

# **Endogenous optimal currency areas: The case of the Central African Economic and Monetary Community**

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## **Abstract**

The Central African Economic and Monetary Community (CAEMC) has been a monetary union for several decades now. According to the hypothesis of endogenous optimal currency areas, the degree of business cycles synchronization across its member states should be significantly higher today than 40 years ago. This paper examines cycle synchronization along three different statistical dimensions and shows that (i) synchronization has remained low throughout the period 1960-2007, but (ii) it has marginally increased over time. These findings bear important implications for the design of the economic integration process in Africa. A chronology of business cycles in CAEMC countries is provided.

**Keywords:** Business cycles, turning points, synchronization, optimal currency areas.

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## 1. Introduction

Monetary unification is nowadays a key objective of many African regional economic communities (REC)<sup>1</sup>. As a consequence, a lively debate on whether specific regional clusters of African countries configure as optimal currency areas (OCA) is currently ongoing (see for instance Agbeyegbe, 2008; Bangake, 2008; Carmignani, 2006; Fielding et al. 2004, Karras, 2007). Most of the existing research however focuses on the *ex-ante* assessment of conditions for an OCA. The issue of the potential endogeneity of OCA is instead largely neglected<sup>2</sup>. The purpose of this paper is to fill in the gap. Its relevance is twofold. From an academic perspective, the existence in Africa of currency unions that did not necessarily meet the OCA conditions at the time of their formation creates the opportunity for a direct test of the endogeneity hypothesis. From a policymaking perspective, the finding that currency unions are endogenous would imply that quick monetary integration is a worthwhile option in the context of the regional economic integration process. On the contrary, if currency unions were not endogenous, then a speedy monetary unification would not benefit countries collectively and might therefore jeopardize the whole regional integration initiative.

The idea that OCA might be endogenous has gained momentum following the seminal work of Frankel and Rose (1998). They find that in a panel of OECD economies, the

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<sup>1</sup> UNECA (2004) provides a comprehensive assessment of regional integration in Africa. Out of 14 RECs, 9 target a complete monetary and economic unification, albeit the time horizon differs across RECs. The creation of a continental monetary and economic union in 2023-2028 is also one of the key objectives of the African Union.

<sup>2</sup> A notable exception is Fielding and Shields (2005). Differences between their paper and this paper are discussed below.

intensity of cross-country bilateral trade increases the bilateral correlation of a measure of economic activity. This result is combined with evidence provided by Rose (2000) that currency unions increase bilateral trade in a standard gravity model framework. Thus, OCA would be endogenous in the sense that when a currency union is formed, trade integration between its members increases, which in turn makes their business cycles more synchronized. In fact, deeper trade integration might not be the only channel through which monetary unions self-validate. Corsetti and Pesenti (2002) propose a model where pricing strategies in a monetary union induce business cycle synchronization even in the absence of an effect on bilateral trade. Easier technological spillovers (in the spirit of Coe and Helpmann, 1995) might also contribute to greater synchronization in the wake of monetary integration.

Much of the empirical literature on the endogeneity hypothesis follows the track set by Frankel and Rose (1998) and Rose (2000) and uses panel regressions and gravity models to estimate the effects of monetary unions in global data sets<sup>3</sup>. Results are not always unanimous. Fidrmuc (2004) extends the basic specification of Frankel and Rose (1998) and finds that synchronization increases only to the extent that intra-industry trade grows. Belke (2007) instead links business cycle synchronization to similarities in sectoral structures. Barro and Tenreyro (2007) use a newly developed instrumental variables procedure to control for the possible endogeneity of exchange rate arrangements and economic variables. They find, in line with Rose (2000), that a common currency

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<sup>3</sup> Rose (2008) provides a meta-analysis of existing empirical evidence focusing on the European Monetary Union.

enhances trade<sup>4</sup>. However, they also find that a common currency decreases co-movements of shocks to real GDP, which is at odds with the endogeneity hypothesis.

This paper looks at the issue from a different perspective. Instead of estimating panel and/or gravity models on large samples of countries, it tests directly the endogeneity of a specific currency union: the Central African Economic and Monetary Community (CAEMC, perhaps better known with its French name Communauté Economique et Monétaire de l'Afrique Centrale). The CAEMC is indeed a very interesting case study. The currency union was set-up during the colonial period. After independence, the members of the community decided to retain the basic monetary and exchange rate arrangements of the colonial times. This cluster of six countries has therefore been a currency union for several decades now. A straightforward test of endogeneity can be therefore implemented by computing measures of business cycle synchronization across CAEMC countries and then checking whether or not they tend to increase over time. This will require the preliminary identification and dating of the business cycles of CAEMC countries. The resulting chronology represents an important innovative contribution of this paper given that no such a thing is available for CAEMC countries in the literature<sup>5</sup>.

Methodologically, the exercise proposed in this paper is similar to the one undertaken by Savva et al. (2007) and Darvos and Szapary (2008). They both look at whether

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<sup>4</sup> The trade effects of currency unions have been estimated by a large number of studies. Rose (2004) surveys this strand of the literature and provides meta-estimates of the elasticity of bilateral trade to participation into a currency union.

<sup>5</sup> To the best of my knowledge.

synchronization between the EMU and the new/perspective EU members is increasing over time. Their sample is therefore very different from the one used in this paper. Moreover, since new/perspective EU members are not yet EMU members, their analysis cannot be really interpreted as a test of the endogeneity of OCA. Fielding and Shields (2005), on the contrary, specifically look at whether currency unions in west Africa have increased macroeconomic integration in the sub-region. Among the measures of macroeconomic integration that they consider there is bilateral trade intensity and bilateral shock correlations. In this respect, their work provides evidence on whether or not west Africa is an endogenous OCA. There are nevertheless some important differences between their paper and this paper. First of all, they do not identify and date business cycles to assess synchronization across countries. Their test is based on the estimation of panel specifications similar to those of Frenkel and Rose (1998) and Rose (2000). Furthermore, they treat the whole of the African Financial Community (CFA) as a unique monetary union. In fact, the CFA zone consists of two different unions: the West African Economic and Monetary Union (WAMZ) and CAEMC. In spite of common origins and many similarities, WAMZ and CAEMC have different policy-making organs (including different central banks), different trade regimes (there are no free trade arrangements between the two unions), and a different pace of integration (as documented in UNECA, 2004). In conducting a test of endogeneity it is therefore important to separate the two groups.

The main result of this paper can be summarized as follows. The various indicators examined suggest that synchronization across CAEMC countries is generally quite low,

but somewhat increasing over time. Still, this increase is mild in economic and statistical terms, in line with the weak progresses on regional trade integration and macroeconomic policy harmonization/convergence.

The rest of the paper is organized as follows. Section 2 presents the chronology of recessions and expansions in CAEMC countries. Section 3 looks at the evolution of business cycles synchronization in the region. Section 4 provides a discussion of the key results in light of the endogenous OCA hypothesis. Section 5 draws some policy conclusions and sets the lines for future research. Appendix 1 contains a technical discussion of filtering procedures and algorithms for dating the business cycle. Appendix 2 reports the business cycle chronology country by country and some additional results that were not presented in the text for the sake of brevity.

## **2. Detecting and dating business cycle.**

### ***2.1. Methodology for the identification and dating of business cycles***

The assessment of synchronization requires the preliminary identification and dating of business cycles. In a nutshell, this amounts to determining the turning points in the series of a variable that can be regarded as a reliable broad-based measure of economic activity (i.e GDP or industrial production). Starting with the seminal work of Burns and Mitchell (1946), various algorithms for the determination of turning points have been proposed in the literature (see, for instance, the recent contributions of Artis et al. 2004; Proietti,

2005; Harding and Pagan, 2006). Two main approaches can be identified. One goes under the name of *classical cycle* and dates back to the work of Bry and Boschan (1971). The classical cycle selects its turning points on the basis of an absolute decline (or rise) of the reference series. The other approach is called *deviation* (or *growth*) cycle. In this case, the original reference series is first decomposed into a trend and a cyclical component by means of a filtering procedure. Then turning points are identified on the basis of the sequential oscillations of the cyclical component.

When the reference series is relatively persistent and rarely declining in absolute values (as it was for instance the case of GDP series in Europe in the early post-war decades), then the deviation cycle appears to be analytically more valuable. However, in the deviation cycle, the selection of turning points might be sensitive to the choice of the filtering procedure, so that different procedures generate different chronologies. The pragmatic methodological choice made in this paper is to present results based on both approaches. For the deviation cycle, the filter used to de-trend the original reference series is the one proposed by Hodrick and Prescott (1997), HP from now on. A short technical discussion of filtering procedures can be found in the Appendix 1<sup>6</sup>.

The reference series used for identification and dating is log real GDP ( $y$ ). A crucial difference between dating the business cycle of African countries and dating the business cycle of industrial countries is that for African countries GDP series are normally

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<sup>6</sup> Results obtained from the application of another very popular filter, the one proposed by Baxter and King (1999), are substantially the same as those obtained from the HP filter. These additional results are available from the author upon request.

available only on an annual basis. For industrial countries, instead, quarterly if not monthly series are normally available. Given that most of the existing literature focuses on industrial economies, the algorithms are generally designed to fit quarterly or monthly data. Some modifications are therefore necessary to apply them to annual data.

This paper makes use of a simplified version of the algorithm presented by Artis et al. (2004, 2005). In short, the algorithm is based on the following representation. At any point in time  $t$  the economy is either in recession ( $R_t$ ) or in expansion ( $E_t$ ). The state (recession or expansion) observed at time  $t$  continues at time  $t+1$  unless at time  $t+1$  a termination sequence occurs. If a termination sequence occurs, then  $t$  is a turning point (peak of an expansion or trough of a recession) and  $t+1$  is the first period of a new cyclical phase.

In the classical cycle, the expansion termination sequence (ETS) and the recession termination sequence (RTS) are defined as:

$$(1) \quad ETS_t = \Delta y_{t+1} < -c$$

$$(2) \quad RTS_t = \Delta y_{t+1} > c$$

where  $\Delta$  is the first-difference operator (so that  $\Delta y$  is the growth rate of real GDP) and  $c$  is a positive constant. The purpose of introducing  $c$  is to make sure that the algorithm isolates only major fluctuations, thus making the dating process more robust. In the application below, we follow Artis et al. (2004 and 2005) and set  $c = 0.0005$  (=0.5%). In

words, equations (1) and (2) imply that time  $t$  is the peak of an expansion (the trough of a recession) if at time  $t+1$   $y$  decreases (grows) by more than 0.5% relative to year  $t$ . Otherwise, the expansion (recession) continues in  $t+1$ .

In the deviation cycle,  $ETS$  and  $RTS$  are slightly modified to assure that the peak of an expansion (the trough of a recession) does not correspond to a negative (positive) value of the cyclical component of  $y$ . So, let the cyclical component be denoted by  $y^c$ , then:

$$(3) \quad ETS_t = (y_t^c > 0) \cap (\Delta y_{t+1} < -c)$$

$$(4) \quad RTS_t = (y_t^c < 0) \cap (\Delta y_{t+1} > c)$$

Thus, in the deviation cycle, year  $t$  is the peak of an expansion (the trough of a recession) if the cyclical component of real GDP in year  $t+1$  decreases (grows) by more than 0.5% relative to year  $t$  and the cyclical component in year  $t$  is positive (negative). Otherwise the expansion (recession) continues in  $t+1$ .

## **2.2. A business cycle chronology for CAEMC countries**

The algorithm is applied to log real GDP series of the six CAEMC African countries: Cameroon, Central African Republic (CAR), Chad, Congo-Brazzaville, Equatorial Guinea, and Gabon. The sample period is 1960-2007 for all the countries with the exception of Equatorial Guinea, for which the starting date is 1985. GDP data are taken

from the World Bank Development Indicators and the Official Statistics of the Banque Centrale des Etats de l'Afrique Centrale (BEAC).

The annual chronology for each country is reproduced in table A2.1 of Appendix 2. Table 1 below reports some key summary statistics that help characterizing the cyclical fluctuations in the six members of the monetary union. All durations are expressed in years.

#### TABLE 1 ABOUT HERE

A few stylized facts are worth noting. First of all, the classical cycle and the deviation cycle generate significantly different chronologies. The proportion of time in expansion is considerably longer in the classical cycle. This is to be expected, given that the definition of recession in the classical cycle (a decrease in the absolute level of log real GDP) corresponds to a rather unlikely event in most countries. Furthermore, turning points are more frequent in the deviation cycle. As a consequence, the average duration of a cycle is longer in the classical version. This reflects a significantly longer duration of expansions, since recessions tend to be longer in the deviation cycle.

Second, the detailed classical cycle chronology reported in the appendix reveals some common patterns across countries. All countries, with the only exception of Chad, go through at least one period of prolonged expansion, either at the beginning of the sample period (CAR, Congo, Gabon) or towards the end (Cameroon and Equatorial Guinea).

Furthermore, the last years of the sample, characterized by booming oil prices, mark the beginning of a phase of expansion for the region as a whole. The pattern is however much less clear in the deviation cycle chronology, where episodes of prolonged expansion are dispersed over the whole of the sample period and the 2000s are not necessarily associated with an expansion at regional level.

Third, a cursory glance at the sequence of turning points and phases suggests that business cycles are not very much synchronized. In the classical cycle chronology, the six countries happen to be in the same cyclical phase in only 16 out of a total of 48 years. This common cyclical phase is always an expansion; that is, countries are never contemporaneously in a recession. Moreover, there are only two years when more than two countries turn cyclical phase in the same direction: 1987, when four countries reach a trough, and 1988, when three countries reach the peak of an expansion. Cycles look even less synchronized in the deviation cycle chronology, where all countries happen to be in same cyclical phase only twice (1974 and 1998) in 48 years. However, more frequent turning points also imply that countries turn cyclical phase in the same direction more often than in the classical cycle chronology.

Finally, it is interesting to look at cyclical dynamics around 1994, the year of the devaluation of the franc CFA. The chronologies indicate that prior to the devaluation Cameroon went through a phase of prolonged recession. For the other countries, instead, the late 80s and early 90s were a period of volatility, with frequent turning points and short-lasting cycles. Yet, most of the region was in a recession in 1993 and entered an

expansion between 1994 and 1995, at least according to the deviation cycle chronology. This suggests that the devaluation might have effectively boosted the short term macroeconomic dynamics of CAEMC.

### **3. Business cycle synchronization in the CAEMC region over time.**

#### **3.1. *Measuring business cycle synchronization.***

The degree of synchronization of the business cycles of the CAMEC countries is measured along three statistical dimensions. The first one is the intensity of co-movements across countries: the cross-country contemporaneous bilateral correlations of  $y$ ,  $y^c$ ,  $\Delta y$  and  $\Delta y^c$  are computed over four overlapping sub-periods (1960-80, 1970-90, 1980-2000, 1987-2007). An increase in correlation coefficients over time, meaning that synchronization is growing, can be taken as evidence in support of the endogeneity hypothesis. Following Darvas and Szapary (2008), in addition to the contemporaneous correlation, the leads and lags that maximize the bilateral correlations are also calculated. From an OCA perspective, zero or small lags/leads are optimal. Therefore, a progressive decrease of leads/lags is also to be interpreted as evidence that CAEMC is a self-validating monetary union.

The second dimension pertains to the statistical properties of business cycles. The first order autocorrelation ( $AC$ ) and the standard deviation ( $STD$ ) of each of the four series ( $y$ ,  $y^c$ ,  $\Delta y$  and  $\Delta y^c$ ) are computed for each of the six countries over each of the four sub-

periods (1960-80, 1970-90, 1980-2000, 1987-2007). The first order autocorrelation measures the persistence of the cycle, while the standard deviation measures its volatility. The logic underlying the use of these two measures is that business cycles cannot be synchronized if they are very dissimilar in terms of their basic statistical properties. Therefore, a progressive reduction in the cross-country dispersion of *AC* and/or *STD* will be interpreted as an increase in synchronization.

The third dimension is the correspondence of cyclical phases across countries. If countries happen to be in the same phase at the same time, then the delegation of monetary policy to a regional central bank does not compromise the stabilization of the national cycle. If instead, countries go through different phases at different times, a unique regional monetary policy cannot contemporaneously accommodate the stabilization needs of all union members. As a consequence, the discordance of cyclical phases makes the monetary union sub-optimal. The statistical measure of concordance used in this paper follows Harding and Pagan (2001 and 2006). Let  $S_{it}$  be 1 if country  $i$  is in recession at time  $t$ , and zero otherwise. Analogously,  $S_{jt}$  is equal to 1 if country  $j$  is in recession at time  $t$ . Then, the simple matching similarity coefficient (standard concordance index) between the two countries is:

$$(5) \quad I_{ij} = \frac{1}{T} \sum_{t=1}^T [S_{it}S_{jt} + (-S_{it})(-S_{jt})] \quad \text{where } t = 1, \dots, T$$

As discussed by Harding and Pagan (2001), the index (5) is upward biased if cycles are significantly asymmetric; that is, if countries spend much longer time in one cyclical

phase than in the other. To avoid this problem, the index has to be mean-corrected. If  $E[S_{it}]$  and  $E[S_{jt}]$  denote the expected values of  $S_{it}$  and  $S_{jt}$  respectively, then the mean corrected concordance index is written as:

$$(6) \quad I_{ij}^* = \frac{2}{T} \sum_{t=1}^T (S_{it} - E[S_{it}]) (S_{jt} - E[S_{jt}])$$

Both,  $I_{ij}$  and  $I_{ij}^*$  are computed for each pair of countries in CAEMC over each of the four sub-periods. Again, growing values of the two indexes over time will be taken as evidence in support of the endogeneity hypothesis.

### 3.2. Evolution of business cycle synchronization in CAEMC

#### 3.2.1 Evidence from bilateral correlations

Table 2 reports the average contemporaneous correlation coefficient for each country, in each sub-period, and for each variable. For the generic country  $i$ , this average correlation coefficient is simply the average of the bilateral contemporaneous correlations between  $i$  and all of the other countries in the region<sup>7</sup>. The column labeled “Average” reports the average of all bilateral correlation coefficients calculated for a specific sub-period. The last column of the table reports the average of the lag/lead that maximizes the bilateral correlations.

<sup>7</sup> The full set of bilateral correlation coefficients and standard deviations for each reference variable, each sub-period is available upon request from the author.

## INSERT TABLE 2 ABOUT HERE

As expected the bilateral correlations of  $y$  are the highest. However, since they tend to be influenced by the trend of real GDP, they are also the least informative in terms of business cycle synchronization. Therefore, the rest of the discussion focuses on the other three variables.

For each of the other three reference series, the bilateral correlations are rather low and hardly significant in statistical terms<sup>8</sup>. In this sense, there is no evidence of systematic cyclical co-movement across countries in the monetary union. However, when comparing the first sub-period (1960-80) with the last two sub-periods (1980-2000 and 1987-2007), some mild increase in the size of correlation coefficients is observed. In particular, for both  $\Delta y$  and  $\Delta y^c$ , the average bilateral correlation is considerably higher in the last sub-period than in the first sub-period. For the other reference variable,  $y^c$ , the highest average bilateral correlation is observed in the third sub-period. Moreover, for 10 out of 15 country pairs, the bilateral correlation coefficient of  $\Delta y$  and  $y^c$  is higher in 1987-2007 than in 1960-1980; for 9 out of 15 the bilateral correlation coefficient of  $\Delta y^c$  is higher in 1987-2007 than in 1960-1980. One can therefore argue that, while remaining always rather

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<sup>8</sup> As a comparison, consider that the average bilateral correlations between EMU members are as follows. For the variable  $\Delta y$ : 0.406 in 1960-1980, 0.504 in 1970-1990, 0.496 in 1980-2000, and 0.554 in 1987-2007. For the variable  $y^c$ : 0.426 in 1960-1980, 0.570 in 1970-1990, 0.622 in 1980-2000, and 0.647 in 1987-2007. For the variable  $\Delta y^c$ : 0.357 in 1960-1980, 0.466 in 1970-1990, 0.531 in 1980-2000, and 0.653 in 1987-2007. It is interesting to note that these average bilateral correlations are increasing over time. The increase is particularly evident between the third and the fourth sub-period, which implies that the formation of the monetary union in 1999 has consistently strengthened the synchronization of the business cycles of participating members. In this respect, the EMU seems to be an endogenous OCA. The full set of correlations for EMU is available to the interested reader upon request.

low, the degree of co-movement of cyclical fluctuations has to some extent increased over time in the CAEMC area.

The evidence from the last column of the table is consistent with the previous observations. Bilateral correlations are generally maximized for a non-zero lag, which imply a rather low degree of co-movement across countries. However, there is a generalized, mild tendency for lag/lead to decrease over time. In particular, the lead/lag decreases between the last and the first sub-period for 10 out of 15 country pairs when the reference variable is  $\Delta y$ , for 11 out of 15 country pairs when the reference variable is  $y^c$ , and for 9 out of 15 country pairs when the reference variable is  $\Delta y^c$ . On the other hand, an increase in the lag/lead is rare, whatever reference variable is considered.

### *3.2.2 Evidence from first order autocorrelation and volatility*

The extent to which the business cycles of CAEMC countries display similar statistical properties is assessed from the data in Table 3. For each sub-period, the table shows the dispersion across CAEMC countries of (i) the first order autocorrelation coefficient (AC) and (ii) the volatility (STD) of each of the four reference variables. Dispersion is measured by the standard deviation of each variable's distribution across countries. In fact, because data for Equatorial Guinea become available only after 1985, the dispersion is computed for the group of the five remaining CAEMC countries until 1985 and for the full group of six countries afterwards. To make the analysis more robust, the table also

reports the dispersion for the sub-group of five countries that excludes Equatorial Guinea in all sub-periods.<sup>9</sup>

INSERT TABLE 3 ABOUT HERE

Consider AC first. Between the first and last sub-period there is a decrease in dispersion for three out of the four reference variables. Focusing on the three variables that are more informative for business cycle analysis ( $\Delta y$ ,  $\Delta y^c$  and  $y^c$ ), the general pattern is characterized by an increase in dispersion between the first and the second sub-period, followed by a decrease in subsequent sub-periods. However, only for the two detrended series,  $\Delta y^c$  and  $y^c$ , the observed reduction in the third and fourth sub-period is sufficient to bring dispersion below its initial level. The dynamics of dispersion are qualitatively similar when Equatorial Guinea is removed from the sample. That is, the increase in dispersion between 1960-80 and 1970-90 does not appear to be driven by the inclusion of Equatorial Guinea in the CAEMC group.

Turning to STD, its dispersion across countries is generally increasing between the first and the last sub-period. With the exception of  $y$ , this increase is however not particularly strong. Moreover, the pattern is not monotonic and a decrease in dispersion is observed between the second and the third sub-period. It is only in the course of the last sub-period that countries become significantly more different in terms of the volatility of their national cycles. Two complementary factors could account for these growing differences.

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<sup>9</sup> The full sets of first order autocorrelation coefficients and standard deviations calculated for each country and each reference variable in each sub-period are reported in Tables A2.3 and A2.4 in the Appendix.

One is the increasing volatility of international primary commodity prices. Given the high dependence of CAEMC economies on primary commodity exports, more volatile international prices imply more volatile external shocks. The other factor is the transformation of Equatorial Guinea into a very fast growing oil economy at the end of the '90s. As a matter of fact, if Equatorial Guinea is excluded from the sample, the dispersion of STD turns to be lower in the last sub-period than in the first sub-period, even though still increasing between 1980-2000 and 1987-2007.

Overall, the analysis of the statistical properties of business cycles provides rather ambiguous evidence. In terms of their persistence (as measured by AC), the cycles of CAEMC countries might have become marginally more similar over time. In terms of their volatility, stronger similarities started to emerge in the course of the '80s and the early '90s, but the tendency reversed in the late 90s, following internal (oil-boom in Equatorial Guinea) and external (volatility of international prices) shocks.

### *3.2.3 Evidence from concordance indexes*

For each country  $i$ , table 4 shows the sub-period average of bilateral concordance indexes (see equations (5) and (6)) between country  $i$  and all of the other CAEMC members. The last row reports the average of all the 15 bilateral concordance indexes calculated in each sub-period (in fact, due to missing data for Equatorial Guinea, the total number of bilateral concordance indexes calculated in sub-period 1960-80 is 10). Given that there are two possible chronologies, there is a total of four set of indexes: standard index and

mean-corrected index based on the classical chronology and standard index and mean-corrected index based on the deviation chronology.

INSERT TABLE 4 ABOUT HERE

The first striking aspect emerging from the data in the table is a substantial lack of concordance of cyclical phases across CAMEC countries. The standard index ranges between 0.5 and 0.75. However, the mean-corrected index, on average barely above 0, indicates that cycles are largely independent and that the standard index is indeed inflated by the asymmetric duration of expansions and recessions, especially in the classical chronology. As a point of comparison, consider that for European countries, Harding and Pagan (2001) report standard concordance indexes around 0.9 and mean-corrected concordance indexes around 0.8 (somewhat lower values are reported for the only non-EMU member in the sample, the UK).

A second aspect that also appears from the table is that in general, after a decrease between the first and the second sub-periods, concordance indexes tend to increase in the third and the fourth sub-periods. Taking the CAEMC average as a reference, it can be seen that the two mean-corrected indexes as well as the standard index based on the deviation cycle chronology are higher in 1987-2007 than in 1960-80. The standard index based on the classical cycle chronology instead significantly drops in the second and third sub-period, but it is on the rise in the fourth sub-period.

Regional averages however hide different patterns at national level. While Gabon, Congo and Cameroon quite closely replicate the regional dynamic, Chad, CAR and Equatorial Guinea display a more ambiguous evolution. In particular, in CAR none of the indexes is significantly higher in 1987-2007 than in 1960-1980, even though  $I_{ij}^*$  based on the classical chronology increases remarkably during the two intermediate sub-periods. In Equatorial Guinea, standard indexes on average increase, but mean-corrected indexes on average decrease. Finally, in Chad, there appears to be on average an increase of concordance with the rest of the union in terms of classical cycle, but in terms of deviation cycle concordance seems to be diminishing.

To sum up the evidence, the bilateral concordance of cyclical phases remains relatively low throughout the observation period. However, similarly to what observed for other indicators of synchronization, concordance somewhat increases over time.

#### **4. Discussion**

A common pattern seems to emerge from the statistical dimensions investigated in Section 3: synchronization is low, but somewhat increasing over time. What do then these results imply for the endogenous OCA hypothesis?

To answer this question, the results of section 3 must be compared to some benchmark. To this purpose, consider the meta-estimates provided by Rose (2004 and 2008): (i) the formation of a currency union should increase intra-union trade by between 30% and

90%, even though for the EMU the trade effect ranges between 8% and 23%; (ii) each 1% increase in trade between two countries increases the bilateral correlation coefficient of detrended outputs by 0.02. There are of course three main caveats in deriving benchmarks for the CAEMC from these two sets of meta-estimates. One is that most of the papers surveyed in the meta-analysis focus on the EMU, which is structurally a very different monetary union from the CAEMC. The second caveat is that the time-frame of the meta-estimated effects is not explicit. The final caveat is stated explicitly by Rose (2004) in the following terms: “[Thus] it would be unreasonable for anyone to have too much confidence in the meta-analytic estimate of the effect of currency union on trade”.

However, taking all caveats in mind, an increase in the bilateral correlation coefficient of de-trended series between 0.2 and 0.5 can be set a reasonable conservative benchmark. The estimates provided in section 3 seem to put CAEMC below this benchmark, thus confirming that the observed increase in synchronization in the region is marginal. In this respect, it can be argued that the endogenous OCA hypothesis does not fully fit the CAEMC data. That is, as an OCA, CAEMC does not seem to be an endogenous to the extent anticipated by previous empirical work based on panel and cross-country estimates. Yet, some degree of endogeneity is there, as the growing correlations of co-movements, the increasing similarities of cycles’ statistical properties, and a stronger concordance over time indicate.

Several factors could account for the relatively weak endogeneity of CAEMC as an OCA. First of all, the trade effect of the currency union is very weak in the CAEMC region.

Intra-regional trade in current US\$ was 149.26 millions in 1980. By 2007 it reached US\$ 608.62 millions, with an average annual growth of around 11%. However, total international trade of CAEMC countries went up from US\$ 7444.13 millions to US\$ 42808.3 millions over the same period of time. This is equal to an average annual increase of around 17%. The proportion of regional trade in total international trade has therefore decreased, from a mere 2% to an even smaller 1.4%<sup>10</sup>. This in turn reflects the persistence of high non tariff barriers, most notably the lack of physical connectivity across countries and to the poor state of transport infrastructures.

Second, up until 1997, CAEMC did not introduce a rigorous framework for policy harmonization in the region. This has certainly slowed down the convergence of macroeconomic policies. Between 1970 and 2006, the cross-country standard deviation of the budget balance has gone up from 3.65 to 12.33, mostly as a result of increased dispersion in revenues (while dispersion in expenditures is decreasing since 1998). Interestingly, monetary variables also display growing dispersion across countries: from 3.54 to 14.37 for the money growth rate and from 0.86 to 2.47 for the inflation rate. The fact that monetary variables do not converge in spite of a centralized monetary policy is indicative of persistent asymmetries in monetary policy transmission mechanisms. This lack of convergence of macroeconomic policies might have in turn weakened the non-trade channels through which monetary unification is expected to deliver greater business cycles synchronization<sup>11</sup>.

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<sup>10</sup> Trade data are taken from IMF (2008).

<sup>11</sup> For a systematic analysis of macroeconomic policy convergence in the region see UNECA (2007).

A third factor relates to the similarity of production structures in the region. As a matter of fact, all of the economies of CAEMC heavily depend on primary commodities and five of them are oil-economies (even though the timing and intensity of oil exploitation varies considerably across countries). Thus, in absolute terms, the production structures of the six countries are quite homogenous. However, homogeneity has decreased over time. The cross-country dispersion of Herfindhal Index of diversification calculated for three sectors (agriculture, industry and services) has increased by 2.5 times between 1985 and 2007<sup>12</sup>. The increase is even larger if one considers the pre-1985 era, when data for Equatorial Guinea were not available. Increasingly dissimilar productive structures then translate into more asymmetric shocks across countries, especially to the extent that high non-tariff barriers limit the growth of intra-regional trade flows, and therefore weaken the synchronization of cycles<sup>13</sup>.

## **5. Conclusions and directions of future research.**

From a policy perspective, this paper bears implications for both the design of CAEMC policy and institutions and the process of monetary unification in Africa. With respect to the former, CAEMC countries must strengthen policy harmonization and physical connectivity, so to activate the channels through which business cycles can become more synchronized and hence maximize the potential benefits from monetary integration. A

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<sup>12</sup> The index is computed for each country in each period as the sum of squared GDP shares of each sector.

<sup>13</sup> Evidence reported by UNECA (2007) seems to be consistent with this interpretation.

revision of the existent set of convergence criteria might therefore be necessary. Furthermore, countries should take advantage of buoyant oil (and other natural resources) revenues to strengthen the public investment in infrastructures, particularly in relation to regional projects of transport development.

With respect to monetary unification in Africa, the CAEMC experience shows that currency areas are not necessarily optimally endogenous even after a long period of time. Nevertheless, they can be sustained in spite of this lack of optimality and they do tend to generate somewhat more synchronized cycles over time. Therefore, it is probably not necessary that countries fully meet the optimality criteria before new unions are formed, or even before a continental union is envisaged. However, the unification process ought to be gradual and attention must be devoted to the design of institutional arrangements for monetary and exchange rate policy, to the consolidation of political will, and to the preparation of a credible framework to encourage *de facto* convergence of macroeconomic policy instruments.

From a research perspective, a number of issues to be explored in future work are worth a mention. First of all, the statistical analysis of this paper should be extended to the other regional groupings in Africa. Indeed, even if they have not yet achieved the stage of monetary unions, several African RECs are making considerable progresses in terms of trade integration and policy harmonization frameworks. It would be therefore interesting to see whether such progresses are making business cycles more synchronized. Another aspect that should be analyzed is whether there exist clusters of countries, within or

across the borders of existing RECs, which already configure as OCA and/or display the characteristics of fully endogenous OCAs. If such clusters existed, then one could envisage a process whereby monetary unions are first formed in those clusters, and then other countries join in after a gradual transition. Finally, for the specific case of CAEMC, it will be interesting to study the cyclical characterization of macroeconomic policies. This investigation can be done on two levels. At national level, the analysis should establish whether fiscal and monetary policy indicators are pro-cyclical, a-cyclical or anti-cyclical. At regional level, the focus should be on the common monetary policy to understand whether it follows the cycle of any CAEMC member in particular. This would facilitate the assessment for each country of the costs and benefits associated with the weak synchronization of business cycles. In fact, given that the franc CFA is pegged to the Euro, one can imagine that the CAEMC countries which benefit the most from the centralized monetary policy are those whose business cycle is more synchronized with the European business cycle. At least, this would be true to the extent that the European Central Banks bases its monetary policy on the European business cycle.

## Tables

Table 1: Summary statistics of business cycles in CEAMC countries

|                                 | Cameroon | CAR   | Chad  | Congo | Eq Guinea | Gabon |
|---------------------------------|----------|-------|-------|-------|-----------|-------|
| <b>Classical cycle</b>          |          |       |       |       |           |       |
| Total turning points            | 8        | 12    | 18    | 12    | 8         | 10    |
| Average duration of a cycle     | 12       | 8     | 5.33  | 8     | 7         | 9.6   |
| Average duration of a recession | 2.75     | 2.17  | 1.44  | 1.5   | 1         | 1.8   |
| % of time in expansion          | 77.1%    | 72.9% | 72.9% | 81.2% | 85.7%     | 81.2% |
| <b>Deviation cycle</b>          |          |       |       |       |           |       |
| Total turning points            | 17       | 20    | 19    | 16    | 11        | 14    |
| Average duration of a cycle     | 5.6      | 4.8   | 5.1   | 6     | 5.1       | 6.8   |
| Average duration of a recession | 2.7      | 2.2   | 2.2   | 1.9   | 2.5       | 3     |
| % of time in expansion          | 50       | 54.1  | 54.1  | 68.7  | 46.2      | 56.2  |

Note: Reference series is log real GDP for each country (annual data). Sample period is 1960-2007 for each country with the exception of Equatorial Guinea, for which the starting date is 1985. The dating is based on the algorithm described in the text and in Appendix 1. For full chronology, see Appendix 2.

Table 2: Average bilateral correlation coefficients and lag/lead

|   | CMR    | CNG    | GBN    | GNQ    | RCA    | TCD   | Average | Lag/Lead |
|---|--------|--------|--------|--------|--------|-------|---------|----------|
| <b>Log-level of GDP (y)</b>   |        |        |        |        |        |       |         |          |
| 60_80   | 0.694  | 0.741  | 0.783  | n.a    | 0.786  | 0.219 | 0.645   | ..       |
| 70_90   | 0.739  | 0.708  | 0.534  | 0.737  | 0.762  | 0.540 | 0.670   | ..       |
| 80_00   | 0.429  | 0.672  | 0.632  | 0.675  | 0.709  | 0.710 | 0.638   | ..       |
| 87_07   | 0.758  | 0.863  | 0.754  | 0.879  | 0.777  | 0.839 | 0.812   | ..       |
| <b>First difference of log-level of GDP (<math>\Delta y</math>)</b> |        |        |        |        |        |       |         |          |
| 60_80   | -0.129 | -0.108 | 0.081  | n.a    | 0.104  | 0.128 | 0.015   | 1.7      |
| 70_90   | 0.049  | 0.028  | -0.001 | 0.093  | 0.057  | 0.157 | 0.064   | 2.1      |
| 80_00   | 0.175  | 0.030  | 0.076  | 0.027  | 0.114  | 0.073 | 0.083   | 1.5      |
| 87_07   | 0.229  | 0.089  | 0.114  | 0.100  | 0.157  | 0.128 | 0.136   | 1.1      |
| <b>Detrended GDP (<math>y^c</math>)</b>                             |        |        |        |        |        |       |         |          |
| 60_80   | -0.049 | -0.026 | 0.115  | n.a    | 0.130  | 0.233 | 0.081   | 1.8      |
| 70_90   | -0.012 | -0.119 | 0.059  | 0.035  | 0.127  | 0.242 | 0.055   | 1.9      |
| 80_00   | 0.176  | 0.028  | 0.243  | 0.065  | 0.124  | 0.240 | 0.146   | 1.3      |
| 87_07   | -0.039 | 0.062  | 0.147  | 0.054  | -0.033 | 0.089 | 0.047   | 1.2      |
| <b>First difference of detrended GDP (<math>\Delta y^c</math>)</b>  |        |        |        |        |        |       |         |          |
| 60_80   | -0.110 | 0.004  | -0.025 | n.a    | 0.069  | 0.102 | 0.008   | 1.8      |
| 70_90   | -0.093 | 0.008  | -0.043 | -0.023 | 0.024  | 0.172 | 0.007   | 1.7      |
| 80_00   | 0.007  | -0.040 | 0.089  | -0.069 | 0.060  | 0.079 | 0.021   | 1.3      |
| 87_07   | 0.019  | -0.021 | 0.164  | -0.084 | 0.077  | 0.104 | 0.043   | 1.3      |

Note: For each country and each variable, the average bilateral contemporaneous correlation coefficient is computed as the average over each sub-period of the bilateral contemporaneous correlation coefficients between that country and all of the countries in the group. The column labeled “average” shows the average of all bilateral correlation coefficients computed in each sub-period. In the last column, the average lead/lag is computed as the average of the lags/leads that maximize the bilateral correlation coefficients in each sub-period.

CMR = Cameroon, CAR = Central African Republic, TCD = Chad, CNG = Congo, GBN = Gabon, GNQ = Equatorial Guinea.

Table 3: Variation across countries in first order auto-correlation and volatility of cyclical phases

|   | First order autocorrelation (AC) |       |       |       | Volatility (STD) |       |       |       |
|---|----------------------------------|-------|-------|-------|------------------|-------|-------|-------|
|   | 60_80                            | 70_90 | 80_00 | 87_07 | 60_80            | 70_90 | 80_00 | 87_07 |
| <b>Log-level of GDP (y)</b>   |                                  |       |       |       |                  |       |       |       |
| All countries   | 0.182                            | 0.084 | 0.108 | 0.047 | 0.182            | 0.143 | 0.205 | 0.330 |
| Excluding GNQ   | 0.182                            | 0.079 | 0.109 | 0.038 | 0.182            | 0.143 | 0.059 | 0.096 |
| <b>First difference of log-level of GDP (<math>\Delta y</math>)</b> |                                  |       |       |       |                  |       |       |       |
| All countries   | 0.133                            | 0.412 | 0.393 | 0.331 | 0.036            | 0.037 | 0.033 | 0.040 |
| Excluding GNQ   | 0.133                            | 0.311 | 0.410 | 0.356 | 0.036            | 0.036 | 0.012 | 0.022 |
| <b>Detrended GDP (<math>y^c</math>)</b>                             |                                  |       |       |       |                  |       |       |       |
| All countries   | 0.253                            | 0.339 | 0.199 | 0.111 | 0.024            | 0.026 | 0.018 | 0.026 |
| Excluding GNQ   | 0.253                            | 0.273 | 0.203 | 0.090 | 0.024            | 0.026 | 0.012 | 0.016 |
| <b>First difference of detrended GDP (<math>\Delta y^c</math>)</b>  |                                  |       |       |       |                  |       |       |       |
| All countries   | 0.127                            | 0.308 | 0.152 | 0.081 | 0.026            | 0.027 | 0.021 | 0.030 |
| Excluding GNQ   | 0.127                            | 0.229 | 0.169 | 0.085 | 0.026            | 0.028 | 0.016 | 0.022 |

Note: For each reference variable and each sub-period the table reports the variation of AC and STD across the CEAMC members. Variation is measured by the standard deviation of AC and STD across countries in each sub-period. For each reference variable, the first row (labeled “All countries”) refers to the variation measured across all CAEMC members; the second row (labeled “Excluding GNQ”) refers to the variation measured across CAMEC members excluding the Equatorial Guinea. The full set of AC and STD data by country and sub-periods is given in Tables A2.3 and A2.4 in the Appendix.

Table 4: Concordance index, averages by country

|           |       | Classical cycle |                | Deviation cycle |                |
|-----------|-------|-----------------|----------------|-----------------|----------------|
|           |       | Standard        | Mean corrected | Standard        | Mean corrected |
|           |       | $(I_{ii})$      | $(I_{ii}^*)$   | $(I_{ii})$      | $(I_{ii}^*)$   |
| CMR       | 60-80 | 0.71429         | -0.0068        | 0.4881          | -0.01361       |
|           | 70-90 | 0.60433         | 0.00359        | 0.49524         | -0.00202       |
|           | 80-00 | 0.59048         | 0.06259        | 0.5619          | 0.07619        |
|           | 87-07 | 0.67619         | 0.11156        | 0.5619          | 0.10159        |
| CAR       | 60-80 | 0.77381         | 0.07483        | 0.46429         | -0.02154       |
|           | 70-90 | 0.60606         | 0.00532        | 0.4381          | -0.05916       |
|           | 80-00 | 0.55238         | 0.02449        | 0.4381          | -0.07664       |
|           | 87-07 | 0.6381          | 0.07347        | 0.46667         | -0.05079       |
| Chad      | 60-80 | 0.66667         | 0.04762        | 0.60714         | 0.10601        |
|           | 70-90 | 0.67013         | 0.0886         | 0.52381         | 0.01831        |
|           | 80-00 | 0.64762         | 0.08889        | 0.54286         | 0.02812        |
|           | 87-07 | 0.71429         | 0.08707        | 0.57143         | 0.06757        |
| Congo     | 60-80 | 0.77381         | 0.03288        | 0.42857         | -0.05272       |
|           | 70-90 | 0.69784         | 0.06411        | 0.37143         | -0.13284       |
|           | 80-00 | 0.60952         | 0.05079        | 0.48571         | -0.02902       |
|           | 87-07 | 0.69524         | 0.06803        | 0.51429         | -0.00408       |
| Eq Guinea | 60-80 | ..              | ..             | ..              | ..             |
|           | 70-90 | 0.58182         | -0.05455       | 0.24762         | -0.24675       |
|           | 80-00 | 0.60952         | 0.01088        | 0.50476         | 0.00907        |
|           | 87-07 | 0.6381          | -0.02177       | 0.44762         | -0.04807       |
| Gabon     | 60-80 | 0.7381          | 0.01701        | 0.46429         | -0.02154       |
|           | 70-90 | 0.63203         | 0.05051        | 0.41905         | -0.08646       |
|           | 80-00 | 0.60952         | 0.0381         | 0.55238         | 0.03492        |
|           | 87-07 | 0.73333         | 0.07347        | 0.5619          | 0.04354        |
| CAEMC     | 60-80 | 0.733           | 0.033          | 0.490           | 0.000          |
|           | 70-90 | 0.632           | 0.026          | 0.415           | -0.08          |
|           | 80-00 | 0.603           | 0.045          | 0.514           | 0.007          |
|           | 87-07 | 0.683           | 0.065          | 0.520           | 0.018          |

Note: For each country and sample period, the table reports the average of the bilateral concordance indexes (see equations (5) and (6)). The CAMEC average is obtained as the average of all the bilateral concordance indexes calculated in each sub-period. The full set of bilateral concordance indexes by pairs of countries is reported in Tables A2.5, A2.6, A2.7 and A2.8.

## Appendix A1. Technical discussion: Dating algorithm and filtering procedure

### *Formulation of dating rules*

The core of the dating procedure is the identification of peaks ( $P$ ) and troughs ( $T$ ) in a reference series that summarizes the level of economic activity. Let this series (most often the log real GDP or industrial production) be  $y_t$ , where  $t$  indicates time.

Bry and Boschan (1971) formulate the following rule for the identification of  $P$  and  $T$ :

$$(A1.a) \text{ Peak at } t \quad y_t > y_{t-k}, y_t > y_{t+k}, k = 1 \dots K$$

$$(A1.b) \text{ Trough at } t \quad y_t < y_{t-k}, y_t < y_{t+k}, k = 1 \dots K$$

where  $K = 2$  for quarterly time series (typically GDP) and  $K = 5$  for monthly time series (typically industrial production).

Following Harding and Pagan (2001), the rule can be expressed in a more compact way as:

$$(A2.a) \text{ Peak at } t \quad \Delta_k y_t > 0, \Delta_k y_t < 0$$

$$(A2.b) \text{ Trough at } t \quad \Delta_k y_t < 0, \Delta_k y_t > 0$$

where  $\Delta_k y_t = y_t - y_{t-k}$ . In words, a recession occurs if the level of economic activity declines for  $k$  periods and an expansion if it increases for the same interval.

Artis et al. (2004) generalize the rule through a Markov Chain representation whose core parameters are (i) the conditional probability of making a transition from expansion to peak and (ii) the conditional probability of making a transition from recession to trough. These are in turn non-parametrically scored according to the available time series  $y_t$ . The rule for scoring the transition probabilities is based on the definition of expansion termination sequence ( $ETS_t$ ) and recession termination sequence ( $RTS_t$ ):

$$(A4.a) \quad ETS_t = \left[ y_{t+1} < 0 \right] \cap \left[ y_{t+2} < 0 \right]$$

$$(A5.a) \quad RTS_t = \left[ y_{t+1} > 0 \right] \cap \left[ y_{t+2} > 0 \right]$$

The sequences (A4.a) and (A5.a) define the homolog of the dating rules of Bry and Boschan (1971) and Harding and Pagan (2001) for the case of quarterly date with a two quarters minimum duration imposed for each phase.

#### *Algorithm used in this paper*

The dating rules and algorithm used in this paper are based on a representation drawing most of its elements from Artis et al. (2004). The cycle consists of two mutually exclusive phases, recession  $R_t$  and expansion  $E_t$ . An expansion always terminates with a peak and a recession always terminates with a trough. At any point in time  $t$  the economy

is therefore in one (and only one) of four possible states: expansion continuation ( $EC_t$ ), peak ( $P_t$ ), recession continuation ( $RC_t$ ), trough ( $T_t$ ). Clearly,  $EC_t$  and  $P_t$  are the two states belonging to the expansion phase  $E_t$  and  $RC_t$  and  $T_t$  are the two states belonging to the recession phase  $R_t$ .

Since expansion and recession are mutually exclusive, the probability of transition from  $EC_t$  to  $RC_{t+1}$  and from  $RC_t$  to  $EC_{t+1}$  is zero. That is, from  $EC_t$  the economy can transit to either  $EC_{t+1}$  or  $P_{t+1}$ . Symmetrically, from  $RC_t$ , the system can only transit to either  $RC_{t+1}$  or  $T_{t+1}$ . In the same vein, from  $P_t$  the system can only transit towards one of the two states of the recession phase ( $RC_{t+1}$  or  $T_{t+1}$ ) and from  $T_t$  it can only transit to one of the two states of the expansion phase ( $EC_{t+1}$  or  $P_{t+1}$ ). Artis et al. (2004) work with quarterly data and impose a minimum duration of two quarters for each phase. This implies that there is no transition from  $P_t$  to  $T_{t+1}$  and from  $T_t$  to  $P_{t+1}$ . However, in this paper data have annual frequency and the restriction of the minimum duration of each phase is inevitably set to 1 period (read, 1 year), so that the sequences  $\{P_t, T_{t+1}\}$  and  $\{T_t, P_{t+1}\}$  are admissible.

Whether from  $EC_t$  the economy transits to  $EC_{t+1}$  or to  $P_{t+1}$  depends on the realization of an expansion termination sequence at time  $t+1$ . The expansion termination sequence used in this paper is a straightforward adaptation of (A4.a) to the case of annual data:

$$(A5.a) \quad ETS_{t+1} = \Delta y_{t+2} < -c$$

where the constant  $c = 0.005$  replaces 0 so to exclude minor fluctuations from the chronology. Based on (A5.a), time  $t + 1$  is a peak if the GDP decreases by  $c$  at time  $t + 2$ . Otherwise,  $t + 1$  is the continuation of an expansion. Note that, (A5.a) also establishes whether the system at  $T_t$  transits towards  $EC_{t+1}$  or  $P_{t+1}$ : if in  $t + 2$  GDP decreases by at least  $c$ , then  $t + 1$  is a peak of the expansion; if instead at  $t + 2$  the GDP increases (or decreases by less than  $c$ ), then  $t + 1$  is the continuation of the expansion.

The dating rule for the recession follows the same logic. Whether from  $RC_t$  the economy transits towards  $RC_{t+1}$  or to  $T_{t+1}$  depends on the realization at time  $t + 1$  of the recession termination sequence:

$$(A5.b) \quad RTS_{t+1} = \begin{cases} 1 & \Delta y_{t+2} > c \\ 0 & \text{otherwise} \end{cases}$$

In words, from a state of recession continuation in year  $t$ , the economy goes to a trough in year  $t + 1$  if in period  $t + 2$  the GDP increases by at least  $c$ . Otherwise, the system will be in recession continuation in year  $t + 1$ . Again, the  $RTS$  specified in (A5.b) also defines the direction of transition of the system from  $P_t$ : if in  $t + 2$  GDP increases by at least  $c$ , then the system goes from  $P_t$  to  $T_{t+1}$ ; otherwise the system goes from  $P_t$  to  $ER_{t+1}$ .

In short, the algorithm is programmed as follows:

1. If at time  $t$  the system is in  $EC_t$  and  $ETS_{t+1}$  is true, then  $t + 1$  is a peak and the system transits to  $P_{t+1}$ ; if the system is in  $EC_t$  and  $ETS_{t+1}$  is not true, then  $t + 1$  is the continuation of the expansion and the system transits to  $EC_{t+1}$ .
2. If at time  $t$  the system is at  $P_t$  and  $RTS_{t+1}$  is true, then  $t + 1$  is the trough of a recession and the system transits to  $T_{t+1}$ ; if the system is at  $P_t$  and  $RTS_{t+1}$  is not true, then  $t + 1$  is the continuation of a recession and the system transits to  $RC_{t+1}$ .
3. If at time  $t$  the system is in  $RC_t$  and  $RTS_{t+1}$  is true, then  $t + 1$  is the trough of a recession and the system transits from  $RC_t$  to  $T_{t+1}$ ; if instead  $RTS_{t+1}$  is not true, then the recession continues and the system transits from  $RC_t$  to  $RC_{t+1}$ .
4. If at time  $t$  the system is in  $T_t$  and  $ETS_{t+1}$  is true, then  $t + 1$  is the peak of an expansion and the system transits from  $T_t$  to  $P_{t+1}$ ; if instead  $RTS_{t+1}$  is not true, then the system transits from  $T_t$  to  $EC_{t+1}$ .

### *The deviation cycle*

The deviation cycle is obtained from the de-trended component of  $y_t$ . Several de-trending methods are available in the literature. This paper uses two different filtering procedures: the Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997) and the Baxter and King (BK) filter (Baxter and King, 1999).

The original series  $y$  is assumed to result from the combination of two processes:

$$(A6.a) \quad y_t = y_t^s + y_t^c$$

$$(A6.b) \quad \text{Var}(\Delta y_t^s > 0); \quad \text{Var}(y_t^c > 0);$$

$$(A6.c) \quad y_t^s \approx I(1); \quad y_t^c \approx I(0)$$

$y^s$  is the permanent component and it is normally referred to as the trend while  $y^c$  is the cyclical component. The deviation cycle refers to peaks and troughs of the cyclical component  $y^c$ .

Econometrically, the problem is how to extract  $y^s$  from the observed series  $y$ . The HP filters computes the permanent component of  $y$  by minimizing the variance of  $y$  around  $y^s$ , subject to a penalty that constrains the second difference of  $s$ . Formally,  $y^s$  is the solution to the following constrained minimization:

$$(A7.a) \quad \min_{y_t^s} \sum_{t=1}^T (y_t - y_t^s)^2$$

$$(A7.b) \quad \text{subject to } \sum_{t=2}^{T-1} \left[ y_{t+1}^s - y_t^s - (y_t^s - y_{t-1}^s) \right]^2 \leq \lambda$$

The cyclical component is then determined residually as  $y_t^c = y_t - y_t^s$ . For the purpose of this paper, the smoothing parameter  $\lambda$  is set according to the algorithm proposed by Ravn and Ugh (2002).

To overcome some of the drawbacks of the HP filter, Baxter and King (1999) propose a bandpass filter of finite order  $K$  which (i) has trend-reducing properties and (ii) yields no

phase shifts in the filter output. Operationally, the filter is defined as a finite moving average:

$$(A8.a) \quad y_t^s = \sum_{j=-K}^K a_j L^j y_t$$

where  $a_j$  are symmetric weights and  $L$  denotes the backshift operator ( $L^n y_t = y_{t-n}$ ). The symmetric weights are determined as the solution to the following minimization problem (see Woitek, 1998):

$$(A8.b) \quad \min_{a_j} Q = \int_{-\pi}^{\pi} |\beta(\omega) - \alpha(\omega)|^2 d\omega$$

$$(A8.c) \quad \text{subject to } \alpha(0) = 0$$

where  $|\beta(\omega)|$  is the “ideal” filter gain with cut-off frequencies  $\omega_1$  and  $\omega_2$ . Once the trend component is determined from (A8.a) and the solution of the minimization problem, the cyclical component  $y^c$  is obtained residually as  $y_t^c = y_t - y_t^s$ .

In the specific case of the data-set used for this paper, the two filtering procedures return remarkably similar cyclical components. As a consequence, the deviation chronology is the same in the two cases. The paper only reports results based on HP filtered series.

After de-trending the original series  $y$ , the dating algorithm is applied to the cyclical series  $y^c$  with one key modification. Following Artis et al. (2004), when dealing with deviation cycles, it is necessary to prevent that a peak is located when output is below trend level. This is so since an expansion must have brought output above trend. Similarly, a trough cannot be located when output is above trend level, since an expansion must have brought output below trend. Therefore, the *ETS* and *RTS* are redefined as follows:

$$(A9.a) \quad ETS_{t+1} = (\forall_t^c > 0) \cap (\Delta y_{t+2} < -c)$$

$$(A9.b) \quad RTS_{t+1} = (\forall_t^c < 0) \cap (\Delta y_{t+2} > c)$$

The new sequences (A9.a) and (A9.b) replaces the definitions (A5.a) and (A5.b) when applying the algorithm to the cyclical component  $y^c$ .

Appendix A2. **Tables**

Table A2.1. Business cycle chronology: Classical cycle

| Year | Cameroon | CAR | Chad | Congo | Eq<br>Guinea | Gabon |
|------|----------|-----|------|-------|--------------|-------|
| 1960 | EC       | EC  | EC   | EC    | ..           | EC    |
| 1961 | EC       | P   | EC   | EC    | ..           | EC    |
| 1962 | EC       | RC  | P    | P     | ..           | EC    |
| 1963 | EC       | T   | R    | T     | ..           | EC    |
| 1964 | EC       | EC  | T    | EC    | ..           | EC    |
| 1965 | EC       | EC  | P    | EC    | ..           | EC    |
| 1966 | P        | EC  | T    | EC    | ..           | EC    |
| 1967 | T        | EC  | EC   | EC    | ..           | EC    |
| 1968 | EC       | EC  | EC   | EC    | ..           | EC    |
| 1969 | EC       | EC  | EC   | EC    | ..           | EC    |
| 1970 | EC       | EC  | P    | EC    | ..           | EC    |
| 1971 | EC       | EC  | T    | EC    | ..           | EC    |
| 1972 | EC       | EC  | P    | EC    | ..           | EC    |
| 1973 | EC       | EC  | T    | EC    | ..           | EC    |
| 1974 | EC       | EC  | EC   | EC    | ..           | EC    |
| 1975 | P        | EC  | EC   | EC    | ..           | EC    |
| 1976 | T        | EC  | EC   | P     | ..           | P     |
| 1977 | EC       | EC  | EC   | T     | ..           | RC    |
| 1978 | EC       | P   | P    | EC    | ..           | RC    |
| 1979 | P        | RC  | RC   | EC    | ..           | T     |
| 1980 | T        | RC  | P    | EC    | EC           | EC    |
| 1981 | EC       | T   | EC   | EC    | EC           | P     |
| 1982 | EC       | PC  | EC   | EC    | EC           | T     |
| 1983 | EC       | T   | EC   | EC    | EC           | EC    |
| 1984 | EC       | EC  | EC   | P     | EC           | P     |
| 1985 | EC       | EC  | P    | RC    | P            | RC    |
| 1986 | P        | P   | RC   | RC    | T            | RC    |
| 1987 | RC       | T   | T    | T     | EC           | T     |
| 1988 | RC       | EC  | EC   | EC    | P            | EC    |
| 1989 | RC       | EC  | P    | EC    | T            | EC    |
| 1990 | RC       | RC  | T    | EC    | P            | EC    |
| 1991 | RC       | RC  | EC   | EC    | T            | P     |
| 1992 | RC       | RC  | P    | P     | EC           | T     |
| 1993 | RC       | T   | T    | RC    | EC           | EC    |
| 1994 | T        | EC  | EC   | T     | EC           | EC    |
| 1995 | EC       | P   | EC   | EC    | EC           | EC    |
| 1996 | EC       | T   | EC   | P     | EC           | EC    |
| 1997 | EC       | EC  | EC   | T     | EC           | EC    |
| 1998 | EC       | EC  | P    | P     | EC           | P     |
| 1999 | EC       | EC  | RC   | T     | EC           | T     |

|      |    |    |    |    |    |    |
|------|----|----|----|----|----|----|
| 2000 | EC | EC | T  | EC | EC | EC |
| 2001 | EC | P  | EC | EC | EC | EC |
| 2002 | EC | RC | EC | EC | EC | EC |
| 2003 | EC | T  | EC | EC | EC | EC |
| 2004 | EC | EC | EC | EC | EC | EC |
| 2005 | EC | EC | EC | EC | P  | EC |
| 2006 | EC | EC | EC | EC | T  | EC |
| 2007 | EC | EC | EC | EC | EC | EC |

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Note: EC = expansion continuation, P = peak of an expansion (turning point), RC = recession continuation, T = through of a recession (turning point)

Table A2.2. Business cycle chronology: Deviation cycle

| Year | Cameroon | CAR | Chad | Congo | Eq<br>Guinea | Gabon |
|------|----------|-----|------|-------|--------------|-------|
| 1960 | RC       | EC  | EC   | EC    | ..           | EC    |
| 1961 | T        | P   | EC   | EC    | ..           | P     |
| 1962 | EC       | RC  | P    | P     | ..           | RC    |
| 1963 | EC       | RC  | R    | T     | ..           | RC    |
| 1964 | EC       | RC  | T    | EC    | ..           | T     |
| 1965 | EC       | RC  | P    | P     | ..           | P     |
| 1966 | P        | TR  | RC   | RC    | ..           | RC    |
| 1967 | T        | PE  | RC   | T     | ..           | RC    |
| 1968 | EC       | T   | T    | EC    | ..           | RC    |
| 1969 | EC       | P   | EC   | EC    | ..           | RC    |
| 1970 | P        | RC  | P    | EC    | ..           | RC    |
| 1971 | RC       | RC  | RC   | EC    | ..           | RC    |
| 1972 | RC       | RC  | RC   | EC    | ..           | RC    |
| 1973 | T        | T   | T    | EC    | ..           | T     |
| 1974 | EC       | P   | EC   | EC    | ..           | EC    |
| 1975 | P        | T   | EC   | P     | ..           | EC    |
| 1976 | T        | EC  | EC   | RC    | ..           | P     |
| 1977 | EC       | EC  | EC   | T     | ..           | RC    |
| 1978 | P        | P   | P    | EC    | ..           | T     |
| 1979 | RC       | RC  | RC   | EC    | ..           | EC    |
| 1980 | T        | RC  | T    | EC    | EC           | EC    |
| 1981 | P        | T   | EC   | EC    | P            | EC    |
| 1982 | RC       | P   | EC   | P     | RC           | EC    |
| 1983 | T        | T   | P    | RC    | RC           | EC    |
| 1984 | EC       | EC  | T    | RC    | T            | P     |
| 1985 | EC       | EC  | P    | RC    | P            | RC    |
| 1986 | P        | P   | RC   | T     | T            | RC    |
| 1987 | RC       | T   | T    | EC    | EC           | T     |
| 1988 | T        | EC  | EC   | EC    | P            | EC    |
| 1989 | P        | P   | P    | EC    | RC           | EC    |
| 1990 | RC       | RC  | T    | EC    | RC           | EC    |
| 1991 | RC       | RC  | EC   | EC    | T            | P     |
| 1992 | RC       | T   | P    | P     | P            | RC    |
| 1993 | RC       | EC  | T    | RC    | RC           | RC    |
| 1994 | T        | EC  | EC   | T     | RC           | T     |
| 1995 | EC       | P   | EC   | EC    | T            | EC    |
| 1996 | EC       | T   | EC   | P     | EC           | EC    |
| 1997 | EC       | EC  | EC   | T     | EC           | EC    |
| 1998 | P        | EC  | P    | P     | EC           | P     |
| 1999 | RC       | EC  | RC   | T     | P            | T     |
| 2000 | RC       | EC  | RC   | EC    | RC           | EC    |

|      |    |    |    |    |    |    |
|------|----|----|----|----|----|----|
| 2001 | RC | P  | RC | EC | T  | P  |
| 2002 | RC | RC | T  | P  | EC | T  |
| 2003 | RC | T  | EC | RC | EC | EC |
| 2004 | RC | EC | P  | T  | P  | EC |
| 2005 | T  | EC | RC | EC | RC | EC |
| 2006 | EC | EC | RC | EC | RC | EC |
| 2007 | EC | EC | RC | EC | RC | EC |

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Note: EC = expansion continuation, PE = peak of an expansion (turning point), RC = recession continuation, TR = through of a recession (turning point)

Appendix A2. 3 First order autocorrelation of references variables

|     | 60-80   | 70-90  | 80-00  | 87-07  | 60-80  | 70-90  | 80-00  | 87-07  |
|-----|---|--------|--------|--------|--|--------|--------|--------|
|     | <b>Log-level of GDP (y)</b>   |        |        |        | <b>Detrended GDP (y<sup>c</sup>)</b>                               |        |        |        |
| CMR | 0.837   | 0.899  | 0.674  | 0.874  | -0.129   | -0.035 | 0.285  | 0.145  |
| CNG | 0.838   | 0.879  | 0.562  | 0.814  | 0.519  | 0.597  | 0.395  | 0.057  |
| GBN | 0.881   | 0.720  | 0.819  | 0.768  | 0.398  | 0.352  | 0.155  | 0.260  |
| GNQ | ..  | 0.693  | 0.816  | 0.898  | ..   | -0.352 | 0.349  | 0.337  |
| CAR | 0.901   | 0.760  | 0.648  | 0.810  | 0.125  | -0.049 | -0.093 | 0.212  |
| TCD | 0.461   | 0.768  | 0.806  | 0.820  | 0.308  | 0.252  | -0.015 | 0.063  |
|     | <b>First difference of log-level of GDP (<math>\Delta y</math>)</b> |        |        |        | <b>First difference of detrended GDP (<math>\Delta y^c</math>)</b> |        |        |        |
| CMR | 0.023   | 0.224  | 0.543  | 0.771  | -0.203   | -0.225 | -0.392 | -0.070 |
| CNG | 0.282   | 0.569  | 0.523  | 0.003  | 0.051  | 0.148  | -0.062 | -0.285 |
| GBN | 0.355   | 0.302  | -0.086 | -0.149 | 0.000  | -0.056 | -0.200 | -0.241 |
| GNQ | ..  | -0.557 | 0.435  | 0.378  | ..   | -0.723 | -0.334 | -0.136 |
| CAR | 0.104   | -0.284 | -0.241 | 0.103  | -0.233   | -0.474 | -0.461 | -0.170 |
| TCD | 0.198   | 0.126  | -0.283 | 0.061  | -0.031   | -0.194 | -0.417 | -0.246 |

Note: For each country and each sub-period, the table shows the first order autocorrelation coefficient of each of the four reference variables. CMR = Cameroon, CNG = Congo, GBN = Gabon, GNQ = Equatorial Guinea, CAR = Central African Republic, TCD = Chad.

Table A2.4. Volatility of business cycles in CAMEC countries

|     | 60-80   | 70-90 | 80-00 | 87-07 | 60-80  | 70-90 | 80-00 | 87-07 |
|-----|---|-------|-------|-------|--|-------|-------|-------|
|     | <b>Log-level of GDP (y)</b>   |       |       |       | <b>Detrended GDP (y<sup>c</sup>)</b>                                   |       |       |       |
| CMR | 0.273   | 0.402 | 0.123 | 0.161 | 0.039  | 0.048 | 0.036 | 0.021 |
| CNG | 0.314   | 0.401 | 0.138 | 0.151 | 0.085  | 0.093 | 0.046 | 0.038 |
| GBN | 0.544   | 0.291 | 0.156 | 0.168 | ..   | 0.021 | 0.073 | 0.083 |
| GNQ | ..  | 0.113 | 0.632 | 0.961 | 0.019  | 0.026 | 0.029 | 0.025 |
| CAR | 0.137   | 0.083 | 0.077 | 0.084 | 0.049  | 0.061 | 0.054 | 0.054 |
| TCD | 0.075   | 0.159 | 0.238 | 0.342 | 0.058  | 0.053 | 0.034 | 0.016 |
|     | <b>First difference of log-level of GDP<br/>(<math>\Delta y</math>)</b> |       |       |       | <b>First difference of detrended GDP<br/>(<math>\Delta y^c</math>)</b> |       |       |       |
| CMR | 0.065   | 0.072 | 0.058 | 0.042 | 0.058  | 0.053 | 0.034 | 0.016 |
| CNG | 0.053   | 0.072 | 0.070 | 0.033 | 0.038  | 0.043 | 0.040 | 0.028 |
| GBN | 0.128   | 0.139 | 0.064 | 0.061 | 0.095  | 0.105 | 0.059 | 0.054 |
| GNQ | ..  | 0.041 | 0.139 | 0.139 | ..   | 0.037 | 0.085 | 0.095 |
| CAR | 0.031   | 0.042 | 0.048 | 0.039 | 0.024  | 0.038 | 0.043 | 0.033 |
| TCD | 0.068   | 0.091 | 0.081 | 0.087 | 0.056  | 0.074 | 0.074 | 0.073 |

Note: For each country and each sub-period, the table shows the standard deviation of the four reference variables. CMR = Cameroon, CNG = Congo, GBN = Gabon, GNQ = Equatorial Guinea, CAR = Central African Republic, TCD = Chad.

Table A2. 5 Standard bilateral concordance index: classical cycle

|           |       | CMR   | CAR   | Chad  | Congo | Eq Guinea | Gabon |
|-----------|-------|-------|-------|-------|-------|-----------|-------|
| CMR       | 60-80 |       | 0.762 | 0.619 | 0.761 | ..        | 0.714 |
|           | 70-90 |       | 0.714 | 0.667 | 0.619 | 0.545     | 0.476 |
|           | 80-00 |       | 0.714 | 0.619 | 0.524 | 0.619     | 0.476 |
|           | 87-07 |       | 0.714 | 0.667 | 0.667 | 0.667     | 0.667 |
| CAR       | 60-80 | 0.762 |       | 0.762 | 0.809 | ..        | 0.762 |
|           | 70-90 | 0.714 |       | 0.762 | 0.619 | 0.364     | 0.571 |
|           | 80-00 | 0.714 |       | 0.619 | 0.428 | 0.524     | 0.476 |
|           | 87-07 | 0.714 |       | 0.667 | 0.571 | 0.571     | 0.667 |
| Chad      | 60-80 | 0.619 | 0.762 |       | 0.667 | ..        | 0.619 |
|           | 70-90 | 0.667 | 0.762 |       | 0.667 | 0.636     | 0.619 |
|           | 80-00 | 0.619 | 0.619 |       | 0.714 | 0.619     | 0.667 |
|           | 87-07 | 0.667 | 0.667 |       | 0.809 | 0.619     | 0.809 |
| Congo     | 60-80 | 0.762 | 0.809 | 0.667 |       | ..        | 0.857 |
|           | 70-90 | 0.619 | 0.619 | 0.667 |       | 0.727     | 0.857 |
|           | 80-00 | 0.524 | 0.428 | 0.714 |       | 0.619     | 0.762 |
|           | 87-07 | 0.667 | 0.571 | 0.809 |       | 0.619     | 0.809 |
| Eq Guinea | 60-80 | ..    | ..    | ..    | ..    |           | ..    |
|           | 70-90 | 0.545 | 0.364 | 0.636 | 0.727 |           | 0.636 |
|           | 80-00 | 0.619 | 0.524 | 0.619 | 0.619 |           | 0.667 |
|           | 87-07 | 0.667 | 0.571 | 0.619 | 0.619 |           | 0.714 |
| Gabon     | 60-80 | 0.714 | 0.762 | 0.619 | 0.857 | ..        |       |
|           | 70-90 | 0.476 | 0.571 | 0.619 | 0.857 | 0.636     |       |
|           | 80-00 | 0.476 | 0.476 | 0.667 | 0.762 | 0.667     |       |
|           | 87-07 | 0.667 | 0.667 | 0.809 | 0.809 | 0.714     |       |

Note: For each pair of countries, the table reports the standard bilateral concordance index  $I_{ij}$  (see equation (5) in the test for definition). The concordance index in this table is computed on the basis of the classical cycle chronology.

Table A2.6. Mean-corrected bilateral concordance index: classical cycle.

|         |       | CMR    | CAR    | Chad   | Congo  | Eq Guinea | Gabon  |
|---------|-------|--------|--------|--------|--------|-----------|--------|
| CMR     | 60-80 |        | 0.041  | 0      | -0.027 | ..        | -0.041 |
|         | 70-90 |        | 0.122  | 0.095  | -0.014 | -0.091    | -0.095 |
|         | 80-00 |        | 0.204  | 0.095  | 0      | 0.068     | -0.054 |
|         | 87-07 |        | 0.186  | 0.104  | 0.104  | 0.082     | 0.082  |
| CAR     | 60-80 | 0.041  |        | 0.159  | 0.059  | ..        | 0.041  |
|         | 70-90 | 0.122  |        | 0.190  | -0.014 | -0.273    | 0      |
|         | 80-00 | 0.204  |        | 0.095  | -0.095 | -0.027    | -0.054 |
|         | 87-07 | 0.186  |        | 0.104  | 0.009  | -0.014    | 0.082  |
| Chad    | 60-80 | 0      | 0.159  |        | 0.032  | ..        | 0      |
|         | 70-90 | 0.095  | 0.190  |        | 0.063  | 0.030     | 0.063  |
|         | 80-00 | 0.095  | 0.095  |        | 0.159  | 0         | 0.095  |
|         | 87-07 | 0.104  | 0.104  |        | 0.172  | -0.068    | 0.122  |
| Congo   | 60-80 | -0.027 | 0.059  | 0.032  |        | ..        | 0.068  |
|         | 70-90 | -0.014 | -0.014 | 0.063  |        | 0.030     | 0.254  |
|         | 80-00 | 0      | -0.095 | 0.159  |        | 0         | 0.190  |
|         | 87-07 | 0.104  | 0.009  | 0.172  |        | -0.068    | 0.122  |
| Eq Guin | 60-80 | ..     | ..     | ..     | ..     |           | ..     |
|         | 70-90 | -0.091 | -0.272 | 0.030  | 0.030  |           | 0.030  |
|         | 80-00 | 0.068  | -0.028 | 0      | 0      |           | 0.014  |
|         | 87-07 | 0.082  | -0.014 | -0.068 | -0.068 |           | -0.041 |
| Gabon   | 60-80 | -0.041 | 0.041  | 0      | 0.068  | ..        |        |
|         | 70-90 | -0.095 | 0      | 0.063  | 0.254  | 0.030     |        |
|         | 80-00 | -0.054 | -0.054 | 0.095  | 0.190  | 0.014     |        |
|         | 87-07 | 0.082  | 0.082  | 0.122  | 0.122  | -0.041    |        |

Note: For each pair of countries, the table reports the standard bilateral concordance index  $I_{ij}^*$  (see equation (6) in the test for definition). The concordance index in this table is computed on the basis of the classical cycle chronology.

Table A2.7: Standard bilateral concordance index: deviation cycle

|           |       | CMR   | CAR   | Chad  | Congo | Eq Guinea | Gabon |
|-----------|-------|-------|-------|-------|-------|-----------|-------|
| CMR       | 60-80 |       | 0.428 | 0.667 | 0.524 | ..        | 0.333 |
|           | 70-90 |       | 0.714 | 0.714 | 0.381 | 0.238     | 0.428 |
|           | 80-00 |       | 0.619 | 0.619 | 0.428 | 0.571     | 0.571 |
|           | 87-07 |       | 0.571 | 0.619 | 0.524 | 0.476     | 0.619 |
| CAR       | 60-80 | 0.428 |       | 0.762 | 0.333 | ..        | 0.333 |
|           | 70-90 | 0.714 |       | 0.714 | 0.286 | 0.190     | 0.286 |
|           | 80-00 | 0.619 |       | 0.524 | 0.333 | 0.381     | 0.333 |
|           | 87-07 | 0.571 |       | 0.476 | 0.476 | 0.333     | 0.476 |
| Chad      | 60-80 | 0.667 | 0.762 |       | 0.333 | ..        | 0.667 |
|           | 70-90 | 0.714 | 0.714 |       | 0.286 | 0.286     | 0.619 |
|           | 80-00 | 0.619 | 0.524 |       | 0.333 | 0.571     | 0.667 |
|           | 87-07 | 0.619 | 0.476 |       | 0.476 | 0.667     | 0.619 |
| Congo     | 60-80 | 0.524 | 0.333 | 0.333 |       | ..        | 0.524 |
|           | 70-90 | 0.381 | 0.286 | 0.286 |       | 0.333     | 0.571 |
|           | 80-00 | 0.428 | 0.333 | 0.333 |       | 0.571     | 0.762 |
|           | 87-07 | 0.524 | 0.476 | 0.476 |       | 0.381     | 0.714 |
| Eq Guinea | 60-80 | ..    | ..    | ..    |       |           | ..    |
|           | 70-90 | 0.238 | 0.190 | 0.286 | 0.333 |           | 0.190 |
|           | 80-00 | 0.571 | 0.381 | 0.571 | 0.571 |           | 0.428 |
|           | 87-07 | 0.476 | 0.333 | 0.667 | 0.381 |           | 0.381 |
| Gabon     | 60-80 | 0.333 | 0.333 | 0.667 | 0.524 | ..        |       |
|           | 70-90 | 0.428 | 0.285 | 0.619 | 0.571 | 0.190     |       |
|           | 80-00 | 0.571 | 0.333 | 0.667 | 0.762 | 0.428     |       |
|           | 87-07 | 0.619 | 0.476 | 0.619 | 0.714 | 0.381     |       |

Note: For each pair of countries, the table reports the standard bilateral concordance index  $I_{ij}$  (see equation (5) in the test for definition). The concordance index in this table is computed on the basis of the deviation cycle chronology.

Table A2.8. Mean-corrected bilateral concordance index: deviation cycle.

|           |       | CMR    | CAR    | Chad   | Congo  | Eq Guinea | Gabon  |
|-----------|-------|--------|--------|--------|--------|-----------|--------|
| CMR       | 60-80 |        | -0.054 | 0.163  | -0.014 | ..        | -0.150 |
|           | 70-90 |        | 0.213  | 0.218  | -0.109 | -0.264    | -0.068 |
|           | 80-00 |        | 0.136  | 0.136  | -0.054 | 0.068     | 0.095  |
|           | 87-07 |        | 0.127  | 0.127  | 0.095  | -0.032    | 0.190  |
| CAR       | 60-80 | -0.054 |        | 0.267  | -0.104 | ..        | -0.195 |
|           | 70-90 | 0.213  |        | 0.218  | -0.204 | -0.312    | -0.211 |
|           | 80-00 | 0.136  |        | -0.004 | -0.195 | -0.113    | -0.206 |
|           | 87-07 | 0.127  |        | -0.032 | -0.095 | -0.159    | -0.095 |
| Chad      | 60-80 | 0.163  | 0.267  |        | -0.179 | ..        | 0.172  |
|           | 70-90 | 0.218  | 0.218  |        | -0.245 | -0.208    | 0.109  |
|           | 80-00 | 0.136  | -0.004 |        | -0.195 | 0.078     | 0.127  |
|           | 87-07 | 0.127  | -0.032 |        | -0.034 | 0.168     | 0.109  |
| Congo     | 60-80 | -0.014 | -0.104 | -0.179 |        | ..        | 0.086  |
|           | 70-90 | -0.109 | -0.204 | -0.245 |        | -0.147    | 0.041  |
|           | 80-00 | -0.054 | -0.195 | -0.195 |        | 0.077     | 0.222  |
|           | 87-07 | 0.095  | -0.095 | -0.034 |        | -0.109    | 0.122  |
| Eq Guinea | 60-80 | ..     | ..     | ..     | ..     |           | ..     |
|           | 70-90 | -0.264 | -0.312 | -0.208 | -0.147 |           | -0.303 |
|           | 80-00 | 0.068  | -0.113 | 0.078  | 0.077  |           | -0.063 |
|           | 87-07 | -0.032 | -0.159 | 0.168  | -0.109 |           | -0.109 |
| Gabon     | 60-80 | -0.150 | -0.195 | 0.172  | 0.086  | ..        |        |
|           | 70-90 | -0.068 | -0.211 | 0.109  | 0.041  | -0.303    |        |
|           | 80-00 | 0.095  | -0.206 | 0.127  | 0.222  | -0.063    |        |
|           | 87-07 | 0.190  | -0.095 | 0.109  | 0.122  | -0.109    |        |

Note: For each pair of countries, the table reports the standard bilateral concordance index  $I_{ij}^*$  (see equation (6) in the test for definition). The concordance index in this table is computed on the basis of the deviation cycle chronology.

## References:

Agbeyegbe, T.D. (2008). On the feasibility of a monetary union in the Southern Africa Development Community. *International Journal of Finance and Economics*, 13, 135 - 204

Artis, M. Marcellino, M. and Proietti, T. (2004). Dating the Euro-Area Business Cycle. *Oxford Bulletin of Economics and Statistics*, 66, 537-565

Artis, M. Marcellino, M. and Proietti, T. (2005). Characterizing Business Cycles for Accession Countries. *Journal of Business Cycle Measurement and Analysis*, 2, 7-41.

Bangake, C. (2008). Exchange Rate Volatility and Optimum Currency Area: Evidence from Africa. *Economics Bulletin*, 6, 1-10.

Barro, R. and Tenreyro, S. (2007). *Economic Effects Of Currency Unions*. *Economic Inquiry*, 45,1-23.

Baxter, M. and King, R. (1999). Measuring Business Cycles: Approximate Band-Pass Filters For Economic Time Series. *Review of Economics and Statistics*, 81, 575-593.

Belke, A. (2007). Endogenous Optimum Currency Areas and the Blend of Sectors - On the Determinants of Business Cycle Correlation across European Regions. *Journal of Economic Integration*, 22, 26-49

Bry, G. and Broschan, C. (1971). *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*. New York, NBER.

Burns, A.F. and Mitchell, W.C. (1946). *Measuring Business Cycles*. New York, NBER.

Carmignani, F. (2006). The Road to Regional Integration in Africa: Macroeconomic Convergence and Performance in COMESA. *Journal of African Economies*, 15, 212-250.

Coe, D.T. and Helpmann E. (1995). International R&D Spillovers. *European Economic Review*, 39, 859-887.

Corsetti, G. and Pesenti, P. (2002). Self-Validating Optimum Currency Areas. NBER Working Paper 8783.

Darvas, Z. and Szapáry, G. (2008). Business Cycle Synchronization in the Enlarged EU. *Open Economies Review*, 19, 1-19.

Fidrmuc, J. (2004). The Endogeneity of the Optimum Currency Area Criteria, Intra-industry Trade, and EMU Enlargement. *Contemporary Economic Policy*, 22, 1-12.

Fielding, D., Lee, K. and Shields, K. (2004). The Characteristics of Macroeconomic Shocks in the CFA Franc Zone. *Journal of African Economies*, 13, 488-517

Fielding, D. and Shields, K. (2005). The Impact of Monetary Union on Macroeconomic Integration: Evidence from West Africa. *Economica*, 72, 683-704.

Frankel, J. and Rose, A. (1998). The Endogeneity of Optimal Currency Area Criteria. *Economic Journal*, 108, 1009-1025.

Harding, D. and Pagan, A. (2001). Extracting, Using and Analysing Cyclical Information. MPRA Paper 15, University Library of Munich, Germany.

Harding, D. and Pagan, A. (2006). Synchronization of cycles. *Journal of Econometrics*, 132, 59-79.

Hodrick, R. and Prescott, E. (1997). Postwar U.S. Business Cycles: An Empirical Investigation. *Journal of Money, Credit, and Banking*, 29, 1-16.

IMF – International Monetary Fund (2008). *Direction of Trade Statistics*. Washington.

Karras, G. (2007). Is Africa an Optimum Currency Area? A Comparison of Macroeconomic Costs and Benefits. *Journal of African Economies* 16, 234-258.

Proietti, T. (2005). New algorithms for dating the business cycle. *Computational Statistics and Data Analysis*, 49, 477-498.

Ravn M. and Uhlig H. (2002). On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations. *Review of Economics and Statistics*, 84, 371-375.

Rose, A. (2000). One Money, One Market: Estimating the Effect of Common Currencies on Trade. *Economic Policy*, 30, 9-45.

Rose, A. (2004). A Meta-Analysis of the Effect of Common Currencies on International Trade. NBER Working Paper 10373

Rose, A. (2008). EMU, Trade and Business Cycles Synchronization. Mimeo. Haas School of Business, University of California, Berkeley.

Savva, C., Neanidis, K., and Osborn, D. (2007). Business Cycle Synchronization of the Euro Area with the New and Negotiating Member Countries. University of Manchester, Centre for Growth and Business Cycle Research, Working Paper 091.

UNECA – United Nations Economic Commission for Africa (2004). *Assessing Regional Integration in Africa*. Addis Ababa, Ethiopia.

UNECA – United Nations Economic Commission for Africa (2007). *Convergence économique en Afrique Centrale*. Bureau Sous-regional pour l’Afrique Centrale, Yaounde, Cameroon.

Woitek, U. (1998). A Note on the Baxter-King Filter. University of Glasgow, Department of Economics Working Paper 9813.