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Full Length Research Paper

Identifying Opportunities in Togo's Agriculture: Case of the Savannah Region

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The objective of this paper is to identify opportunities to enhance agriculture's contribution to economic growth in Togo. To achieve this objective the study combines Policy Analysis Matrix (PAM) and Data Envelopment Analysis (DEA) techniques to identify the profit maximizing maize, rice and soybean farmers in the Savannah region of Togo and then computed alternative PAMs based on average observed and profit-efficient farming conditions. The results reveals that maize, rice and soybean farmers are not viable in the long run because they are making losses at social prices. However, efficient farmers make substantial positive profits and the society also makes welfare gains from resources allocated to maize and soybean production. Consequently, policies based on dissemination of best agricultural practices could improve overall efficiency of these cropping systems. Rice production does not seem profitable in social prices even for efficient farmers. Future research could therefore focus on the main differences in farming technology and practices between profit-efficient farmers and other farmers.

Keywords: Data Envelopment Analysis, Policy Analysis Matrix, Savannah region of Togo.

INTRODUCTION

With a population of more than 6 million people and an average per capita Gross National Product (GNP) of US$ 440, Togo is one of the world's least developed countries. The agricultural sector, which is dominated by small-scale, subsistence farming, forms the foundation of the national economy and constitutes the primary source of livelihood for the overwhelming majority of the population. In 2012, the sector employed more than 70 percent of the labour force and contributed 40 percent of GDP and 36 percent of total export revenues. The agricultural production environment is characterized in Togo by a joint combination of low land productivity and harsh weather conditions (e.g., high average temperature, scarce and erratic rainfall). These result in very low yields and food insecurity. This challenge has been worsen during the period of 2007-2008.

Indeed, like most of the countries in the world, Togo experienced between late 2007 andmid-2008 an unprecedented crisis of food stuffs. It was argued that this crisis was linked on the one hand, to insufficient domestic supply and partly to higher food prices on the international market. The volatility of food prices or amplitude of price movements over that period of time has been especially problematic. This phenomenon was more pronounced in cereal prices such as maize and rice.

This crisis which has taken a humanitarian and social facet raises some important policy questions about agricultural structural development strategies and prospects in Togo. Thus, the Ministry of Food, Agriculture and Livestock (MFAL) developed the National Program for Investment in Agriculture and Food Security (PNIASA) aimed at improved growth in incomes by increasing productivity and total production of three main staple cash crops that are maize, rice and cassava. These measures, given their urgency nature, have not been preceded by an ex-ante identification of the agricultural priorities and prospects. Indeed, such a program should have been based on a study which identifies crops that have the high potential to significantly add to the Gross Domestic Product. The extent to which a specific cropping system can add to the national income may significantly vary across crop types. Consequently, this study aims to assess the ability of maize, rice, and soybean farming systems to add to national income in the Savannah region of Togo. Specifically, we are interesting in evaluating the private and social profitability of maize, rice, and soybean cultivation in the Savannah region of Togo by combining two different analytical tools: the policy analysis matrix (PAM) and technical efficiency analysis, namely the data envelopment analysis (DEA). The assessment of different farming systems' potential to support national income will be important to inform policies or programs aiming to boost agricultural production such as PNIASA.

Even though PNIASA program is implemented in the five administrative regions of Togo, our study focuses on the Savannah region for several reasons. The Savannah region is the poorest region despite its relative market access. Its agriculture is typical of the constraints on agriculture in the country. Located in the driest part of the country, climatic risk is very high for agricultural activity. Poverty is widespread. All these result in high potential vulnerability of farmers falling within the Savannah region of Togo. Consequently, it is no surprise that such a study has the Savannah region as its study site. One last thing need to be clarified before moving further. In this study only three crops that are Maize, Rice and Soybean are considered. The two first staples are considered because they fall within the range of staples PNIASA aims to enhance the productivity while Soybean is chosen because it is a merging crop in Togo. Cassava is not considered because of lack of data.

The structure of the paper is as follows: The next section outlines the methodology framework. Section 3 presents some descriptive statistics and the discussion of the empirical results. The section 4 concludes.

METHODOLOGY

Study Site

The study focuses on farmers of the Savannah region of Togo which covers 15% of the country's land mass. The Savannah Region, the northernmost of the country, is located between longitudes 0° and 1° E and latitudes 10 ° and 11 ° N and covers two agro-ecological zones.
The region is characterized by less than 1100mm mean annual rainfall. A short rainy season (June to October) alternates with a long dry season of 7 months (November- May) annually. The growing season is about 80-110 days. The dry spells (droughts) are common in the growing season often resulting in crop failures. Agriculture in this zone is characterized by traditional bush-fallow shifting cultivation of arable crops; pastoral herding; and irrigation farming. Constraints facing farmers, (in their agricultural activities) among others, include: low rainfall, drought, low fertility of the sandy and rocky soils. Several reasons explain the choice of the Savannah region in Togo.

Data

This paper uses survey data that was collected in May–June 2012 from four districts in Savannah region of Togo (DSID Center for agricultural statistics, informatics and documentation, 2012). The districts are Tandjoare, Tone, Oti and Kpendjal, for a total of 200 farm households. Fifty farmers were surveyed from each district. Secondary data were extracted from the market reports and previous studies. Output is measured in kilograms of crop production. The fixed input is cultivated land, measured in hectares. Variable inputs are labour, capital, fertilizers, seeds, and agrochemicals, all of which are measured in Fcfa. Tradable inputs include seed, fertilizer, and agrochemicals. Domestic cost factors include labour and capital. Labour input includes both the on-farm labour of the farmer and his or her household and hired labour. Capital inputs include the cost of use of farm-owned machinery, equipment, and tools.

Policy Analysis Matrix (PAM) Framework

The policy analysis matrix (PAM) is a computational framework developed by Monke and Pearson (1989), and augmented by Masters and Winter-Nelson (1995) as a result of developments in price distortion. It is a budget-based method for quantitative economic policy analysis, which allows for the assessment of public investment projects and government policies in the agricultural sector mainly (Monke and Pearson 1989; Pearson, Gotsch, and Bahri 2003; Winter-Nelson and Aggrey-Fynn, 2008). Indeed, the PAM allows to measure efficiency in production, comparative advantage and the degree of government intervention (impact of policy) on commodity production. The conventional PAM consists of two Accounting identities (Table 1). The first identity defines profitability as the difference between revenues and

Table 1 PAM framework

	Cost			
	Revenue	**Tradable**	**Domestic factor**	**Profit**
Private price	A	B	C	D
Social price	E	F	G	H
Divergence	I	J	K	L

Source Developed by Monke and Pearson (1989)
Private Profits D=A-B-C; Social Profit H=E-F-G; Output transfers I=A-E; Input Transfer; Factor transfer K=C-G, Net Transfer L=D-H or L=I-J-K

costs, measured in either private or social terms. The second identity measures the effects of divergence (distorting policies and/or market failures) as the difference between observed private values and social values that would prevailed if divergence were removed. There are two types of profits; private profits evaluated at market prices and social profits evaluated at social or efficiency prices. If there are no market distortions, the two are often the same. If, however, there are market failures or distortions then the two diverges from one another. Their divergence acts as a signal for policy intervention. Thus, a PAM can shed light on the existing economic efficiency of the crop production system, the degree of distortion on input and output markets, and the extent of resource transfers within the economy (Monke and Pearson 1989).

The first (private prices) row's data reflects the private profitability of the cropping system given existing technologies, output values, input costs, and the policy environment in the country (D=A-B-C). This captures the competitiveness of the agricultural system given current technologies, prices of input, output values and policy transfer. The second row of the PAM is used to measure social profit which is calculated at shadow price. The social profit reflects social opportunity costs and it measure efficiency and comparative advantage. A positive social profit indicates that the system uses scarce resources efficiently and contributes to national income (Nelson and Panggabean, 1991; Keyser, 2006). A negative social profit indicates social inefficiencies and suggests that production at social costs exceed the costs of import, thus indicating that the sector cannot survive without government intervention at the margin. The final row of the matrix represents transfers that come into play due to policy-induced market distortions. This captures the divergences between the first row (measured at private prices) and the second row (measured at social prices). The difference between private and social values of costs, revenues and profits can be explained by policy interventions (Mohanty, *et al.,* 2003; Wiendiyati, *et al.,* 2002; Esmaeili, 2008). Several important to better understand the extent of transfers and external Competitiveness of crop farming systems, one can calculate several ratios (Monke and Pearson 1989). In this paper, to evaluate whether maize, rice, and soybean farming systems in the Savannah region of Togo enjoy a comparative advantage in relation to the international market, we calculate for each crop the private cost ratio, the domestic cost ratio, and the subsidy ratio to producers. The private cost ratio (PCR) is the ratio between the cost of domestic factors and the value added, calculated at private market prices: PCR=C/(A-B). A given crop farming system is considered competitive at private prices if the PCR is less than or equal to one. The domestic cost ratio (DCR) is the ratio between the cost of domestic factors and the value added, calculated at social prices: DCR=G/(E-F). A given crop farming system is considered competitive at social prices if the DCR is less than or equal to one (Monke and Pearson 1989; Reig-Martinez, Picazo-Tadeo, and Estruch 2008). The subsidy ratio to producers (SRP) measures the net policy transfer to producers as a share of total social revenues. The SRP is a useful ratio because it, "shows the proportion of revenues in parity prices that would be required if a single subsidy or tax were substituted for the entire set of commodity and macroeconomic policies" (Monke and Pearson 1989). The subsidy ratio to producers presents an overall comparison of the extent to which all policy subsidizes the given crop farming system. Moreover, the SRP can be disaggregated into component transfers to show separately the effects of output, input, and factor policies (Monke and Pearson 1989).

By doing these computations, we assume that maize, rice, and soybean farmers in the Savanna region are optimally operating under existing conditions in terms of profit-efficiency while in the reality they might not. Indeed, one may argue that smallholder farmers would not actually exhibit production-efficiency behaviour. To account for this potential drawback in PAM's analysis, we used a second method which is the Data Envelopment Analysis (DEA). This method is applied in this analysis to estimate profit-efficient levels of input use, costs, and output for maize, rice, and soybean production. Profit-efficient levels refer to the adjustment of maize, rice, and soybean farms' input and output vectors to achieve maximum profits, for a given set of prices, fixed factors, And the current state of technology in the country. These efficient plans are achievable for most maize, rice, and

Soy bean farmers and represent the productive systems that would prevail if farmers were optimally operating under existing conditions in terms of profit-efficiency. Consequently, we use DEA to compute maize, rice, and soybean production plans that maximize short-run profit for farmers. In general, DEA allows evaluation of the performance of peer farmers by constructing a surface over the data that allows the observed behaviour of a given farmer to be compared with the best observed practices (Reig-Martinez, Picazo-Tadeo, and Estruch 2008).

Data Envelopment Analysis Framework

Estimation of efficiency follows non-parametric and parametric techniques. The non-parametric technique constructs frontiers and measures efficiency relative to the constructed frontier using linear programming techniques such as Data Envelopment Analysis (DEA).

The parametric technique estimates frontiers and provides efficiency using econometric methods such as Stochastic Frontier Approach and distance functions. The conventional approach to the estimation of production functions consists of first specifying a parametric form for the function and then fitting it to observed data by minimizing some measure of their distance from the estimated function (Banker and Maindiratta, 1988). Statistical tests are performed by postulating again a parametric form for the distribution of the deviations of observed data from the fitted production function. The fundamental weakness of this approach lies in its inability to theoretically substantiate or statistically test the maintained hypotheses about the parametric form for the production function and the postulated distribution for the disturbance term. Furthermore, it is not immediately apparent what restrictions these hypotheses impose on the production correspondence (Javed *et al*., 2008).

Because of these reasons, we use DEA technique to estimate farmers' efficiency in the study area. DEA is a non-parametric approach based on utilizing the linear programming techniques to measure the efficiency and/or inefficiency. It constructs a linear piecewise frontier from the observed data, thus, it does not require any assumptions about the functional form and the distribution of error terms. Thus, DEA has main advantages in terms of not requiring the assumption of a functional form to specify the relationship between inputs and outputs, and the assumption about the distribution of the underlying data (Coelli, 1995 and Krasachat, 2003). DEA efficiency measures are relative, as they refer to the sample they are calculated from. These relative rankings can be fragile if the number of firms in the sample is small Relative to the number of outputs and inputs being Considered (Andreu, 2008).

According to Coelli*, et al*. (1998), it is necessary to select orientation from input oriented DEA model or output oriented DEA model according to which quantities the decision maker has more control over. Smallholder farmers in the study areas have more control over inputs than outputs. Accordingly, input oriented DEA model will be used in the study. Besides, it is pointed out that constant return to scale DEA model is only appropriated when all firms are operating at optimal scale. However, it is not possible to hold this assumption in agriculture in the study areas since smallholder farmers face constraints. As a result the variable returns to scale DEA model was applied for this study. The outcomes of DEA of this study were efficiency scores which represent performance indicators as 1 = best performance and 0 = worst performance. The best of efficient DMUs lie on the frontier while the inefficient ones lie below the frontier. The efficient DMUs can be considered as benchmark of the inefficient DMUs. The inefficient DMUs can improve their performances to reach the efficient frontier by decreasing their current input levels (Cooper *et al.,* 2006). The efficiency scores can be calculated by using a linear programming model as presented in Charner*et al.* (1978).

The linear programming model for this study is, therefore, constructed as follows:

$$\underset{\Delta,\lambda}{Min\ \Delta_j}$$

$$S.t \qquad \sum_{j=1}^{n} y_j\lambda_j - y_j \geq 0$$

$$x_{ij}\Delta - \sum_{j=1}^{n} x_{ij} \geq 0$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$0 \leq \Delta \leq 1$$

Where $= \Delta_j\ is$ a scalar which indicates the efficiency scores of the jth household; yj = a 1xn vector of output produced by n households; xij = a m x n input matrix andλ_j = a n x 1 vector of weight value.

The assumptions of this model are that a given farm household j produces output yj using a combinations of inputs xij (i = labour, seed, fertilizer); and an input oriented production frontier of variable returns to scale (VRS). The objective function is a scalar that represents the minimum level to which the use of inputs can be reduced without altering the output level. It is the global technical efficiency score (GTE) for the DMU "j''. If this index is equal to one, the production unit is considered efficient. If it is less than one there is some degree of technical inefficiency. An index equal to one ensures that the use of all inputs cannot be reduced at the same time

Table 2 Observed and profit-maximizing plans for Maize for maize (average per ha)

Variables	Units	Average	Profit-maximizing	Variation (%)
output	Kg	1614.6	1939.5	20.1
Inputs				
Labour	CFA	63,600	44,850	-29.4
Family Labour	CFA	41,250	34,350	-16.7
Hired Labour	CFA	22,350	10,475	-53.1
Capital	CFA	6,250	6,100	-2
Seeds	CFA	2,675	2,325	-13.1
Fertilizer		31700	14,350	-54.7
Agrochemical		7,22	4,125	-42.9

Source Author's computation based on DSID 2012

Table 3 Observed and profit-maximizing plans for Rice for maize (average per ha)

Variables	Units	Average	Profit-maximizing	Variation (%)
output	Kg	2,008	2700.5	34.5
Inputs				
Labour	CFA	127,925	157,375	23
Family Labour	CFA	81,000	124,225	53.3
Hired Labour	CFA	46,925	8,350	-82.25
Capital	CFA	6,250	4,375	-3
Seeds	CFA	7,000	5,750	-17
Fertilizer	CFA	24,900	14,475	-42.2
Agrochemical	CFA	9,000	7,000	-22.2

Source Author's computation based on DSID 2012

Although a variation in the use of one of them may improve efficiency (Iraizoz*et al*., 2003).The individual DEA efficiency score varies between 0.00 and 1.00. This means the efficiency scores are double-truncated at 0 and 1.

RESULTS AND DISCUSSION

Subsistence farmers dominate the agricultural sector in Togo, particularly in the food crops' farming. They cultivate on average about 1.5 hectares of land using traditional farming techniques. They commonly get seeds from the previous harvest. Intercropped farming systems are the most preferred because it helps partly to cope with the risk total crop production failure. Large farms usually do not produce food crops such as maize, rice and soybean.

Farm households in the study area have limited access to capital. They consequently use mainly hand tool in their farming practices. Average sizes of sown areas for maize, rice and soybean are 2.2, 1.25 and 0.5 hectares respectively. The average total output for maize, rice and soybean are 3.1, 2.0 and 1.1 ton respectively.

Observed Average and Profit Maximizing Production Plans

We use data envelopment analysis to estimate profit-maximizing production plans for the three crops production. The results reveal that 33 maize farmers, 22 rice farmers, and 15 soybean farmers are efficient in terms of profit maximization for given input and output prices and the current state of farming technology in the country. The summary of the observed and the profit-maximizing production plans for the three considered crops are reported in the tables 2 to 4 (for more details on this see the tables 5 to 7 of the appendices). Overall, achieving profit efficiency for all the three crops implies on average an increase in crop yields and a reduction in the use of hired labour and tradable inputs. It is however worth mentioning differences that exist across the three crops' farming systems.

The table 2 below indicates that the profit maximizing maize producers produce 20 percent more output per hectare (yield) while spending nearly 13 percent, 55 percent and 43 percent less in respectively seed, fertilizer and agrochemicals. The DEA analysis for maize also suggests that achieving profit efficiency involves, on

Table 4 Observed and profit-maximizing plans for Soybean for maize (average per ha)

Variables	Units	Average	Profit-maximizing	Variation (%)
output	Kg	950.6	1209.8	27.2
Inputs				
Labour	CFA	88,600	94,850	-7.1
Family Labour	CFA	53,750	46,850	-12.9
Hired Labour	CFA	34,850	22,975	-34
Capital	CFA	6,250	6,125	-2
Seeds	CFA	2,675	2,325	-13.1
Fertilizer	CFA	37,500	14,350	-54.7
Agrochemical	CFA	7,225	4,125	-42.9

Source Author's computation based on DSID 2012

Average, significant reduction in the use of labour. However, there is apparently no difference in the use of capital when moving from average to efficient productive plan.

The result assigned in the table 3 likewise indicates that rice yields per hectare are higher by about 35 percent for efficient rice farmers. We note that there is a neglect difference in the use of capital per hectare between profit-efficient and average farmers. However, achieving profit efficiency in rice production generally involves significant reductions in the use of hired labour, fertilizer and seed. Conversely, the use of family labour increases by 53 percent when moving from observed average to efficient rice production. This suggests that efficient rice farmers mainly depend on family labour and employ little hired labour.

Likewise the table 4 shows that profit-maximizing soybean farmers produce about 27 percent more output per hectare than average farmers. The findings included in that table also suggest that reaching profit efficiency involves, on average, a significant reduction in the use of fertilizer and hired labour.

The results of the traditional PAM's analysis for maize with a profit function that includes family labour in domestic cost factor (Table 1 of the appendices) shows that maize farming is profitable for the observed average farm in private prices, but is not profitable in social prices. However, the results from the PAM analysis with profit-efficient data suggest that maize farming is profitable under production plans that maximize profits both in private and social prices. Further, PAM analysis for maize with a profit function that excludes family labour from domestic cost factor assumes that the net operating profit of the farm is the return to family labour and indicates that maize farming is profitable for both observed average and profit-efficient farmers in both private and social prices.

The calculation of PCR and DCR for Maize farming illustrates the basic weaknesses and strengths of this farming system in the Savannah region. First, the remuneration the domestic cost factors per hectare exceeds the value added per hectare by 11 percent when computed at social prices with a profit function that includes family labour in domestic cost factors. Nevertheless, in all other cases both the PCR and DCR remain significantly below one, suggesting the ability of the Maize farming system to create value for maize farmers and also to add to the national income at social prices. The computation of the subsidy ration to producers indicates that the net policy transfer a share of the total social revenues stood at 29 percent and 20 percent for average and profit-efficient maize farmers, respectively.

Considering the rice farming, the classical PAM analysis with a profit function that includes family labour in domestic cost factor (table 2 in the appendices) reveals that rice farming is not profitable for the observed average farm both in private and social prices. Moreover, the results from PAM analysis with profit-efficient data show that rice farming is profitable under production plans that maximize profit only in private prices. Moreover, PAM analysis for rice farming with profit function that exclude family labour from domestic cost factor shows that rice farming is profitable for both observed average and profit-efficient farmers in both private and social prices.

The PCR and DCR values reveal that the compensation of domestic factors per hectare exceeds the value added per hectare by 5 percent when determined at private prices, and by 24 percent when computed at social prices. However the computed PCR and DCR ratios for profit-efficient farmers suggest that soybean farming can add value to the national income under profit-maximizing environment. Moreover, when we assume that net operating profit is a return to family labour, then the results change significantly and both PCR and DCR remain significantly below unity, suggesting that the soybean farming system creates value for the growers and also adds to the national income at social prices. The computation of the subsidy ratio to producers indicates that society transfers up to 15 percent to soybean farmers.

When we turn to rice farming, the conventional PAM analysis with a profit function which includes family labour in domestic cost factor shows that rice farming is not profitable for the observed average farm both in private and social prices. Further, the results from the PAM analysis for rice farming with a profit function that excludes family labour from domestic cost factor reveals that rice farming is profitable for both observed average and profit-efficient farmers in both private and social prices.

However, analysing PCR and DCR for rice farming we conclude that rice farming system is not able to add to the national income at social prices when family labour in accounted in the domestic cost factors. For instance, the payment to the domestic cost factors per hectare for the observed average farmer exceeds the value added per hectare by 6 percent, when computed at private prices and by 29 percent when computed at social prices.

Likewise, the remuneration of the domestic cost factors per hectare exceeds the value added per hectare by 71 percent when computed at social prices even for profit-efficient rice farmers. However, if we exclude family labour from the domestic cost factor, both the PCR and the DCR become significantly less than one, pointing to the competiveness of the rice farming system to create value for farmers and also to add to the national income at social prices. The computation of the subsidy ratio to producers indicates that the net policy transfer, as a share of the total social revenues, stood at 25 percent and 21 percent for observed and profit-efficient rice farmers, respectively.

Finally, traditional PAM analysis for soybean production with a profit function that includes family labour in domestic cost factor suggests that soybean farming in not profitable for both observed average and profit-efficient farmers both in private and social prices. However, the results from PAM analysis with profit-efficient data show that soybean farming under production plans that maximize profits is profitable in private prices, but not in social prices. Moreover, PAM analysis for soybean production with profit function that excludes family labour from the domestic cost factor shows that soybean farming is profitable for both observed average and profit-efficient farmers in both private and social prices.

PCR and DCR reveal weaknesses and strengths of soybean farming under observed average production plans. The compensation of the domestic factors per hectare exceeds the value added per hectare by 6 percent, when computed at private prices, and by 16 percent when computed at social prices. However, the computed PCR and DCR ratios for profit-efficient farmers suggest that soybean farming can add value to the national income under profit-maximizing conditions. Further, if we assume that net operating profit is a return to family labour, then the results change significantly and both the PCR and the DCR remain significantly below Unity, suggesting that the soybean farming system creates value for the growers and also adds to the national income at social prices. The computation of the subsidy ratio to producers indicates that society transfers up to 12 percent to soybean producers.

CONCLUSIONS AND POLICY IMPLICATIONS

This study identified the ability of maize, rice, and soybean farming systems to add to national income in the Savannah region of Togo. Two analytical methods, namely PAM and DEA were used. This allowed us to generate average and profit-efficient productive plans for each crop farming system.

The results suggest that the maize farming system is mainly profitable under both average and profit-efficient production systems. The traditional PAM results reveal that the soybean farming system is not viable under the observed average production plan. However, soybean production becomes profitable under profit efficient farming. Moreover, the rice farming system is mainly not profitable. Thus, one may argue that, in the long run, the survival of Togo’s rice farming system is clearly compromised because of its lack of international competitiveness.

However, given the fact that family labour is the most important input in the maize, rice, and soybean production in Togo, how it is accounted for significantly affects the profitability and competitiveness of these crops. The results suggest that if we consider net farm revenues as returns to family labour, the conclusions will change dramatically. This provides a different perspective pointing to the ability of maize, rice, and soybean farming systems in Togo to create value for farmers and also to add welfare gains to the society.

The findings of the study have important policy implications. First, policies based on dissemination of best practices could improve overall efficiency of maize, rice, and soybean farming systems in Togo. For example, bridging the gap between average and profit-efficient farming practices can increase the net operating incomes of average maize farmers by more than 75000 Fcfa (US$ 167) per hectare. The main question here however is: what are the existing differences in farming technology and practices between profit-efficient farmers and other farmers? Second, while this analysis indicates that more intensive use of tradable inputs, such as fertilizer, might enhance the efficiency of maize, rice, and soybean farming systems, it does not suggest that under currently available farming practices low levels of fertilizer use is the most important constraint to increasing the production of these crops. Given the limited share of fertilizer costs in total farm cost, it is unlikely that fertilizer subsidies will lead to improved farming efficiency. It is worth noting that the fertilizer application rate is lower for the profit-

Farmers compared with the observed average farmers.

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APPENDICES

Table 1 PAM for maize: including family labour in domestic cost factor

Panel A. PAM under observed productive plans: Maize (CFA)							
		Costs					
		Tradable inputs			Domestic factors		
	Revenue	Seed	Fertilizer	Agrochemical	Labour	capital	Profits
Private	157,425	2675	31,700	7,223	63,600	6,250	45,977
Social	114,375	2725	41,050	7,375	63,600	6,250	-6,625
Transfers	23,050	-50	-10,150	-152	0.00	0.00	33,402
Panel B. PAM under profit-efficient productive plans: Maize (CFA)							
		Costs					
		Inputs			Domestic factors		
	Revenue	Seed	Fertilizer	Agrochemical	Labour	Capital	Profits
Private	189,100	2,325	14,350	4,125	44,850	6,250	117,200
Social	161,425	2,375	18,950	4,200	44,850	6,250	84,800
Transfers	27,675	-50	-4,600	-75	0.00	0.00	32,400

Source Author's computation based on DSID 2012

Table 2 PAM for Soybean: including family labour in domestic cost factor

Panel A. PAM under observed productive plans: Soybean (CFA)							
		Costs					
		Tradable inputs			Domestic factors		
	Revenue	Seed	Fertilizer	Agrochemical	Labour	capital	Profits
Private	118,675	6,550	6,875	5,575	99,800	6,325	-6,450
Social	113,025	6,675	9,075	5,675	99,800	6,325	-14,525
Transfers	15,650	-125	-2,200	-100	0.00	0.00	13225
Panel B. PAM under profit-efficient productive plans: Soybean (CFA)							
		Costs					
		Inputs			Domestic factors		Profits
	Revenue	Seed	Fertilizer	Agrochemical	Labour	Capital	
Private	234,325	7.525	5,000	4,900	79.550	4,825	136,025
Social	207,875	7.675	6,600	5,000	79.550	4,825	104,225
Transfers	26,450	-150	-1,600	-100	0.00	0.00	28,200

Source Author's calculation based on DSID 2012

Table 3 PAM for rice: including family labour in domestic cost factor

Panel A. PAM under observed productive plans: Rice (CFA)							
	Revenue	Costs					
		Tradable inputs			Domestic factors		Profits
		Seed	Fertilizer	Agrochemical	Labour	capital	
Private	207,850	8,075	28,300	10,525	164,800	6,775	-10,625
Social	189,800	8,225	37,350	10,725	164,800	6,775	-38,075
Transfers	38,050	-150	-9,050	-200	0.00	0.00	47,400
Panel B. PAM under profit-efficient productive plans: Rice (CFA)							
	Revenue	Costs					
		Inputs			Domestic factors		Profits
		Seed	Fertilizer	Agrochemical	Labour	Capital	
Private	265,650	5,800	2,650	8,700	207,950	3,700	36,850
Social	221,275	5,925	3,500	8,875	207,950	3,700	-8,675
Transfers	44,375	-125	-850	-175	0.00	0.00	45,525

Source Author's computation from DSID 2012

Table 4 PAM for maize: excluding family labour from domestic cost factor

Panel A. PAM under observed productive plans: Maize (CFA)							
	Revenue	Costs					
		Tradable inputs			Domestic factors		Profits
		Seed	Fertilizer	Agrochemical	Labour	capital	
Private	157,250	2,675	31,700	7,225	22,350	6,250	87,050
Social	134,375	2,725	41,850	7,375	22,350	6,250	53,825
Transfers	22,875	-50	-10,150	-150	0.00	0.00	33,225
Panel B. PAM under profit-efficient productive plans: Maize (CFA)							
	Revenue	Costs					
		Inputs			Domestic factors		Profits
		Seed	Fertilizer	Agrochemical	Labour	Capital	
Private	189,100	2,325	14,350	4,125	10,475	6,125	151,700
Social	161,450	2,375	18,950	4,200	10,475	6,125	119,325
Transfers	27,675	-50	-4,600	-75	0.00	0.00	32,400

Source Author's computation from DSID 2012

Table 5 PAM for Soybean: excluding family labour from domestic cost factor

Panel A. PAM under observed productive plans: Soybean (CFA)							
	Revenue	**Costs**					
		Tradable inputs			**Domestic factors**		**Profits**
		Seed	**Fertilizer**	**Agrochemical**	**Labour**	**capital**	85,950
Private	138,675	6,550	6,875	5,575	27,400	6,325	67875
Social	123,025	6,675	9,075	5,675	27,400	6,325	
Transfers	15,650	-125	-2,200	-100	0.00	0.00	18,075
Panel B. PAM under profit-efficient productive plans: Soybean (CFA)							
	Revenue	**Costs**					
		Inputs			**Domestic factors**		**Profits**
		Seed	**Fertilizer**	**Agrochemical**	**Labour**	**Capital**	
Private	234,325	7.525	5,000	4,900	20,250	4,825	191,825
Social	207,875	7,675	6,600	5,000	20,250	4,825	163,525
Transfers	26,450	-150	-1600	-100	0.00	0.00	28300

Source Author's estimation from DSID 2012

Table 6 PAM for Rice: excluding family labour from domestic cost factor

Panel A. PAM under observed productive plans: Rice (CFA)							
	Revenue	**Costs**					
		Tradable inputs			**Domestic factors**		**Profits**
		Seed	**Fertilizer**	**agrochemical**	**Labour**	**capital**	
Private	227,850	8,075	28,300	10,525	70,725	6,775	103,450
Social	189,800	8,225	37,350	10,725	70,725	6,775	56,000
Transfers	38,050	-150	-9,050	-200	0.00	0.00	47,450
Panel B. PAM under profit-efficient productive plans: Rice (CFA)							
	Revenue	**Costs**					
		Inputs			**Domestic factors**		**Profits**
		Seed	**Fertilizer**	**agrochemical**	**Labour**	**Capital**	
Private	265,650	5,800	2,650	8,700	14,950	3,700	229,850
Social	221,275	5,925	3,500	8,875	14,950	3,700	184,325
Transfers	44,375	-125	-850	-175	0	0	45,525

Source Author's estimation from DSID 2012