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 (OCA), the degree of business cycles synchronization across its member states should be significantly higher today than 40 years ago. Investigating the empirical validity of this hypothesis is important in the context of the African economic integration process. If currency unions are endogenous, then quick monetary integration is a worthwhile option that can be used to accelerate economic integration. 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.

This paper assesses the endogeneity of CAEMC as an OCA by examining the cross-country synchronization of business cycles along three statistical dimensions: bilateral correlation of cyclical co-movements, similarity of cycle statistical properties, and concordance of cyclical phases. Its innovative contribution is threefold. First, it provides a direct test of the endogeneity hypothesis on a specific currency union. Most previous studies instead rely on panel estimates of global datasets. Second, it expands the existing literature on the monetary geography of Africa. Indeed, there are several papers that study whether or not specific African regions are OCA. However, these papers generally look at the ex-ante conditions for optimality, leaving the issue of endogeneity of OCA criteria unexplored. The paper fills in this gap. Third, the paper presents a business cycle chronology for the six CAEMC members, thus opening up new opportunities to understand the cyclical characterization of economic systems and policies in the region.

The main result of the analysis is that (i) the degree of synchronization of business cycles across CAEMC countries has remained low throughout the period 1960-2007, but (ii) it has somewhat increased over time. This increase is however marginal in both economic and statistical terms, thus implying that CAEMC currency union is not as endogenous as one would expect from previous empirical results obtained from global datasets. The reason why the endogeneity effect is so weak is that its channels of transmission are not work: intra-regional trade is very low and macroeconomic policies across union members do not seem to converge. Furthermore, increasingly different productive structures also reduced the intensity of synchronization. The policy implications of the analysis then concern the design of policy and institutions in the CAEMC and the way forward for monetary unification in Africa.

EPrint Type:	Departmental Technical Report
Keywords:	Business cycles, turning points, synchronization, optimal currency areas.
Subjects:	
ID Code:	JEL Classification: E32, E39, F15, O10.
Deposited By:	

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Abstract

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1. Introduction

Monetary unification is nowadays a key objective of many African regional economic communities (REC)[1]. 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; Tapsoba, 2009). 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[2]. 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 even if shocks are asymmetric across countries in the same region (as it is often the case in Africa, see for instance Buigut and Valev, 2005; Houssa, 2008; Khamfula and Huizinga, 2004). On the contrary, if currency unions were not endogenous, then a speedy monetary unification would not

[1] 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.

[2] A notable exception is Fielding and Shields (2005). Differences between their paper and this paper are discussed below. Tapsoba (2009) also provides evidence on endogeneity by adding a dummy variable for membership in a monetary union to the list of regressors in his analysis of the determinant of the synchronization of cycles between pairs of countries.

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 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[3]. 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.

[3] Rose (2008) provides a meta-analysis of existing empirical evidence focusing on the European Monetary Union.

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 enhances trade[4]. However, they also find that a common currency decreases co-movements of shocks to real GDP, which is at odds with the endogeneity hypothesis. Tapsoba (2009) estimates the determinants of synchronization in a large group of African countries. He finds that bilateral trade integration increases synchronization, albeit the effect is quantitatively smaller than what usually reported for industrial economies. After controlling for bilateral trade, the residual effect of monetary unions on synchronization is found to be statistically insignificant.

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

[4] 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.

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[5].

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 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 (WAEMU) and CAEMC. In spite of

[5] To the best of my knowledge.

common origins and many similarities, WAEMU 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 between the two groups. CAEMC is retained as the object of investigation in this paper because it has received less attention than WAEMU in previous work.

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 A1 contains a technical discussion of filtering procedures and algorithms for dating the business cycle. Appendix A2 reports the business cycle chronology country by country and some additional results that were not presented in the text for the sake of brevity. Appendix A3 presents results from an alternative approach to the analysis of synchronization in the CAEMC region.

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 A1[6].

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 available only on an annual basis. For industrial countries, instead, quarterly if not monthly series are 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 through of a recession) and t+1 is the first period of a new cyclical phase.

[6] 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.

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

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

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

where Δ is the first-difference operator (so that Δy 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 $c = 0.005$ (=0.5%). In words, equations (1) and (2) imply that time t is the peak of an expansion (the through 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 $t+1$.[7]

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

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

[7] The magnitude of fluctuations in CAEMC countries is relatively larger than in European countries. This might suggest setting c above the 0.5% threshold value used by Artis et al. (2004 and 2005). As a sensitivity check, the values 0.75% and 1% have also been used. Results are not qualitatively different from those reported in tables 1 and 4. The additional results obtained from values of c = 0.75% and 1% are available from the author upon request.

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 A2. 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. However, it does not imply that following the devaluation cycles across countries have become systematically more synchronized.

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, Δy and Δy^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, Δy and Δy^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:

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

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 $E[S_{i=jt}]$ denote the expected values of S_{it} and S_{jt} respectively, then the mean corrected concordance index is written as:

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

Both, I_{ij} and I^{*}_{ij} are computed for each pair of countries in CAEMC over each of the four sub-periods. Again, increasing 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[8]. 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.

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.

[8] The full set of bilateral correlation coefficients and standard deviations for each reference variable, each sub-period is available upon request from the author.

For each of the other three reference series, the bilateral correlations are rather low and hardly significant in statistical terms[9]. 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 Δy and Δy^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 15 country pairs, the bilateral correlation coefficient of Δy and y^c is higher in 1987-2007 than in 1960-1980; for 9 out of 15 the bilateral correlation coefficient of Δy^c is higher in 1987-2007 than in 1960-1980. One can therefore argue that, while remaining always rather low, the degree of co-movement of cyclical fluctuations has to some extent increased over time in the CAEMC area[10].

[9] As a comparison, consider that the average bilateral correlations between EMU members are as follows. For the variable Δy: 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 Δy^c: 0.357 in 1960-1980, 0.466 in 1970-1990, 0.531 in 1980-2000, and 0.653 in 1987-2007.

[10] As discussed in the Appendix A1, the statistics reported in table 2 for y^c and Δy^c are obtained from a Hodrick-Prescott trend-cycle decomposition of y with λ set according to the algorithm of Ravn and Uhlig (2002). The synchronization patterns observed from table 2 hold when a value $\lambda = 100$ (as originally proposed by Hodrick and Prescott, 1997) is used. As a matter of fact, the cyclical components obtained with λ=100 look remarkably similar to those obtained when setting λ according to Ravn and Uhlig's algorithm. Let y^{c100} be the cyclical component computed using $\lambda = 100$ and yc^{RU} the cyclical component computed using the Ravhn and Uhlig's algorithm. The average correlation between y^{c100} and yc^{RU} is 0.8, while the average correlation between Δy^{c100} and Δyc^{RU} reaches 0.9. Moreover, the series y^{c100} and yc^{RU} are in the same cyclical phase on average 87% of the times. The only substantive change when using λ = 100 is that the peak in the synchronization of y^c series is observed in the second sub-period (1970-1990) and not in the third sub-period (1980-2000). Correlations coefficients are also marginally higher when using λ = 100, but their trend remains only weakly upward sloping.

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 Δy, 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 Δy^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.[11]

[11] 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.

ISERT 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 (Δy, Δy^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, Δy^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. 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 dynamics, 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 in the 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 marginally increases over time.

3.3. Sensitivity and robustness

The conclusion drawn from the analysis of the previous subsections is that the synchronization of cycles across CAEMC countries is generally low and only weakly increasing over time. As further discussed in Section 4, this means that the currency union is not as endogenously optimal as one would expect from previous empirical results. This subsection considers alternative partitions of the sample period 1960-2007 to test the robustness of the above general conclusion and to see whether any structural changes have taken place in the region that might have offset the endogeneity effect.

An increase in the synchronization of cycles between two countries can occur through any of the following channels (see, for instance Tapsoba, 2009): (i) deeper bilateral (or intra-regional) trade integration, (ii) increased similarity of macroeconomic policies, (iii) increased similarity of productive structures, and (iv) increased trade intensity with the rest of the world. The endogeneity effect should operate through the first two channels, in the sense that the formation of a currency union is expected to increase bilateral trade and strengthen policy harmonization between the participating countries. However, if at the same time the countries in the currency ions face an increase in the degree of diversity of their productive structures and/or a decrease in their volume of trade with the rest of the world, then the endogeneity effect will be (to some extent) neutralized. These considerations suggest splitting the sample period in sub-periods such that within each sub-period the degree of similarity of productive structures across countries and/or the intensity of trade with the rest of the world are relatively constant. In this way, the evolution of synchronization within each sub-sample is only driven by changes in bilateral trade intensity and policy harmonization. In other words, within each sub-period, the only channels at work are those through which the endogeneity effect is expected to be transmitted. One can the assess separately the strength of the endogeneity effect and the potential countervailing impact of structural changes in production structures and trade shocks.[12]

Empirically, the diversity of production structures between any two CAEMC members *i* and *j* at time *t* is defined as:

(7) $PD_{ijt} = \frac{1}{3}\sum_{m=0}^{3}\left|v_{m,it} - v_{m,jt}\right|$

[12] If the sample period were split in subsamples such that within each subsample bilateral trade intensity and policy harmonization are constant, then the endogeneity effect of the currency union would be voided by construction. Appendix A3 presents an alternative approach to the problem of controlling for structural changes in other determinants of synchronization.

where *m* is a generic production sector (agriculture, industry or services) and v_m denotes its GDP share. The index (7) is computed for each possible pair of CAEMC countries using data from the World Development Indicators of the World Bank. The average of (7) taken over all possible pairs of countries then measures the degree of diversity of productive structures in the CAEMC region and it is denoted as PD_t. This index increases over time, ranging from 0.465 over the decade 1965-75 to 0.694 over the decade 1995-05. The increase however does not occur uniformly over time: throughout the '70s and the '80s the index remains well below 0.55 and it significantly grows only towards the end of the sample period.

To see to what extent the observed increase in the diversity of productive structures might have defused the endogeneity effect, the 1960-2007 is split in sub-periods according to values of PD_t. The problem is to identify the date (or dates) at which the system moves from a *low-PD* regime to a *high-PD* regime (or vice-versa). Once identified, these dates can then be used to define sub-periods characterized by a relatively stable degree of diversity of productive structures. To be able to analyze the evolution of synchronization within sub-periods, each sub-period will have to be further partitioned into partially overlapping "blocks" of 10 year each. This in turn implies that each sub-period should be of at least 15 years, so to allow at least two blocks that overlap for five years.

Hamilton (1989) proposes a dating procedure that makes use of a two-state Markov-switching regime representation of PD_t. The application of this procedure yields a regime-switching date at 1992.[13] Between 1960 and 1992 (*low-PD* regime) *PD* averages at 0.486 while between 1992 and 2007 (*high-PD* regime) the average is 0.67. The ten year blocks are then 1962-72, 1967-77, 1972-82, 1977-87, 1982-92, 1987-97, 1992-02, and 1997-07. The first five of these blocks fall within the *low-PD* regime, the last two blocks fall within the *high-PD* regime while the block 1987-97 overlaps both regimes and is therefore regarded as transitory. The measures of synchronization described in subsection 3.1 are recomputed for each block and averages across blocks within each of the two sub-periods. Table 5 reports, for each of the three reference variables Δy, y^c, and Δy^c, the average of bilateral correlations taken over all pairs of countries. Averages of the other measures of synchronization tell a very similar and are available upon request.

INSERT TABLE 5 ABOUT HERE

To start with, consider the top part of the table, where the average bilateral correlation is shown for each variable and each block. If the increase in the diversity of productive structures across countries is the reason why monetary unification has not resulted into a sharp increase in synchronization, then one should observe fast growing correlations during the *low-PD* regime and weakly growing (or even decreasing) correlations during the *high-PD* regime. In fact, the data in the table suggest that during the *high-PD* regime correlations have on average marginally decreased, even though the extent of this decrease varies considerably depending on the reference variable considered. This is consistent with the idea that when productive structures have become very different across countries, business cycles have become less synchronized. However, the average

[13] The switching date does not change if Equatorial Guinea is excluded from the sample.

correlation in the *high-PD* regime is generally higher than the average correlation in the *low-PD* regime (as the data in the bottom part of the table make clear). More importantly, during the *low-PD* regime, correlations do not display any strong tendency to increase. On the contrary, they remain generally low and below 0.1. In this sense, the increase in productive structure diversity across countries did not favor greater synchronization. But even during a time when productive structures were not so different, synchronization remained low and hardly growing over time.

The other variable that might have countervailed the effect of monetary unification on synchronization is total trade integration (*TT*) with the rest of the world. As discussed in previous work (see for instance Baxter and Kouparitsas, 2005 and Tapsoba, 2009), larger trade flows with the rest of the world can increase the bilateral synchronization of cycles between countries *i* and *j* over and above any effect due to bilateral trade. Possible transmission channels of this effect include greater opportunities for technological spillovers and/or a higher likelihood of experiencing similar global shocks. In this sense, total trade integration might have been an obstacle to greater synchronization in the region only to the extent that it has decreased over time, reflecting a progressive isolation of CAEMC countries from global trade links. However, this does not seem to be the case. For each pair of countries *i* and *j*, *TT* can be simply measured as the sum of exports and imports of *i* plus the sum of exports and imports of *j* divided by the sum of GDP of *i* and *j*. Taking averages over all pairs of CAEMC countries, an average of trade intensity of the CAEMC region is the obtained. This average increases from 1.403 in 1965-75 to 1.853 in 1995-05. With the exception of a few years before the 1994 devaluation, *TT* increases steadily throughout the sample period. Because trade intensity is not decreasing over time, one can reject the idea that synchronization was kept low by negative trade shocks. Even so, it is interesting to analyze possible regime switches in the *TT* series. The only significant change in regime occurs in 1994, most likely in association with the devaluation of the CFA. Following that devaluation, CAEMC also started a series of reforms to promote intra-regional trade and foster regional economic integration. One therefore wonders to what extent the switch from *low-TT* to *high-TT* regime and the reforms introduced after the devaluation affected synchronization. The rest of the subsection is devoted to answering thing question.

To some extent, the data reported for the period 1987-2007 should already capture any possible effect from devaluation and reforms. Moreover, the partition used in Table 5 (with a switch date at 1992) is very similar to the one that would be obtained by imposing a switch date at 1992. The evidence presented in that table is therefore most likely to be provide a good representation of possible changes in patterns of synchronization caused by the re-alignment of the exchange rate and the reforms. Nevertheless, as a further sensitivity check, correlations and concordance indexes have been recomputed for the sub-period 1994-2007 (and are available upon request). It turns out that they are quite similar to those reported for the sub-period 1987-2007. The only significant change is indeed observed with respect to the average correlation of y^c. Its average between 1994 and 2007 is 0.1, thus higher than the average computed for 1987-2007 (0.047, see table 2). However, it must be noted that this average of 0.1 is still lower than the average of the sub-period 1980-1993 (0.138) and it is only marginally higher than the average of the first sub-period 1960-1980. This confirms that the devaluation and the post-1994 reforms did not cause a structural break in the evolution of synchronization.[14]

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".

[14] A further confirmation of this conclusion comes from the fact that there is no structural break in the time series of the standard deviation of y^c, Δy^c and Δy across countries. If the post-1994 reforms had effectively increased synchronization to a significant extent, then annual series of the standard deviation should exhibit a break around 1994. Various versions of Chow's test reject this hypothesis.

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 as endogenous as it would be expected from the result of previous panel and cross-country estimates. Yet, some degree of endogeneity is there, as the growing correlations of output fluctuations, the increasing similarities of cycles' statistical properties and a stronger concordance of cyclical phases over time indicate.

The question that remains to be discussed is then what prevents CAEMC from being a fully endogenous OCA. As noted in Section 3.3, the increase in diversity of productive structures has somewhat reduced synchronization, but it cannot take all the blame for the weakness of the endogeneity effect. The same is true for structural chances in total trade intensity with the rest of the world. What really explains the lack of endogeneity is probably the fact that the two main channels through which a monetary union becomes optimally endogenous, namely the intensification of intra-regional trade and the harmonization of policies across countries, are not fully at work in CAEMC. 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%[15]. 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. In a similar vein, CAEMC did not introduce a rigorous framework for policy harmonization in the region until 1997. This certainly goes some length in explaining the lack of convergence of macroeconomic policies across union members. 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.[16].

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

[15] Trade data are taken from IMF (2008).

[16] For a systematic analysis of macroeconomic policy convergence in the region see UNECA (2007).

connectivity, so to activate the channels through which business cycles can become more synchronized and hence maximize the potential benefits from monetary integration. A 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, four issues to be explored in future work are worth a mention. First, 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. Second, future research should analyzed whether or not 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. Third, 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. Fourth, the statistical methodology could be extended to perform a formal test of synchronization in CAEMC countries vs. other country groupings (in Africa and/or outside Africa). The test would require the creation of country groupings whose members are selected at random and/or on the basis of criteria other than participation in the same currency union. A measure of synchronization in these groupings should be then computed and a distribution derived. This distribution can then be used for statistical inference on the significance of the degree of synchronization observed in the CAEMC group.

Tables

Table 1: Summary statistics of business cycles in CEAMC countries

	Cameroon	CAR	Chad	Congo	Eq Guinea	Gabon
Classical cycle						
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%
Deviation cycle						
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
				Log-level of GDP (*y*)				
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	..
				First difference of log-level of GDP (Δy)				
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
				Detrended GDP (y^c)				
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
				First difference of detrended GDP (Δy^c)				
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
				Log-level of GDP (y)				
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
				First difference of log-level of GDP (Δy)				
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
				Detrended GDP (y^c)				
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
				First difference of detrended GDP (Δy^c)				
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 raw (labeled "All countries") refers to the variation measured across all CAEMC members; the second raw (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 (I_{ij})	Mean corrected (I_{ij}^*)	Standard (I_{ij})	Mean corrected (I_{ij}^*)
	60-80	0.71429	-0.0068	0.4881	-0.01361
CMR	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
	60-80	0.77381	0.07483	0.46429	-0.02154
CAR	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
	60-80	0.66667	0.04762	0.60714	0.10601
Chad	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
	60-80	0.77381	0.03288	0.42857	-0.05272
Congo	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
	60-80	..	..	..	..
Eq Guinea	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
	60-80	0.7381	0.01701	0.46429	-0.02154
Gabon	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
	60-80	0.733	0.033	0.490	0.000
CAEMC	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.

Table 5 Average of bilateral correlations over 10-year blocks and sub-periods

	Low-PD period					*Transition*	*High-PD period*	
	1962-72	**1967-77**	**1972-82**	**1977-87**	**1982-92**	**1987-97**	**1992-02**	**1997-07**
Δy	0.142	0.042	0.034	0.071	0.098	0.171	0.048	-0.020
y^c	0.137	-0.003	0.058	0.065	0.003	0.065	0.144	0.038
Δy^c	0.108	0.013	0.022	0.002	-0.006	0.072	0.064	0.046

	Low-PD period		*High-PD period*
	1962-92	**1977-92**	**1992-07**
Δy	0.040	0.012	0.113
y^c	0.037	0.027	0.117
Δy^c	-0.007	-0.022	0.037

Note: The top part of the table shows the average of bilateral correlations for each block of ten years. The bottom part of the table shows the average of bilateral correlations for the two sub-periods corresponding to low-PD regime (1962-92) and high-PD regime (1992-07) and for a spell of 15 years (1977-92) prior to regime switch.

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) *Peak at t* $\{y_t > y_{t-k}, y_t > y_{t+k}, k = 1....K\}$

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

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) *Peak at t* $\{\Delta_k y_t > 0, \Delta_k y_t < 0\}$

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

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) $ETS_t = \{(\Delta y_{t+1} < 0) \cap (\Delta_2 y_{t+2} < 0)\}$

(A5.a) $RTS_t = \{(\Delta y_{t+1} > 0) \cap (\Delta_2 y_{t+2} > 0)\}$

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) $ETS_{t+1} = \{\Delta y_{t+2} < -c\}$

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) $RTS_{t+1} = \{\Delta y_{t+2} > c\}$

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) $y_t = y_t^s + y_t^c$

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

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

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

(A7.b) 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 λ is set according to the algorithm proposed by Ravn and Uligh (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) $$y_t^s = \sum_{j=-K}^{K} a_j L^j y_t$$

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) $$\min_{a_j} Q = \int_{-\pi}^{\pi} \left| \beta(\omega) - \alpha(\omega) \right|^2 d\omega$$

(A8.c) subject to $\alpha(0) = 0$

where $|\beta(\omega)|$ is the "ideal" filter gain with cut-off frequencies ω_1 and ω_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 computing the filter, the range of durations is set from a minimum of two years to a maximum of eight years.

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 leve, since an expansion must have brought output below trend. Therefore, the *ETS* and *RTS* are redefined as follows:

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

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

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. **Additional results**

Table A2.1. Business cycle chronology: Classical cycle

Year	Cameroon	CAR	Chad	Congo	Eq 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

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

Table A2.2. Business cycle chronology: Deviation cycle

Year	Cameroon	CAR	Chad	Congo	Eq 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

Note: EC = expansion continuation, P = peak of an expansion (turning point), RC = recession continuation, T = trough 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
		Log-level of GDP (y)				**Detrended GDP (y^c)**		
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
		First difference of log-level of GDP (Δy)				**First difference of detrended GDP (Δy^c)**		
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. *, **, *** denote statistical significance at the 10%, 5%, 1% confidence level.

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
	Log-level of GDP (y)				**Detrended GDP (y^c)**			
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
	First difference of log-level of GDP (Δy)				**First difference of detrended GDP (Δy^c)**			
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
	60-80		0.762	0.619	0.761	..	0.714
CMR	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
	60-80	0.762		0.762	0.809	..	0.762
CAR	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
	60-80	0.619	0.762		0.667	..	0.619
Chad	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
	60-80	0.762	0.809	0.667		..	0.857
Congo	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
	60-80	..	..	..	..		..
Eq Guinea	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
	60-80	0.714	0.762	0.619	0.857	..	
Gabon	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
	60-80		0.041	0	-0.027	..	-0.041
CMR	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
	60-80	0.041		0.159	0.059	..	0.041
CAR	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
	60-80	0	0.159		0.032	..	0
Chad	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
	60-80	-0.027	0.059	0.032		..	0.068
Congo	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
	60-80	..	..	..	..		..
Eq Guin	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
	60-80	-0.041	0.041	0	0.068	..	
Gabon	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
	60-80		0.428	0.667	0.524	..	0.333
CMR	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
	60-80	0.428		0.762	0.333	..	0.333
CAR	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
	60-80	0.667	0.762		0.333	..	0.667
Chad	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
	60-80	0.524	0.333	0.333		..	0.524
Congo	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
	60-80	..	..	..			..
Eq Guinea	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
	60-80	0.333	0.333	0.667	0.524	..	
Gabon	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
	60-80		-0.054	0.163	-0.014	..	-0.150
CMR	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
	60-80	-0.054		0.267	-0.104	..	-0.195
CAR	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
	60-80	0.163	0.267		-0.179	..	0.172
Chad	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
	60-80	-0.014	-0.104	-0.179		..	0.086
Congo	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
	60-80	..	..	..	..		..
Eq Guinea	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
	60-80	-0.150	-0.195	0.172	0.086	..	
Gabon	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.

Appendix A3. **Evidence from a regression approach**

Regression analysis of the determinants of synchronization is usually performed on large sample of countries across different regions (see for instance Tapsoba, 2009). As discussed in the introduction, there are good reasons to focus on a single region (CAEMC in the case of this paper) and use a different statistical methodology. Nevertheless, it is interesting to see whether the overall conclusions of the paper hold when standard regression models are employed.

Previous research on the endogeneity of OCA (see Frenkel and Rose, 1998 and Corsetti and Pesenti, 2002) suggests that the creation of a monetary union between two countries, i and j, is expected to strengthen the bilateral correlation of business cycles (σ_{ij}) through two channels: (i) stronger bilateral trade and (ii) greater coordination/harmonization of domestic macroeconomic policies. In addition to bilateral trade and policy harmonization, there are other two main factors that can affect σ_{ij} (see the discussion in Tapsoba, 2009): (iii) the difference in productive structures across countries and (iv) total trade intensity of the two countries.

A simple formal representation of these relationships is as follows:

(A10) $\rho_{ijt} = f(TI_{ijt}, TT_{ijt}, PD_{ijt,} PS_{ijt})$

(A11) $TI_{ijt} = g(MU_{ijt}, \boldsymbol{Z}_{ijt})$

(A12) $PS_{ijt} = h(MU_{ijt}, \boldsymbol{W}_{ijt})$

Where ij denote the pair of two generic countries, t denotes time, ρ is the measure of synchronization of their business cycles, *TI* is the trade intensity between the two countries, *TT* is the total trade of the two countries with the rest of the world, *PD* is the index of diversity of production structures, *PS* the measure of policy similarities between the two countries, *MU* an indicator that captures common membership in a monetary union, $\boldsymbol{Z}$ is a vector of other determinants of trade intensity and $\boldsymbol{W}$ is a vector of other determinants of policy similarities (*PD* is an element of both $\boldsymbol{Z}$ and $\boldsymbol{W}$ and $\boldsymbol{Z}$ and $\boldsymbol{W}$ have several other elements in common). The reduced form model is then obtained by substituting (A11) and (A12) into (A10):

(A13) $\rho_{ijt} = f(g(MU_{ijt,}\boldsymbol{Z}_{ijt}), h(MU_{ijt,}\boldsymbol{W}_{ijt})TT_{ijt}, PD_{ijt})$

The most obvious complication in estimating equation (A13) on a sample that only includes CAEMC countries is the empirical definition of *MU*. In the literature that makes use of the regression approach, *MU* is generally defined as a dummy variable that takes value 1 if *i* and *j* are in the same monetary union. Applying this definition to the present context would imply that *MU* is a vector of 1s and hence that it corresponds to the intercept of the regression equation. An alternative definition is therefore necessary. In principle, one could create a variable that measures the "effective" engagement of a country in the monetary union. Of course, to avoid endogeneity problems, this effective engagement should not be measured by (a) correlation of cycles with other countries, (b) intensity of bilateral trade, and (c) degree of policy harmonization. In practice, designing and measuring such a variable would be quite difficult and it would involve some significant degree of subjectivity.

A more practical approach is to think of the monetary union effect in terms of time trend: if the currency union is endogenously optimal, then σ_{ij} should increase over time after controlling for other possible determinants of synchronization. *MU* can therefore be coded as a time trend and a positive and statistically significant coefficient on this time trend will be taken as evidence that the CAEMC currency union is optimally endogenous. The results from regressing σ_{ij} on a time trend and additional controls are reported in Table A3.1 below.

Table A3.1: Regression analysis

	1		2		3		4	
Constant	0.071	*	0.098		-0.662		-0.169	
MU (Time trend)	-0.003		0.003		-0.011		..	
PD	..		-0.146	**	-0.244	***	-0.274	***
TT	..		0.016		0.071	*	0.055	*
Distance	..		..		-0.228	***	-0.223	***
Economic size	..		..		0.055	***	0.043	**
Common border	..		..		-0.184	**	-0.185	**
Landlocked	..		..		0.163		0.149	
R^2	0.10		0.19		0.46		0.44	
Obs	105		105		105		105	

Notes, *, **, *** denote statistical significance at the 10%, 5%, and 1% level respectively.

The sample period for estimation is 196-2007 (the panel is however unbalanced because data for Equatorial Guinea are available only since 1987). This period is divided into overlapping blocks of 10 years each. Synchronization in each block is measured as the average of bilateral correlations of the cyclical components of GDP. Estimation is by OLS. The Hausman test of endogeneity reveals that both *PD* and *TT* are exogenous to the dependent variable. Nevertheless, all of the regressions have been re-run using a 2SLS, with PD and TT instrumented by their lagged values, and results did not significantly differ from those obtained from OLS estimation.

In column 1, no additional control variable is used. The time trend is largely insignificant, denoting that there is no significant increase in synchronization over time. *PD* and *TT* are measured as the corresponding variables in subsection 3.3. of the paper. Their inclusion in column 2 does not change the result on the time effect. At the same time, there is evidence that increasing diversity of productive structures reduces synchronization to a significant extent. In column 3, the variables in vectors ***Z*** and ***W*** are added. These include standard gravity variables: the product of the log GDP of the two countries to capture total economic size, a dummy variable taking value 1 if the two countries share a common border, a dummy variable taking value if either of the two countries is landlocked, and the log of the distance between the two countries. Other popular gravity variables (such as dummies for common language and common colonizer) display too little variation in the sample of CAEMC countries. The gravity variables plus *PD* and *TT* are also taken to be a good representation of the other determinants of policy harmonization.[17] The only counterintuitive result in column 3 is the positive coefficient on the landlocked dummy variable. However, for the purpose of estimating the effect of the time trend on synchronization, nothing changes between column 3 and columns 1 and 2. In this respect, the regression analysis confirms the results reported in the rest of the paper concerning the weakness of the endogeneity effect in the CAEMC region.

The estimation of a regression model can be helpful in conducting a second type of exercise. In fact, the idea that the effect of a monetary union on synchronization can be fully accounted for by a time trend might be too restrictive. A more flexible approach is to re-estimate the regression model in column (3) without time trend to obtain the fitted values $\hat{\rho}_{ij}$ and then compare these fitted values with the observed correlations σ_{ij}. If the all other determinants of synchronization are correctly accounted for, then the difference between actual and fitted value represents the effect of the monetary union and therefore captures the extent to which CAEMC is an endogenously optimal OCA. The equation without time trend is re-estimated in column (4) of table A3.1. Table A3.2 below reports the average difference between actual and fitted values for every pair of CAEMC countries over the entire sample period and for every ten-year block across all pairs of countries.

Two main observations can be drawn from the table. First, the difference between actual and fitted values does not significantly increase over time. This again suggests that the CAEMC currency union is not strongly endogenously optimal. Second, for a few bilateral

[17] Another possible exogenous determinant of policy harmonization is the similarity of exchange rate arrangements. However, since all countries in this sample are in a monetary union, this variable is not relevant in the present context.

pairs, the difference is quite large, meaning that for those pairs the currency union has indeed contributed to strengthening the synchronization of cycles. However, when taking the average over all pairs, the difference reduces to 0.021. This is equivalent to a mere 7% of the total standard deviation of the actual values of σ_{ij}. Again, the conclusion is that the currency union has somewhat strengthened bilateral correlations, but this effect is quite marginal and – on average - insufficient to result in a significantly upward sloping trend of synchronization over time.

Table A3.2. Difference between actual and fitted correlations of y^c

Average effect by country pair				Average effect by 10-year block	
CMR-CNG	-0.010	CNG-TCD	-0.082	1	0.125
CMR-GBN	-0.244	GBN-GNQ	-0.061	2	-0.018
CMR-GNQ	0.272	GBN-RCA	-0.020	3	0.018
CMR-RCA	0.004	GBN-TCD	0.215	4	0.044
CMR-TCD	-0.056	GNQ-RCA	-0.202	5	-0.037
CNG-GBN	0.335	GNQ-TCD	0.378	6	0.003
CNG-GNQ	-0.269	RCA-TCD	0.136	7	0.084
CNG-RCA	-0.071			8	-0.028

Note the last block (8) includes 12 years: 195-2007.

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