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Research Article

Are Fertilizer Subsidies Costs Offset By Increasing Food Production? The Case of Mali

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Abstract

The global food and nutrition crisis 2007/2008 has resulted a price spike of staples, which caused hunger riots in several African countries, placing again, the food and nutrition security issue at the heart of concerned sates. This papers focuses on the evolution of the parameters of agricultural production in Mali between two periods, (2000-2007) without the fertilizer subsidies and (2008-2015) with the fertilizer subsidies. Then, it analyzes the potential effects of the contribution of fertilizer subsidy to agricultural production in order to prevent food crisis.

The finding showed that the current mechanism of fertilizer subsidy is not yet favorable to the revival of the production of food grains, millet, sorghum, maize and rice, but rather, to that of an industrial crop, including cotton. However, the need to revive the production of cereals remains a priority in order to, protect the country from the adverse effects of food and nutrition crises in the future, which have justified the establishment of these fertilizer subsidies.

Introduction

The global food and nutrition crisis 2007/2008 has resulted a price spike of staples, which caused hunger riots in several African countries[1], placing again, the food and nutrition security issue at the heart of concerned sates. To prevent the human suffering effects of such crises in the future, countries have experienced or adopted different agricultural policies in support consumers prices and production. But most countries opted for supporting agriculture and food production rather than investing in price support for edible grains.

Mali, like many African countries[2], has implemented various policies including[3], fertilizer subsidy to reduce input cost to increase significantly grain production which is also the staple diet of the population. Through these interventions, the Government hopes to increase agricultural production to solve food security issues by increasing cereals supply[4] (millet, sorghum, maize, wheat, rice, etc.). This cost reduction will deflect the upward trends in the price of cereals and limit social, economic and political risk that could arise in urban centers.

However, ten years after the implementation of this policy of fertilizer subsidy, its effectiveness on the increasing of productivity and agricultural production is increasingly questioned by the stakeholders, including producers. Similarly, policy makers and donors ask themselves the following questions:

- What results were obtained through the interventions carried out on agricultural production? (Including the fertilizer and seed subsidy)?
- What have been the benefits to producers and consumers?
- Should we continue these interventions (granting of subsidies) and how to incentivize grain production?

This is in order to elevate the beneficial results consideration above to the enlightenment of all stakeholders on the performance of states' interventions. This article has been produced to replace opinions with an analysis of fact to help implement better decisions. It focuses on the case of Mali, which, since the global food and nutrition crisis 2007/2008, every year provides subsidies to farmers (agricultural inputs, including fertilizers, seeds and pesticides).

In a specific way, the article aims to answer the following questions:

- Do fertilizer subsidies help to improve the productivity of cereal production?
- Do we get more when we spend more?
- What are the actual increases in production and productivity attributable to fertilizer subsidies?
- What are the lessons to be learned from these interventions?
- What are the areas for improvement in the efficiency of the system?
- Would alternative investments yield more production per FCFA?

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1. Riots took place in Senegal, Burkina Faso, Cameroon, etc.

2 Senegal has established the "Great Agricultural Offensive for Food and Abundance (GOANA).

3 Fertilizer subsidies began with rice initiative in 2008. Under this grant, the Government committed to subsidize up to 50% the price of fertilizer and improved seeds whose prices fixed at 12,500 CFA francs per 50 kg bag.

4 Volume of goods or services offered for sale in a market.

To answer these questions, the following methodology was used.

Methodology

We reviewed the scientific literature for the formulation of an econometric model to capture the effects of the subsidies, the collection of data on the overall supply[5] of agricultural production (millet, sorghum, maize, rice and cotton) and on the selling prices of these products to consumers.

In a theoretical way, the study uses the concept of the supply function which connects the quantity of good offered in a market at its selling price. In addition to this price, the quantity supplied also depends on several other factors, including the prices of factors of production and other goods used in that production. We assume that the quantities produced also depend on the amount of the subsidy.

Indeed, subsidies in economic regulation have been highlighted by several authors 5;6;2.The Subsidy is considered as a negative tax, a sum of money transferred from the government to producers or consumers which depends of the quantity of products sold or purchased. The granting of a subsidy is equivalent to a decrease in production cost up to the amount of the subsidy. The drop in production cost increases the production capacity of producers. It follows then that an increase in production is accompanied by a decline in the purchase price to consumers. Price reduction stimulates the demand and lower cost increases the supply of these products. In this regard, although the subsidy is paid to producers, consumers are also beneficiaries.

According to these theoretical considerations, two assumptions emerge:

1. The first assumption connects the quantities produced at the market prices through the supply and demand law. In other words, when the price increases the producers are more inclined to increase production. In contrast, a decline in prices discourages producers which leads to a decrease in the quantities produced;
2. The second assumption connects production to the amount of the subsidy. The quantities produced increase with high amounts of subsidy, whereas they decrease with relatively small amounts of subsidy.

We will use these two assumptions to formulate the relationship between volume of the agricultural production and the selling prices of products on the one hand and with the amounts of subsidies on the other hand. To this effect, an econometric model[6] for supply of agricultural products has been used as a function of the selling price of agricultural products and of the amounts of subsidies of fertilizer 4;3.

Thus, for each of the targeted products, an econometric model was formulated to analyze the variation in output depending on the variation of the selling prices and the amount of the fertilizer subsidies.

The specification of the model is presented as follows:

$$[O^{i,t} = f(P^{i,t}, S^{i,t})]$$

Where:

$O^{i,t}$=the quantity of product I in year t .

F =the function linking the production to the selling price and the amount of fertilizer subsidy.

$P^{i,t}$=the average selling price of product I in year t.

$S^{i,t}$=the grant allocated to the product I in year t.

With regard to the functional form of the econometric model, we have opted for a Logarithmic Function (taking the logarithm of the variables in the model) due to its advantages, not only to significantly reduce the size of numbers, but also and especially for the ease that it offers for the interpretation of the results. It is as follows:

$$[\log O^{i,t} = \alpha \log P^{i,t} + \beta \log S^{i,t} + \gamma]$$

Where:

α= the price's elasticity of the supply.

β = the subsidy's elasticity of the supply.

γ= the constant of the model.

The coefficients of the logarithmic model represent the elasticities of supply of agricultural production[7]. The price's elasticity of the supply is defined as the ability of the production to increase or decrease in volume compared to the variation of the selling price. In the same way, the subsidy's elasticity of the supply is the ability of production to increase or decrease in volume compared to the variation of the amount of the subsidies.

The model thus formulated allows capture of the effects of the selling prices of agricultural products and of the amounts of subsidy of fertilizers on agricultural production. To estimate and to test the coefficients of the model, the collection of data on the agricultural production, the amounts of the grants and the selling prices of the products on the periods without the subsidy (2000-2007) and with the subsidy (2008-2015) was necessary.

To this effect, the collection of data on agricultural production and the amounts of grants have been made from the Web site (http//www.countrystat.org), of documents of the plans of the agricultural campaign of 2012-2013 to 2016-17 and of the collection of the statistics of the agricultural sector of the department of Cell of Planning and Statistics of Ministries in charge of Agriculture and Livestock.

The amounts of the grants are annually distributed between the Malian Company for the Development of Textiles (CMDT), the Offices of irrigation and the Regional Directorates of Agriculture (DRA) following the main systems of agricultural production in force, cotton, rice and dry cereals.

With regard to the series of the sale price of agricultural products, they have been provided by the Observatory of Agricultural Markets (OMA) for the period studied from 2000 to 2015.

The analysis of the data has been made using the statistical software "R" that is useful to help compare the average of the production parameters between the periods without and with the subsidy on one hand. And on the other hand, to estimate and test the coefficients of

5 Offer applied at a macro level, it is the aggregation all offers of goods in different markets, irrespective of the nature of the product. Also referred to as aggregate supply.

6 Econometrics is a branch of economics that aims to estimate and tests business models, based on data from observation of the real functioning of the economy or from controlled experiments.(wikipedia.org)

7 In economics, elasticity measures the variation of a quantity caused by the change in another variable (wikipedia.org)

the elasticities of the selling prices of the products and of the amounts of fertilizer subsidy allocated to different crops. The statistical significance of the estimates and of the tests carried out have been given by the "t-Student" and the value of the probability "p-value"[8].

If the value of the "p-value" is greater than the threshold of 5%, then we accept the null hypothesis of elasticity coefficients of the model. In this regard, the model does not allow one to conclude the existence of a relationship between agricultural production and the selling prices of the products and the amounts of fertilizer subsidy.

On the other hand, if the value of the "p-value" is lower than the threshold of 5%, one concludes, the non-Nullity of the coefficients of the model. In this case, the coefficients of the elasticities are significant and the model is considered valid. According to the threshold of significance, one to several marks of "stars" appear on the estimated coefficient. The more stars, the greater significance.

The results of the analysis and estimates made are presented in the sections that follow.

Results

The results are presented in two sections. The first focuses on the evolution of the parameters of production between the periods without and with the grant. The second analyzes the potential effects of the contribution of fertilizer subsidy to agricultural production.

Production parameters before and after the fertilizer subsidy

For each of the agricultural productions targeted and for each of the parameters of production, the averages of the parameters of production before and with the subsidy as well as their difference are presented in the table that follows. The statistical significance of the difference of mean average is given by the "t-value" of the "t-student" and the value of the probability "p-value" (Table 1).

For the millet, the results show that the difference in productionbetween the two periods was significant in view of the fact thatthe value of "p-value" is less than 0.05. This increase has beenaccompanied by a significant increase in yields. This is translated bya gain in productivity during the period of subsidy.

Concerning the sorghum, these are the land areas and the productionwhich have increased rather significantly. However, no improvementof the productivity has been recorded. This indicates that theincrease in the production of the sorghum has been linked to that ofthe land area.

With regard to the maize, all the parameters of production (landarea, production and yield) have experienced a significant increasewith the subsidy. As well, the production has quadrupled and theperformance has increased more than two-thirds (2/3). Accordingly,during the period of distribution of the subsidy of fertilizers, productionand productivity have been increased.

With regard to the rice, it is the land area and the production thathave experienced significant increases, while the yield has stagnated. Moreover, the consumption of fertilizer per hectare has not increasedwith the subsidy of fertilizer because of the fact that the producershad already applied the recommended dosages, particularly the zoneof office of Niger. This shows that the increase in the productionof rice is linked to that of the areas explained in part by thedissemination of Nerica better rice seeds from producers and theincrease in irrigation development.

With regard to cotton, the increases in areas and production recordedare not significant between the two periods without and with thesubsidies. While the productivity of the cotton has stagnated duringthe two periods. This means that the subsidy of fertilizer has nothelped to improve the productivity of cotton, nor even, to furtherincrease the production compared to its level before the period ofdistribution of fertilizer subsidies. The peak of the production ofcotton of 620, 665 metric tons in 2003 has never been reached duringthe period of distribution of grants of fertilizer (Figure 1).

Production	Parameter	Before Subsidies (A)	After Subsidies (B)	Difference (A-B)	t-Student	P-Value
Millet	Area (ha)	1E+06	2E+06	302696	2.14	0.05
	Production (t)	1E+06	2E+06	512510**	4.61	0
	Yield (t/ha)	0.71	0.89	0.18**	3.41	0
Sorghum	Area (ha)	806426	1E+06	422591**	4.04	0
	Production (t)	676946	1E+06	543815***	6	0
	Yield (t/ha)	0.85	1.01	0.16	1.96	0.07
Maize	Area (ha)	319512	643383	323870**	3.93	0
	Production (t)	478374	2E+06	1035425**	6.05	0
	Yield (t/ha)	1.47	2.44	0.96**	4.15	0
Rice	Area (ha)	389067	672069	283003.**	5.09	0
	Production (t)	889337	2E+06	905767**	5.4	0
	Yield (t/ha)	2.28	2.74	0.46	1.69	0.12
Cotton	Area (ha)	412506	454770	42265	-0.61	0.55
	Production (t)	411415	456909	45494	0.61	0.55
	Yield (t/ha)	1	1	0	0.03	0.98

Table 1: Comparison of means of production parameters before and after fertilizer subsidies.

8 This number is used in inferential statistics to conclude whether to accept or reject the result of a statistical test. Statistical inference is to induce the unknown characteristics of a population from a sample from this population.

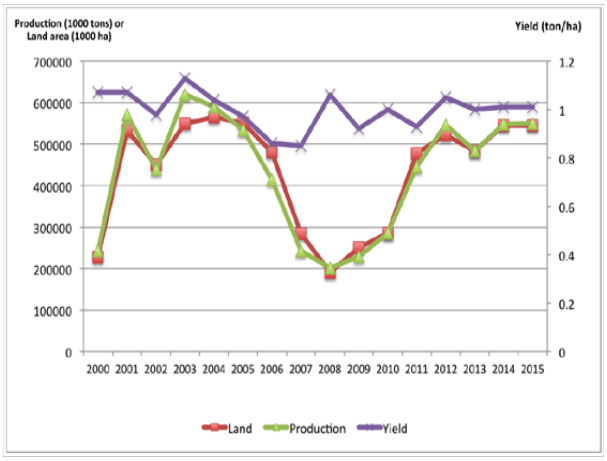

Figure 1: Evolution of Cotton production parameters to 2000 to 2015.

In contrast, the subsidy of fertilizer has permitted the resumption of cotton cultivation by farmers who had started to abandon it in favour of producing grains since the beginning of the decade 2000. In effect, the production of cotton had continued to fall to its lowest level of 201,462 metric tons in 2008. But, the subsidizing of fertilizers has mobilized the producers around this cotton cultivation through the increase of land areas, which has led to the recovery of the sector. In this regard, fertilizer subsidies have been decisive in the survival of the cotton sector in Mali. However, they have not led to significantly improved production or the productivity of the sector compared to its level before the fertilizer subsidy program.

In summarizing the previous analyzes, it is apparent that the productions of cereals such as millet, sorghum, maize, and rice have increased significantly during the period of the distribution of the subsidy, but only the productivity of the millet and maize have undergone improvements, those of sorghum and rice having stagnated. With regard to cotton, no significant improvement has been recorded, both at the level of production and the productivity compared to the period before the distribution of fertilizer subsidies.

However, it remains that the recorded increases cannot be explained only by the distribution of fertilizer subsidies. Other factors including the climate, the equipment, the hydro-agricultural development, varieties and improved seeds, the conformance of the agricultural calendar and educational improvement, etc., have had to contribute. In this regard, the following section has been devoted to the evaluation of the contributory share of fertilizer subsidies in agricultural production.

Fertilizer subsidy impact assessment on agricultural production

The effects of subsidies have been estimated on five (5) models of econometric regressions, production of millet, sorghum, maize, rice and cotton as a function of the selling prices of the products and of the amounts of the subsidies allocated to different crops. For each of the econometric regressions, the coefficients represent the elasticities and those between parentheses indicate the standard errors from the estimates. While the validity of the model is given by the coefficients of determination"R2", adjusted "R2" and the "F Statistic"[9].

The analysis of the results shows that the coefficient of elasticity of the production of cotton in relation to the amount of the fertilizer subsidies has been significant and that an increase of 10% of this amount leads to an increase in the production of cotton of 9.39%.

Consequently, the supply of cotton is highly reactive to a variation in the amounts of fertilizer subsidies. Thanks to the incentives induced by the grants of fertilizer, producers have been able, in the very short term, to mobilize to increase the production of cotton. This demonstrates a positive effect of fertilizer subsidies on the production of cotton and its strong capacity for mobilization of producers around this culture.

In contrast, for cereals (millet, sorghum, maize and rice), the effects of the subsidy of fertilizers are not yet perceptible. Because, no significant statistical relationship could not be established between the production and the amounts of fertilizer subsidies. This demonstrates that the effects of fertilizer subsidies remain low and that they do not significantly increase the production of grain. This low impact is explained in part by the low share of fertilizer subsidies allocated to cereals. This finding was confirmed by the results of the study on the analysis of the effects and impacts of the subsidy of agricultural inputs in Mali. This in turn had raised the problem of the orientation of the maximization of the fertilizer subsidy to the cotton production and not a corresponding benefit to cereals production (Table 2) [1-6].

Conclusion and Perspective

The global food and nutrition crisis 2007/2008 resulted in hungerriots in several African countries.To protect themselves from theeffects of such crises in the future, Mali, like several other Africancountries, has put in place a policy to support agricultural production,in particular,the subsidy of fertilizer cost. But, nearly ten yearsafter the establishment of this policy, its effectiveness is increasinglyquestioned by the producers, the funders and policy makers.

The present article provides elements of response to these questions.To this effect, it uses a comparison test of averages of theproduction parameters (land area, production and yield) andbetween the periods before the subsidy (2000-2007) and with thesubsidy (2008-2015) to analyze the developments on the one handand an econometric model to capture the effects of the increasesrecorded and which are attributable to fertilizer subsidies on theother hand.

It is clear from the analyzes carried out, that the current mechanismof fertilizer subsidy is not yet favorable to the revival of theproduction of food grains, millet, sorghum, maize and rice, butrather, to that of an industrial crop, including cotton. However,theneed to revive the production of cereals remains a priority in orderto, protect the country from the adverse effects of food storage andnutrition a crises in the future, which have justified the establishmentof these fertilizer subsidies.

In this regard, the effects of the subsidy policy of fertilizers onagricultural production are thus mixed due to a striking contrastbetween the expected results and those experienced in the courseof the period studied. These subsidies have not helped to improvethe production and productivity of cereals. On the other hand, theyhave mobilized the producers around the cultivation of cotton bythe increase in cotton crop areas. However the subsidies have notregistered a significant impact on the productivity and productionwhich have instead stagnated relative to their levels of before thefertilizer subsidy.

9 A statistical quantity which provides information on model validity following a fisher distribution with (p, n - p - 1) degrees of freedom. If F calculated > "F1−α(p,n−p−1)" theoretical, where is the risk of the first kind, we reject the null hypothesis of the model coefficients (wikipedia.org).

	Millet (1)	Sorghum (2)	Maize (3)	Rice (4)	Cotton (5)
Amount of cereal subsidies	0.024 (0.113)	-0.177 (0.139)	0.059 (0.268)		
Selling price of millet	0.329 (0.307)				
Selling price of Sorghum		0.146 (0.406)			
Selling price of maize			0.515 (0.969)		
Amount of rice subsidies				0.470 (0.321)	
Selling price of rice				1.561 (1.215)	
Amount of cotton subsidies					0.939*** (0.192)
Selling price of cotton					0.287 (0.352)
Constant	12.536*** (1.477)	13.633*** (1.927)	11.577* (4.648)	5.022 (6.898)	8.742*** (1.879)
N	7	7	7	7	7
R2	0.247	0.294	0.072	0.420	0.876
Adjusted R2	-0.130	-0.059	-0.392	0.130	0.814
Residual Std. Error (df = 4)	0.154	0.191	0.369	0.249	0.153
F Statistic (df = 2; 4)	0.656	0.832	0.155	1.448	14.101**

Table 2: Fertilizer subsidies impact on agricultural production in Mali.

Note: ***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Accordingly, in a perspective of recovery of food production and nutrition, it will be necessary to improve the policy and efficiency ofthe current system of subsidy. This quest for performance requires arevisit the current system of subsidy for fertilizers for the future, toreform it in taking into account the points of weaknesses in order toadapt it to the funding needs of food production in the framework ofprevention of food and nutrition crises. In this perspective, severaloptions, can be explored through:

- The examination of the share of fertilizer subsidies allocated to cereal crops in order to make the necessary corrections to increase significantly the production of grain. Presently, the share of cereals in the current system of fertilizer subsidies remains low. In short "one size fits all" has not worked for its intended results. In the light of the available data, the share of cereals represents less than 50% of the total amount of fertilizer subsidies to food agriculture, during the period studied from 2008 to 2015. This distortion in the allocation of subsidies of fertilizer in part explains its low contribution to productivity and the production of grain;
- The total overhaul of the current system of subsidy in general and fertilizer in particular based on the support to the production through the funding of the factors of production, including the inputs, to the benefit of cost production in the marketing of grain has failed. This option, while stimulating overall agricultural supply by the application of subsidies through ultimate support of the price of production, may supports the many problems of storage, transport, marketing and final sale of produce during the harvest period;
- It is also conceivable that a combined policy of complex support to the production and marketing of cereals could improve the present situation. In this regard, the subsidy of fertilizers could be a part of a combined set of policies used to build the stock of food security with purchases at guaranteed prices. Any surplus of production could be sold on stored for emergencies.This will require the involvement of the Office of the Food Security Commissioner, given that any subsidy of fertilizer combined with other policy components is needed to boost the production, of grain in order to protect the country from the food and nutritional crises in the future.

In conclusion, Governments know that citizens require sufficientfood to eat to maintain health and wellbeing. The Mali fertilizersubsidy program was a useful experiment in this direction and theresults show that the failure of the program to increase cereal grainproduction requires some policy readjustments. Since most policiesrest on a system of rewards, the strategy change may be morecomplicated than simply subsidizing one more product. In fact, theproject made use of better seeds of rice and dry cereals that helpedimprove the production of cereal.

By keeping careful records of production and investment, wecan know exactly which factors seem subject to incentive stimulationand we can make adjustments in policy if the subsidiesare not producing the desired result. Thus a dynamic policy thatcan be changed as we go is better than a fixed policy that is inflexible.

What factors might contribute to an effective agricultural policy?

Here are some for consideration:

1. Find out what is not working and fix it. Poor soils produce poor crops;
2. Invest in subsidies that produce near term good results. Some crops require lots of fertilizer maize and cotton deplete the soil unless soil-building crops are rotated. If insufficient seeds are planted, the harvest will be insufficient;
3. Invest in discovering new technologies that will produce better results, such as better seeds, genetically modified crops, better fertilizers and better methods;
4. Adopt proven improvements to increase the yield benefits of the most desirable crops.

Strategy changes must be closely coupled to changing results. Let'sexamine a policy set that has a fixed overall money cost over aperiod of time and see how the allocation of funds may change asresults become known.

The New Policy of Period 1 invests some money investigating newseeds and new techniques and educating farmers on better methods.

Half the funds are invested in supporting grain prices and 30%invested in fertilizer subsidies.

In Period 2, changes are made. Research discoveries are appliedand educational materials are used to teach farmers new methods. Grain incentives and subsidies are increased and cotton subsidies aredecreased.

In Period 3, the research findings have been applied and are yieldinglarger grain crops. Our initial investment in education is payingoff, so we reallocate less money to this task. We see that we areexceeding our required grain production quota so we may exportgrain or store it for emergencies.

Notice that changes are made in response to results experienced. Ifand when surplus is obtained we may invest in grain marketing orstorage for emergencies. We have not increased the amount of theagricultural support program but we have reallocated the funds tothe indicated tasks.

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