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Macroeconomic effects of semi-subsistence agricultural productivity growth: Evidence from Benin and extension to the WAEMU countries

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ABSTRACT

This paper studies the macroeconomic effects of an agricultural productivity growth in a semi-subsistence agriculture. To that end, a dynamic computable general equilibrium (CGE) model is used with the 2015 social accounting matrix (SAM) data of Benin. The results, with a few exceptions, are then extended to the West African Economic and Monetary Union (WAEMU) countries based on their SAM data. The simulation results suggest that an agricultural productivity growth could improve the overall economic growth, reduce trade deficit and enable an increase in households' incomes as well as government revenues. In particular, the food industry and the salary earning households appear to be the main beneficiaries. Overall, these results suggest that public policies that promote growth in food crops productivity may turn out to be more effective in achieving greater economic performance and poverty reduction.

Introduction

Agricultural productivity growth has considerable multiplier effects on the rest of the economy, especially in developing countries where agriculture occupies a large share of national income, employment and external trade [14,17,36]. In most developing countries, agriculture is characterized by semi-subsistence where farmers care both for home consumption and market sales. Hence, semi-subsistence involves agricultural households that allocate part of the production into auto-consumption and the residual is traded in the market. Production systems under which some crops (cash crops) are solely produced for export markets (e.g., cotton, coffee, cocoa, cashew nuts, rubber) and other crops (food crops) are produced for both auto-consumption and domestic markets (e.g., maize, millet, rice and tuber crops) are also prevalent in a semi-subsistence agriculture [32]. A productivity growth in a semi-subsistence agriculture could occur from total factor productivity growth as households adopt new technological approaches of production. The Total Factor Productivity (TFP) is the residual obtained after deducting the share of output from major inputs such as capital and labor [39]. Improving agricultural productivity could be achieved through the adoption of high-yielding crop varieties, improved irrigation and water

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management techniques, effective soil management practices and the use of fertilizers. This improvement in agricultural productivity is seen as having the potential to significantly impact economic growth in developing countries, particularly in countries where the share of the agricultural sector in the economy is large.

The role of agriculture in economic and social development of a country has long sparked controversial debates. The neoclassical school of thought [34,37] considers rising agricultural productivity as the basis for structural transformation of an economy through the increase in the demand for industrial products and reallocation of agricultural labor surplus toward the modern industrial sector. Thus, the systematic reallocation of factors of production from an agricultural sector, characterized by decreasing returns, to an industrial sector with high production and increasing returns to scale, is necessary for economic development [1]. In terms of trade effects, the increase in productivity improves the trade balance through lower food imports, increases exports capacity, decreases and stabilizes food prices [3,11]. Growth in agricultural productivity also has an impact on poverty reduction, as rural households, mostly made up of unskilled labor, are more likely to derive their income from agricultural production activities [9]. Consequently, the increase in agricultural productivity enables poverty reduction through the effects of direct and indirect general equilibria that it induces on the economy [42].

This classical approach of the effects of agricultural productivity growth on the economy has been criticized by several authors. It has been pointed out [27] that these positive effects of productivity are obtained only in an open economy when countries have a comparative advantage in the production from the agricultural sector. Similarly, rural incomes do not increase sustainably like agricultural productivity improves due to the deterioration in terms of trade of agricultural products resulting from price inelasticity [3]. Moreover, agricultural productivity gains cannot reduce poverty if the fall in producer prices is greater than productivity gains [41]. Dercon [13] points out that in an open economy where agricultural goods and industrial goods can be traded, linkages between the two sectors become less important for overall growth. Consequently, there is no need to increase agricultural productivity to induce economic development and reduce poverty. Hence, theoretical models suggest mixed roles of agriculture in development. These various roles depend on the structure of the economy. Thus, in semi-subsistence agriculture-based economies, agricultural productivity growth could be the main driver of economic growth and poverty reduction. Whereas in countries that have already undergone structural transformations, agriculture being not so important as an economic activity, could only contribute marginally to economic growth.

Agriculture plays an important role in the Sub-Saharan African (SSA) economies. Firstly, most people in SSA live in rural areas (about 62.1%), and those that are employed in agriculture are about 57.9%. Secondly, agriculture is the main source of income for 10%–25% of urban households [45]. Given the importance of agriculture in the development process, several continental and regional policies have been put in place to foster agricultural growth. At the continental level, the comprehensive African agriculture development program (CAADP) was adopted by the African Union (AU) in 2003. The second pillar of this program is to improve market access through construction of rural infrastructures, enacting trade policies and product transformation schemes so as to boost productivity growth and improve competitiveness. At the regional level, the WAEMU has put in place a regional level agricultural development policy (PAU) document in 2001. The goal of the PAU is to contribute to meeting food needs in a sustainable manner, so as to achieve economic and social development of the member states and reduce poverty [43]. In Benin, agriculture occupies a key place in the economy. In fact, from 1994 to 2014, the contribution of the agricultural sector to the economic growth was about 4.33% [45]. Hence, this study seeks to address the fundamental research question of what are the macroeconomic effects of a potential semi-subsistence agricultural productivity growth?

Specifically, this study seeks to address the following questions; (1) what are the effects of food and cash crops' productivity growth on sectoral activities and GDP? (2) How is trade affected by potential food and cash crops' productivity growth? (3) What are the welfare implications in terms of changes in households and government revenues induced by the increase in food and cash crops productivity? The answers to these questions could help guide policy practices in terms of actions that could be taken in agricultural sector to boost economic growth in developing countries where agriculture is currently the main activity of most households.

The objective of this research is to study the macroeconomic effects of semi-subsistence agricultural productivity growth, using evidence from Benin, and then by extension from the WAEMU member states. Specifically, it aims at (i) measuring the effects of an agricultural productivity growth on sectoral activities and the GDP; (ii) analyzing the impact on trade outcomes; and (iii) evaluating the effects on households' income and government revenue. To reach these objectives, the paper relies on a dynamic computable general equilibrium (CGE) modeling framework with data, mainly drawn from 2015 social accounting matrix (SAM) of Benin and of the WAEMU countries. Despite the availability of theoretical arguments on the potential effects of an agricultural productivity growth in developing countries, only a few studies have attempted to test these arguments empirically using a CGE modeling framework. Hence, the contribution of this paper is twofold. First, it shows how agricultural productivity growth from cash crops (e.g., cotton) could differ from that of food crops (e.g., cereals and tuber crops). Second, it demonstrates how elements of the TFP in a dynamic CGE model could be used in a simulation to inform policies on how agricultural investments could be guided to be effective in the improvement of the welfare in rural and urban areas alike. Furthermore, given the similarities in the share of the agricultural sector in the WAEMU member states' economies, this study shows that an overall inference could be made, with a few exceptions, from the study of one country to the others based on common characteristics in a CGE model setting.

The paper is organized as follows. After the introduction, the second section presents a background on the role of agriculture in economic development and the effects of its productivity growth on other sectors. The third section presents the dynamic CGE model used to assess the impact of an agricultural productivity growth. The fourth section deals with the

analysis and interpretations of the CGE model simulation results. Finally, the fifth section is devoted to the conclusion and the implications in terms of policy recommendations.

Background to the role of agricultural productivity growth in economic development

The size of the agricultural sector in developing countries indicates that changes affecting agriculture can have equilibrium effects on the economy. Economic theories and models from the work of Johnston and Mellor [24] provide insight into the mechanisms (or the transmission channels) by which an agricultural productivity growth stimulates the overall economic growth and triggers poverty reduction. Thus, this section examines the theoretical and empirical literature foundations of the role of agriculture in economic development.

Theoretical aspects of agricultural productivity growth

Development theories have offered various views on the structural transformation mainly through the role of agriculture. Lewis [25] and Rostow [34] consider modern economic growth to be essentially identifiable with industrialization. Indeed, these authors consider agriculture as a source of employment and a pool of labor for the modern industrial sector, which has greater productivity and increasing returns to scales. This modern sector, which has higher growth potential, gradually absorbs agricultural workers. Fei and Ranis [18] see the agricultural sector as a surplus labor sector with a very low reference wage. Schultz [38] also stresses the importance of agriculture through food supply. For that author, in poor countries, the process of economic growth can only begin when these countries are able to produce the major part of their food needs, because imports are expensive and these countries have few resources. Moreover, high food prices would exacerbate the cost of living, especially for low-income households. The need to satisfy basic needs implies that agricultural growth must match up with the population growth in order to avoid the “Malthusian trap”. Hence, agricultural surplus is a necessary condition for initiating the development process. From these points of view, structural change leading to the emergence of an industrial economy is accompanied by a fall in the share of agriculture in the GDP and the labor force employed [31]. The end result of the structural transformation is an economy in which productivities of capital and labor in agriculture are equalized with those of the other sectors [23]. Therefore, agriculture contributes passively to development through agricultural productivity growth that provides food and employment for the process of industrialization.

However, the passive role of agriculture in development has been challenged by the dynamism of the green revolution in Asia, as agricultural growth is seen as necessary to the development and the transformation of a traditional economy into a modern economy. Hayami and Ruttan [20] proposed an “induced innovation model” stressing the fact that technical progress is important to agricultural growth which is endogenous to the country’s economic system. In other words, the success of an agricultural innovation is a dynamic process that reflects natural resources endowments; the level of demand for agricultural products and inputs’ supply from the industrial sector; as well as the incentive structure for farmers, scientists, public and private sectors. The green revolution and the induced innovation model have also revealed the need to promote linkages between the agricultural and non-agricultural sectors to sustain an agricultural productivity growth. Thus, the growth of the industrial sector does not occur independently from the agricultural sector. Moreover, Mellor [29] shows that agricultural productivity growth has a general equilibrium impact on productivity through the existence of production and consumption linkages between the agricultural sector and the non-agricultural sector (in particular the industrial sector). On the one hand, it increases income, agricultural profitability and domestic demand for industrial goods. On the other hand, it reduces nominal wages as well as costs in the industrial sector, and lowers food prices. In addition, it increases the competitiveness of agricultural and industrial exports, which generates foreign currency gains. Hence, an agricultural productivity growth increases income earned by poor farmers and boosts rural and urban employment through linkages with the rural non-farm economy, which may positively affect economic growth and reduces poverty with multiplier effects on the overall growth of the economy [21] .

Empirical aspects of agricultural productivity growth

Several previous empirical studies have analyzed the effects of an agricultural productivity growth on economic outcomes. Al-Haboby et al. [2] find that, when both direct and indirect effects of an agricultural growth are accounted for, an agricultural productivity growth contributes more to poverty reduction than growth in any other sectors. This contribution to poverty reduction, which is transmitted mainly through the channel of the labor market, is systematically higher than the share of agriculture in the GDP. Similarly, Datt and Ravallion’s [10] research on India shows that prices and wages derived from food crops’ productivity growth are more important in reducing rural poverty in the long run than the direct effects which dominate in the short run. Moreover, although low food prices reduce agricultural incomes, the experience of the green revolution in Asia shows that the TFP has grown faster than the fall in food prices leading to a favorable situation for poor producers and consumers [26]. Cao and Birchenall [6] find that an agricultural TFP growth has been an important source of economic growth in India and China as it has allowed for a reallocation of agricultural labor to Industry and Services sectors. Similarly, Chen and Liao [7], using a neoclassical two-sector growth model (agricultural and non-agricultural sectors) find that an agricultural productivity growth plays a larger role than a non-agricultural productivity growth in long-term structural change of the economy of the United States. In the long run, an agricultural pro-

ductivity growth reduces agricultural capital and labor and increases non-agricultural capital. However, Bustos et al. [5], in analyzing the effects of an agricultural productivity growth on the industrialization in Brazil, find that these effects depend on the factor bias of technological change. Thus, when technological change in agriculture reduces agricultural labor, it can promote industrialization, whereas when it allows for land increase, agricultural productivity growth can delay industrialization.

Moreover, the relationship between agriculture and economic growth has recently been reexamined in the context of dynamic general equilibrium models. The authors use theoretical models of general equilibrium in which various sectors such as agriculture, interact with the non-agricultural sectors during the development process. Yang and Zhu [46] use a dynamic two-sector model of England and demonstrate that, without increasing agricultural productivity, an agriculture-based economy cannot overcome the limited endowment of natural resources, and therefore cannot sustain the process of economic growth. Irz and Roe [22] have also found that a minimum rate of agricultural productivity growth is needed to counter population growth and avoid the Malthusian trap. The current demographic and technological characteristics of several SSA countries are consistent with such a poverty trap. Indeed, a number of studies [15,16] on developing countries suggest that overall gains in economic output growth and poverty reduction can be obtained from investment in agricultural productivity. For example, McArthur and Sachs [28] use a CGE model for Uganda and show that strong economic growth can be achieved by directing official development assistance towards financing policies that improve agricultural productivity. In fact, the increase in the productivity of food crops releases an important quantity of labor force towards cash crops and services. Furthermore, as a consequence, it leads to the fall in local food prices which improves trade deficit (because of the reduction in food imports), and increases tax revenues (because of the increase in volume of trade).

Materials and methods

We use a dynamic CGE model previously developed by Decaluwé et al. [12] to simulate the macroeconomic effects of an agricultural productivity growth in Benin, and extend the results to the other WAEMU countries based on the social account matrices and similarities in the economic structure of these countries (the CGE model is presented in the Supplementary materials). The choice of this model is motivated by the desire to uncover the overall effects of a productivity growth from the agricultural sector on the other sectors. A CGE model fits well these types of studies [21]. The model is based on the updated 2015 social accounting matrix of Benin and all the WAEMU countries obtained from Bayale, et al. [4]. The matrices are computed using cross-entropy method proposed by Fofana, et al. [19] to update and balancing the 2007 SAM. The SAM has three sectors which are agriculture, industry and services.

The agricultural sector has five subsectors, the industrial sector has five subsectors as well, and the Services sector has ten subsectors. Producers in each sector maximize profits by combining intermediate inputs, labor and capital. Constant Elasticity of Substitution (CES) production functions are used so as to reflect sector-specific technologies and the assumption of Leontief perfect complementarity between intermediate inputs and value added. The labor market is divided into skilled and unskilled labor markets. Skilled and unskilled labors are mobile between sectors while capital becomes static after it is invested. Economic performance is also affected by trade and fluctuations in market prices. It is assumed that producers supply their products to domestic product markets according to a CES aggregation function. International trade is captured by allowing production and consumption to shift imperfectly between domestic and foreign markets with respect to the relative prices of imports, exports and domestic products. More specifically, the Armington CES functions are used for imports and Constant Elasticity of Transformation (CET) functions for exports. Table 1 shows the structure of the Beninese economy in 2015.

The share of the agricultural sector in Benin reveals that food crops have the highest share in the value added followed by livestock and hunting, forestry, cash crops and fishery. In principle, all these agricultural subsectors are important to be considered (in respect to public policy) to foster the production of the agricultural sector. In particular, the production of food crops and cash crops are most prevalent / common activities in rural areas even if most rural households may combine several agricultural activities to minimize climatic risk and smooth their consumptions. Although food crops have the highest share in the value added of the agricultural sector, (and this applies to all the WAEMU member states as well), this subsector is still less formal and yields are often lower than in the cash crops subsector. As a result, most agricultural investments are often guided toward cash crops production. Benin is a net exporter of agricultural goods, and this is driven by the food and cash crops subsectors' performance, but a net importer of industrial goods and services. Given the pace of population growth, it is urgent to raise agricultural production through increase in yields, particularly yields of food crops and cash crops. The changes in the level and the structure of the economic activities in our simulations are obtained by adjusting growth in Total Factor Productivity (TFP) of food and cash crops in the CGE model. Implied changes in output and demand for factors therefore depend on the relative intensities of factors in these sectors, while changes in consumer demand depend on the baskets of household consumption and the estimated price and income elasticities. Demand and total supply are balanced by changes in market prices. The model results are thus largely determined by the unique structural characteristics of the Beninese economy, which are derived from economic data.

The results of this simulation are extended to the WAEMU countries based on the similarities in the structure of the member states' economies (Benin is himself member of the WAEMU).

Table 1
Structure of the Beninese economy in 2015.

Sectors	Part of total (%)			Part of GDP (%)	
	Added Value	Exports	Imports	Exports	Imports
Agriculture	23.34	6.33	0.95	1.44	0.33
Food crops	13.67	2.03	0.87	0.46	0.30
Cash crops	2.19	4.30	0.03	0.98	0.01
Livestock and hunting	3.77	0.00	0.02	0.00	0.01
Forestry	2.73	0.01	0.01	0.00	0.00
Fishery	0.98	0.00	0.01	0.00	0.00
Industry	15.11	72.22	73.18	16.40	25.02
Extractive industry	0.53	0.01	0.48	0.00	0.17
Agro-industry	5.38	25.51	21.88	5.79	7.48
Textile industry	3.18	21.06	8.67	4.78	2.96
Other industries	6.03	25.65	42.15	5.82	14.41
Services	61.55	21.44	25.86	4.87	8.84
Electricity, gas and water	1.70	0.00	2.75	0.00	0.94
Construction	9.82	0.00	0.57	0.00	0.19
Commerce	. 1043	0.00	0.00	0.00	0.00
Catering and housing	3.40	15.63	3.48	3.55	1.19
Transport	13.01	1.11	14.13	0.25	4.83
Financial activities	1.39	0.47	2.28	0.11	0.78
Non-tradable Service	10.84	0.00	0.00	0.00	0.00
Education	2.39	0.00	0.00	0.00	0.00
Health	0.67	0.00	0.00	0.00	0.00
Other services	7.90	4.22	2.65	0.96	0.91
Total	100.00	100.00	100.00	22.70	34.19

Source: Author's computations based on updated 2015 SAM of Benin.

Results and discussion

This section presents the simulation results of an agricultural productivity growth in semi-subsistence agriculture. The first simulation involves a 1% annual increase in the TFP of food crops (Scenario 1), while the second simulation involves a 1% annual increase in the TFP of cash crops (Scenario 2) in order to compare the effects of these shocks on sectoral activities, the GDP growth, households' and government's income between 2015 and 2022. This 1% increase is in line with the implementation of the National Agricultural Investment Plan and other national agricultural development plans. Also, the choice of 1% increase in the TFP growth implies doubling crop yields only after a century, and reflects the deceptive technical change rate observed in the West African region's agriculture in recent years [30]. Therefore, it is more cautious to simulate this low level of productivity growth than a higher one. The average percentage difference between the reference scenario without a productivity shock and the results obtained subsequently to the shock determines the effects over the period.

Impact on sectoral activities and GDP

The potential effects of the simulated productivity shocks on sectoral activities and the gross domestic product are shown in the Supplementary Materials (Table S1). Under both scenarios (Scenarios 1 and 2), the increase in productivity triggers an overall average increase in sectoral activities (Agriculture, Industry and Services sectors). The only exceptions are that, the demand for unskilled labor in the agricultural sector has decreased under Scenario 1, while under Scenario 2, the demands for both skilled and unskilled labor have decreased in the agricultural sector and the demand for skilled labor in the Services sector has decreased as well. The reductions in the demand for labor show that the increase in productivity causes substitution effects between capital and labor in the production process with higher substitution effects under the Scenario 2.

These results are consistent with what the literature has predicted for developed countries [25,34], even if some authors recently find that, the replacement of labor by capital in developing economies may be slower than observed during the industrial revolution in the western countries [17] in the process of the structural transformation. The key message in favor of public policies is that the structural transformation from a traditional economy to a modern economy with a smaller agricultural sector requires heavy investments in agriculture (through improvement of agricultural seeds, reduction of risks in the agricultural sector, mechanization, development of agricultural infrastructures, the use of fertilizers and so on) to increase productivity in the sector. Furthermore, the comparison and the contrast of the two simulation exercises show that even though both simulations yield positive value added in the three economic sectors, it is clear that the size of the impacts is much higher when the shock occurs in the cash crops subsector. As of the reduction of the demand for labor, the shock from food crops has relatively lower effects than that of cash crops, in particular from the demand of unskilled labor standpoint (in an economy with excess labor supply). Finally, it is also worth noticing that the increase of the TFP

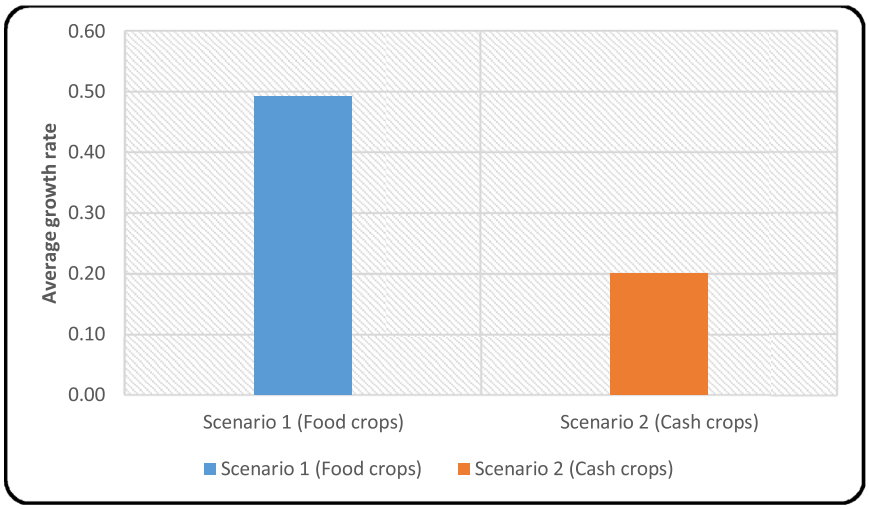

Fig. 1. Average change in economic growth under the two simulated scenarios.

in the agricultural sector is equivalent to an increase in efficiency in the use of factors in the production process. This increase in efficiency may result in a reduction of demand for factors in the subsectors that are directly affected by the efficiency measures and a shift to other sectors. Hence, the success of the structural transformation hangs on the ability of the economy to absorb the excess labor supply into the industrial and Services sectors.

In regard to the effects of the food and cash crops' productivity growth on GDP, Fig. 1 shows that the effect on the economic growth induced by positive food crops' productivity shock is much higher on average (0.49% or an equivalent of $40.6 million USD in 2015) than that of cash crops' productivity shock (0.2% or an equivalent of $16.6 million USD in 2015). These results are mainly driven by the size of the share of the value added of food crops in the GDP. In fact, the food crops subsector accounts for about 14% of the total value added while the cash crops subsector accounts only for about 2%. As a result, a positive productivity shock on food crops is likely to contribute more to the GDP growth. These numbers are in fact moderate. However, in a country where the poverty rate is about 49.5% in 2015 [44], about half of the population or an equivalent of 5 million people live with about $2/day, these moderate effects might be quite significant in terms of improving the welfare of the poorest population.

Effects on trade

The effects of food and cash crops' productivity growth on trade are given in the Supplementary Materials (Table S2). Under the two simulated scenarios, imports of agricultural products have decreased on average while exports of agricultural products have increased on average as predicted in the literature [29]. Domestic sales have also increased under both scenarios. With few exceptions, this tendency of decline in imports and increase in exports as well as in domestic sales is observed in the Services sector across the two scenarios. It is only in the Industrial sector where imports have increased instead under the two scenarios. These results are consistent with the effects of a potential increase in domestic supply of food and cash crops, and have benefits for Industrial and Services sectors as predicted in the theoretical literature [11]. The food industry subsector has mainly benefited through the availability of domestic agricultural products for processing. In the Services sector, the increase in food crops productivity has raised imports of services due to the increase in the demand for services. The main cash crop produced in Benin is cotton and this is the main driver of the results under the Scenario 2. In fact, under this scenario, all imports from the Industrial sector increase with the exception of the textile industry (−0.23%) while all exports in the sector decrease with the exception of the textile industry (2.59%). This positive impact on the textile industry is due to the fact that cotton is the main intermediate consumption good of the textile industry. In addition, there is a reduction in exports prices (−0.16%) and domestic prices (−0.1%). In the Services sector, the increase in the productivity of cash crops has a negative impact on exports of services by 0.22% and a positive impact on imports of services by 0.57%. This last phenomenon could be well understood by the fact that the increase in the revenues has worked also towards importing services in a country where the Services sector still depends a lot on foreign imports.

All the positive effects on trade can be well captured globally with the effects of the productivity shocks on the trade balance. Overall, Fig. 2 shows that the trade balance increases by 1.19% due to the increase in food crops productivity, and only by 0.93% due to the increase in the productivity of cash crops. The food crops subsector is the main supplier of raw materials to the industrial sector (It accounts for 28.02% of exports and 22.04% of imports) while the cash crops subsector is the main supplier of raw materials to the textile industry (It accounts for 25.56% of exports and 8.57% of imports). Consequently, the increase in the productivity of food crops has a higher positive effect on foreign trade. Besides

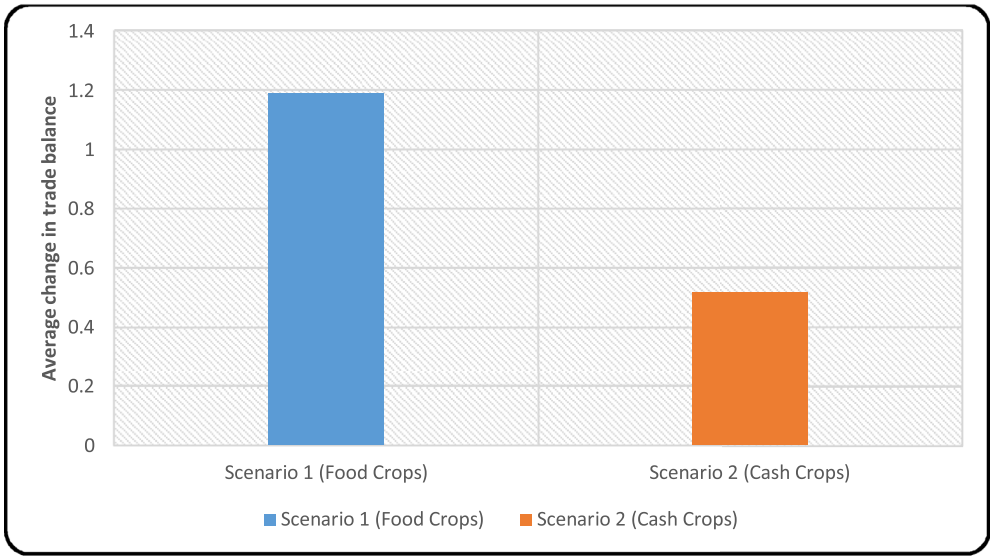

Fig. 2. Average change in trade balance across the two simulated scenarios (%).

Table 2
Change in remuneration of factors and disposable income (%).

	Scenario 1 (Food crops)			Scenario 2 (Cash crops)		
	Skilled labor	Unskilled labor	Capital	Skilled labor	Unskilled labor	Capital
Wage rate	1.24	0.13	0.68	0.28	0.16	0.14
	Variation of disposable income			Variation of disposable income		
Salaried households		**0.79**			**0.23**	
Public sector		0.81			0.23	
Formal private sector		0.81			0.23	
Informal private sector		0.75			0.22	
Rural households		**0.22**			**0.16**	
Industrial crops producers		0.13			0.15	
Food crops producers		0.05			0.15	
Livestock producers		0.58			0.18	
Fish producers		0.12			0.16	
Other households		**0.46**			**0.19**	
Independent and non-agricultural employer		0.36			0.18	
Non-working		0.56			0.20	

the fact that a positive trade balance has a positive impact on the welfare of rural households that are directly producing these crops, indirect effects on the currency and government taxes are the main arguments that should motivate public policies in favor of directing more investments into improving agricultural productivity. [28].

Effects on households' income and government revenue

Table 2 presents the effects of the two productivity shock scenarios on the different categories of households. Under both scenarios, the return on capital and the wage rate of skilled labor as well as the wage rate of unskilled labor have increased consistently with the theoretical literature predictions [29]. These positive effects on returns to factors, which are the main sources of income for households, have subsequently increased the disposable income for salaried households, rural households, and other households alike. In addition, the consumer price index declines under the Scenario 1 by 0.88% in line with the decline in exports and domestic sales' prices of agricultural products (Fig. 3). Consequently, rising productivity of food crops has a positive effect on the purchasing power of households. The effect on government revenues is also positive. This increase in revenues of the government is mainly due to the increase in income taxes on firms, indirect taxes, imports taxes and households' taxes (See Table S4 in Supplementary Materials). Also, the increase in productivity of food crops has raised the returns on capital in the Agricultural, Industrial, and Services sector (Table S3 in the Supplementary Materials). Thus, the purchasing power of households has increased as households' income increase more than the consumer price index. Overall, Fig. 3 shows that rising productivity of food and cash crops improves households' income and government revenue. Specifically, it leads to a greater increase in salaried households' incomes than that of other households (Table 2). Further-

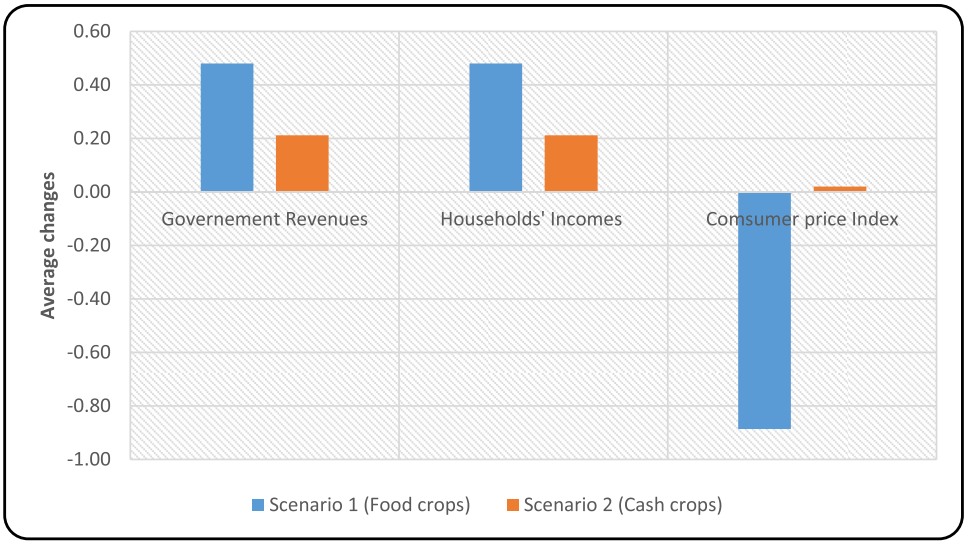

Fig. 3. Changes in government revenues, households' incomes and consumer price index under the two simulated scenarios.

Table 3
Shares of food crops, cash crops and the agricultural sector in the total value added in the WAEMU.

Country	Benin	Burkina	Cote d'Ivoire	Guinea Bissau	Mali	Niger	Senegal	Togo
Share of food crops in VA (%)	13.67	12.67	14.4	23.33	13.48	23.87	4.69	16.61
Share of cash crops in VA (%)	2.19	4.22	7.31	5.38	4.18	2.39	1.58	1.05
Total agriculture in VA (%)	23.34	26.9	24.83	40.1	40.1	44.68	14.09	24.76

Note: VA is the value added obtained from the updated 2015 SAM.

more, when we consider the improvement of purchasing power, the increase in the productivity of food crops reduces the consumer price index while the rise in productivity of cash crops increases this index.

These results are consistent with a previous work [10] which shows that agricultural productivity growth has decisive effects on poverty reduction through the channels of declining consumer price index and rising wages for skilled and unskilled labor. These macroeconomic effects are not limited to the only rural households but also extended to the urban households that could benefit from better food prices.

Extension to the WAEMU countries

Benin is a member state of the West African Economic and Monetary Union (WAEMU) countries which is made up of eight countries (Benin, Burkina Faso, Cote d'Ivoire, Guinea Bissau, Mali, Niger, Senegal and Togo). A close look at the data of the WAEMU countries (Table 3) drawn from their SAM, shows that all the member states have several similarities in their economic structure. Except in the case of Senegal, the share of the agriculture sector in the total value added of all these countries is higher than that of Benin. The share of cash crops in the total value added varies from 1.05 in Togo to 7.31 in Cote d'Ivoire which exports mainly cocoa, coffee and cashew nuts. As for the share of staple crops, the shares are sufficiently high even if Burkina Faso, Mali and Senegal have their shares of food crops in the total value added less than that of Benin. Given these similarities, it is expected that with fewer exceptions, the overall results that are obtained in the case of Benin are applicable to all these countries where agriculture is mainly practiced in a semi-subsistence setting. That is, more investments in agriculture are warranted to improve economic growth, increase employment and income that could have significant impacts on trade balance and poverty reduction. The importance of looking at the macroeconomic effects of an agricultural productivity growth at the WAEMU level is also motivated by the fact that all these eight countries share the same currency, the CFA franc. As a result, a strong improvement in trade balance is needed to improve the stability of the common currency and country level economic outlook at least in the short run. In the long run, structural reforms may be needed to develop the Industrial and Services sectors (and reduce the informal sector that dominates the Services sector) and achieve the structural transformation of these economies as predicted by theoretical findings [31].

Conclusion

A dynamic computable general equilibrium model is used to evaluate the effects of an agricultural productivity growth in semi-subsistence agriculture using evidence from Benin and extending the results to the WAEMU countries. An agricultural

productivity growth has positive effects on the GDP and incomes. Specifically, the increase in the productivity of food crops has higher positive effects than that of cash crops. Income distribution results seem to be mixed, as salaried households are the main beneficiaries of an increase of agricultural productivity. Trade balance would increase by 1.19% after food crops' productivity growth while it would increase only by 0.93% with the increase in cash crops productivity. Finally, the increase in food crops productivity has a negative impact on consumer price index while the increase in cash crops productivity has raised the consumer price index (with a resulting negative overall effect on food price index). In terms of cross-sectoral effects, the results show that food and textile industries are the main beneficiaries of an increase in the agricultural productivity growth. A close look at the structure of the WAEMU countries' economy reveals that the findings of this study could hold for these countries as well.

These results are consistent with those that have been found in the literature using similar modeling framework. In fact, some authors have shown that, increasing agricultural productivity in developing economies would have important effects on employment and trade [8]. In particular, they have found that, increasing agricultural productivity would reabsorb workers in the informal sector back into agriculture. A study using Mexican data have revealed that for 20% increase in the agricultural productivity, the share of total labor force in the informal sector falls significantly [35]. These studies have also proved that, such increase in the productivity would also have positive effect on exports which would improve trade balance as shown in our study. Our overall results on productivity and trade are further consistent with studies using CGE models in Bangladesh [33] and in Benin [40] with focus on trade liberalization.

Therefore, investing in the modernization of agricultural technologies could improve economic performance in semi-subsistence agricultural economies. Likewise, the exchange of technology through international cooperation and technical assistance with countries that are seen as agricultural powers, and foreign direct investments could improve knowledge in the agricultural sector and boost productivity. These countries could also facilitate the development of value chains in the agricultural sector by promoting or participating in the construction of processing industries to transform agricultural raw materials into processed products for consumption. They may also want to provide the agricultural sector with a legal framework that protects investments and promotes a public-private partnership for the establishment of agricultural industries. All these measures should be taken with a focus on food crops.

Finally, this paper does not take into account the impacts of climate change in simulating agricultural productivity growth. Thus, it would be important in the future research to include climate change factors such as temperatures and precipitations to the analysis. The paper also does not use micro-simulations to assess the microeconomic impacts of an agricultural productivity growth. Future research might consider simulations across all the six subsectors of the agricultural sector (food crops, cash crops, livestock and hunting, forestry and fishery) in the eight WAEMU countries to pinpoint major effects of a general agricultural productivity growth on regional economic performance.

Declaration of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sciaf.2019.e00222.

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