Agricultural Productivity and Poverty Alleviation: What Role for Technological Innovation

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Abstract: *The role of agriculture in economic development remains much debated. This paper takes an empirical perspective and focuses on the relationships between agriculture productivity and poverty reduction. The contribution of agriculture sector to poverty is shown to depend on its own growth performance, its indirect impact on growth in other sectors, the extent to which poor people participate in the sector, and the size of the sector in the overall economy. Bringing together these different effects and taking into consideration the role played by technological innovation, we use an aggregate annual panel data, on a sample composed of 32Sub-SaharanAfrica (SSA) countries, from 1990-2011 to estimate a simultaneous equation model that capture the interrelationship between agriculture productivity, technological innovation and poverty. Findings show first that agricultural productivity contributes significantly to economic growth and poverty in SSA. Second, technological innovation appears to have a positive and significant impact on poverty through its direct and indirect impact*

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Around the world, agriculture is and will continue to be a major building block in the achievement of the Millennium Development Goals (MDGs). Recent statistics show that agricultural production needs to increase by 70 percent by 2050 in order to feed the world (World Bank, 2007). However, hunger and malnutrition persist in many countries, often because of slowly agricultural productivity (AP)[i]. The expected increases in agricultural demand, associated with population growth hand increase per capita incomes, will require continued increase in agricultural growth. History shows that different rates of poverty reduction over the past 40 years have been closely related to differences in agricultural performance particularly the rate of growth of agricultural growth. In simple terms, this means that these are the countries that have managed to increase their agricultural productivity that have managed to reduce their poverty rates (Abare, 2001). According to that, agriculture remains the economic heart of most developing and developed countries.

The productive potential of agriculture is varied and depends on the natural resource endowment, geographical location, links with the rest of the economy and social dimensions of the population. Some authors expected that, success strategies from pro-poor growth in agriculture passed through improved agricultural productivity and technological innovation (Bravo-Ortega and Lederman, 2005). These efforts should focus on the improving conditions for greater access to technological innovation because it is pointed that technological change in agriculture is essential for reducing poverty, fostering development, and stimulating economic growth especially in developing countries. Thereby, the agricultural development model, in many developing countries, is based primarily on technical aspects. The objective of this model is not only physically increase the productivity of agricultural land, but also to increase participation of small and medium farmers in the production. In this context, it tries to provide farmers' technological package "designed as the main instrument to increase agricultural production and to reduce poverty.

Further, if empirical efforts showing the relationships among agricultural growth and economic growth have grown considerably over the last few years, this paper differs and focuses on agricultural sector development and poverty reduction. More specifically, the objectives of this paper are to identify the various channels through which agricultural productivity influence poverty reduction and to investigate the role played by technological innovation in determining agricultural performance. The paper utilizes aggregate annual panel data, on a sample composed of 32Sub-SaharanAfrica (SSA) countries, from 1990-2011 to estimate a simultaneous equation model that capture the interrelationship between agriculture productivity, technological innovation and poverty. In section 2, we present an overview of the literature on the relation connecting agriculture productivity and poverty. Section three discusses empirical model and describes the variables. Model appraisal and validation are handled in section four. The paper concludes in section five.

Literature Review

In recent years, agriculture became an important part of the livelihoods of many poor people, and it is frequently argued that agricultural productivity is a fundamental pre-requisite for poverty reduction (Byerle et al., (2005) Johnston and Mellor (1961)) account explicitly for agriculture as an active sector in the economy. In addition to labor and food supply, agriculture plays an active role in economic growth through important production and consumption linkages (DFID, 2005). On the consumption side, a higher productivity in agriculture can increase the income of the population, thereby creating demand for domestically produced industrial output. Such linkage effects can increase employment opportunities, thereby indirectly generating an increase of income. Moreover, agricultural goods can be exported to earn foreign exchange in order to import capital goods. Agriculture contributes to both income growth and poverty reduction in both developed and developing countries by generating employment and providing food at reasonable prices. It provides food, income and jobs and hence can be an engine of growth in agriculture-based countries and an effective tool to reduce poverty. It can thus facilitate development by allowing a sustained transfer of resources from agriculture to the rest of the economy, including through the supply of capital to other sectors.

The most direct contribution of agricultural growth is through generating higher incomes for farmers. Two conditions affect the influence of this on poverty. First, there is the degree to which the poor are engaged in farming. The second condition is the extent to which output growth raises incomes. In particular, if land is scarce, increased returns to agriculture may be reflected in higher land rents. In cases where the poor till land belonging to others, the capitalization of benefits into higher rents could seriously undermine the contribution to poverty reduction.

Economic literature offers four transmission mechanisms critically link changes in agricultural performance, more especially productivity increases, to progress in reducing poverty: the direct and relatively immediate impact of improved agricultural performance on incomes; impact of cheaper food for poor; agriculture's contribution to growth and the generation of economic opportunity in the non-farm sector; and agriculture's fundamental role in stimulating and sustaining economic transition, as countries shift away from being primarily agricultural towards a broader base of manufacturing and services (Allen, 1994).

Empirical studies support the view that agricultural growth promotes poverty reduction (see the review by Thirtle et al., 2001; Hanmer and Nashchold, 2000; Irz et al, 2001; Kanwar, 2000; Matsuyama, 1992; Ravallion and Datt, 1999; Stern, 1996; Timmer, 2003; Wichmann, 1997). For example, Matsuyama (1992) shows that improving agricultural productivity has probably been the single most important factor in determining the speed and extent of poverty reduction during the past 40 years. Much of this evidence is derived from the Green Revolution in Asia. Examples from Africa are noticeably fewer. In the same context, Warr (2001) provided evidence that growth in agriculture in a number of South East Asian countries significantly reduced poverty, but this was not matched by growth in manufacturing. Gallup et al. (1997) showed that every 1% growth in per capita agricultural Gross Domestic Product (GDP) led to 1.61% growth in the incomes of the poorest 20% of the population much greater than the impact of similar increases in the manufacturing or service sectors. This result is confirmed by Stern (1996) which found a similar and significant relationship between growth in the agricultural and non-agricultural sectors during 1965–1980 for a large number of developing countries.

In terms of the role of agricultural growth in reducing poverty, Thirtle et al. (2001) concluded from cross-country regression analysis that, on average, every 1% increase in labor productivity in agriculture reduced the number of people living on less than a dollar a day by between 0.6 and 1.2%. In the same vein of studies, De Janvry and Sadoulet (2000) estimate that in Asia, a 10% increase in total factor productivity in agriculture would raise the incomes of small-scale farmers by 5%. At the same, Hazell and Haddad (2001) estimated that a 1% addition to the agricultural growth rate in India stimulated a 0.5% addition to the growth rate of industrial output, and a 0.7% addition to the growth rate of national income.

Numerous other studies reveal similar results, but emphasize the important qualification that the degree to which agricultural growth reduces poverty is usually conditional upon the initial distribution of assets (in particular land) and the initial level of inequality (Bourgignon and Morrison, 1998; Timmer, 2003; De Janvry and Saddoulet, 2000; Andersson-Djurfeldt, 2013). Lipton and Longhurst (1989) and Hazell and Ramasamy (1991) provide similar evidence.

Finally, economic literature offers three major opportunities that can transform the agriculture of a country into a force for economic growth and thereby can reduce poverty: advances in science and technology; the creation of regional markets; and the emergence of a new crop of entrepreneurial leaders dedicated to the continent's economic improvement. The following paragraph focuses on the role of technological innovation in determining the relationships between agriculture productivity and poverty reduction.

Technological Innovation and Agricultural Performance

Having reviewed the role that agriculture can play in economic growth and poverty, we now look at the role that can play technological innovation in agriculture productivity and by consequence, in reducing poverty. Agricultural science, technology, and innovation are vital to promoting development and poverty reduction (Binswanger and Townsend, 2000). To this end, many studies on agricultural research, extension, and education have highlighted the importance of technological innovation and policies in these areas (De Janvry and Sadoulet, 2000). Thereby, technological innovation can benefit the poor in many different ways: First, it can help poverty alleviation directly by raising the incomes of poor farmers who adopt the resulting technological innovation. Second, technological change can help reduce poverty indirectly through the effects which adoption, by both poor and non-poor farmers, can have on the real income of others largely through lower food prices for consumers and increased employment and wage effects in agriculture and other sectors of economic activity through production, consumption, and savings linkages with agriculture.

Technological innovation is considered now as an integral part of the reform package needed to stimulate agricultural growth and poverty (Lopez and Valdez, 2000). More than by just spurring economic growth, technology can do much to reduce poverty and environmental damage. It can increase the supply of food and reduce morbidity and mortality, particularly in developing country. It can also increase the supply of water and, it can lower the costs and increase the supply of energy to the poor. The reason for the choice of technologies innovations, as a determinant factor of agricultural productivity is linked to the fact that growth and performance in agriculture and food sectors is central to any strategy of reducing poverty and increasing economic growth and poverty (Datt and Ravallion, 1998).

In this context, Warr (2001) used a computable general equilibrium (CGE) model, loosely styled on the case of the Philippines, to show how, in a small open economy, technical improvements in farming are likely to benefit labour, especially if the technical change is labour-using or land-saving. However, Hazell and Haddad, (2001) show that when output increase is due to technical innovation, benefits to the poor who farm, and for whom farming provides the majority of their income, may be limited for several reasons: adoption by the poor can be limited by a lack of access to inputs and to the knowledge necessary to use the technology. When technology and policies are biased against smallholders, agricultural growth can even have perverse effects on poverty (Datt and Ravallion, 1998).

In SSA countries, national and international agricultural research investments have generated a range of improved technologies, especially of modern varieties of the major food crops. A number of Consultative Group on International Agricultural Research (CGIAR) centers, have partnered with national programs and led major technology development efforts aimed at raising the yields of major food crops or averting yield losses that threatened the livelihoods of millions of Africans (Bravo-Ortega and Lederman, 2005).

Finally, access to technological innovation is essential if we are to make agriculture the main driver of pro-poor growth. It can make agriculture more responsive, dynamic, and competitive. Households and businesses are highly dependent on both access to technological innovation for their agricultural production and labor to produce surpluses (Wichmann, 1997).

Empirical Model Specification, Sample and Variables Descriptions

Model Specification and Descriptions of Variables

Recall that the principal objective of this study is to estimate the role of agricultural growth in reducing poverty rates. The key feature of this study centre's on the way in which agricultural growth affects poverty directly and indirectly via economic growth taking into account the role that can play technological innovation in this relationship, which has been largely ignored by the previous estimates. To accomplish this, we specify a simultaneous equations model that consists of a series of three equations describing the behavior of poverty and economic growth facing a change in agricultural growth in the presence of an improvement in technological innovation. In particular, the model consists of a poverty equation, growth equation and agriculture productivity equation.

The first endogenous variable in the model is poverty, which is measured as the household final consumption expenditure per capita to GDP over the period 1990-2011. We introduce in the poverty equation a set of control variables that are commonly used as factoring explaining poverty. We introduce the income inequality to capture the kind of distribution of income, GDP per capita growth to capture the economic development, the number of telephone mainlines per 1000 people as indicator to measure the quality of infrastructure and population growth.

The second endogenous variable in the model is agricultural. We explain this variable by a set of variables that determine agricultural growth: Agricultural irrigated land (% of total agricultural land), employees in agriculture (% of employment) and an indicator measuring the level of technological innovation measured by agricultural machinery (tractors per 100 sq km of arable land).

The third endogenous variable in the model is economic growth, which is measured as the average of growth rate of real Gross Domestic Product (GDP) per capita over the same period. The growth equation specification follows the commonly accepted form in the cross-country growth literature (Barro, 1991), and includes a group of economic variables that have been identified by empirical growth literature as robust determinants of economic growth, (Levine and Renelt, 1992). In addition to technological innovation, the growth equation includes other variables. The first variable is the average years of secondary schooling in the total population to capture the level of human capital, it is expected to have a positive impact on economic growth. The equation also include rate of inflation (it is introduced in to the model to capture the impact of macroeconomic stabilization on poverty), trade openness to capture the degree of international openness on economic growth.

The complete model used in this paper to estimate the impact of agricultural growth on poverty is based on the model of Alen and Coulibaly (2009) and it has the following formula:

$$POV_{it} = \delta_0 + \delta_{1it} AG_{it} + \delta_2 GDPG_{it} + \delta_3 TI_{it} + \delta_4 INQ_{it} + \delta_5 POP_{it} + \delta_6 TEL_{it} + \xi_{1it} \quad (1)$$

$$GDPG_{it} = \gamma_0 + \gamma_1 AG_{it} + \gamma_2 TI_{it} + \gamma_3 INF_{it} + \gamma_4 TRADE_{it} + \gamma_5 SCH_{it} + \gamma_6 FD_{it} + \xi_{2it} \quad (2)$$

$$AG_{it} = \alpha_0 + \alpha_{1it} GDPG_{it} + \alpha_2 TI_{it} + \alpha_3 AIL_{it} + \alpha_4 EA_{it} + \xi_{3it} \quad (3)$$

Where:

POV: design poverty index which is measured by the household final consumption expenditure to GDP as a proxy of poverty (Odhiambo, 2009, 2010).

AP: the agricultural productivity measured by agriculture, value added (% of GDP).

TI: represent the technological innovation indicator measured by agricultural machinery (tractors per 100 sq km of arable land).

GDPG: the growth of GDP per capita.

INQ: represent the income inequality measured by Theil Index[ii].

POP: represent the growth population. It is expected to have a negative effect on poverty reduction.

TRADE: defined as the sum of exports and imports as a share of GDP. It is introduced into the model to capture the degree of international openness. In this context, Matsuyama (1992) suggests that the relation between agricultural growth and overall poverty depends on the openness of a country to international trade and that agricultural growth goes hand in hand with the with the increase in household income.

FD: is an indicator of financial development measured by domestic credit to private sector to GDP.

INF**:** The rate of inflation, it is introduced into the model to capture the impact of macroeconomic stabilization on poverty. Inflation is afact or worsening poverty because it has a negative impact on the real value of assets and the purchasing power of household incomes. It is measured by inflation consumer prices available in World Bank.

AIL: Agricultural irrigated land. It is expected to have a positive effect on agricultural growth.

EA: is employee's agriculture.

SCH: is the log of the average years of secondary schooling in the total population which measures human capital.

TEL: is an indicator measuring the level of infrastructure. It is measured by the average of the number of telephone mainlines per 1000 people.

How can Agricultural Growth Affect Poverty Reduction?

Poverty equation shows that a change in AP by one unit causes poverty to change by an amount equal to δ_1. Furthermore, poverty equation shows that a change in economic growth index by one unit causes poverty to change by an amount equal to δ_2. However, agricultural growth equation shows that a change in AP by one unit can also induce a change in the economic growth index by an amount equal to γ_1 which means that the effect of change in AP by one unit is not limited to its direct influence on poverty, but also includes the indirect impact via economic growth channel. Thus, the total impact of AP on poverty equals the sum of direct impact and indirect impact.

This effect can be calculated by finding the derivative of growth with respect to AP, which is equal to:

$$\frac{\partial Poverty}{\partial AP} = \delta_1 + \delta_2 \frac{\partial Growth}{\partial AP} = \delta_1 + \delta_2 * \gamma_1 \tag{4}$$

By the same, the total effect of technological innovation on poverty can be calculated by finding the derivative of poverty with respect to technological innovation, which is equal to:

$$\frac{\partial Poverty}{\partial TI} = \delta_3 + \left(\delta_2 \frac{\partial Growth}{\partial TI} \right) + \left(\delta_3 + \delta_1 \frac{\partial AP}{\partial TI} \right) = \delta_3 + \delta_1 * \gamma_2 + \delta_3 + \delta_1 * \alpha_2 \tag{5}$$

Estimating the above complete system of equations and finding $\gamma_1, \gamma_2, \delta_1, \delta_2$, δ_3 and α_2 allows us to test whether and how agricultural growth and technological innovation affects poverty reduction.

Sample and Data Sources

Annual time series data, which covers the period 1990-2011, is utilized in this study. The data used in the study are obtained from the web site of the World Bank. The sample size and the period of our study are limited by the availability of data.

Our sample is conducted for 32 countries in Sub-Saharan Africa in which the agricultural sector contributes at least 10 percent of the gross domestic product (GDP) and where the majority of the poor depends upon agriculture for their livelihood. Although the choice of countries[iii] is governed by the availability of data, the included countries broadly cover the whole of SSA.

Estimation Method

In a simultaneous equation model, like the one developed in the previous section, a dependent variable in one equation can be an explanatory variable in other equations in the model. For example, in equation (3), AP is the dependent variable, which is determined by economic growth and other variables, but at the same time AP enters the growth equation (2), as an explanatory variable. As a result, some of the explanatory variables in simultaneous equation models are endogenous and, therefore, are correlated with the disturbance terms in all the structural equations of the model. As a consequence, using Ordinary Least Square, OLS, to estimate the structural equations will result in inconsistent estimates for the model parameters. A consistent estimation for the model parameters requires using an estimation method that can deal with the endogeneity problem.

But before considering the method of the estimation, the identifiability of the model has to be checked because estimation methods that can be used in the context of simultaneous equation models are functions of identification criteria for estimating the model and the endogeneity problem. In our case, the model presented is over identified. On the other hand, our model is characterized by the presence of an endogeneity problem of order two, by definition, why the estimate by the method of least squares would be triple registered (For details on the method used, it is recommended to refer to the work of Bourbonnais, 2002). This estimation method is based on the principle of application of the method of least squares in three stages.

The Agriculture Sector in Sub-Saharan Africa

Although SSA countries are heterogeneous population, today remains predominantly rural (65%), assets are primarily in agriculture (60%) and rural agricultural households (95%) even though they are most often pluriactive. The rest of the working population is engaged in non-agricultural informal activities (25-30%), mainly urban, and in the formal sector industries and services (5 to10% maximum). Agricultural sector constitute the main economic mainstay of the region, and will remain so for the next fifteen years. This durable weight of agriculture is due to several factors: the lack of effective industrialization despite rapid urbanization, low prospects of development of other sectors in a highly competitive international context, a generalized pressure on labor markets makes it difficult to immigrate to developed countries.

In this regard, the situation in SSA is particularly: if its demographic transition is committed and marked by a high mobility of the population (with urbanization rate which reach 40%, the urban population was multiplied by 12 since 1960), its economic structure has changed little: low diversification; a significant weight of agricultural activities in GDP, foreign trade and especially employment. Urbanization has developed without industrialization, unlike other parts of the world.

Hence, if the potential of agriculture in sub-Saharan Africa is the engine of global growth for the majority of countries in the region and is essential for poverty reduction and food security, unexploited potential of this can significantly compromised the role that agriculture can play in reducing poverty (World Bank, 2007).

Results and Interpretations

Recall that the main aim of this paper is to test whether AP can affect poverty by positively influencing economic growth, and to evaluate the significance of any such effect taking into consideration the role of technological innovation. Thus, the parameters of interest in Table 1are: (1) The coefficient that describes the effect of AP on poverty, δ_1. (2) The coefficient that describes the effect of economic growth on poverty, δ_2. (3) The coefficient that describes the effect of AP on economic growthγ_1 and (4) the coefficients that describes the effect of Technological innovation respectively on poverty, economic growth and agricultural growth δ_3 , γ_2, and α_2.

Table 1. Simultaneous equation estimation of poverty, growth and agricultural productivity (3SLS)

Variables	Poverty	GDP Growth	Agr. Growth
AP	0.098	0.904	--
	(2.62)**	(2.56)**	--
GDPG	0.252	--	0.019
	(2.25)**	--	(5.63)***
TI	0.316	0.025	-0.507
	(4.19)**	(3.77)**	(-2.15)**
INQ	0,213	--	--
	(1,94)**	--	--
POP	0.608	--	--
	(0.88)	--	--
TEL	0.321	--	--
	(1.77)*	--	--
INF	--	-0.03	--
	--	(-0.52)	--
TRADE	--	0.307	--
	--	(2.69)**	--

SCH	--	0.022	--
	--	(2.45)**	--
FD	--	0.016	--
	-	(4.89)***	--
AIL	--	--	0.451
	--	--	(2.04)**
EA	--	--	0.73
	--	--	(1.75)*
constante	0.213	-0.041	0.022
	(5.24)**	(-2.48)**	(2.76)**
Observations	704	704	704
R^2	0,431	0,383	0,294

*Notes: * significant at 10% ** Significant at 5%; *** Significant at 1%.*

Table 1 report the estimation results of the simultaneous equation model using the 3SLS method for the period 1990-2011:

The first column presents the estimation results of the poverty equation. In this equation, all the explanatory variables have the expected sign and are statistically significant, expect population growth which has the right sign but is not significant. The results demonstrate that per capita income growth has a significant poverty-reducing effect where a 1% increase in per capita incomes reduces poverty by 0.25%. In particular, the equation shows that the coefficient of agricultural growth, which most interests us in this estimate, it appears to be significantly positive showing the positive effects that can play agriculture on the processes of poverty reduction. A 1% change in agricultural productivity raises household final consumption expenditure by about 0.09%, confirming the important role of agriculture sector in SSA in reducing poverty rate. This result is consistent with many empirical studies on SSA (Tiffen, 2003; Diao et al. 2005, 2007 and Arega and Ousmane, 2009) that shows a significant role played by agriculture in SSA accelerating economic growth and, by consequently, reducing the poverty rate. Concerning the effect of inequality on the incidence of poverty, results shows that the coefficient of inequality measured by the Theil index is significantly negative, confirming its robustness. As an increase of this index by 1 percentage point leads to a decrease in household consumption expenditure by 0.21 point, which aggravates the poverty rate. This result seems to reinforce those obtained by various studies on the relationship between increasing inequality and poverty (Arega and Ousmane, 2009). This suggests that the most effective method to reduce the poverty rate is certainly reducing inequalities by means of a better redistribution of wealth.

As regards the impact of technological innovation on poverty rate, the equation shows that the variable has positive and statistically significant direct impacts on poverty. An increase of technological innovation by 1% leads to decrease in poverty rate by 0.31 %. Finally, infrastructural quality, as captured by telephone line per 1000 people, play significant role in poverty alleviation. This result is consistent with the study of Parker et al., (2008) which showed that people must access to infrastructure services, such as mains water, safe sanitation, mains power supplies, maintained roads and telephones. This allows us to say that it is necessary to invest considerably in infrastructure because, as account given the low population density in SSA countries, the infrastructure that connects farmers to markets is costly and investment in road infrastructures, institutions and the public sector are essential.

The second column in Table 1 presents the estimation results of the economic growth equation. We notice that all the explanatory variables have the expected sign and are statistically significant. Moreover, the results show that technological innovation, as captured by the agricultural machinery, tractors per 100 sq. km of arable land, play a significant role in determining economic growth and thereby in reducing poverty. The coefficient on agricultural growth is positive and statistically significant as expected. A 1% change in agricultural productivity raises GDP per capita by about 0.9%, confirming the heavy reliance of SSA economies on agricultural productivity. In this context, the World Development Report 2008 (World Bank, 2007) notes that GDP growth originating in agriculture is about four times more effective in raising incomes of extremely poor people than GDP growth originating outside the sector. The results show also that a higher level of human capital is associated with a faster economic growth rate.

The third column in Table 1 shows the estimation result of the Agricultural Growth equation. As expected, the results indicate that AP is affected positively and significantly by economic growth. A 1 % change in per capita income growth raises agriculture productivity by about 0.02. As regards, agricultural machinery has a significant impact on agriculture productivity. Employee’s agriculture plays a significant role in agriculture performance. Consistent with the fact that labor is a critical constraint in Sub-Saharan African agriculture, it has the largest productivity elasticity of 0.73, implying that a 1% change in employee’s agriculture raises agriculture productivity by about 0.73%. The results show that agricultural irrigated land has a positive and significant impact on agriculture growth and consequently on poverty eradication. Probably due to the dominance of rain fed, rather than irrigated, agriculture in SSA, irrigation has turned out to have insignificant effect on agricultural productivity.

Determining the Total Effects of Agriculture and Technological Innovation on Poverty Alleviation

Table 2 and 3 summarizes the results regarding the impact of AP and technological innovation on poverty: As reported in the Table 2, the results show the direct impact of AP on economic growth where an increase in AP by one point leads to a decrease in poverty by 0.098 point. Concerning the indirect impact of AP on poverty, it can be computed by the product of the coefficient of economic growth in the poverty equation and the coefficient of AP in the growth equation ($\delta_2 * \gamma_1 = 0.015$). Thus, the combined effects suggest that the total impact of AP on poverty is equal to the sum of the direct and indirect effect which is equal to 0.325 which indicates that an increase in AP by one point leads to decrease in the rate of poverty by 0.325 point.

Table 3 shows that, the elasticity presented, represent the percentage change in poverty associated with a 1% change in technological innovation. The elasticity of poverty with respect to technological innovation is 0.18, implying that a 1% increase in technological innovation decreases poverty by 0.18%. Moreover, an improved of technological innovation by one point leads a decrease in poverty rate by 0.184 point divided between a direct effect of 0.116 point and a indirect effect via stimulating agriculture performance and economic growth by 0.068 point.

Table 2. The impact of agriculture on poverty

	the direct impact of agriculture on poverty	the indirect impact of agriculture on poverty	The total impact on poverty
The coefficient	δ_1	$(\delta_2 * \gamma_1)$	$\delta_1 + (\delta_2 * \gamma_1)$
The estimated coefficient	0.098	0.252*0.904=0.227	0.325

Table 3. The impact of technological innovation on poverty

	the direct impact of technological innovation on poverty	the indirect impact of technological innovation on poverty		The total impact on poverty
		via economic growth	via agriculture	
The coefficient	δ_3	$\delta_1 * \gamma_2$	$\delta_3 + \delta_1 * \alpha_2$	$\delta_3 + \delta_1 * \gamma_2$
The estimated coefficient	0.116	0.002	0.066	0.184
		0.068		

Overall, the results presented above make it very clear that AP has a significant impact on poverty beyond its direct and indirect impact; an impact that works via improving the economic growth. The results also show that the indirect impact is of considerable volume and is comparable to the direct or traditional impact. More importantly, the results indicate that the indirect impact of AP on poverty is far greater than, or more than the double that of the direct impact of AP on poverty. By the same, the results presented shows that technological innovations play an important role in determining the relationships between agricultural performance and poverty and that through its direct and indirect impact via economic growth and agriculture productivity.

Finally, we notice that the empirical results presented above are based on a sample of 32 countries, which is quite small number. The reason for using this small sample is the lack of data for some variables of some countries. As a consequence, the results might be sensitive to the sample choice. Moreover, the results might be sensitive to model specification and the choice of the controlling variables. Thus, in following research, the robustness of the results can be tested: by using a larger country sample, and second, by controlling for more poverty determinants.

Conclusion

This paper set out to tackle two very specific research questions concerning (1) the importance and magnitude of agricultural productivity on poverty alleviation (2) the relationship between technological innovation, agriculture productivity and poverty. Using an aggregate annual panel data, on a sample composed of 32 Sub-Saharan Africa countries, from 1990-2011 to estimate a simultaneous equation model that capture the interrelationship between agriculture productivity, technological innovation and poverty, our findings indicate that agricultural growth contributes significantly to poverty alleviation in SSA. The results suggest that agricultural growth would lead to a 32% decrease in poverty: this effect is divided on a direct impact of 0.98% and an indirect impact via economic growth equal to 0.22%.

As regards the effects of technological innovation on poverty, results demonstrate that 1 % change in technological innovation leads to a decrease in poverty rate by 0.18 %. This implies that SSA countries accelerating growth agriculture is fundamental to reduce poverty and allow countries to achieve economic transformation. This passes through the ability of agriculture to generate employment, to stimulate the economy through linkages, and to reduce the real cost of food accounts. It also requires that the Government must intervene to invest in new technology in order to allow farmers to benefit from the fruits of technological innovation and that, by improving agricultural productivity and consequently reducing the poverty rate.

Hence, the positive prospects for SSA agriculture will not take shape without a concerted and determined political action, especially if agricultural growth must be sustainable and result in a significant reduction in poverty. Many problems must be overcome, including the growing technological gap, the slow development of markets for inputs and outputs and services associated markets, the slow progress of regional integration, lack of governance and institutional weakness in some countries, conflict, HIV-AIDS and other diseases. Linking small farmers to markets and help them adapt to new conditions and become more productive, increase rural employment opportunities, reduce risk and vulnerability, especially climate extremes and fluctuations prices and improve access to resources and skills will be among the measures to be taken to ensure that agricultural and rural growth goes hand in hand with poverty reduction.

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[i]Agricultural productivity is defined as agricultural value added per hectare of agricultural land where: (i) value added in agriculture measures the output of the agricultural sector less the value of intermediate inputs; (ii) agriculture comprises

value added from forestry, hunting, and fishing as well as cultivation of crops and livestock; and (iii) agricultural land is measured as the sum of arable land, permanent cropland, and permanent pasture (World Bank, 2007).

[ii]This indicator is calculated by the University of Texas. It is available on the http://utip.gov.utexas.edu site.

[iii]The list of countries are : Benin, Botswana, Burkina Faso, Burundi, Central African Republic, Cote d'Ivoire, Djibouti, Ethiopie, Gambie, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, South Africa, Swaziland, Tanzanie, Togo, Uganda, Zambie and Zimbabwe.