is a combination of a change in the domestic currency ER against euro and dollar. Three different cases will be an expression of a change of the euro value in terms of the dollar. Our point is not to determine whether the net effect will be positive or negative when the euro-dollar varies. We are merely interested in the description of the subsequent TB movements in the aftermath of the euro-dollar exchange rate[5]. The three cases are:

The euro depreciation against the dollar and a home currency depreciation against the euro

[4] According to European Commission (2001), the nominal effective exchange of the euro was 13% lower than at launch while the real effective ER depreciate by 17% by the end of 2000.

[5] The exports and the imports can easily expressed as depending on relative prices; what will lead to a similar econometric specification.

Consider first that the dollar appreciates in comparison to the euro while the domestic currency depreciates more vis-à-vis the dollar than the euro does; what is expressed by $e_{\$} > e_{€} > 0$. Even if we assume that the price elasticity of export demand by EMU consumers ($|\eta_{x/p_x}|$) is lesser than the one of domestic import demand ($|\eta_{m/p_m}|$), the net effect is undetermined but two opposite movements will occur. Indeed, the euro depreciation against the dollar will firstly entail an improvement of the TB through the direct price effect before a deterioration takes place as the volume effect makes exports and imports decrease.

The euro depreciation against the dollar and the home currency appreciation against the euro

In this case, a depreciation of the euro vis-à-vis the dollar is expressed by $e_{\$} > 0$ and $e_{€} < 0$. After a initial positive impulse through the direct price effect, a deterioration of the TB is expected because of the volume effect. An increase of export price ($p_x > 0$) due to the appreciation of the dollar vis-à-vis the home currency ($e_{\$} > 0$), will lead to a fall in export volume while a decrease of import price (p_m) due to the depreciation of the euro expressed in terms of home currency ($e_{€} < 0$) will lead to an increase of imports. As a result, a depreciation of the euro against the dollar is likely to first improve and then deteriorate the TB of our typical small developing country.

The euro depreciation against the dollar and the home currency anchorage to the euro

Now consider that the home currency is anchored to the euro. It means that we have $e_{\$} > 0$ and $e_{€} = 0$ as we assume that the value of the home currency in terms of the euro is fixed. A depreciation of the euro against the dollar will work only through changes in the export value. The initial price effect that makes the TB to improve through the export value increase ($p_x > 0 \Rightarrow tb > 0$) is followed by a deterioration ($tb < 0$) due to volume effect that works like this: $p_x > 0 \Rightarrow x < 0 \Rightarrow tb < 0$. It is clear that in the case of an anchorage of the home currency to the dollar, we obtain the same TB *improvement-deterioration* effect when the euro depreciates against the dollar. But all the effect is obtained through changes of the value and the volume of exports.

Proposition 2 *A depreciation of the euro against the dollar is likely to induce an improvement of a typical SSA's country TB through a price effect before a decline take place because of a volume effect. Thus, it can be expected that frequent changes of the euro-dollar ER entail frequent movements of the TB.*

4.3 Some Stylized Facts: EMU vs SSA Trade Relationships

As a preliminary step to look for any empirical link between the euro-dollar ER and some African TBs, this section is going to provide some stylized facts which are the background of our theoretical model from the preceding section.

A very interesting fact featuring economic interdependence between SSA and the EMU is that the latter turns out to be a major provider of imports. For countries like Senegal, Mauritania, Comoros or Cameroon, the amount of European products represent on average more than 60% of the total imports for the nineties. Moreover, Cape Verde has recorded on average for the same period 70% of its total import provided by European countries. Furthermore, the share of SSA's country imports that are provided by the United States (US) is small. For the countries shown in the table 4.7, only Angola and Sao Tome and Principe have recorded in average 12,9% and 14,44% of their total imports from the US. But for the all other countries, the share of US products in the total imports was on average between 0,16% and 9,74% during the same period under review. Moreover, the whole European Union (EU) has a larger share in the SSA import brakdown by provider. Inasmuch as basic commodities represent the larger part of SSA's countries exports which are mainly invoiced in dollar, the fluctuations of the euro-dollar ER are likely to have an impact on the current accounts of SSA's countries.

As shown in Table 4.8, exports to EMU represent the larger part of total exports for many SSA's countries. Actually, as in case of the imports, the differences of magnitude between flows to EU and EMU are very small. The fact is that the expected further convergence in European Union makes the table of exports to the EU relevant. Considering for example 1997 in Table 4.8, we see that for many the studied countries, the exports are mainly directed toward EU countries. The share of products exported to EU countries in total exports are 69%, 71%, 88% and 68% for respectively Cameroon, Sierra-Leone, Sao-Tome and Principe and Uganda. Then, the spillover effects of variations of EU or EMU economic activity are likely to affect African economies.

The intuition behind the model of the trade balance we proposed is based on the fact that exports are mainly basic commodities or raw materials that are invoiced in dollars on international places. Depending on data availability, we present in Table 4.1 the shares of non-manufactured goods in the total merchandise exports of some SSA's countries.

Except for Mauritius, which mainly exports manufactured goods, all other countries of interest whose data are available were exporting mainly basic commodities or raw ma-

Table 4.1: Shares of Non-manufactured Goods in Total Exports in % by category.

Countries	Fuel	Ores and Metals	Agricultural raw mat.	Food	Total
Angola (1990)	93	6	-	-	99
Benin (1999)	1	-	80	15	96
Cameroon (1990)	50	7	14	20	91
Guinea (1999)	-	71	1	8	89
Kenya (1999)	8	3	8	58	78
Madagascar (1990)	1	8	4	73	86
Malawi (1990)	0	0	2	93	95
Mali (1999)	0	0	94	5	99
Mauritius (1999)	0	0	0	24	24
Niger (1999)	0	67	1	29	97
Senegal (1990)	17	10	3	53	83
Togo (1999)	0	27	34	21	82

Source: World Bank, *World development indicators, 2001.*

terials until 1999. For countries like Senegal and Madagascar whose non-manufactured goods exports accounted for less than 50% of the total in 1999[6], the model we suggest holds for the period before 1999.

4.4 Empirical Investigation of the Euro-Dollar Exchange Rate Impact

This section is devoted to the study of European Monetary integration externalities through trade links as explained in the preceding section. We try to answer the following questions: Are the nominal current balance of some developing countries sensitive to variation of euro-dollar ER given the trade invoicing pattern ? Does the volatility of the euro-dollar ER affect African TBs? The investigation of volatility transmission issue, which is our main concern, closely depends on the answer to the first question as explained below.

4.4.1 Methodology and Data

Our theoretical framework suggests an improvement of our typical African TB followed by a deterioration when the euro depreciates against the dollar. By the direct nominal effect, the TB has to be improved before the price effect works as in the traditional J-curve model. It follows that volatility could be transmitted from the euro dollar exchange rate to an African TB.

[6]See data of World Bank *World Development Indicator of 2001.*

The use of an empirical version of the J-curve model is impossible because there are neither quarterly GDP data nor their proxies for African countries. That is why a bivariate time series methodology is used. The aim is to investigate the empirical evidence of the link suggested between the euro-dollar exchange rate and the TBs of some African countries. Failing to find any empirical link means that the volatility transmission cannot be confirmed by the available data.

Since we assume that, on the one hand, the euro-dollar ER could have an impact on African country TBs but on the other hand, the converse is not true, an appropriate method for our study is the estimation of transfer functions (see Enders, 1995, chap. 5) that could capture the effect of the euro-dollar ER on SSA's country TBs. But before looking for the existence such functions, a test of cointegration and Error Correction Model (ECM) validation is applied. We will look for the existence of a transfer function model if the data are not proved to be cointegrated and the ECM fails to fit the data.

Consider the following transfer function model:

$$y_t = a_0 + A(L)y_{t-1} + C(L)z_t + B(L)\epsilon_t \tag{4.5}$$

where A(L), B(L) and C(L) are polynomials in the lag operator L. y_t and z_t are respectively the TB of a SSA's country and the euro-dollar exchange rate in the period t while ϵ is a white noise. C(L) is called the transfer function because it depicts how a movement in the exogenous variable, z_t, will influence the endogenous variable y_t according to a specific path time. If this impact is robust, z_t will be used to predict future values of y_t.

Our task is to estimate a parsimonious model, assuming that innovations in y_t have no effect on the z_t sequence, so that $Ez_t\epsilon_{t-i} = 0$ for all values of i and t. Thus, as the first step, we have to calculate the cross-correlations between y_t and the different z_{t-i}:

$$\rho_{yz}(i) \equiv \frac{cov(y_t, z_{t-i})}{\sigma_y \sigma_z} \tag{4.6}$$

where σ_y and σ_z are respectively the standard deviations of y_t and z_t. Failing to get at least one significant cross-correlation coefficient leads to rejection of any impact of z_{t-i} on y_t. The parsimonious model that will be drawn will not contain any z_{t-i} and no transfer function will prevail if none of C(L) element is considered as different from zero.

The critical value at 5% level of significance is the standard deviation of cross-correlation coefficient multiplied by two, i.e. two standard deviations. A calculated

positive (negative) coefficient will be significant if it exceeds (or is less than) two standard deviations. The standard deviation is obtained from the following expression:

$$s_{yz}(i) = (T - i)^{-\frac{1}{2}} \tag{4.7}$$

where T is the number of usable observations.

Conversely, finding significant cross-correlation coefficients implies a Box-Jenkins like methodology to determine the accurate transfer function C(L) that will allow for measuring the impact of a change in z_t on y_t.

If the z_t sequence is a stationary ARMA process of the form:

$$D(L)z_t = E(L)\varepsilon_t \tag{4.8}$$

where $D(L)$ and $E(L)$ are polynomials in the lag operator L and ε_t a white noise, we will use the residuals $\hat{\varepsilon}_{zt}$ from the estimated model to replace the z_t sequence as the residuals are expected to be white noises. They will be combined with a filtered y_t sequence, noted y_{ft} and obtained by multiplying y_t by $D(L)/E(L)$.

As regards the data, we have constructed bilateral quarterly TBs of ten African countries for which either the main trading partners or the main import providers are EMU country members. We also constructed a quarterly weighted euro-dollar ER indicator (WEDER). Our sample is composed of ten SSA's countries for which data were available, namely Angola, Benin, Cameroon, Congo, Gabon, Guinea, Ivory Coast, Mali, Niger and Togo.

The TBs we obtained are in domestic currencies. They were built from export and import series of the IMF Direction of Trade (DOT), given in dollar. Domestic exports and imports of African countries to and from European countries are first converted into European currencies, and then into domestic currencies, using ERs given in the IMF International Financial Statistics (IFS).

Moreover, euro-dollar ER indicators are obtained using quarterly bilateral ERs against the dollar, weighted by the import shares of each European country in imports of African countries. All the ERs used are the average value for the periods considered.

The WEDERs were then used to compute real exchange rate (RER) indicators as they were multiplied by export price indicators and divided by the indicator imports from the EMU (a mixed index of wholesale and export price of the Euro area). The short term movements of the RERs are expected to initially affect positively the TB and then to have a negative impact. It means that the theoretical euro-dollar ER effect will be confirmed by data if, at least, the first significant coefficient of the RERs (z_t)

on the TB (y_t) has a minus sign while the following coefficients have a plus sign. All the data are transformed in logarithm.

4.4.2 Estimating Transfer Functions

Now we turn to the estimation of plausible transfer function models in the form of Equation 4.5 where the TB of each studied country is the dependent variable (y_t) and the euro-dollar RER is the independent variable (z_t). The TB is the logarithm of the ratio of exports to EMU on imports from EMU.

The first step of our time series analysis is the test for the presence of unit roots in our various series. For all the series, we perform the Augmented Dickey-Fuller (ADF) which is widely used. As Table 4.2 shows, the rejection of unit roots prevails for almost all the TB series, but for Benin , Cameroon and Gabon, while six of the ten RER series are generated by Difference Stationary (DS) processes. The appropriate transformations are done below before proceeding to next step.

Table 4.2: The ADF test results

Country	series	Types***	ADF	
			t-stat**	critical value*
Angola	TB	No u.r.	-4.816389	-3.4681
	RER	DS	-1.511519	-1.9445
Benin	TB	DS	-1.382846	-1.9445
	RER	No u.r.	-2.505374	-1.9445
Cameroon	TB	DS	-1.552643	-1.9442
	RER	DS	-1.540214	-1.9443
Congo	TB	No u.r.	-6.433205	-3.4673
	RER	DS	-0.499072	-1.9444
Gabon	TB	DS	-1.814034	-1.9445
	RER	DS	0.041537	-1.9445
Guinea	TB	No u.r.	-5.483921	-2.8986
	RER	DS	-1.408637	-1.9444
Ivory coast	TB	No u.r.	-5.167915	-2.8986
	RER	DS	-1.907215	-19445
Mali	TB	No u.r.	-4.912178	-2.8986
	RER	No u.r.	-2.323523	-1.9445
Niger	TB	No u.r.	-3.876116	-3.4696
	RER	No u.r.	-3.876116	-3.4696
Togo	TB	No u.r.	-5.835685	-3.4673
	RER	No u.r.	-3.802509	-3.4696

*MacKinnon critical values for rejection of hypothesis of a unit root at 5% level.
** The t-stat. are those we use to accept or reject the unit roots null hypothesis.

The appropriate number of lags for the autoregressive process used to perform the ADF test is determined by the Schwarz Bayesian criterion (SBC) and the Akaike information criterion (AIC). When the two criteria lead to different results, the SBC will be used as a last resort. Indeed, the SBC allows to select a more parsimonious model than the AIC (see Enders, 1995, chap. 2).

We are checking for the existence of cointegration between the y_t and z_t of Cameroon and Gabon, following the Johansen methodology. The results (see Table 4.9) do not

indicate the presence of any cointegration at standard significance levels. For all the rest of the couples of series, the necessary condition of having the same order of integration was not fulfilled. All variables that are DS in Table 4.2 are integrated of order 1 ,(I(1)), the other being stationary (I(0)).

The second step of our analysis is the estimation of the process that generates the different series of the weighted euro-dollar RER indexes. Since (z_t) series of Angola, Cameroon, Congo, Gabon, Guinea and Ivory Coast are DS, we use their first differences in the rest of the analysis below, i.e. Δz_t.

We fit ARMA models to almost all the RERs since appropriate tests indicate that they are not white noises (only the Cameroon RER series appears to be a white noise). We have checked the accuracy of our estimations by testing the residuals that turn out to be white noises. The parsimonious models we retained are reported in Table 4.3. The residuals are stored to be used as pure innovation in the RER sequences.

Table 4.3: Parsimonious models for the weighted euro-dollar indexes of each country

Series	Model	Filter $\frac{D(L)}{E(L)}$
Angola	$\Delta z_t = (1+0.43L)\varepsilon_t$	$1-0.43L+0.19L^2$
Benin	$z_t = 0.88z_{t-1} + (1+0.37L)\varepsilon_t$	$1+0.51L-0.19L^2$
Cameroon	*White noise*	*No filter*
Congo	$\Delta z_t = (1+0.41L)\varepsilon_t$	$1-0.41L+0.17L^2$
Gabon	$\Delta z_t = (1+0.43L)\varepsilon_t$	$1-0.43L+0.17L^2$
Guinea	$\Delta z_t = (1+0.30L)\varepsilon_t$	$1-0.30L+0.08L^2$
Ivory Coast	$\Delta z_t = 1.24\Delta z_{t-1} + (1-0.29)\varepsilon_t$	$1+1.24L-0.29L^2$
Mali	$z_t = 1.32z_{t-1} - 0.35z_{t-3} + (1-0.23L-0.75L^2)\varepsilon_t$	$1+1.5L+0.35L^2-0.27L^3$
Niger	$z_t = 0.94z_{t-1} + (1+0.32L)\varepsilon_t$	$1+0.62L-0.2L^2$
Togo	$z_t = 0.93z_{t-1} + (1+0.44)\varepsilon_t$	$1+0.93L-0.41L^2+0.18L^3$

Since all the z_t — or Δz_t —, but that of Cameroon, are not white noises, we need to build a filter for y_t series in order to compute cross-correlograms of the two variables. Table 4.3 also shows the filters to be used. Each y_t is multiplied by the appropriate filter —$\frac{D(L)}{E(L)}$ — to obtain the filtered TB series, y_{ft}, that will finally be used.

Then, we perform the cross-correlograms between the y_{ft} and the stored residuals to look for significant coefficients. For Cameroon, we don't need to use the residuals, as the z_t proves to be the right series. Table 4.4 contains the cross-correlation coefficients that allow to select the candidate transfer function models to fit. The lower part of the table gives the significance levels at 5% for various size (T) of samples. The coefficients in bold are significant when compared to the 5% level value. The range of lags we consider is 0 to 8 quarters because we assume that all effect of the real exchange rate change has to be observed during the following two years.

We find one cross-correlogram coefficient that is significant for four countries, namely Angola (lag 8), Gabon (lag 5) and Mali (lag 2). The Benin case is the unique that exhibits more than one significant coefficients, i.e.; the coefficients at lags 0, 1, 4, 6 and 8 are all significant at 5% level. Togo's line displays two coefficients whose values are close to the limit of significance for lags 5 and 8. We take these lags into account when performing our tests, as well as the lag 3 for Angola as the coefficient at this lag is somewhat close to the limit too. The comparison of the coefficients with the critical values leads us to test various candidate transfer function models for each of the five countries mentioned above.

Table 4.4: Cross-correlation coefficient for selection of candidate transfer function models and the significance at 5% level

Lag (i)	0	1	2	3	4	5	6	7	8	T
Angola	0.0827	-0.0470	0.0627	0.1978	-0.1605	0.1054	-0.0209	0.0808	**-0.2479**	77
Benin	**0.3374**	**0.2637**	-0.0779	0.1828	**0.2489**	0.1404	**0.2866**	-0.1381	**0.2605**	76
Cameroon	0.0134	0.1371	0.0267	0.0800	-0.0653	-0.0030	-0.1431	0.0660	0.0286	82
Congo	0.0099	0.0462	0.0430	-0.0366	-0.1802	0.0569	0.0140	0.0103	0.1337	77
Gabon	0.0334	0.0464	0.0576	-0.0547	-0.1463	**0.2439**	-0.1340	0.0232	-0.0909	76
Guinea	0.0953	-0.1569	0.0232	-0.0604	-0.0729	-0.0448	-0.1310	0.0048	0.1029	77
Ivory Coast	-0.1551	-0.0556	0.0036	-0.0059	0.0935	0.1148	0.0576	0.0781	0.1139	77
Mali	0.0058	-0.1611	**-0.2883**	-0.0459	0.1128	-0.0703	-0.1349	-0.0187	0.0657	79
Niger	-0.0526	-0.0286	-0.0255	0.0529	0.1081	0.1068	-0.0010	0.0659	0.0179	77
Togo	0.0087	0.0832	-0.0790	-0.0943	0.1143	0.1956	0.0051	0.0421	**0.2265**	76
Critical	0.221	0.222	0.224	0.225	0.226	0.228	0.229	0.231	0.232	$T = 82$*
values	0.225	0.226	0.228	0.229	0.231	0.232	0.234	0.236	0.237	$T = 79$*
at	0.228	0.229	0.231	0.232	0.234	0.236	0.237	0.239	0.241	$T = 77*$
5% level	0.229	0.231	0.232	0.234	0.236	0.237	0.239	0.241	0.243	$T = 76*$

* T gives number of observations for with the significance levels are computed.
Bold format shows cross-correlogram coefficients that are significant.

We have retained the best candidate model, basing ourselves on the AIC and SBC. Table 4.5 gives transfer functions (the best candidate among many others by country) that we managed to test. Apart from the case of Benin, the coefficients of the z_t (or Δz_t) have not been significant, implying that there is no valid transfer function. Considering the Benin case for which a transfer function can be validated, we notice that a depreciation of the euro against the dollar seems to improve the TB with a significant positive impact at lags 0, -1 and -8. Apparently, the "inverted J-curve"–like effect we described does not completely work because only the initial positive effect seems to be confirmed. But remember that the euro-dollar series is in level while the TB series is first difference. Thus, a smaller change observed at lag -8 could mean that a depreciation of the euro-dollar RER entails a weaker change after an increase (of the change) from lag 0 to -1. This meets partially the "inverted J-curve" dynamics we described. The positive impact of a euro depreciation increases before decreasing.

The absence of a RER impact on TBs for nine out of the ten countries of our sample is confirmed by the bivariate analysis performed with data that are not transformed in logarithms and when the nominal exchange rate is the explicative variable. In fact, no

Table 4.5: The best candidate transfer function models estimated

Country	transfer function model	AIC/SBC
Angola	$y_t = 0.77y_{t-1} + 0.46\Delta z_{t-3} - 0.31\Delta z_{t-8}$ (9.5) (1.83) (-1.21)	0.82/0.92
Benin	$\Delta\, y_t = -0.32\Delta\, y_{t-2} + \mathbf{3.17}^*\, z_t + \mathbf{4.82}^*\, z_{t-1} + \mathbf{2.75}^*\, z_{t-8}$ (-2.9) **(2.74)** **(4.16)** **(2.41)**	1.51/1.63
Gabon	$\Delta\, y_t = -0.69\Delta\, y_{t-1} - 0.40\Delta\, y_{t-2} + 0.37\Delta\, z_{t-1}$ (-6.39) (-3.67) (1.28)	0.64/0.73
Mali	$y_t = -3.14 + 1.58\, y_{t-1} - 1.51\, y_{t-2} + 1.16\, y_{t-3} - 0.49\, y_{t-4} - 0.28\, z_{t-2}$ (-11.80) (14.65) (-8.89) (6.86) (-4.54) (-0.58)	1.83/2.02
Togo	$y_t = -2.25 + 0.78\, y_{t-1} - 0.47\, y_{t-2} + 0.45\, y_{t-3} + 0.99\, z_{t-5}$ (-8.15) (7.04) (-3.47) (4.01) (1.16)	1.77/1.93

(*****) indicates the transfer function coefficients that are significant at 1% level.

valid transfer function could be obtained according to the standard levels of significance, even for Benin. But the use of data in logarithms and the RER as an explanatory variable of the TB behavior is more in line with the existing literature. Moreover, the use of data in logarithms is more appropriate, given our theoretical model.

As we noticed above, a drawback of our bivariate analysis is that it does not completely reflect the theoretical model. We possibly loose the information that domestic and trading partner GDPs contain. We attempt to check the robustness of our findings by performing a multivariate analysis. An additional variable for which quarterly data are available is included, namely the EMU real GDP that we write as w_t. We choose to conduct a cointegration analysis followed by a VECM estimation when it can be validated. Notice that this multivariate analysis remains incomplete as data of African quarterly real GDP are not available.

Because of the pattern of the EMU GDP series, we impose an intercept (C) both in the CE and in the VARs. We include 7 lags in the model as we assume that two years is the normal period during which an impact of a RER change has to be observed. Under this assumption we perform Johansen cointegration tests and find the existence of one cointegrating equation (CE) only for Benin. For all other countries the cointegration hypothesis is rejected (See Table 4.10 in Appendix). Indeed, the null hypothesis (H_0) of zero CE can be accepted when the λ_{trace} is lesser than the critical value at 5% level (This means the rejection of the existence of any cointegration). According to the results shown in Table 4.10, a VECM can be estimated only for Benin. The results are contained in Table 4.11.

Contrary to the long-run relationship between y_t, z_t and w_t that the result of Johansen cointegration test suggests, the interpretation of the VECM turns out to be somewhat ambiguous. Actually, the constrained coefficients of the cointegrating equation are not significantly different from zero, casting doubt on the existence of a long-run (equilibrium) relationship between the TB of Benin, the euro-dollar exchange rate and the GDP of EMU. However, we base ourselves on the Johansen test results to maintain a long-run relationships component in the VECM. Neglecting this weakness, we can in turn notice that the cointegrating vector suggests that the TB of Benin is positively influenced by the euro-dollar RER and the EMU GDP; which is plausible. In fact, if the value effect prevails, a depreciation of the euro against the dollar will make the TB improve. The positive correlation between the TB and the EMU GDP is obvious.

Furthermore, the coefficient of the ECM term is significant and has the right sign in the TB (Δy_t) equation. Its value is small (-0.065). Conversely, the coefficient of the ECM term in the EMU GDP equation does not have the right sign. We can neglect it because of its very small value (-0.0004). This indicates that the EMU GDP is not affected by the long-run relationship with the TB of Benin and is consistent with the asymmetry in country size. All the residuals of the VECM equations are stationary according to the Ljung-Box statistics test (4.12). We, then, cautiously validate the VECM and examine its VAR components.

We first notice that the euro-dollar RER is not significantly (except for a weak impact of Δy_{t-7}) affected by the TB of Benin. This result supports our view on the exogeneity of the euro-dollar RER in our bivariate analysis. Besides, a percent change of the euro-dollar RER has an impact on the percent change of the TB of Benin. A lagged increase (at lag -5) of the change is observed and is followed by a decrease (at lag -6). This is somewhat consistent with our finding of the bivariate analysis according to which an increase in the level of the euro-dollar RER (a depreciation of the euro) causes first an increasing change (from lag 0 to -1) in the Benin TB before leading to a smaller (ever positive) change of the TB.

Indeed, the absence of any cointegrating vector between the variables of all other countries, except for Benin, also adds some support to our bivariate analysis findings. Moreover, we find similar results when estimating an unconstrained VAR model with 7 lags. Only the TB of Benin (at lags -6 and -7) exhibits a significant lagged impact of the euro-dollar RER.

This weak evidence of euro-dollar RER impact on African trade balances can be partly explained by the recording methods of trade flows and a particular settlement process of African exports during the eighties. By convention, exports (or imports) are

recorded in many countries only when the buyer actually becomes the owner (IMF, 2003). However, there is a lag between shipment of an export and receipt of an import, especially for goods that are shipped over long distances. Because of delays and contract implications that insulate trade flows from price movements, the dynamics of the impact of exchange rate variations on TBs could be difficult to actually be captured by available data. This is true for all trade data, especially for countries which have small resources to devote to data mining in order to improve data quality.

In addition, a large part of African exports are handled through economic aid package, becoming then insulated from price and exchange rate movements. For some years, orthodox practices in international trade have been enforced by the World Trade Organization which imposes the abolition of quotas and aid packages including warranted quotas of exports to the European Union as foreseen in the former Lome Agreements. African trade data that will be more suitable for analyzes like the one we performed in this chapter will probably be available in the next decades. Indeed, at that time, long series of African trade unaffected by particular settlement agreements will be available.

Given the results found above, only Benin's economy in our sample can be affected by the euro behavior vis–à–vis the dollar. The currently observed appreciation of the European currency is likely to induce a deterioration of the TB of Benin. A such outcome increases the vulnerability of SSA's economies to external shocks from which there is no way to protect. This appreciation makes the value of imports grow while the value of exports deceases. In addition, if the euro proves to be more volatile than the former European currencies, the current "quasi-bipolar" world economy will be likely to have induced a systemic risk of external balance volatility for Sub-Saharan African countries whose TBs behave like that of Benin. Nevertheless, according to our findings, this is not a general case.

4.5 Concluding remarks

The aim of this study was to deal with one of the plausible channels through which the behavior of the euro could affect the economies of the Sub-Saharan Africa, especially the impact of changes of the euro-dollar exchange rate on the trade balance of these countries. An analytical definition of a typical SSA's country trade balance shows that a depreciation of the euro vis–à–vis the dollar is likely to first entail an improvement of an African trade balance through a direct price effect. Then, this improvement is followed by a deterioration because of the volume effect which is similar to that of the traditional J-curve. In turn, our econometric estimations find a possible impact of the euro-dollar

exchange rate on the TB only for Benin. This means that the "inverted J-curve" effect is possible but can not be generalized. Of course, we have to cautiously interpret the results as the lack of data implies a "second best" empirical model specification.

Appendix

Table 4.6: Share of European country products in global imports of African countries from EMU in %: Averages for the periods studied.

Countries		Aust.	B.& L.*	Finl.	France	Germ.	Irel.	Italy	Netherl.	Port.	Spain
	Total**	0,44	6,90	0,19	19,47	8,08	0,28	8,65	10,25	35,75	9,98
Angola	80,s	0,65	6,13	0,28	22,66	11,53	0,20	10,99	12,55	26,45	8,58
	90's	0,25	7,62	0,11	16,50	4,88	0,36	6,48	8,11	44,41	11,28
	Total	9,98	6,24	0,13	47,74	8,68	0,37	9,30	13,27	0,22	4,16
Benin	80,s	18,16	5,22	0,10	43,03	6,99	0,05	10,93	12,17	–	3,31
	90's	2,36	7,20	0,16	52,12	10,26	0,67	7,79	14,29	0,21	4,96
	Total	0,57	8,20	0,67	63,22	10,11	0,92	7,52	4,82	0,23	3,74
Cameroon	80,s	0,62	5,69	0,36	66,09	10,46	0,73	7,76	4,31	0,25	3,72
	90's	0,51	10,54	0,96	60,54	9,79	1,10	7,29	5,29	0,21	3,76
	Total	0,15	6,31	0,19	65,08	5,69	0,43	11,61	7,19	0,49	2,86
Congo	80,s	0,15	3,94	0,05	73,23	5,86	0,16	7,92	4,20	0,36	4,12
	90's	0,15	8,52	0,31	57,49	5,53	0,67	15,04	9,98	0,61	1,69
	Total	0,13	4,06	0,10	75,55	5,76	0,43	5,01	6,15	0,18	2,63
Gabon	80,s	0,15	3,46	0,07	76,85	7,14	0,27	4,90	4,89	0,11	2,16
	90's	0,12	4,62	0,12	74,33	4,48	0,59	5,12	7,33	0,24	3,06
	Total	1,72	13,50	0,17	53,46	8,62	0,32	8,04	7,30	0,55	6,31
Guinea	80,s	0,45	11,31	0,16	57,08	9,81	0,35	8,04	5,69	0,52	6,59
	90's	2,90	15,54	0,18	50,10	7,51	0,30	8,04	8,80	0,57	6,05
	Total	0,37	5,76	0,56	63,12	7,56	0,63	8,09	8,47	0,29	5,15
Ivory C.	80,s	0,38	4,31	0,49	64,42	7,55	0,45	7,46	9,70	0,24	4,99
	90's	0,36	7,11	0,62	61,92	7,58	0,80	8,67	7,32	0,32	5,31
	Total	0,88	8,67	0,30	60,14	12,19	0,22	7,19	5,59	0,12	4,69
Mali	80,s	0,42	5,23	0,27	60,77	14,81	0,03	8,45	5,11	0,06	4,86
	90's	1,32	11,88	0,33	59,54	9,75	0,40	6,02	6,04	0,18	4,53
	Total	0,80	7,53	0,27	62,63	12,92	0,54	6,98	6,27	0,33	1,72
Niger	80,s	1,38	3,08	0,15	66,49	13,74	0,10	7,72	5,06	0,27	2,01
	90's	0,27	11,66	0,38	59,05	12,16	0,95	6,30	7,39	0,39	1,45
	Total	0,88	6,85	0,27	49,03	12,19	0,32	7,86	17,24	0,30	5,07
Togo	80,s	1,16	5,74	0,26	48,27	11,22	0,21	6,55	21,27	0,22	5,10
	90's	0,62	7,89	0,27	49,73	13,08	0,43	9,08	13,48	0,37	5,05

Source: Data from IMF, DOTS. The shares are calculated by the author.

* Imports from Belgium (B.) and Luxembourg (L.)are cumulated.
** "Total" stands for the whole period that covers the eighties and the nineties.

Table 4.7: Import Pattern of Selected African countries in %.

Country	From	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Average
Angola	EU	70,0	68,3	74,5	62,4	49,9	61,8	52,0	58,3	52,1	46,1	59,5
	EMU	64,0	63,6	69,0	58,4	46,5	58,1	47,3	51,1	47,5	39,9	54,5
	US	9,6	10,8	6,5	12,8	15,6	15,4	14,5	13,7	17,6	13,0	12,9
Benin	EU	53,1	54,9	52,9	50,7	53,1	51,5	49,5	48,3	48,6	47,6	51,0
	EMU	50,1	50,6	47,3	43,5	42,9	42,5	40,1	39,1	41,1	38,6	43,6
	US	5,7	5,5	4,8	3,2	5,3	4,4	3,3	5,7	4,5	3,0	4,5
Cameroon	EU	68,4	66,7	70,1	69,6	69,6	65,1	63,2	59,5	65,1	65,0	66,2
	EMU	65,2	62,6	66,8	66,3	64,5	61,0	58,4	55,4	60,5	61,9	62,3
	US	3,3	4,0	4,8	5,4	7,2	4,0	5,8	8,8	5,1	3,0	5,2
Cape Verde	Eu	81,7	76,3	72,6	68,8	87,8	83,3	67,8	63,4	83,1	86,3	77,1
	Emu	73,1	70,4	65,0	61,7	79,3	77,8	62,1	52,0	79,2	82,5	70,3
	US	4,7	3,2	2,5	11,2	2,3	3,1	22,7	8,6	4,0	2,7	6,5
C.A.R	EU	65,6	66,4	73,3	60,1	63,0	51,3	49,1	65,0	64,5	63,4	62,2
	EMU	63,5	65,5	71,8	57,6	61,4	50,2	47,2	62,8	62,3	58,2	60,1
	US	0,9	0,8	0,8	5,0	3,8	3,9	2,6	3,7	4,3	3,1	2,9
Chad	EU	65,4	68,1	80,3	69,2	64,3	62,3	67,8	60,7	54,4	49,1	64,2
	EMU	62,8	65,7	78,2	66,2	61,2	60,1	64,1	58,6	52,8	47,3	61,7
	U-S	5,3	8,9	4,2	7,5	7,2	7,2	2,1	2,6	2,3	1,9	4,9
Comoros	EU	82,4	81,0	63,1	66,4	49,0	68,5	70,5	71,5	74,5	51,3	67,8
	EMU	79,7	79,0	62,3	65,3	45,6	65,9	69,4	70,9	73,6	48,1	66,0
	U-S	0,0	0,0	0,6	0,2	0,2	0,4	0,0	0,2	0,4	0,2	0,2
Congo D.R.	EU	48,5	61,0	52,3	43,4	39,2	37,4	37,9	34,7	33,5	30,6	41,8
	EMU	45,3	57,0	46,9	39,5	36,2	35,1	35,4	31,8	31,9	29,7	38,9
	U-S	7,6	6,8	4,5	4,9	4,5	6,3	6,0	4,3	4,1	3,5	5,2
Congo Rep.	EU	66,5	65,3	63,3	62,9	71,7	78,2	85,4	62,4	59,5	56,1	67,1
	EMU	63,7	62,9	60,9	59,9	66,9	74,3	81,9	56,0	51,5	51,8	63,0
	U-S	13,5	6,7	8,7	4,3	7,9	6,9	4,5	10,1	10,3	8,8	8,2
Ivory C.	EU	62,3	59,7	56,3	54,3	53,7	58,9	54,8	56,5	57,1	53,9	56,7
	EMU	58,9	56,7	53,4	51,0	51,2	55,2	51,0	52,2	53,7	50,6	53,4
	U-S	4,5	4,5	4,0	4,8	7,0	6,6	5,3	5,8	5,3	4,0	5,2
Gabon	EU	73,1	60,1	69,0	68,6	73,6	71,4	66,6	60,2	64,4	81,7	68,9
	EMU	68,7	54,3	64,7	64,0	67,0	66,0	62,6	56,1	60,7	79,7	64,4
	U-S	6,6	8,9	6,5	6,0	6,3	7,0	6,5	7,5	6,2	3,4	6,5
Guinea	EU	60,0	52,5	49,1	48,6	55,2	52,5	47,4	50,3	52,3	54,4	52,3
	EMU	55,7	49,9	46,8	45,6	49,2	48,3	43,1	45,8	48,9	49,5	48,3
	U-S	8,0	13,6	7,8	9,0	8,1	9,6	11,4	11,7	9,6	8,6	9,7
Guinea Bissau	EU	62,5	56,6	55,6	43,0	45,4	50,1	60,2	45,3	53,9	46,4	51,9
	EMU	59,3	53,6	51,9	39,2	38,9	45,3	54,2	41,3	50,6	41,4	47,6
	U-S	1,1	1,4	1,3	1,4	0,7	0,6	7,3	3,7	1,3	1,3	2,0
Mauritania	EU	70,5	70,0	59,7	63,1	64,5	58,9	68,8	57,1	62,4	58,8	63,4
	EMU	68,8	68,0	58,0	59,1	56,9	56,1	64,1	54,0	59,1	56,5	60,1
	U-S	3,3	4,9	11,5	3,8	2,8	7,6	2,9	3,4	3,8	5,2	4,9
Madagascar	EU	68,3	58,3	56,6	54,6	50,6	53,4	53,2	50,6	49,7	57,4	55,3
	EMU	61,8	53,8	52,5	52,0	47,8	51,0	51,0	48,0	47,8	55,3	52,1
	U-S	2,4	4,0	1,4	2,6	9,0	2,9	1,9	1,6	1,6	1,4	2,9
	EU	90,5	83,5	84,0	82,8	89,4	89,5	88,0				87,4
	U-S	0,3	0,1	0,2	0,1	0,2	0,2	0,1				0,2
Sao T & P	EU	59,7	75,8	65,0	78,5	50,2	79,1	83,6	24,7	64,6	85,5	66,7
	EMU	55,6	69,0	58,2	61,1	41,6	69,5	73,4	12,7	58,7	72,3	57,2
	U-S	28,2	13,7	8,1	6,7	26,2	4,5	0,6	34,7	21,1	0,6	14,4
Senegal	EU	65,3	63,8	57,8	59,3	65,2	61,7	65,6	64,8	63,3	62,3	62,9
	EMU	62,6	61,0	55,2	56,7	61,2	57,2	61,1	61,3	59,7	59,5	59,5
	U-S	4,2	6,9	6,4	6,6	4,5	5,1	3,8	3,7	4,1	3,7	4,9

EU, EMU and U-S stand respectively for European Union, European Monetary Union and United States.
Source: IMF, *Direction of Trade Statistics, June 2001.*

Table 4.8: Shares of Export to EMU in total exports in %.

Region	1990	1991	1992	1993	1994	1995	1996	1997
Africa (all)	45	47	45	41	43	44	43	42
Sub-Sah. Africa	47	49	46	40	44	44		
Angola	36	33	32	20	24	23	20	15
Benin	24	20	44	21	39	32	28	21
Burkina Faso	41	14	12	32	30	31	24	35
Burundi	43	41	34	64	61	63	19	66
Cameroon	68	81	76	69	74	71	73	69
Cape Verde	86	80	83	25	71	64	78	75
Central African	34	57	68	81	53	57	48	48
Chad	74	60	74	69	59	66	62	63
Comoros	78	64	56	22	18	73	57	73
Congo Rep. of	61	58	60	51	54	59	56	37
Congo Dem. Rep	65	66	54	56	58	60	62	58
Côte d'Ivoire	53	55	57	53	55	57	63	53
Equatorial Guin	91	95	94	67	67	36	23	42
Ethiopia	40	54	49	51	55	62	55	52
Gabon	47	49	40	23	28	22	14	12
Gambia	52	65	76	46	46	26	73	86
Ghana	63	85	30	43	50	49	53	49
Guinea	57	57	60	60	61	65	49	39
Guinea-Bissau	56	23	54	59	51	55	72	18
Kenya	37	51	33	39	41	40	40	39
Liberia	42	55	76	67	69	72	53	48
Madagascar	46	49	50	62	63	69	70	69
Malawi	48	41	46	31	37	35	28	29
Mali	36	33	48	37	47	35	33	35
Mauritania	60	56	51	58	54	56	55	61
Mauritius	79	79	78	71	73	73	74	73
Mozambique	22	20	35	35	41	38	42	42
Niger	77	88	85	60	75	76	54	46
Nigeria	37	38	41	32	39	34	36	29
Réunion	86	81	84	82	82	86	83	83
Rwanda	64	73	85	68	64	38	30	68
Sao Tomé & Prin	72	14	80	71	57	83	86	88
Senegal	48	51	40	40	41	58	27	16
Seychelles	50	47	26	27	20	19	22	58
Sierra Leone	67	61	47	52	51	51	66	71
Tanzania	40	49	42	43	40	38	30	32
Uganda	75	75	71	67	69	79	73	68
Zimbabwe	42	43	35	33	37	36	33	33

Source: IMF, *Direction of Trade Statistics, 1998.*

Table 4.9: Johansen cointegration test results: the Cameroon and Gabon bivariate analysis

CAMEROON

Eigenvalue	λ_{trace}	5% Critical Value	1% Critical Value	$H = 0$: No. of CE(s)
Test assumption: No intercept or trend in the CE(s)				
0.029938	3.875720	12.53	16.31	None
Intercept (no trend) in the CE(s)				
0.110921	10.89010	19.96	24.60	None

GABON

Eigenvalue	λ_{trace}	5% Critical Value	1% Critical Value	$H = 0$: No. of CE(s))
No intercept or trend in the CE(s)				
0.063354	6.987373	12.53	16.31	None
Test assumption: Intercept (no trend) in the CE(s)				
0.065446	8.499501	19.96	24.60	None

Table 4.10: Johansen cointegration test results for the multivariate model

Eigenvalue	λ_{trace}	5% Critical value	1% Critical value	H_0
Angola				
0.233098	25.75219	29.68	35.65	0
0.052035	6.909032	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Benin				
0.295028	36.52979	29.68	35.65	0
0.147273	11.70843	15.41	20.04	1
L.R. test indicates 1 cointegrating equation(s) at 1% significance level				
Cameroon				
0.208434	20.80076	29.68	35.65	0
0.037381	3.270098	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Congo				
0.245849	25.79715	29.68	35.65	0
0.066534	5.763571	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Gabon				
0.220077	23.70618	29.68	35.65	0
0.074297	6.058420	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Guinea				
0.245953	24.19263	29.68	35.65	0
0.040048	4.149319	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Ivory Coast				
0.113146	15.17175	29.68	35.65	0
0.085208	6.646430	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Mali				
0.218288	25.21720	29.68	35.65	0
0.103010	7.732109	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Niger				
0.201984	25.99401	29.68	35.65	0
0.129532	9.974557	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				
Togo				
0.220420	24.82919	29.68	35.65	0
0.094693	7.150199	15.41	20.04	1
L.R. rejects any cointegration at 5% significance level				

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

Table 4.11: The estimation the VECM for Benin multivariate analysis

The cointegrating equation with normalized coefficients (ECM)

y_t	z_t	w_t	C
1.0000	− 48.27044	− 10.74886	2.346717
	(0.87)	(−0.72)	

Error Correction:	Δy_t	Δz_t	Δw_t
ECM	**-0.064579**	0.002115	**-0.000424**
	(-3.54094)	(-1.06970)	**(-2.50371)**
Δy_{t-1}	**-0.332429**	-0.002413	**-0.004520**
	(-2.41677)	(-0.16183)	**(-3.53857)**
Δy_{t-2}	**-0.364725**	-0.014847	**-0.002788**
	(-2.63843)	(-0.99070)	**(-2.17165)**
Δy_{t-3}	-0.102275	0.009336	-0.002401
	(-0.70628)	(0.59471)	(-1.78513)
Δy_{t-4}	-0.334151	0.020783	-0.001806
	(-2.31763)	(-1.32968)	(-1.34910)
Δy_{t-5}	-0.280703	0.005926	-0.001073
	(-1.92912)	(0.37564)	(-0.79421)
Δy_{t-6}	-0.208679	-0.018549	-0.000261
	(-1.47340)	(-1.20804)	(-0.19846)
Δy_{t-7}	-0.199999	**-0.028215**	-0.001366
	(-1.58620)	**(-2.06416)**	(-1.16657)
Δz_{t-1}	-0.956597	0.230620	-0.018824
	(-0.74529)	(-1.65737)	(-1.57917)
Δz_{t-2}	-1.783.543	0.025268	**0.027435**
	(-1.36847)	(0.17884)	**(-2.26666)**
Δz_{t-3}	2.712.934	0.170433	-0.012703
	(-1.92957)	(-1.11815)	(-0.97286)
Δz_{t-4}	-0.134549	0.074683	0.009372
	(-0.09185)	(0.47026)	(0.68890)
Δz_{t-5}	**3.138.200**	-0.116692	-0.004005
	(-2.22611)	(-0.76354)	(-0.30588)
Δz_{t-6}	**-5.184.643**	-0.116388	0.005164
	(-3.51937)	(-0.72876)	(0.37744)
Δz_{t-7}	1.418.616	0.069578	-0.027288
	(0.89709)	(0.40585)	(-1.85812)
Δw_{t-1}	-1.727.815	-0.277749	0.149745
	(-1.14556)	(-0.16986)	(-1.06906)
Δw_{t-2}	-1.712.793	-1.216.338	0.114661
	(-1.18282)	(-0.77481)	(0.85262)
Δw_{t-3}	-2.220.949	-1.136.231	-0.010815
	(-1.50605)	(-0.71071)	(-0.07897)
Δw_{t-4}	1.686.494	-0.673059	0.168743
	(-1.16076)	(-0.42730)	(-1.25058)
Δw_{t-5}	7.714.289	-1.038.441	0.092521
	(0.52150)	(-0.64754)	(0.67349)
Δw_{t-6}	2.318.291	-1.141.804	-0.111306
	(0.16969)	(-0.77090)	(-0.87726)
Δw_{t-7}	1.177.965	2.774.414	0.026627
	(0.86381)	(-1.87666)	(0.21025)
C	0.174083	0.014743	**0.003666**
	(-1.13720)	(0.88839)	**(-2.57883)**

(.): $t - value$ are in parentheses
In bold: the significant coefficients

Table 4.12: The stationarity test of the Benin VECM residuals

Equations	Calculated Q-statistic	α probability
Δy_t	14.360	0.572
Δz_t	17.681	0.343
Δw_t	9.928	0.870

The table χ^2 for 16 lags and 71 observations is 26.296.
The **Q-stat** is the Ljung-Box statistic calculated with 16 lags.