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No. 05/14

Testing Real Convergence in the ECOWAS countries in Presence of Heterogeneous Long-Run Growths : A Panel Data Study

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Acknowledgements

We are grateful to our colleagues at the WAEMU Commission for providing us remarks on preliminary versions of the paper. In particular, we would like to thank, Abdoulaye Diop and Joachim Ouedraogo. We also thank the participants to the Annual AFRISTAT Conference. Their remarks helped us to improve the paper

October 2005

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Abstract

In this paper, we examine the issue of b - convergence of per-capita GDP in the ECOWAS countries under the assumption of parameter heterogeneity. We apply panel data techniques to an error-correction model that allow us to take into account latent heterogeneities across the countries. In comparison with the standard growth equations, the novelty comes from the fact that the slopes of the long-run growth equations are assumed to differ across the countries. If the economic structures are truly heterogeneous, then using average-based estimators yields results that are more robust than those derived from pooled-based estimators. The results suggest opportunities for policymakers to achieve real convergence through more coordinated policies

Outline

1. Introduction
2. The model
3. Empirical Analysis
4. Common Factor Analysis
5. Conclusions

I. INTRODUCTION

In this paper, we examine the issue of b-conditional convergence of per-capita GDP in the ECOWAS countries[1] under the assumption of parameter heterogeneity. In its basic formulation, the b-convergence approach assumes that all countries converge towards a common steady-state level of per-capita GDP. Meanwhile, this view has been criticized, notably by the endogenous growth theory. It has been argued that per-capita income is driven by country-specific factors that influence growth endogenously. The endogenous growth approach is very helpful to understand why divergence between poor and rich countries can persist indefinitely: differences come from increasing returns in the high income countries[2]. Such an argument is, however, not valid when we compare the standard of living of countries that belong to a group of low income countries. Since most of the latter are characterized by non-increasing returns to scale, sources of potential divergence among them are of a different nature. The magnitude and significance of the effects of population growth, investment rates,, human capital and policy variables on economic growth vary across countries. For instance, it is unlikely that the impact of Government spending or of external aid on per-capita income is the same for all countries, irrespective of their level of development. In the empirical literature, many studies provide evidence of slope heterogeneity in growth equations for low income countries (see, Desdoigts (1999), Rappoport (2000), Durlauf *et al*. (2001), Kourtellos (2003), Canarella and Polland (2004). However, very few studies concern the Sub-Saharan African countries, in spite of the importance of the convergence issue for the region. Over the last two decades, these countries have been characterized a decline –at the best a stagnation- of their per-capita GDPs, though some of them experienced a surge in growth during the 1990s. Divergence in the standard of livings is observed, meaning that some countries are escaping from poverty while others are trapped. Lack of convergence across the ECOWAS countries can be explained by a strong heterogeneity of the economic structures, which implies that the countries evolve along different long-run paths. The heterogeneities are symptomatic of differences in the efficiency of capital utilization, in the capacity of absorption of aid, in competitiveness, in the conducing of economic policies. If divergence in the ECOWAS countries is caused by heterogeneous structures, then

1 ECOWAS (CEDEAO in French) was settled in 1975 among the following Sub-Saharan West African countries: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, the Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra-Leone and Togo.

2 See, among others, Romer (1990), Grossman and Helpman (1991), Aghion and Howitt (1992).

this motivates the existing activist economic policies that try to shape growth processes jointly. Indeed, in 1994, a subgroup of eight countries (that form the WAEMU[3]) has adopted a pact (called Convergence, Stability, Growth and Solidarity Pact) in order to foster growth and reduce poverty through common macroeconomic policies. In 2000, five other countries have projected to form a common economic and monetary union with the WAEMU countries in the forthcoming years[4]. But before forming a monetary union with the WAEMU countries, the WAMZ countries find it necessary to achieve economic convergence with an emphasis on growth. All these coordinated economic policies are fully justified, if it is proved that the determinants of economic growth affect the countries' standard of living differently.

To examine this issue, we apply panel data techniques to an error-correction model that allow us to take into account latent heterogeneities across countries. In comparison with the standard growth equations, the novelty comes from the fact the slopes of the long-run growth equations are assumed to differ across countries. If the economic structures are truly heterogeneous, then using average-based estimators yields results that are more robust than those derived from pooled-based estimators. This paper is in line with the recent efforts to incorporate dynamic effects in the African growth equations through the use of panel data (see McCoskey (2002), Paap *et al*. (2004),Wane (2004)). Our approach adds to the existing literature in several aspects. We compare the results based on the mean group estimator (MGE) (both the short-run and long-run elasticities vary across countries) with those obtained under the assumption that slope heterogeneity only holds in the long-run[5.] The use of econometric methods that combine pooling and averaging approaches raises the following question: should we assume heterogeneity in the short-run and/or in the long-run coefficients? It is common in the literature to use pooled mean group estimators (PMGE) , assuming short-run heterogeneity but long-run slope homogeneity (for an application to Sub-Saharan African countries, see Wane (2004)). However, if the countries follow different long-run growth paths (as is usually suggested by the empirical observation of the per-capita GDPs over several decades), it is restrictive to assume

3 WAEMU (UEMOA in French) is composed of the following countries : Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo.

4 The five countries are the Gambia, Ghana, Guinea, Nigeria and Sierra Leone. These countries created the West African Monetary Zone (WAMZ).

5 Using the MGE estimator, originally proposed by Pesaran *et al.* (1999), one assumes that both the short-run and long-run coefficients of a panel regression vary across countries. The authors also propose a Pooled Mean

long-run slope homogeneity. Accordingly, instead of a PMGE estimator, we shall rather use an estimator with slope heterogeneity in the long-run and homogenous short-run elasticities. This means that we are assuming that the countries has the same rate of convergence, which is not an heroic assumption for the ECOWAS economies. Our results are supportive of convergence of regional per-capita *GDP*.

Evidence b -divergence from panel data regressions with slope heterogeneity only indicates that differences in economic structures implies some difficulties for the countries to converge to a common long-run steady-state growth. But it does not tell us whether we are right when assuming that the countries have heterogenous economic structures. Even if this is suggested by the empirical observation, this assumption must be tested formally. To tackle this issue, we use recent econometric tools based on common factor analysis. These allows us to deeply examine which of the growth determinants fail to account for the joint dynamics of the countries' per capita *GDP*.

The paper is organised as follows. In section 2, we present the empirical model. Section 3 contains the econometric results. Section 4 focuses on the common factor analysis. Finally, section 4 concludes the paper.

2. THE MODEL

The empirical model is as follows:

$$\Delta y_{it} = b_i (y_{it-1} - q_i' X_{it-1}) + a_i' Z_{it} + e_{it}, \quad i = 1,\ldots, N, \quad t = 1,\ldots,T \tag{1}$$

where i indicates the country, t is time, y is the per-capita GDP, X is a vector of the determinants of growth and Z is a vector of the lagged observations of Δy and ΔX . e is a disturbance term and q_i , a_i are vectors of parameters. $b_i < 0$ indicates convergence towards a country's steady state, while $b_i \geq 0$ indicates a non convergence. The following variables enter the list of the regressors: the log of investment rate (*INV*), the log of population growth (*POP*), adults' illiteracy rate (*ILLET*), adults' school enrolment (*ENROL*), the log of inflation rate

Group Estimator (PMG), which is based on the assumption that only the short-run parameters differ across

(*INFL*), the degree of openness (*OPEN*), the log of domestic credit to private sector in percentage of *GDP* (*CREDIT*), the log of foreign aid per capita (*AID*)and the log of Government consumption expenditures (*GOV*). Equation (1) is the error-correction formulation of a conditional convergence equation usually written as follows:

$$\Delta y_{it} = \tilde{b}_i y_{it-1} + \tilde{a}_i' Z_{it} + \tilde{e}_{it}, \quad i = 1,\ldots,N, \quad t = 1,\ldots,T \tag{2}$$

We consider the ECM formulation because the impact of growth determinants may be different over the business cycle (in the short-run) and in the long-run. This is the case for variables such as the investment rate, human capital, trade, *etc*. We expect the following causal relationships between the exogenous variables and the real per capita *GDP*.

- *INV*: the role of capital accumulation as a central element of sustained growth in Africa has been extensively documented in the literature, so that the coefficient of the investment rate must be positive[6].
- *POP*: to understand the role of demography on per capita GDP, what matters is not the population growth rate *per se*, but the consequences in terms of changing age structure of the population[7]. A large share of non-working population lowers labour input per capita, depresses the accumulation rate, thereby reducing the growth of per-capita GDP. Conversely, if the demographic growth is associated with an ability to absorb an expanding labour force, then the impact on GDP is positive. For our sample, we expect an ambiguous sign. On the one hand, the age structure of the population in the WAEMU countries shows an important proportion of population under the age of 15 years (nearly 40%) and a dependency ratio exceeding 100%). The resulting increase in the gap in food self-sufficiency yield us to expect a negative impact on per-capita GDP. Further, the dependency ratio shows an upward trending in relation with the negative effects of AIDS epidemic. On the other hand, the inclusion of Nigeria in the sample (which accounts for more than 50% of the population of ECOWAS and 75% of the GDP of the WAMZ) can yield a positive sign, given the important growth rates this country usually experiments.
- *ILLET*, *ENROL* : in light of the results obtained in the literature, we expect an ambiguous impact of human capital (proxies are the adults' illiteracy rate and enrolment rate in primary

countries.

6 See, among others, Berthélémy and Söderling (2001)

7 For the theoretical basis of this argument, the reader can refer to Kelley and Smith (1995), Lindh and Malmberg (1999), Williamson and Hatton (2000).

school) on per-capita GDP. Some papers document a very low effect of human capital investments on growth. Accordingly, one may expect to find small coefficients for our variables (possibly, non-significant coefficients). Other report that the impact can be negative when countries have low endowment in human capital[8]. Human capital can also positively affect the level of GDP, through its effects on productivity and economic policies. All in all, the signs of our two human capital variables can be either positive or negative.

- *GOV*: in a standard open economy, public spending has a positive demand impact, especially in the short-run (demand boom being associated with a higher growth). Meanwhile, this effect can be overwhelmed by negative supply-slide influences, if the increased spending implies distortionary taxes. *GOV* also captures unproductive spending in the Barro and Lee (1993)'s sense. In the latter case, one may expect a negative coefficient.
- *OPEN*: openness to trade is measured by the trade share in *GDP* (the sum of the ratios of exports and imports over *GDP*). The exports are introduced to capture the impact of export earning capacity on growth. Many ECOWAS countries face unfavourable exports trends for several reasons: regional integration is not a substitute to small domestic markets, the countries' comparative advantage is narrow in foreign markets, agricultural productivity is small, few of the countries have fabric-making capacity *etc*…Paralleling this, the countries shows a broad dependence on imports. These elements have a dampening effect on the economic growth. We thus expect a negative sign of the coefficient for the variable *OPEN*.
- *AID* : we expect a positive effect of external aid. This can results from either direct or indirect impacts. The direct effect results from the increased resources available to finance growth. The indirect effect comes from the positive links between aid and reforms : conditional aid can result in a higher quality of economic policies[9].
- *CREDIT*: introducing this variable allows to capture the impact of the banking intermediation on the real activity. Credit is widely used an intermediate target by the Sub-Saharan countries' central banks. However, we expect to find a negative impact on per-capita *GDP*. Indeed, in spite of the reforms undertaken during the 90s, the financial context is characterized by high domestic interest rate that discourages private investment. The latter is and crowed out: small-to-medium firms, rural entrepreneurs usually fail to obtain financial resources from the banking sector. On average, the banking sector length in a Sub-Saharan country is around 1% (this can

8 For an empirical study concerning the impact of human capital on growth, see Schultz (1999).

be compared with 20% in Latin American countries and nearly 85% in the industrialized economies.

• *INFL*: whether inflation is a robust determinant of growth is still a subject of debate in the literature. Some studies find that its influence strongly decline when other determinants of growth are included in the regression, while others report the opposite conclusion[10]. In applications specific to developing countries, authors find a negative inflation-growth relationship when inflation goes above a threshold of 7-11% but a non significant effect below this threshold (see Khan and Senhadji (2000)). Our sample include both low and high inflation countries (low inflation rates in the WAEMU countries is explained by the pegging of the CFA franc to the French Franc and to Euro today. The other ECOWAS countries experience inflation rates well above the 7-11% threshold). It is thus difficult to predict the sign of the inflation variable in our growth equation.

3. EMPIRICAL ANALYSIS

Our panel is composed of the following twelve countries: Benin, Burkina-Faso, Cape Verde, Côte d'Ivoire, the Gambia, Ghana, Guinea-Bissau, Mali, Niger, Nigeria, Senegal and Togo. The other ECOWAS countries were not included in the sample, because too many data were unavailable. Data are annual and cover the years 1985-2003. Appendix A contains more details about the series used.

3.1 *Panel Unit Root And Cointegration Tests*

We begin our analysis by applying the Im, Pesaran and Shin (1997)'s panel unit root test (henceforth IPS) to the individual series. The test is based on the following regression:

$$\Delta\tilde{y}_{it} = a_i + b_i t + r_i \tilde{y}_{it-1} + e_{it}, \quad i = 1,\ldots,N \quad t = 1,\ldots,T \tag{3}$$

where $e_{it} \approx N(0,\Omega)$. We "remove" cross-section dependencies by considering demeaned data:

$$\tilde{y}_{it} = y_{it} - y_{.t} \quad \text{where} \quad y_{.t} = \frac{1}{N}\sum_{i=1}^{N} y_{it} \tag{4}$$

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9 For an overview of the links between aid and reform, see Devaradjan and Holmgren (2001).

10 For competing views about the robustness of inflation in a growth equation, the reader can refer to Levine and Zervos (1993), Sala-I-Martin (1997), Gosh and Wolf (1998), Gosh and Phillips (1998).

Suppose that y_{it} is the per-capita income for country i for the year t. The IPS test works as follows. One testes the null hypothesis

$$H_0 : r_i = 0 \quad \text{for all } i$$

and the alternative

$$H_1 : r_i < 0, \ for\ i = 1,\ldots,N_1 \ and \ r_i = 0 \ for\ i = N_1 + 1,\ldots,N$$

Given the definition in equation (4), $\tilde{y}_{it}$ is country i's per-capita income relatively to the cross-section average. Therefore, under the null, all the countries diverge from each other. However, rejecting the null does not imply overall convergence, since there may exist sub-groups of country that diverge. The tests does allows heterogeneous long-run paths and the regression can include both heterogeneous intercepts and trends[11.]

Now, if y_{it} is one of the exogenous variables defined above, then the IPS tests can be viewed as one way to test whether the dynamics inherent to the growth determinants are homogenous or not across the countries. So, rejecting the null hypothesis can be viewed as a first signal of heterogeneous economic structures. Table 1 reports the results of the IPS test. With the possible exceptions of inflation and population growth, the evidence overwhelmingly support the presence of a unit root in per-capita GDP and in many of the determinants of growth. The rejection of the null hypothesis implies that, at least one country diverges from the others. A possible source of divergence may come from the fact that growth reacts in different ways to its determinants, depending upon the country under examination. Testing for cointegration between per-capita GDP and its determinants therefore requires a careful attention. A rejection of the cointegration hypothesis would imply that the estimation of a growth equation is not meaningful, in the sense that there does not exist a long-run stable relationship between per-capita income and its determinants. To see whether the slope heterogeneity assumption is crucial in the conclusions drawn from the cointegration analysis, we apply two panel cointegration tests. In one case, we assume homogenous slopes whereas in the second case we allow for

11 Note that this approach is similar to Bernard and Durlauf (1995)'s methodology in time series, with the exception that a country *j*'s per-capita income is substituted for $y_{.t}$. In our case, Côte d'Ivoire and Nigeria could play the role of reference countries. Meanwhile, doing this yields a strong bias against convergence. Indeed, Côte d'Ivoire accounts for 40% of the GDP of the WAEMU countries and Nigeria accounts for 75% of the GDP of the WAMZ countries. These countries have a high standard of living in comparison with the others.

the coefficients to vary across countries. The testing procedure is based on Pedroni (1999). Because the latter has been used in a number of papers, we do not expose it here, but refer the reader to the literature. The results are shown in tables (2a) to (2c). The statistics based on slope homogeneity assumption are referred as *Panel r*, *Panel PP* and *Panel ADF* (they are obtained from pooled-based estimators). Those obtained under the assumption of heterogeneous slopes are referred as *Group r*, *Group PP* and *Group ADF* (there are obtained from average-based estimators). The numbers reported must be compared to the critical values of a *N(0,1)* variable (either $|1.64|$ at the 10% nominal level of significance, or $|1.96|$ at the 5% nominal level).

The tests are firstly applied to a basic Solow growth equation (the regression includes the following four regressors : *INV*, *POP*, *ILLET* and *ENROL*). The average-based statistics all support the cointegration assumption, while this assumption is rejected by two tests over three in the case on the pooled-based estimator (see table 2a).

We then consider two examples of augmented Solow growth models (tables 2b and 2c). The results reflect that the robustness of the conclusions drawn from the test is conditioned by the regressors included in the equation. In table 2b, we consider a group of exogenous variables for which there should not be big differences across countries in terms of their dynamic behaviour (we add to the basic Solow growth model the following variables: *AID*, *GOV* and *INFL*). The tests all yield the same conclusion, whether one consider homogenous cointegration relationships or heterogeneous long-run equations. If we substitute *CREDIT* and *OPEN* for *AID* and *GOV*, the conclusions become more mixed since one statistics yields to accept the null assumption of no cointegration.

3.2 *Panel Regressions : Mixed Evidence Of Convergence*

The estimation of equation (1) can potentially suffer from two problems: individual effects biases and endogeneity biases. Individual effects biases may arise when the countries specific effects are wrongly assumed to come only from differences in the slopes of the intercepts. As mentioned in the introduction, heterogeneity can be more general, implying differences across countries in the marginal impacts of the explanatory variables on long-run per-capita growth. We therefore assume that, at least, the

parameters in the vector q vary across countries. Endogeneity biases arise if the assumption of non correlation between the regressors and the disturbance term is violated. This is indeed the case if the explanatory variables are determined simultaneously with the per-capita GDP. To avoid potential inconsistencies, several estimators can have be applied. Some procedures rely on GMM estimators[12], other methods are based on parametric corrections (for instance the dynamic OLS estimator). In this paper, we use a nonparametric correction by applying a fully modified OLS estimator (FMOLS) to our sample. To allow for heterogeneous long-run coefficients, we use the average-based FMOLS estimator suggested by Pedroni (2001). We further use an error-correction model to estimate the short-run coefficients. We use two estimators: in one case, the short-run slopes are assumed to vary across countries, while in the other case they are assumed to be homogenous.

Table 3 reports the regressions for the ECOWAS countries. There is a clear evidence that the conclusion in terms of conditional convergence differ with different estimation methods. Indeed, when the short-run coefficients are assumed to vary across countries, we find a negative and significant value for b ($\hat{b} = -0.121$). This yields us to conclude in favour of the convergence hypothesis. Meanwhile, with the estimator that combines average-based (in the long-run) and pooled-based coefficients (in the short-run), the conclusion is that the countries diverge: the estimate value of b is significantly positive ($\hat{b} = 0.0046$ with a significant *t-ratio* $\hat{t}_{\hat{b}} = 1.64$ at the 10% nominal level,). This contradictory results raises some questions about their economic meaning.

On one hand, with regard to some empirical stylised facts, little evidence is found to substantiate claims of convergence within the ECOWAS countries. Figure 1 shows the log of per-capita GDPs. The graph suggests that the countries remain at their "initial" position at the end of the period (exceptions are Cape Verde, Côte d'Ivoire and Niger). This observation is in line with a usual empirical finding in the literature that the Sub-Saharan economies evolve close to their

12 A commonly used estimator is the Arellano and Bond (1991)'s. See also, Arellano and Bover (1995), Alonso-Borrego and Bond (1999).

steady-state equilibrium. We further observe that distances between the curves do not narrow (the economies follow their own long-run growth path). We distinguish several groups of countries. Some countries lag behind the others and not to escape the poverty trap : Niger, Nigeria and Togo. Indeed, these countries' per-capita income shows a declining trend since 1997. Evidence of convergence is observed between Benin and Ghana on one side, and between Burkina Faso, Mali and Nigeria in the other side (high growth rates since the mid nineties helped Burkina Faso closing the gap with other richer countries). We finally observe a catching-up dynamics of Senegal with Côte d'Ivoire, due to the slowest growth rates of the latter since 1999. These observations are confirmed by figure 2, which reports the per-capita GDPs for the sub-sample of WAEMU countries. These findings play against the convergence hypothesis.

On the other hand, the assumption of *short-run* heterogeneity is economically meaningful. Indeed, if the countries are close to their long-run growth steady-state (see our comments above), then deviations from the long paths can be viewed as the result of policy mistakes, or fluctuations due to external shocks. Usually, it is recognized that the Sub-Saharan African countries have heterogeneous conditions, so that policies have to be tailored to country-specific conditions to spur growth (for an illustration, see Baldacci *et al*. (2003)). Further, shocks have asymmetric effects on the ECOWAS countries, as documented in many studies[13.] The interesting question is how to capture such short-run heterogeneities in an econometric model. Shocks that affect the ECOWAS countries are exogenous in nature (and can thus be considered as random): climate, price shocks, terms of trade shocks, world demand fluctuations, *etc*…In this case, the heterogeneity is captured by the error terms and the short-run elasticities are assumed not to vary across countries. Two other arguments are worth pointing out that motivate the assumption of slope homogeneity for the short-run coefficients in our regressions. The first is economic. Most of the countries are participants to economic and monetary unions. This implies that some institutional factors are likely to make the fluctuations affecting the economies in the short-run more similar: peer pressure, the adoption of convergence criteria, regional surveillance. The second argument is econometric. As mentioned

13 See, among others, Fielding and Shields (2001), Masson and Pattillo (2001, 2004), Debrun *et al.* (2002), Akanni-Honvo (2003).

in the introduction, the results based exclusively on average-based estimators substantially reduces the number of

degree of freedom of the regressions, which has some implications on the robustness of the estimations. The estimated value of b with the average-based estimator is –0.121, which implies that the poorer countries catch up with the richer at a rate of 12.% a year. With this rate a country should spend less than 7 years to cover half of the distance between its initial position and its steady. This finding is clearly not in line with the empirical observation.

The preceding remarks lead us to be more confident about the results obtained under the assumption of homogeneous short-run elasticities and heterogeneous long-run elasticities. We are thus tempted to conclude that there seems to be a divergence of per-capita income for the ECOWAS countries. A similar equation is estimated, by considering the sub-sample of WAEMU countries (see table 4). As is seen, the estimated value of b is smaller and significantly null ($\hat{b} = 0.001$, with a t-ratio $\hat{t}_{\hat{b}} = 0.41$). Although there is no evidence of convergence, the WAEMU per-capita GDPs do not divergence. This may be attributed to that WAEMU is characterized by a higher integration than ECOWAS.

3.3 *Panel Regressions : Which Factors Inhibit Growth And Which Spur Growth?*

This section comments the estimates of the long-run equations for both the full sample (table 3) and the WAEMU countries (table 4).[14] Two variables enter significantly with the expected signs. Countries experience an increase in per-capita GDP, if their investment rate is higher, or their aid per-capita increases. The positive sign of the investment variable captures the positive effect of saving on long-run growth. In the Sub-Saharan countries, higher amounts of concessional aid push up long-run growth through the following channel. The external financing yields to increase selective and productive current expenditures, for instance those affected to poverty reduction projects.

14 The short-run coefficients deserves no special comment, because the variables have a similar impact on per-capita GDP in the short- and long-run.

Increase in trade openness decreases the growth of per-capita income. This may indicate that the elements that should be conducive to growth are not relevant in the African context. Indeed, from the perspective of endogenous growth theories, trade openness has a positive impact on growth and per-capita GDP through endogenous technical progress. New technologies facilitate diversified inputs or outputs and improve productivity gains. Further, trade promotes economic progress through the technology incorporated in imported goods. The ECOWAS countries have highly specialized export and import structures, which increases their vulnerability to external trade shocks. For the WAEMU countries, despite the promotion of a trade union policy, the correlation of terms of trade shocks remain low, which impediments the ability of the region to absorb the negative effects of shocks.

The elasticity of government consumption ratio is positive, which reflects a predominance of demand-side effects (part of this category of expenditures comprises wages and salaries). Further, it is worth pointing out that, in the empirical literature, fiscal deficits (implied by a reduction in government consumption) negatively affects growth in countries with unfavourable macroeconomic condition. For countries with a modicum of macroeconomic stability (for instance those with a low inflation rate), increased public deficits do not dampen growth. For instance, Baldacci *et al*. (2003) find that increases in current government spending were compatible with higher growth in Benin, the Gambia and Senegal. The positive sign in our equation may be explained by the fact that our sample comprises a majority of WAEMU countries, for which macroeconomic stability is reflected by low levels of inflation rates. This is confirmed, when we consider the sub-sample of WAEMU countries : the coefficient is higher (0.116) in comparison with the estimate obtained for the full sample (0.09).

The estimates of the human capital variables are in line with those found elsewhere in the literature. The enrolment ratio is not significant in the full sample regression. This can be attributed to possible collinearity between this variable and other explanatory variables (for instance, *AID*). Another finding is the positive sign of the illiteracy rate in the ECOWAS regression and the negative sign of enrolment rate in the regression corresponding to the WAEMU countries. At first glance, this could be interpreted as follows : an improvement (*resp*. a deterioration) in human capital have a negative (*resp*. positive) impact on the growth rate of per-capita income. Although surprising, these
results are however in line with the conclusions found in other studies. For instance, to explain the negative sign of enrolment rates in growth equations, Knight *et al*. (1993)

observe that in poor countries enrolment rate continue to rise up, even when growth rates fall. The same argument hold to explain the positive sign of the coefficient of the variable *ILLET*: illiteracy rates continue to have an upward trend during periods of higher growth rates[15].

The credit variable seems to inhibit growth and thereby to dampen the level of per-capita income in steady state. As expected, the sign of the negative for both samples.

The inflation rate elasticities are positive, but small in magnitude. The positive sign captures the situation frequently observed, notably in the WAEMU countries, of low inflation rates situations coexisting with low growth rates and low level of per-capita income. The small magnitude underlines the dichotomy between the real and the monetary sector: the inflation rate is mainly determined by the Central Banks' monetary policy, while growth is influenced by the fiscal policies.

Finally, we see that population growth has opposite effect in the full sample and in the sub-sample of WAEMU countries. For the latter, the negative sign captures the detrimental effects of overpopulation.

4. COMMON FACTOR ANALYSIS

Up to now, we have assumed heterogeneous long-run growth elasticities across the countries, without questioning the sources of such heterogeneity. It is interesting to examine more deeply which of the explanatory variables account for differences across countries. Such a study may motivate activist economic policies, by indicating the variables on which most coordination is required to reduce the asymmetries between the countries and favour a convergence toward a common long-run growth path. In order to explore this, iot is convenient to perform a common factor analysis. Our approach relies on Bai and Ng (2002).

15 We however find a short-run positive impact of enrolment rate in the regression corresponding to the WAEMU countries. This would mean that any improvement in human capital has only a temporary positive effect on the long-run per-capita income.

Intuitively, the method amounts to see whether there are common factors driving the countries' growth dynamics together and to examine whether the explanatory variables are one of these common factors. The presence of common factors indicates homogenous dynamics across the countries. The methodology is briefly sketched in appendix B. We comment on our main findings, for the ECOWAS sample[16.] In table 5, we report the values of some information criteria, obtained by using the common factor analysis. For each criterion, the optimal number of common factors correspond to the minimum of the values reported in each column. We have between two and four potential variables that account for the joint dynamics of the countries' long-run per-capita GDP. However, the common factors are unobservable. This is why one is entitled to ask whether the growth determinants could be one of these. As indicated in the appendix, a simple way to check this is to make a regression of each explanatory variable on the vectors of loading factor and to define a 95% confidence interval for the fitted values. To test whether an explanatory variable is a true underlying factor, we plot the confidence interval and the mean-average of the explanatory variable in the same figure. The latter must lie within the interval bounds.

From inspection of figures 3 to 9, we notice that all the variables lie outside the confidence interval. For *AID* and the human capital variables (*ILLET* and *ENROL*), except the first two years, their values are often inside the bounds. Clearly, this is not the case for the other variables. What this means is that external aid and human capital variables have the same impact on per-capita GDP across the countries. Conversely, the others (most of which depend upon economic policies) drives the economies towards different long-run growth paths. This finding can be a motivation for the countries to achieve greater real convergence, through more coordination (fiscal policy discipline, common trade policy, common monetary policies).

16 We do not apply the analysis to the sub-sample of WAEMU countries, given the nonparametric nature of the method, which requires the highest number of observations.

5. CONCLUSION

The main findings of this research can be summarized as follows. The results show evidence of structural heterogeneity: the marginal impact of the growth determinants on per-capita income vary across countries. These heterogeneities imply that the countries follows individually their long-run growth paths. Further, there is some evidence of no real convergence between the countries (even a divergence is found if we consider all the ECOWAS countries). The main economic policy implication of these results is the following. The results motivate activist coordination policies to reduce the structural heterogeneity. This subject is already in the policy agenda of both the WAEMU and ECOWAS countries: policymakers think that real convergence is conditioned by nominal convergence, hence the decisions to adopt institutional frameworks to allow a better coordination of economic policies.

Appendix A. Data

The data are from the World Bank Development Indicators and composed of the following series.

Endogenous variable :

- *GDP*: log of GDP per-capita (constant, 1995, US $)

Exogenous variables:

- *ILLET*: illiteracy rate, adult total (% of people ages 15 and above)
- *ENROL*: school enrolment, primary (% gross)
- *EXPORTS*: exports of goods and services (% GDP)
- *IMPORTS*: imports of goods and services (% GDP)
- *OPEN* : log of *EXPORTS+IMPORTS*
- *INV* : log of gross fixed capital formation (% GDP)
- *POP*: log of population growth (annual %)
- *AID* : log of aid per capita (current US $)
- *INFL*: inflation, consumer prices (annual %)
- *GOV* : log of Government final consumption expenditures (% GDP)
- *CREDIT*: log of domestic credit provided by the banking sector (% GDP)

Appendix B. Common factor analysis

The methodology relies on Bai and Ng (2002). Let us consider a series $\{y_{it}\}, i = 1,\dots,N \text{ and } t = 1,\dots,T$. A common factor, denoted F_t, is an unobservable variable that drives the observations in y_{it} together. The common factor model is written as follows:

$$y_{it} = \sum_{j=1}^{r} l_{ij} F_{jt} + e_{it}, \quad F_{jt} = F_{jt-1} + u_t \cdot$$

u_t and e_{it} are $I(0)$ processes. We assume that there are r common factors. Two individuals y_{it} and y_{kt} are correlated because they share the same unobservable common factors. It is further assumed that the non-stationarity of the series y_{it} comes from the fact that the common factors have a unit root (they are common stochastic trends).

The first step is to find the number of common factors (that is to estimate *r*), to estimate l_{ij} and the common stochastic trends F_{jt} .The estimates are obtained by solving the follong optimisation problem:

$$V(r) = \Lambda_i, F_{\min} (NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} (y_{it} - l_i^{'} F_t)^2$$

under the constraint $F^{'}F/T^2 = I_r$, $l_i^{'} = (l_{i1}, l_{i1}, \ldots, l_{ir})$, $F_t = (F_{1t}, F_{2t}, \ldots, F_{rt})$, $\Lambda_i = (l_1, l_2, \ldots, l_r)^{'}$ and F is the common factor matrix. The column components of this matrix are the estimated eigenvectors corresponding to the r largest eigenvalues of the $T \times N$ matrix $YY^{'}$, where Y is the matrix of observations $(y_1, y_2, \ldots, y_N)$ and $y_i = (y_{i1}, y_{i2}, \ldots, y_{iT})^{'}$. If we denote $\hat{F}$ the estimated common factor matrix, we have

$$\Lambda_i^{'} = \hat{F}Y / T^2$$

It is easy to see that the optimisation solution depends on *r*, for which an optimal value has to be estimated. This can be done by using criteria involving penalty functions, denoted $g(N,T)$, that depend on both N and T. Several penalty functions have been proposed in the literature. The central point is to choose a penalty function that implies strong consistency, that is

$$\underset{N,T\to\infty}{p\lim} (\hat{r} - r) = 1$$

where $\hat{r}$ is an estimate of *r*. The criteria used in this paper rely upon Bai and Ng (2002):

$$PC_1(r) = V(r) + r\hat{s}^2 a_T \left(\frac{N+T}{NT} \right) \ln\left(\frac{NT}{N+T} \right),$$

$$PC_2(r) = V(r) + r\hat{s}^2 a_T \left(\frac{N+T}{NT} \right) \ln\left(C_{NT}^2 \right),$$

$$PC_3(r) = V(r) + r\hat{s}^2 a_T \left(\frac{\ln C_{NT}^2}{C_{NT}^2} \right)$$

where $\hat{s}^2$ is a consistent estimate of $(NT)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} E(e_{it}^2)$, $C_{NT} = \min\left[\sqrt{N}, \sqrt{T}\right]$ and $a_T = T / [4 \ln T]$.

Once the common factors have been estimated, step 2 consists in studying the relationship between the common factors and the exogenous variables. Suppose that $\{x_T\}_{t=1}^{T}$ is the observable series and $\hat{d}$ is an *OLS* estimate of d in the following regression

$$x_t = \hat{F}_t d + v_t,$$

where v_t is an error term. We consider that x_t is one of the common factors or a combination of the latter, if $x_t \in I_{95}$. I_{95} is the 95% confidence interval for x_t defined as

$$\left(\hat{d}'\hat{F}_t - 1.96 S_t N^{-1/2}, \hat{d}'\hat{F}_t + 1.96 S_t N^{-1/2}\right),$$

where

$$S_t = \left[\hat{d}' V_{NT}^{-1}\left(\frac{1}{N}\sum_{i=1}^{N}\hat{e}_{it}\hat{l}_i\hat{l}_i'\right)V_{NT}^{-1}\hat{d}\right]^{1/2}.$$

V_{NT} is a diagonal matrix consisting of the first *r* largest eigenvalues of $YY'/(T^2 N)$.

Table 1 – Panel unit root (demeaned data)[*]

Variable	Level	1st difference	Conclusion
ILLET	3.93	-6.83	*I(1)*
ENROL	2.69	-6.57	*I(1)*
INFL	-4.39	-	*I(0)*
GDP	0.61	-9.85	*I(1)*
EXPORTS	-0.88	-48.70	*I(1)*
IMPORTS	-0.23	-39.29	*I(1)*
AID	2.20	-35.28	*I(1)*
GOV	-0.08	-45.85	*I(1)*
CREDIT	0.70	-46.00	*I(1)*
INV	-0.33	-45.28	*I(1)*
POP	-	-	TS

*The numbers must be compared to the critical value :-1.99 (critical value from IPS table for T=20 and N=10 at the 5% level of confidence). TS means “trend stationary”.

Table 2a – Panel cointegration tests (demeaned data)[*] *: basic Solow model*[**]

Homogenous slopes			Heterogenous slopes		
Panel	Panel	Panel	Group	Group	Group
r	*P*	*A*	*r*	*P*	*A*
	P	*D*		*P*	*D*
		F			*F*
0.607	-2.983	-1.571	1.718	-4.735	-2.892

* Statistics are distributed as *N(0,1)* distribution. The null of no cointegration is rejected when the reported values are higher than $|1.96|$ (at 5% level of significance) or $|1.64|$ (at 10% level of significance).

** Solow basic model - Endogenous variable : *GDP* : exogenous variables *: INV*, *ENROL*, *POP*

Table 2b – Panel cointegration tests (demeaned data) : augmented Solow model***

Homogenous slopes			Heterogenous slopes		
Panel *r*	Panel *PP*	Panel *ADF*	Group *r*	Group *PP*	Group *ADF*
2.11	-5.49	-2.79	3.17	-6.77	-2.50

* Statistics are distributed as *N(0,1)* distribution. The null of no cointegration is rejected when the reported values are higher than $|1.96|$ (at 5% level of significance) or $|1.64|$ (at 10% level of significance).

** Augmented Solow model - Endogenous variable : *GDP* - Exogenous variables *: INV, ENROL, POP, ILLET, INFL, AID, GOV.*

Table 2c – Panel cointegration tests (demeaned data) : augmented Solow model***

Homogenous slopes			Heterogenous slopes		
Panel *r*	Panel *PP*	Panel *ADF*	Group *r*	Group *PP*	Group *ADF*
2.673	-3.51	-0.398	3.704	-4.663	-0.725

* Statistics are distributed as *N(0,1)* distribution. The null of no cointegration is rejected when the reported values are higher than $|1.96|$ (at 5% level of significance) or $|1.64|$ (at 10% level of significance).

** Augmented Solow model - Endogenous variable : *GDP* - Exogenous variables *: INV, ENROL, POP, ILLET, INFL, CREDIT, OPEN.*

Table 3 – Panel ECM model – ECOWAS countries : 1985-2003 (demeaned data)

Long-run equation : Pedroni FMOLS estimator		
Exogenous variables	Coefficient	t-ratio
INV	0.012	3.94
POP	0.063	2.05
ILLET	0.035	3.11
ENROL	0.0008	0.558
INFL	0.0006	3.23
CREDIT	-0.070	-5.91
OPEN	-0.026	-2.41
AID	0.053	12.53
GOV	0.099	12.85
Short-run parameters : Pedroni FMOLS estimator*		
Exogenous variables	Coefficient	t-ratio
Δ *POP*	0.119	2.65
Δ *ILLET*	-0.079	-2.22
Δ *CREDIT*	-0.058	-5.47
Δ *OPEN*	-0.036	-3.70
Δ *AID*	0.0075	5.77
Δ *GOV*	0.038	4.53
Error-Correction term	-0.121	-3.34
Short-run parameters : pooled estimator*		
Exogenous variables	Coefficients	t-ratio
Δ *INV*	0.056	3.57
Δ *AID*	0.043	3.77
Δ *GOV*	0.047	3.05

Error-correction term	0.0046	1.64

* Only the significant coefficients are reported

Table 4 – Panel ECM model – WAEMU countries : 1985-2003 (demeaned data)

Long-run equation : Pedroni FMOLS estimator		
Exogenous variables	Coefficient	t-ratio
INV	0.045	4.15
POP	-0.056	-4.82
ILLET	-0.166	5.96
ENROL	-0.0008	2.38
INFL	0.0003	5.42
CREDIT	-0.0678	-2.37
OPEN	-0.056	-4.776
AID	0.097	8.00
GOV	0.116	5.82
Short-run parameters : Pooled estimator*		
Exogenous variables	Coefficient	t-ratio
Δ *INV*	0.096	3.73
Δ *ENROLL*	0.003	1.73
Δ *AID*	0.066	3.77
Δ *GOV*	0.065	2.25
Error-Correction term	0.001	0.41

* Only the significant coefficients are reported

Table 5 – Common stochastic trends – ECOWAS countries

	PC1(r)	*PC2(r)*	*PC3(r)*
r=1	0.12×10^{-2}	0.11×10^{-2}	0.10×10^{-2}

r=2	0.103×10^{-2}	0.09×10^{-2}	0.07×10^{-2}
r=3	0.107×10^{-2}	0.08×10^{-2}	0.068×10^{-2}
r=4	0.117×10^{-2}	0.09×10^{-2}	0.066×10^{-2}
r=5	0.133×10^{-2}	0.1×10^{-2}	0.068×10^{-2}
Optimal r	2	3	4

Figure 1
Log of per-capita GDP - ECOWAS countries : 1985-2003

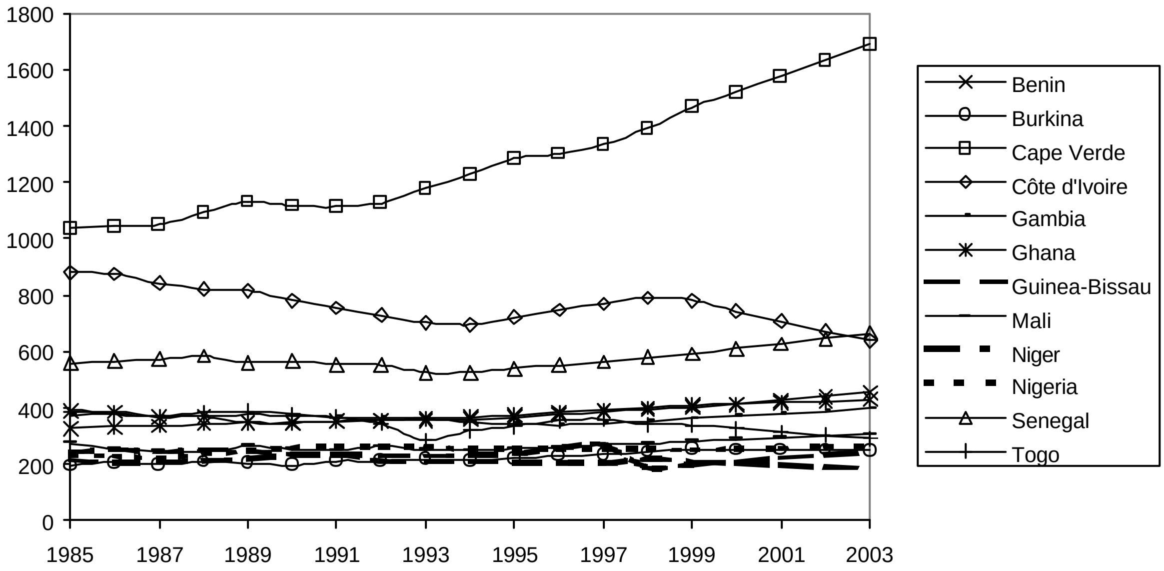


Figure 2
Log of per-capita GDP- WAEMU countries : 1985-2003

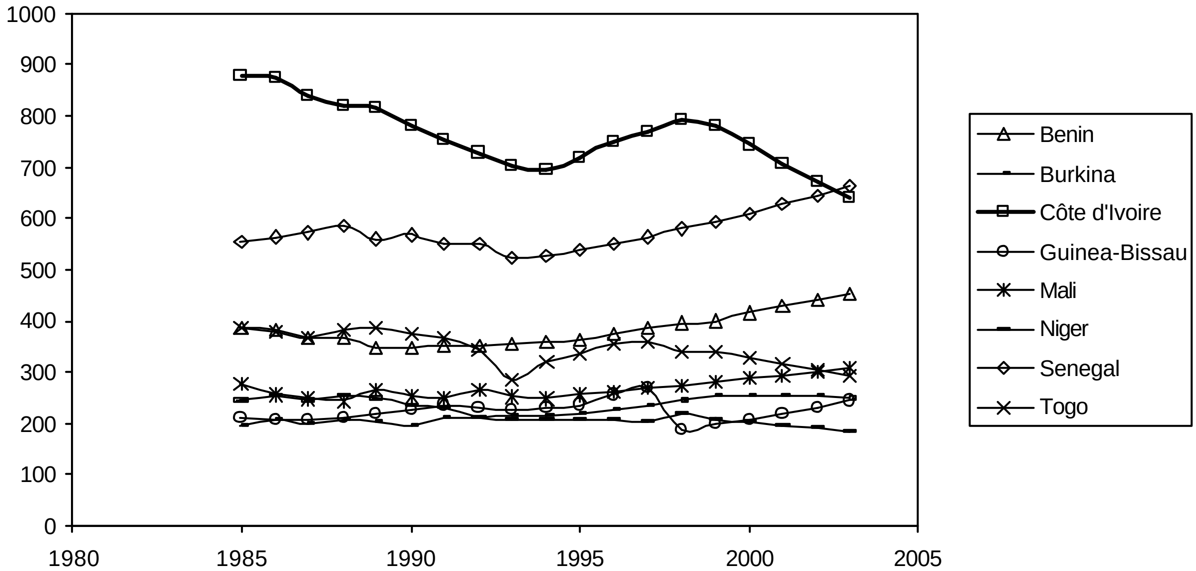


Figure 3 - Loading factor - Confidence interval - Investment

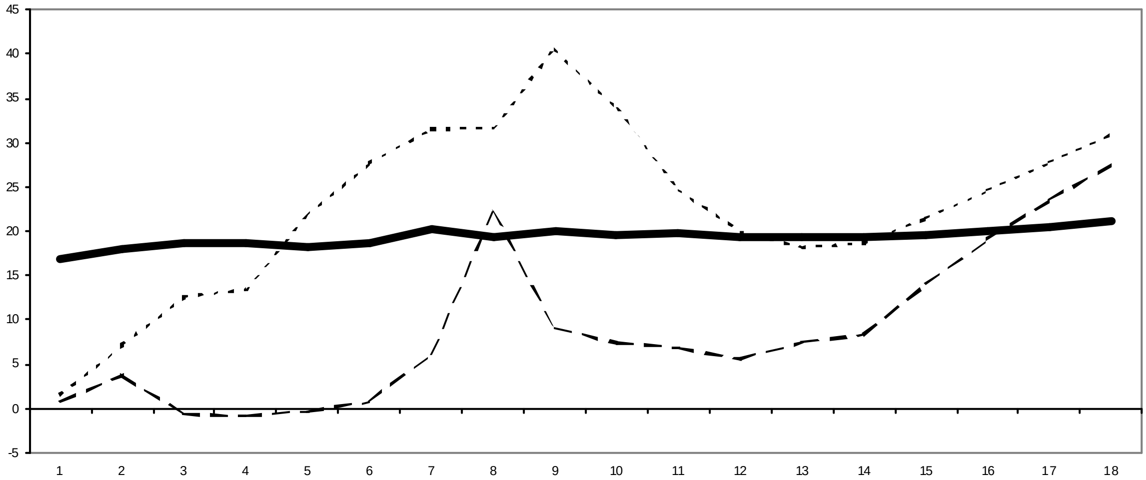


Figure 4 - Loading factor - Confidence interval - Literacy

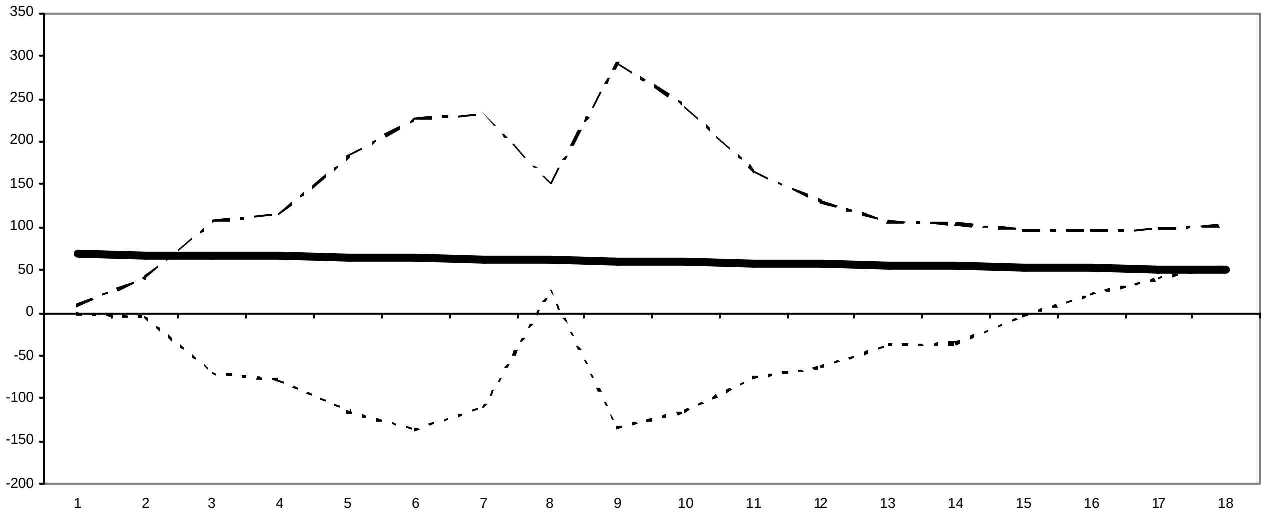


Figure 5 - Loading factor - Confidence interval - Openness

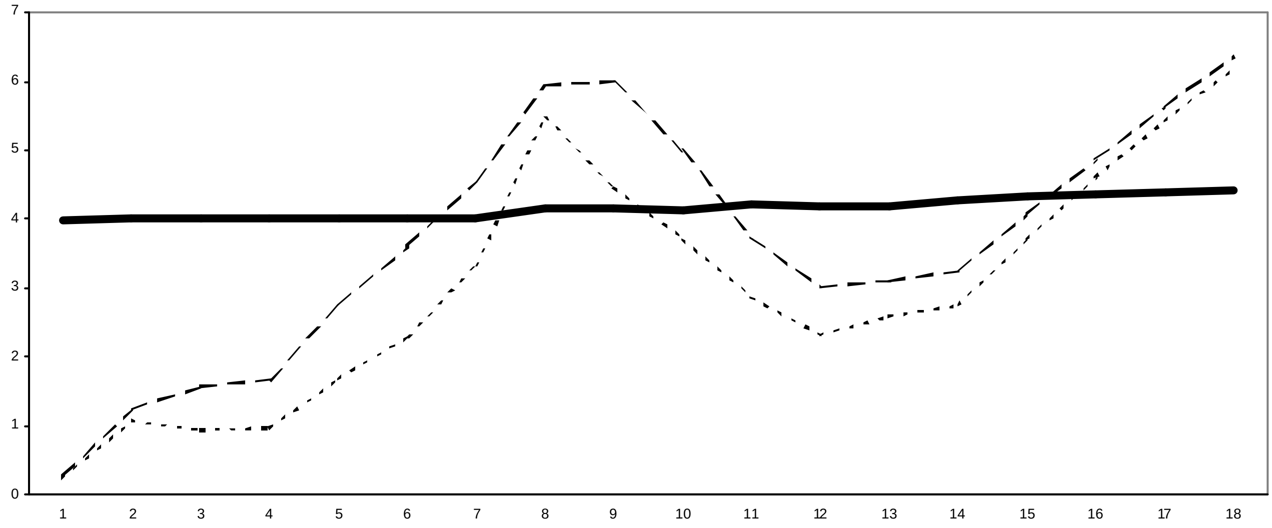


Figure 6 - Loading factor - Confidence interval - Government consumption

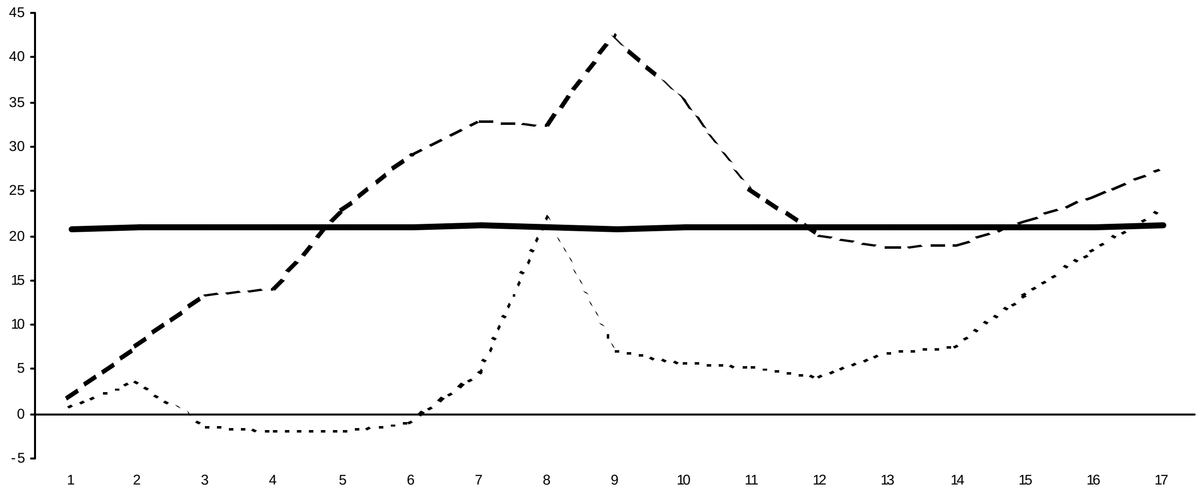


Figure 7 - Loading factor - Confidence interval - Inflation

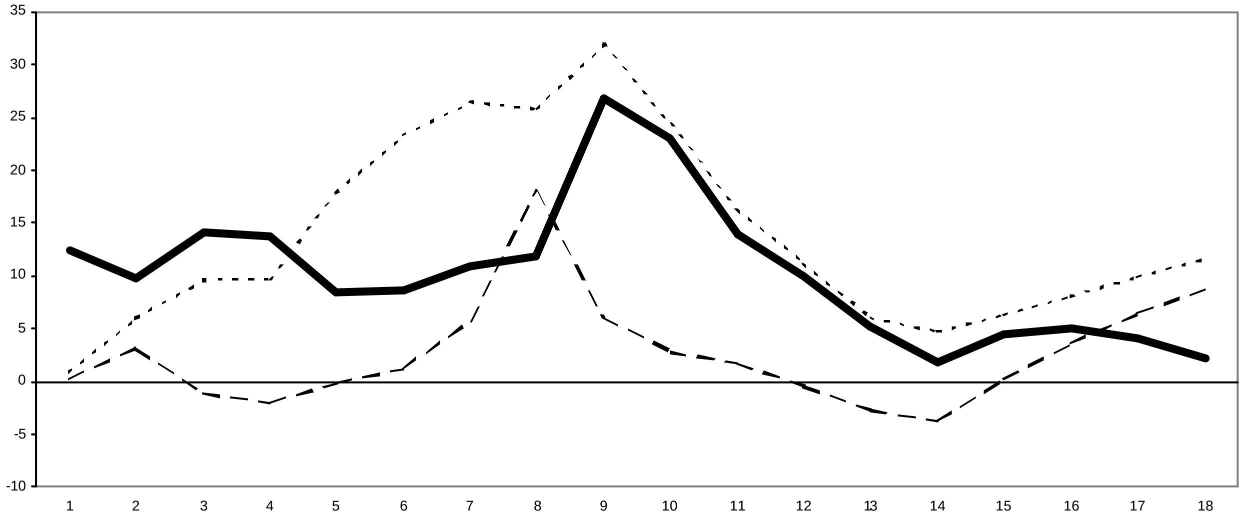


Figure 8 - Loading factor - Confidence interval - Aid

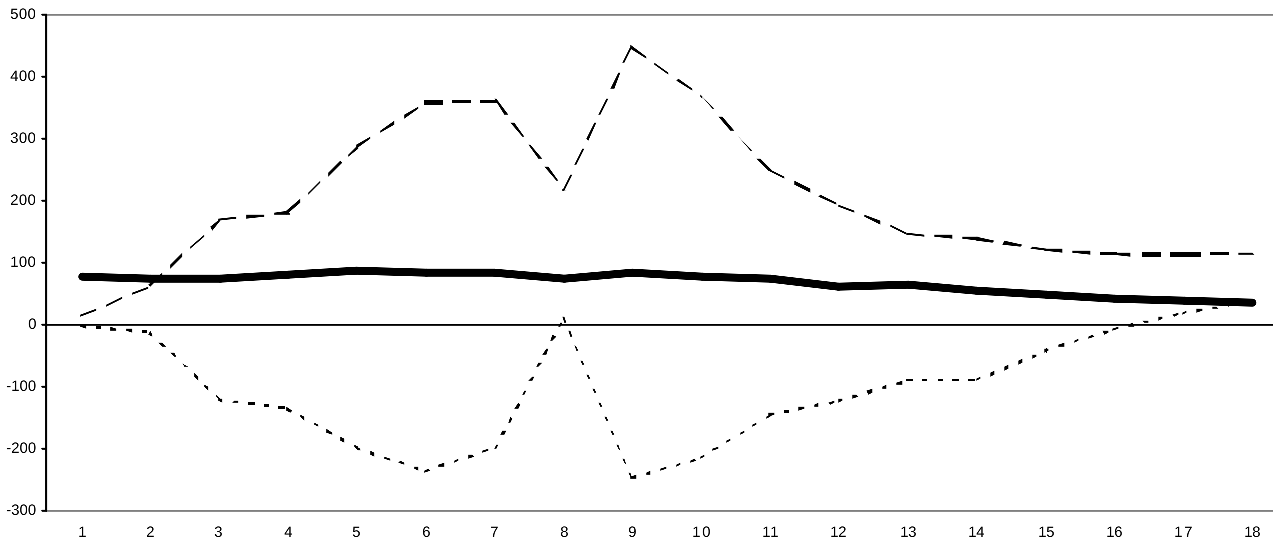
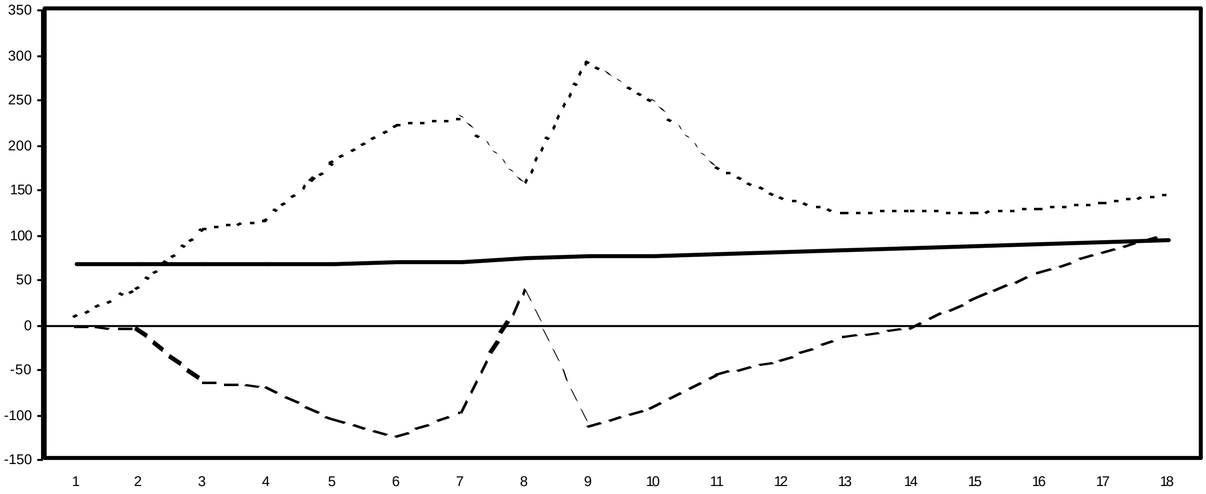


Figure 9 - Loading factor - Confidence interval - Enrolment



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