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# The effect of a positive policy integration on agriculture and climate change adaptation in ECOWAS

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## Abstract

**Background:** The place of agriculture in the economic development process has long been the subject of much criticism. If the authors are unanimous that agriculture contributes to the development of the economy, its role in the growth of other sectors remains unclear. This research examines the contribution of agriculture, industry and services sectors to Gross Domestic Product in Economic Commission of West African States from 1975 to 2014. The study identifies the sector with a greater participation, analyses the robustness of the relationship between the three sectors and discusses the bidirectional causality relationship. Moreover, the interactions between the long-run equilibrium relationships and short-run dynamics are explored through an error correction model. Taking into account climate change, this research establishes by simulation the effect or response to a change in temperature and rainfall on the production of agricultural sector under the assumption of a positive policy integration of Economic Commission of West African States.

**Results:** The causality links between the three sectors are different among countries. Agriculture causes other sectors in some countries, while it is industry or services in other countries. The long-term equilibrium shows that the contribution of agriculture is predominant in Burkina Faso, Gambia and Nigeria. Countries such as Benin, Ghana, Mali, Niger, Senegal and Guinea have a comparative advantage in industry. The simulation confirms the benefits of a positive policy integration in agriculture sector. Indeed, in the scenario of a positive policy integration, the effect of climate change through changes in temperature and rainfall is neutral and without consequences on agriculture per capita income.

**Conclusion:** The implementation of a special program is suggested for each country group based on their comparative advantage. A program between similar countries can be a coping strategy. Positive policy integration is fundamental to reduce the harmful effect of climate change.

**Keywords:** Integration, Climate change, Economic sector, Cointegration, Error correction model

**JEL Classification:** C32, O11, O17, Q17, Q54

## Background

The place of agriculture in the economic development process has long been the subject of much criticism. If the authors are unanimous that agriculture contributes to the development of the economy, its role of engine in the growth of other sectors remains unclear. According to the various controversial results in developing countries on the spillover effects of agriculture in the industry and services sectors, many recent studies continue to deepen the subject and revive the interest on the complexity of the agricultural sector. Agriculture has always been a sensitive sector to the extent that agricultural production provides food for the survival of individuals and nutrition of the population. The upsurge of studies in recent years [1–16] fits into this dynamic to guide public choices by striving to analyze the potential of agriculture.

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An overview of the interdependence between agriculture and the rest of the economy can be summarized in two different schools of thought. Some researchers consider agriculture as the engine of economic growth. Johnston and Mellor [17], Rowthorn [18], Eicher and Staatz [19], De Janvry [20], Rao and Caballero [21] and Delgado [22] are among the pioneers in identifying the basic inter-sectoral linkages of agriculture: producing food for domestic consumption, providing labor surplus for the industrial sector, supplying domestic savings for industrial investment, enlarging the market for services and industrial output, and supplying foreign exchange earnings for imported capital and intermediate goods. Dowrick and Gemmell [7], Thirtle et al. [10], Datt and Ravallion [23], Schultz [24], Giordani et al. [25], Gollin et al. [26], Timmer [27] and Gouel [28] put forward that agriculture is the foundation of any economic development process through strengthened purchasing power, increase in rural incomes and poverty reduction, improvement of food availability and caloric nutrient intake by population, improvement of domestic skills due to a better quality of labor and capital, supply of industrial raw materials, and provision of tools for risk management (food price stability) and enlargement of safety nets. Warr [29], Ligón and Sadoulet [30], Lipton [31], Loayza and Raddatz [32], Bhaduri [33] and Gallup et al. [34] show that an increase in GDP coming from agricultural growth translates into more poverty reduction than industrial and services sectors. Therefore, neglecting the agricultural sector in favor of the industrial sector or policy distortion to the agricultural sector will only lead to negative effects, dismal and slow economic growth, and more inequality in income distribution [35–42].

Other researchers state that agriculture has weak links to other sectors, and its contribution to economic growth is lower because of the low innovation it generates, slow technological progress, and the limited profitability rate for private companies. Technology and innovation are crucial sources to raise human capital for structural change [43] and economic growth [44]. Only the industrial sector has this potential [45]. Among the precursors of this argument, [46–50] claim that the links between agriculture and other sectors are insufficiently robust to speed productivity and increase exports for a dynamic economic growth. Basing their analysis on the comparative advantages between sectors and the externalities of industrial activities, they reject the assertion that agriculture is the engine of the economy and emphasize the industry as the key area where investments and development efforts should be directed. Based on their observation, the real development begins with the industrial revolution (the manufacturing sector). Research and development are the main drivers of technological change, and therefore industry is the driving force of economic growth [51–53]. Consistent with these findings, many developing countries support industrial strategies to benefit from international technology diffusion [59, 60] and have postponed their agricultural development by adopting anti-agricultural policies such as heavy taxation [54–58].

Many criticisms can be addressed to previous research. First, the importance of the agricultural sector is highly dependent of the characteristics of the country in terms of factor endowments. The contribution of agriculture can be significant in one country and not in another because of the difference in factor endowments [61]. Second, many works are unaware of the services sector and are not focused on the simultaneous effects between the three sectors. Third, [62] criticize most of the work done by highlighting the problems related to data treatment in time series, inappropriate specification of the model, and a focus on the relationship between agriculture and growth without an analysis of causal links. Consequently, the findings should not be considered as permanent and require further investigation. Finally, the studies do not involve a regional integration of countries, although some focus on groups of countries.

Taking into account the shortcomings of previous work, this paper looks at the issue from a different perspective. Instead of studying different countries, this study focuses on the contribution that can have regional integration of the Economic Community of West African States (ECOWAS) on agriculture. The model takes into account the agricultural sector, the industrial sector and the services sector and examines their contribution to the economy. In addition, the model analyzes the robustness of the relationship between the three sectors and real Gross Domestic Product (GDP), identifies directional causality links and estimates the long-term equilibrium relationships. This last result will contribute to the large literature that focuses on agriculture through finding the comparative advantages between the three sectors among ECOWAS countries.

The importance of this study is based on the assumption of a positive policy integration. In fact, two dimensions of regional integration exist. The negative policy integration refers to less discrimination between partner countries through border regulations. This consists in trade liberalization via reduction of barriers for the intraregional trade. The aim of negative policy integration is a perfect market integration. However, because of the differences in macroeconomic environment and national policies, the integration of agricultural sector needs from each country more than trade liberalization such as complementary institutional frameworks and coordinating policies. Promoting perfect intraregional trade in agricultural products requires a positive policy

integration which means that common institutions are established to strengthen the relationship between similar countries. The focus of positive policy integration is to improve food security through the creation of new infrastructures and institutions. Negative policy having been largely discussed in studies, we assume a positive policy integration within ECOWAS and simulate its potential effects on agriculture. Under this assumption, a model is built to assess the possible effect of climate change on agriculture. We know from various literature that climate change through rainfall and temperature is an exogenous shock that significantly affects the agricultural sector. We use this information to examine the effect of climate change on the agriculture sector production by considering the ECOWAS integration as positive.

This study discusses the effect of a positive policy integration on agriculture. First, this paper analyzes for each country how, respectively, agriculture, industry and services sectors are affecting the real GDP. Second, we examine the comparative advantages between the three sectors by country and find causality links. Finally, assuming the ECOWAS as positively integrated, an assessment of the effect of climate change (using rainfall and temperature) on agriculture is made.

## Methods

In this section, the conceptual framework, models, estimation methods and data are presented. To analyze the relationship between the three economic sectors, namely agriculture, industry and services sectors, and Gross Domestic Product (GDP), we use the growth accounting framework to detail the sources of growth. To determine the effect of climate change, we use a standard Ricardian framework with a simple Ordinary Least Squares.

To analyze the contribution of each sector to GDP, we consider the following general equilibrium equation of economy:

$$Y = C + I + G + X - M \tag{1}$$

where $C$ is the consumption, $I$ is the investment, $G$ refers to Government expenditure, and $(X - M)$ is the net exports.

To understand how each sector impacts on the economy of ECOWAS countries, we use the growth accounting framework which is generally adopted by authors [4, 15, 63–65]. Developed by neoclassical growth theory, the growth accounting framework helps to find the sources of economic growth. The aggregate output of the economy $(Y)$ is supposed to be the sum of the output of each sector and is specified as:

$$Y_t = \sum_k Y_{kt} \tag{2}$$

where $(Y_t)$ is the aggregate output of economy in period $t$ and $(Y_{kt})$ is the output of sector $k$ in period $t$.

By adopting framework (2) and including agriculture, industry and services sectors, Eq. (1) becomes as:

$$Y_t = A_t + I_t + S_t + H_t \tag{3}$$

$A, I, S$ are the respective output of agriculture, industry and services sectors; $H$ is the aggregate output of all other economic sectors non-included. The resulting model is presented below:

$$\begin{aligned} y_i &= f\left(\text{Agric}_i, \text{Ind}_i, \text{Serv}_i\right) + \varepsilon_i \\ &= \alpha_i \text{Agric}_i + \beta_i \text{Ind}_i + \gamma_i \text{Serv}_i + \varepsilon_i \end{aligned} \tag{4}$$

where $y_i$ is the real GDP of country $i$, $\text{Agric}_i, \text{Serv}_i$ and $\text{Ind}_i$ the respective value added of agriculture, industry and services sectors of country $i$ and $\varepsilon_i$ the error term.

Using a multiple regression analysis, model (4) is estimated for each country of ECOWAS to find the comparative advantages between the three sectors. The estimation of the model is subdivided into three parts. As [66] suggest, most of the time series need to be differenced in order to become stationary. In the first step of the estimation process, we perform the augmented unit root tests of [67] in order to examine the stationarity properties. In the second step, we realize the cointegration test by using Johansen's multivariate test [68] or [69] two-step cointegration test. Based on the result of cointegration test, we perform [70] test to find out the direction of causality between the variables. Finally, if the variables are integrated of order one and cointegrated, we build an error correction model to dissociate the long-run equilibrium relationship and short-run adjustment. This result allows the classification of countries according to one sector of specialization. The sector with higher marginal effect on real GDP is said to have a comparative advantage compared to other sectors and then become the specialization sector of the country. Therefore, countries with the same sector of specialization are grouped in order to develop common institutions (positive policy integration) and implement similar policies. We expect each variable to have a positive contribution to real GDP.

To assess the effect of a positive policy integration on agriculture, we formulate indicators to capture each sector of specialization including a group of countries. Based on the previous results, these indicators suggest that each group of countries is implementing common policies based on their specialization sector. The coefficients $(\alpha_i)$ estimated in the previous model for each country are used as a new variable to assess the productivity of ECOWAS agriculture. The hypothesis of a positive policy integration among ECOWAS countries assumes a perfect integration in each group of countries

through common institutions, infrastructures and policies. Under this assumption, the fifteen coefficients ($\alpha_i$) can be used as only one agriculture variable containing fifteen values. Therefore, ECOWAS is assumed positively integrated based on agriculture. To simulate the effect of climate change, we use the Ricardian framework presented below:

$$Z_{it} = X_{it}B + \sum_j \theta_j f_j(W_{ij}) + \varepsilon_{it} \quad (5)$$

$Z_{it}$ = value of $i$ productivity in year $t$, $X_{it}$ = vector of observable determinants, $W_{ij}$ = represents a series of climate variables (indexed by $j$) for $i$ variable.

Adapting (5) to the study, the model assessing the effect of a positive integration on agriculture by incorporating climate change is as following:

$$g_i = \omega_i * \text{GDPper capita}_i = \beta_0 + \beta_1 \text{Temp}_i + \beta_2 \text{Rain}_i + \sum_k \gamma X_k + \varepsilon_i \quad (6)$$

With $\omega_i = \frac{\alpha_i}{\alpha_i+\beta_i+\gamma_i}$ = percentage of agriculture sector contribution in GDP in country $i, g_i$ = agriculture per capita income in country $i$, $\text{Temp}_i$ = standard deviation of temperature in country $i$, $\text{Prec}_i$ = standard deviation of rainfall in country $i, X_k$ = dummy matrix variable taking 1 if the country is specialized in sector $k$ ($k$ = agriculture, industry or services) and 0 otherwise.

The matrix $X_k$ means that each group of countries has a common project in sector $k$. To avoid bias, as discussed in literature review, we use both rainfall and temperature as climate change variables and estimate the model with a simple OLS as mentioned by Seo [71] to avoid an under-estimation of climate change damage in order to perform right policy recommendations. To capture the importance of positive policy integration, we first regress Eq. (6) without $X_k$. The results will show the impact of temperature and rainfall on agricultural productivity without positive policy integration.

We make all preliminary tests on time series to ensure that the data have been treated before we start any estimation. The adequacy of the specified models is also checked using various diagnostic tests from functional form (Ramsey's RESET test), serial correlation (LM test), heteroscedasticity (White's test) to structural stability (CUSUM tests). After the estimation of the different equation, robustness test and multicollinearity test are done to reinforce the results in order to derive appropriate policy. The sources of data are coming from the World Bank, Africa Development Indicator and countries national meteorological station from 1970 to 2014 and 1980 to 2014 for climate variables. ECOWAS incudes fifteen countries such as Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Ghana, Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo. Therefore, the number of coefficients in the simulation is fifteen (15).

## Results and discussion

### Causality results

Using one optimal lag, the bidirectional causality test demonstrates that GDP Granger causes industry and agriculture sectors (Guinea-Bissau, Niger, Togo, Burkina Faso, Ivory Coast, Gambia) or GDP Granger causes industrial sector and does not causes agricultural sector (Ghana, Sierra Leone) or GDP Granger causes agricultural sector and does not causes industrial sector (Benin, Mali, Senegal, Cabo Verde, Nigeria). This means that the added value of agriculture and industry sectors in 1 year can be explained by the GDP of the previous year. In other words, the level of GDP helps in the prediction of agriculture and industry sectors value added but this does not mean that agriculture and industry value added are the effect of GDP. These Findings can be justified by the fact that in most of these countries the performance of the agricultural sector and the industrial sector are related to the level of investments done. Due to the unstable economic environment, the level of Gross Domestic Product is volatile from 1 year to another, affecting the agricultural and industrial sector in contrast to developed countries where a total investment threshold is predefined and achieved whatever is the variation in GDP. The Granger causality relationship from GDP to services sector is unidirectional in Benin, Togo, Mali, Niger, and Burkina Faso and bidirectional in Nigeria where GDP and services sector are dependent on each other. This means that the level of GDP reached in the previous year contributes to the services value added the next year, in the five respective countries except Nigeria where GDP and services sector have a bidirectional influence. There is therefore a mutual effect on GDP and services in Nigeria which means that policy makers have to focus on all sectors.

The causality relationship from each sector to GDP shows that agriculture and industry sectors Granger cause GDP in Liberia, Nigeria and Mali while only agricultural sector causes GDP in Ghana and only industrial sector causes GDP in Guinea and Benin. These results illustrate that in these countries (Liberia, Nigeria, Mali, Ghana, Guinea and Benin), the influence of the value added of agriculture and industry is significant in predicting GDP. For omitted countries, the influence of each sector in the prediction of GDP is not significant. A comparative analysis between the three sectors demonstrates that industry Granger causes services and agriculture sectors in Benin, Mali and Guinea. The interpretation is that in Benin, Mali and Guinea, industry boosts other

sectors. This sector can be crucial to economic activity regardless of the contribution. In Guinea-Bissau, Togo, Ivory Coast and Niger, services sector Granger causes industry and agriculture sectors but in the case of Togo agricultural sector also causes services sector. Therefore, services sector is crucial in the economy of these countries. In the case of Niger, Liberia, Ghana and Nigeria, agriculture Granger causes industry and services sectors, but in the case of Nigeria industry also Granger causes services sector. The significant influence of agriculture means that it helps to estimate the value added of other sectors. Also, agricultural sector is Granger caused by industrial sector (Ivory Coast and Senegal) and services sector (Burkina Faso, Mali, Senegal and Nigeria), proving that the industry and services sectors, respectively, play a significant role in these economies. In Liberia, there is a bidirectional causality relationship between services and industry sectors. Finally, industrial sector is Granger caused by agriculture and services sectors in Sierra Leone. In Burkina Faso, agricultural sector Granger causes industrial sector and in Ghana and Gambia services sector Granger causes industrial sector. The link between sectors shows that the ECOWAS economies are not the same. If agriculture causes other sectors in some countries, it is industry or services sector that, respectively, causes other sectors in different countries.

In sum, because of the omission of past observations more than 1-year optimal lag, this choice can justify why the value added of agriculture, industry and services sectors does not Granger cause GDP in all countries. In fact, although not well perceived in causality test, the estimated error correction term is negative and statistically significant for each country in the error correction model estimations. This suggests that long-run causality exists from agriculture, industry and services sectors to GDP for each country in a way that past information plays a significant role in determining current production. The findings of the error correction model for each country are summarized in Tables 1 and 2.

After estimating the error correction model for each country, the results are robust for all countries of ECOWAS. In fact, the residual-based Engle and Granger two-step cointegration, significant at 5% for Ivory Coast, Niger, Togo and Cabo Verde as mentioned above, is also tested and significant for other ECOWAS countries. In addition, for the fifteen countries, the error correction term is negative and significant suggesting that a shock exerted on the variables is temporary and leads to the long-term equilibrium. The long-term deviations from imbalance errors are absorbed by the extent of the adjustment. We first discuss the result of the long-term estimation.

#### Long-term results

The value added of agriculture, industry and services sectors seems to have a positive and statistically significant effect on GDP in all the countries. This result presented in Table 1 is consistent with the development economics literature which clearly establishes that agriculture and industry are a key determinant of growth and development. In Benin, one more dollar in industry leads to an increase in GDP of 1.52 dollar while the same dollar in agriculture generates a rise in GDP of 0.67 dollar, and the same dollar in services is related to 1.18 dollar more in GDP. The industry has the greatest GDP contribution followed by the services sector. In addition, both sectors bring back more than the amount invested since the marginal effect is greater than one. This long-term equilibrium confirms the results of causality test. Senegal economy is identical to Benin. The analyses are the same except that an additional dollar in industry leads to an increase in GDP of 1.74 dollar while the same dollar in agriculture generates a rise in GDP of 0.82 dollar and the same dollar in services sector increases GDP by 1 dollar. Similarly, in Mali, industry contributes more to GDP, followed by agriculture because one more dollar in the industry leads to a rise in GDP of 1.28 dollar while the same dollar in agriculture generates an increase in GDP of 1.21 dollar and the same dollar invested in services is linked to 0.92 dollar more on GDP. Industry and agriculture sectors are the driving force of the economy with almost equal contribution. This interpretation also applies in Guinea where industrial sector (1.25) predominates on agriculture (1.16) and services (0.97).

In Burkina Faso, an additional dollar in agriculture leads to an increase in GDP of 1.26 dollar while the same dollar in industry produces an increase in GDP of 1.17 dollar, and the same dollar more in services is linked to 0.94 dollar increase in GDP. Agriculture has the largest share in GDP and is followed by industry. In addition, both sectors bring more than the amount invested in the GDP. However, the service sector is expanding and should not be neglected because its contribution is close to one. This result supports the causal relationship of agriculture to industry. Also in Nigeria, agriculture (1.04 dollar) and services (1.01 dollar) drive the economy with a growing industrial sector (0.96). Similarly, agriculture has the greatest influence in GDP in Gambia. Indeed, one more dollar in agriculture, industry and services sectors causes a rise in GDP, respectively, by 1.24 dollar, 0.96 dollar and 0.87 dollar. The services and industry sectors have a contribution to GDP lower than one. The latter two sectors require special attention in order to increase their productivity. In Ivory Coast, Togo and Niger, the contribution of the three sectors is

**Table 1 Error correction model results of real GDP, long-term coefficients estimated by country**

| Variable | Agriculture | Industry | Services | *R* squared | *F* test |
|---|---|---|---|---|---|
| Benin | 0.676554*** (0.067008) | 1.524916*** (0.030789) | 1.189156*** (0.028032) | 0.999772 | 52,651.13*** |
| Burkina Faso | 1.263994*** (0.045216) | 1.178241*** (0.038701) | 0.941068*** (0.040169) | 0.999835 | 72,825.43*** |
| Cote d'Ivoire | 1.00010*** (6.63E−08) | 1.00000*** (8.88E−08) | 1.00000*** (2.61E−08) | 0.999988 | 1.71E+15*** |
| Cabo Verde | 0.977243*** (0.065816) | 0.987352*** (0.023712) | 1.006853*** (0.005146) | 0.999981 | 543,889.9*** |
| Ghana | 1.075374*** (0.116254) | 1.117078*** (0.086644) | 1.065737*** (0.084165) | 0.999399 | 19,405.17*** |
| Guinea | 1.166375*** (0.269010) | 1.254997*** (0.117791) | 0.978375*** (0.054390) | 0.994176 | 1422.598*** |
| Gambia, The | 1.242085*** (0.150098) | 0.961073 (0.353816) | 0.872697*** (0.096593) | 0.995638 | 1997.257*** |
| Guinea-Bissau | 1.099913*** (0.074936) | 0.718737*** (0.256789) | 1.108949*** (0.083183) | 0.998514 | 8065.76*** |
| Liberia | 0.977561*** (0.010922) | 0.994136*** (0.013594) | 1.00468*** (0.010078) | 0.999859 | 85,063.05*** |
| Mali | 1.219808*** (0.047679) | 1.285884*** (0.082643) | 0.926359*** (0.058848) | 0.999763 | 50,710.71*** |
| Niger | 0.999581*** (0.001928) | 1.005149*** (0.003760) | 0.999959*** (0.001678) | 0.999998 | 5,313,450*** |
| Nigeria | 1.043199*** (0.031625) | 0.966397*** (0.026143) | 1.016225*** (0.005129) | 0.999971 | 348,523.3*** |
| Sierra Leone | 0.99564*** (0.015210) | 1.033609*** (0.023975) | 1.120806*** (0.023778) | 0.999758 | 49,615.86*** |
| Senegal | 0.82589*** (0.136828) | 1.741442*** (0.183018) | 1.000171*** (0.080301) | 0.999452 | 21,885.52*** |
| Togo | 1.00000*** (3.34E−08) | 1.00001*** (9.12E−08) | 1.00001*** (2.13E−08) | 0.999999 | 3.24E+15*** |

*** significant at 1%, standard errors in parentheses

almost identical. Indeed, an additional dollar in any sector increases GDP substantially by the same amount. This distribution confirms that the services sector is crucial in Ivory Coast, Togo and Niger to the point that it competes with agriculture and industry sectors.

The structure of Ghana's economy is similar to that in Ivory Coast with a slight difference. While all sectors have a contribution more than one, the industrial sector has the highest. Indeed, the long-term equilibrium suggests that an additional dollar in industry leads to an increase in GDP of 1.11 dollar while the same dollar in agriculture leads to a rise in GDP of 1.07 dollar, and the same dollar in services sector is related to 1.06 dollar increase in GDP. These values approve the causality tests on the interaction between the three sectors, showing that there are closely interrelated. The causal links are also confirmed in Guinea-Bissau and Liberia where services are dominant. In Guinea-Bissau, if the value added for the services sector increases by 1 dollar, GDP is expected to increase by 1.10 dollar. Furthermore, if the value added of the agricultural sector increases by 1 dollar, GDP is expected to increase by 1.09 dollar. In addition, if the value added of the industrial sector increases by 1 dollar, GDP is expected to rise by 0.71 dollar. In Liberia, one more dollar, respectively, in the services, agriculture and industry sectors generates an increase in GDP of 1 dollar, 0.99 dollar and 0.97 dollar. Given the closed value of the contribution of sectors in GDP, it appears that they are interdependent.

In Sierra Leone, an extra dollar in industry leads to a rise in GDP of 1.03 dollar while the same extra dollar in agriculture generates a rise in GDP of 0.99 dollar, and the same extra dollar in services is linked to 1.12 dollar in GDP. The services and industry sectors bring more than the amount invested in GDP. However, agriculture has significant potential that needs to be valued as in Cabo Verde. In Cabo Verde, one extra dollar in agriculture, industry and services sectors causes a rise in GDP, respectively, by 0.97 dollar, 0.98 dollar and 1 dollar. The agriculture and industry sectors have a lower contribution to GDP. It seems that the connection between sectors is small as pointed out in causality relationship.

**Table 2 Error correction model results of real GDP, short-run coefficients estimated by country**

| | Agriculture | Industry | Services | Error correction term | *R* squared | *F* test |
|---|---|---|---|---|---|---|
| Benin | 0.600978*** (0.111317) | 1.49446*** (0.070427) | 1.206417*** (0.066422) | −0.5261*** (0.171373) | 0.99216 | 1075.701*** |
| Burkina Faso | 1.171238*** (0.033527) | 1.05896*** (0.041646) | 1.054718*** (0.038235) | −1.00628*** (0.166046) | 0.995237 | 1775.94*** |
| Cote d'Ivoire | 1.00000*** (6.80E−08) | 1.00000*** (9.41E−08) | 1.00000*** (3.59E−08) | −0.94030*** (0.171726) | 0.99999 | 8.35E+14*** |
| Cabo Verde | 1.003347*** (0.065481) | 1.00555*** (0.030617) | 0.886433*** (0.009386) | −1.11332** (0.486308) | 0.999371 | 11,515.93*** |
| Ghana | 0.961576*** (0.132024) | 1.07354*** (0.099189) | 1.11465*** (0.082086) | −0.57999*** (0.187000) | 0.990911 | 872.2129*** |
| Guinea | 1.046209*** (0.227180) | 1.17968*** (0.159409) | 0.860847*** (0.104300) | −0.95456*** (0.208105) | 0.947193 | 103.1378*** |
| Gambia, The | 1.045206*** (0.068999) | 9.80E−01*** (0.121522) | 1.020219*** (0.047894) | −0.19033*** (0.079491) | 0.988394 | 723.8797*** |
| Guinea-Bissau | 1.129538*** (0.094447) | 0.60812*** (0.274911) | 1.017329*** (0.072271) | −0.46826** (0.332405) | 0.970789 | 282.4852*** |
| Liberia | 0.997928*** (0.015400) | 0.88025*** (0.023879) | 1.04945*** (0.013750) | −0.6725*** (0.149931) | 0.998865 | 7482.011*** |
| Mali | 1.167569*** (0.048359) | 1.16053*** (0.104115) | 1.03952*** (0.057687) | −0.5425*** (0.173770) | 0.991314 | 970.1084*** |
| Niger | 1.002324*** (0.001850) | 0.98680*** (0.003986) | 1.003035*** (0.002141) | −1.50969*** (0.001850) | 0.999963 0.284307 | 231,016.5*** |
| Nigeria | 1.050634*** (0.019805) | 0.97755*** (0.009682) | 1.016443*** (0.004211) | −0.34036*** (0.083427) | 0.99992 | 87,441.37*** |
| Senegal | 0.890388*** (0.096170) | 1.76797*** (0.207619) | 0.964841*** (0.087333) | −0.32172** (0.125023) | 0.991772 | 1024.506*** |
| Sierra Leone | 0.959042*** (0.033379) | 1.01593*** (0.024373) | 1.164487*** (0.039337) | −0.61992*** (0.153658) | 0.997157 | 2981.036*** |
| Togo | 1.0000*** (4.04E−08) | 1.00001*** (1.09E−07) | 1.00001*** (2.70E−08) | −1.09058*** (0.170111) | 0.99998 | 9.14E+14*** |

*** significant at 1%, ** significant at 5%, standard errors in parentheses

Some strategies such as the promotion of agricultural facilities, a better access to farm inputs and the increased investment in industrial sector need to be implemented.

In summary, the results of the long-term relationship between GDP, agriculture, industry and services sectors are used to classify countries according to their comparative advantage. The contribution of agriculture to the economy of ECOWAS is strong in Burkina Faso, Gambia and Nigeria. Agriculture sector in these countries has a comparative advantage. The strong contribution to GDP suggests that agriculture can converge more quickly on its equilibrium path and have spillover effects in other sectors. Therefore, political and especially institutional reforms in ECOWAS for these three countries are needed to accelerate growth and enable the agricultural sector to reach maturity. The neoclassical theory of economic growth supports the view that determinants of growth having a high marginal efficiency converges along the 'razor's edge'. As a second option, governments of different countries may also agree on a joint program agenda to promote the agricultural sector in their respective countries. The stylized facts such as the partnership between China and the Asian tigers or Brazil, Colombia and Argentina show that this kind of collaboration was the basis for the development of the farming system, high productivity of labor, capital and land, extension of new crop varieties and phenomenal agricultural production. The benefit of this initiative is that at the end, this process will launch the development of market institutions that are favorable to industrial development in ECOWAS. Countries such as Benin, Ghana, Mali, Niger, Senegal and Guinea have an industrial sector that affects the most GDP.

A consultation framework is essential to support industrial development in these different countries while taking precautions to avoid overexploitation of raw materials (Dutch disease) known mainly in Africa as a source of curse. It is well established that industrial development is distinct from agriculture development because it requires innovation and technology. Governments can agree on the creation of a common center of research and development focused only on transformation of agricultural

products based on available technology and the effects of geographic concentration. Many experiments in the USA and Asia reveal that the location and transaction costs are the core of industrial growth. Benin, Ghana, Mali, Niger, Senegal and Guinea all together have sufficient resources to develop this industrial infrastructure before gaining the support of ECOWAS or foreign aid. All these initiatives are likely to boost the markets (information systems, infrastructure, future market, exchange and trade) and the expansion of services. The estimation results reveal that the services sector is important in most countries, although its contribution is not a majority. Excluding Togo and Ivory Coast due to the fact that the three sectors have equal contribution, for all remaining thirteen countries, services sector ranks in the first or second position in terms of contribution to GDP in eight countries. Particularly in Cabo Verde, Sierra Leone, Liberia and Guinea-Bissau services are dominant. This privilege can be interpreted by other countries as a comparative advantage and therefore an alternative to reduce transaction costs. Even if the theory of absolute advantage of Adam Smith shows that the eight countries can offer services, it is optimal for all the eight countries to have a comparative advantage in this sector. Indeed, providing services can be cheaper in Cabo Verde, Sierra Leone, Liberia and Guinea-Bissau if these countries manage to acquire a specialization showing the importance of collaboration. Briefly depending on their area of interest, the countries of ECOWAS can join their forces to undertake priority investment in agriculture, industry or services.

#### Short-term results

The results of short-term dynamics in Table 2 show that there is an improvement or deterioration between the short-term impacts and long-term impacts of the effect of sectors on GDP. For some countries, the economic structure between the three sectors is completely altered which means that the short-term sector of interest can be different from the long-term one. A comparative analysis of the dynamics of short-term and long-term equilibrium for instance illustrates for Benin, Burkina Faso, Ghana, Guinea, Mali and Sierra Leone an increase in the contribution of agriculture and industry over time while the services sector share decreases. The adjustment leads both sectors to achieve greater long-term performance. Their efficiency increases in the long run compared to the short term. This change is so important that it modifies the dominant sector in some countries. This is the case of Ghana, Guinea-Bissau and Mali. In Ghana, in the short term, services are dominant compared to the industry which become the engine of the economy in the long term. In Guinea-Bissau, in short term, agriculture has the significant contribution to the GDP, but in long term this sector is replaced by services. In Mali, the predominance of agriculture in short term gives place to industry in the long run.

In Liberia and Niger, the comparison of the dynamics of short and long term suggests a decline in the contribution of agriculture and services over time while the industrial sector is increasing. For these two countries, only the industrial sector performs in the long term. These results indicate that these countries are subject to the curse of natural resources particularly diamonds and uranium. In the specific case of Niger, the dominance of services in short term is replaced by industry in long term. Appropriate policy measures need to be implemented such as an increase in domestic savings, a more taxation on industry to try to avoid booms, investment in education and infrastructure to increase competitiveness of other sectors and increase in anticorruption efforts. Guinea and Nigeria present inverse performance between the short-term and long-term equilibrium. In Nigeria, over time the performance of all sectors down to reach their long-term path while in Guinea all sectors contribute more than in the short term. This means that currently the Guinean economy is far from the optimum because all sectors are not working under full capacity. A tentative explanation in Nigeria may be related to the lower production of oil and the increase in population. Some work already [72] shows stronger evidence of causal flow from oil production to GDP. Based on this report, oil accounts for 95% of Nigeria's exports and 75% of budgetary revenues. According to IMF, since 1970 Nigeria's revenue and expenditures follow a parallel pattern to oil prices. In periods of high oil prices such as 1979–1982, 1991–1992, 2000–2002 and 2005–2009, revenue and expenditures also experienced sharp increases. From 2005 to 2008, the increase in oil prices led to increased revenue and expenditures for Nigeria's government. The global financial crisis in 2009 led to a fall in global oil prices which caused Nigeria's government revenue to fall accordingly. Indeed, a decrease in the future of oil production or oil price will greatly affect all sectors as oil revenues have strong linkages in financing the rest of the economy. This justification probably explains why all sectors' contribution to GDP falls.

In Cabo Verde, only the industrial sector's contribution decline in long term. Agriculture and services have a participation in GDP higher than the short term, suggesting the non-use of production inputs and the huge potential of services. Services sector remains dominant in the short and long term. In contrast, in Senegal only the contribution of services increases over time, other sectors contribution reduces from short term to long term. The development of crafts and the informal economy may explain this trend in Senegal. In the case of Gambia,

only agricultural performance increases between the short term and the long term confirming that agriculture remains the engine of the economy. These results in the short-run dynamic are consistent with previous findings on the importance in the future of the services sector in all the countries.

### Results on climate change simulation and positive policy integration

The impact of climate change on agriculture is based on a fundamental assumption untested in reality. Our hypothesis states that there is a positive policy integration within ECOWAS in agriculture from 1975 to 2014 suggesting that the impact of agriculture on GDP in different countries can be similar because economic policy is homogenous. This strong assumption helps to estimate the potential impact of climate in a situation of optimum agricultural integration since 1975. After estimating the model, the results of diagnostic tests for functional form (Ramsey's RESET test), serial correlation (LM test), heteroscedasticity (White's test) and structural stability (CUSUM tests) are consistent and significant at 5% level. Therefore, the model is valid. The simulation results presented in Table 3 show that all the coefficients are significant.

The standard deviation of rainfall and temperature negatively affects the share of value added of agriculture in GDP per capita. The climate effect is more pronounced for temperature than rainfall. Indeed, a variation in rainfall of 1 mm (up or down) from the average leads to a decline in agriculture per capita income in the integration of only 1.73 dollar. In contrast, a change in temperature of 1 °C (rise or fall) from the average leads to a decline in agriculture per capita income in the integration of 77.10 dollar over the period. These results show that the effects of climate change are mitigated if countries were truly integrated through negative policy. These signs and analyses are consistent with economic and climate theory well establishing that climate change has a negative effect on agriculture and the impact is generally negative for countries. These results also consolidate the previous work mentioned in the literature review on the importance of climatic factors often underestimated. Restarting the estimation and incorporating the classification of countries based on their comparative advantages among sectors, the results are different. All coefficients are significant at 5% level except rainfall and temperature. Temperature and rainfall are assigned a negative sign, however, insignificant. The interpretation is that taking into account the specialization and the membership of each country in a given sector, the variation in rainfall or temperature has no effect on agriculture per capita income. Otherwise, the deviations of temperature and rainfall from its average have no effect since the coefficients are not robust. In contrast, all the coefficients of common sector endowments or specialization sectors are significant and positive. The coefficient for countries specialized in agriculture is significant. The coefficients allocated to countries with a specialization in industry and services are also significant. For countries with an equal contribution in the three sectors, the coefficient is also significant. The establishment of a joint program between the countries as described above strengthens regional integration by making it not only optimal but also more effective in eliminating shocks. The positivity of the coefficients assigned to each sector or category of countries pointed out the potential in the development of a consultation framework or a program between similar countries. The analyses show that the effects are positive on agriculture per capita income in ECOWAS.

This simulation confirms the benefits of a positive policy integration on agriculture. Indeed, the impact of climate change is different according to the scenarios. Considering regional integration as currently pursued (negative policy integration), the impact of climate change through changes in temperature and rainfall is significant with a negative effect on agriculture per capita income. More precisely, the ECOWAS policy aiming a perfect integration of market through the reduction of barriers is not enough consistent to address the impact of climate change on agriculture per capita income in the region. This case can be described as a second best. In the

**Table 3 Simulation of climate change variables on agriculture income, OLS results**

| Dependent variable: agriculture per capita income | Negative policy integration | Positive policy integration |
|---|---|---|
| | Coefficient | Coefficient |
| Rainfall | −1.73876** (0.773648) | −1.37723 (0.867426) |
| Temperature | −77.1062** (34.44107) | −52.2553 (39.67653) |
| Constant | 487.2617*** (128.5404) | |
| Agriculture specialization | | 423.4782** (153.6900) |
| Industry specialization | | 366.0533** (154.7357) |
| Services specialization | | 394.2739** (156.8512) |
| Non-specialized countries | | 515.4499** (134.3369) |
| *F* test | 3.06011** | 7.880507** |
| *R* squared | 0.33775 | 0.478147 |

*** significant at 1%, ** significant at 5%, standard errors in parentheses

second scenario of a positive policy integration, the effect of climate change through changes in temperature and rainfall is neutral and completely eliminated. This ideal situation calls for the abandonment of selfish interests in each country for the benefit of a better social optimum. The explanation in the two scenarios is justified by the interlinking of economies. When economies with different potential fully benefit from the same environment in terms of market institution, it is easier to absorb shocks because a single economic policy is implemented for all countries. In addition, in the latter scenario, countries also enjoy economies of scale, well known for their key role in the development process. In short, the phenomena of compensation between sectors in different countries can eliminate the negative impact of climate change. On the contrary, in the situation where each country put a policy in place to respond to shocks, adverse effects may occur. The policy adopted in a country affecting another country, the initial economic situation can be even worse and become a vicious circle. Countries should strive for positive policy integration.

## Conclusion and policy recommendation

The agricultural sector is and will long remain an important topic especially with the recurrence of conflict (war and terrorism), food crises, social crises and environmental changes related to climate change. There is no doubt that agriculture will be the summit of much research in the future in developed and developing countries to find alternatives to increase global food reserves and explore new energy sources. Although stylized facts clearly show that industrial development is the pillar of economic development, the industry may be sidelined when access to food is precarious and the daily food intake becomes a matter of survival. The results of this study show the benefits of a positive policy integration on agriculture. Indeed, the impact of climate change is different according to the scenarios. Considering regional integration as currently pursued, the impact of climate change through changes in temperature and rainfall is significant with a high negative effect on agriculture per capita income. In a scenario of a positive policy integration, the effect of climate change through changes in temperature and rainfall is neutral and totally eliminated. This ideal situation calls for the abandonment of selfish interests in each country for the benefit of a better social optimum. The explanation in the two scenarios is justified by the interlinking of economies. When economies with different potential fully benefit from the same environment in terms of market institution, it is easier to absorb shocks because a single economic policy is implemented for all countries. In short, the phenomena of compensation between sectors in different countries can eliminate the negative impact of climate change. Countries should strive for positive policy integration with the development of institutions. A program between similar countries can be a coping strategy. Consequently, positive policy integration is fundamental.

**Abbreviations**

ECOWAS: Economic Commission of West African States; GDP: Gross Domestic Product.

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**Competing interests**

The authors declare that they have no competing interests.

**Availability of supporting datar**

Yes. Supporting data can be accessed by email on aatinta@st.ug.edu.gh.

**Consent for publication**

The author consents for publication.

**Ethical approval and consent to participate**

This study did not require any ethical approval.

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