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Analyzing Profitability of Maize, Rice, and Soybean Production in Ghana: Results of PAM and DEA Analysis

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THE GHANA STRATEGY SUPPORT PROGRAM (GSSP)

WORKING PAPERS

ABOUT GSSP

IFPRI's Ghana Strategy Support Program (GSSP) was launched in 2005 to address specific knowledge gaps concerning agricultural and rural development strategy implementation, to improve the data and knowledge base for applied policy analysis, and to strengthen the national capacity for practical applied policy research. The primary objective of the Ghana Strategy Support Program is to build the capabilities of researchers, administrators, policymakers, and members of civil society in Ghana to develop and implement agricultural and rural development strategies. Through collaborative research, communication, and capacity-strengthening activities and with core funding from the U.S. Agency for International Development/Ghana (USAID), GSSP works with its stakeholders to generate information, improve dialogue, and sharpen decisionmaking processes around the formulation and implementation of development strategies.

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Abstract

The study combines policy analysis matrix (PAM) and data envelopment analysis (DEA) techniques to evaluate the profitability and competitiveness of maize, rice, and soybean production in Ghana. The efficiency of a sample of maize, rice, and soybean growers from four districts of Ghana is analyzed using DEA, while profit maximizing groups of farmers were also identified. Then, PAMs were computed under observed average and profit-efficient farming conditions. Two alternative profit functions were considered: including family labor in domestic cost factor and excluding family labor from domestic cost factor. The results are distinctively different under observed average and profit maximizing conditions. One may argue that average maize, rice, and soybean farmers are not viable in the long term 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. Therefore, policies based on dissemination of best practices could improve overall efficiency of these cropping systems. Rice production does not seem profitable in social prices even for efficient farmers. Finally, excluding family labor from domestic cost factor provides different perspectives that point to the ability of maize, rice, and soybean production to create value for farmers and also to add welfare gains to the society.

Keywords: Ghana, policy analysis matrix, data envelopment analysis, efficient production plans

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Acronyms

DCR	Domestic Cost Ratio
DEA	Data Envelopment Analysis
ECOWAS	Economic Community Of West African States
FOB	Free On Board
IFPRI	International Food Policy Research Institute
METASIP	Medium Term Agricultural Sector Investment Plan
MiDA	Millennium Development Agency
MOFA	Ministry Of Food and Agriculture
PAM	Policy Analysis Matrix
PCR	Private Cost Ratio
SRP	Subsidy Ratio to Producers
VAT	Value Added Tax

Table of Contents

Table of Figures

Introduction

The global economy has been experiencing both higher and more volatile food prices in recent years. The volatility of food prices or amplitude of price movements over a certain period of time has been especially problematic. This phenomenon was more pronounced in cereal prices such as maize and rice. High and volatile food prices may harm both producers and consumers. The negative impact of high food prices on consumers, especially poor ones, is obvious because they need to spend more on their food expenditures. For producers of food, the impact of high food prices is not trivial and depends on whether they are net sellers or buyers of food. However, higher price volatility may harm producers by increasing uncertainty about market prices and making it more difficult for farmers to make sound production decisions (IFPRI 2012).

These dramatic developments in global food markets raise some important policy questions about agricultural strategies and prospects in Ghana. The Ministry of Food and Agriculture (MOFA) developed six strategic programs under the Medium Term Agricultural Sector Investment Plan (METASIP). The second strategic program is aimed at improved growth in incomes by increasing productivity and total production of staple and cash crops, including maize and rice[1].

Maize is the most important staple crop in Ghana and accounts for more than 50 percent of total cereal production in the country. The bulk of maize produced goes into food consumption and it is arguably the most important crop for food security. The development and productivity of the livestock and poultry sectors could also depend on the maize value chain since maize is a major component of poultry and livestock feed. Moreover, maize is the second most important commodity crop in the country after cocoa. Rice is the second most important staple cereal after maize, with substantial and continuing growth in rice consumption over the last two decades (MoFA 2012, MiDA 2010). Rice demand is projected to grow at a compound annual growth of 11.8 percent and maize at 2.6 percent in the medium term (MiDA 2010). However, Ghana is not self-sufficient in either of these staple crops. Thus, it is important to increase productivity and overall production of the crops to meet the country's growing demand for rice and maize and to improve overall food security. Soybean is a relatively new crop in Ghana and mainly used by farmers for crop rotation with maize. All of these crops are primarily cultivated by smallholders under traditional production farming practices and rainfed conditions. Of note is that only 15 percent of total rice production comes from irrigated fields (MiDA 2010).

The importance of these crops for the agricultural sector in Ghana's economy, for food security, and to address the problems of rising food prices and import bills raise important questions about the potential for government policy or investment to enhance the competiveness of their production. This paper evaluates the private and social profitability of maize, rice, and soybean cultivation in three regions of Ghana by combining two different analytical tools: the policy analysis matrix (PAM) and technical efficiency analysis, namely the data envelopment analysis (DEA).

Since the seminal work by Monke and Pearson (1989), the PAM has been widely employed to analyze private and social profitability and competitiveness for a variety of farming systems under different technological and institutional scenarios (Nelson and Panggabean 1991; Yao

[1] The remaining five strategic programs are devoted to supporting food security and emergency preparedness (Program 1), increased competitiveness and enhanced integration into domestic and international markets (Program 3), sustainable management of land and environment (Program 4), science and technology applied in food and agricultural development (Program 5), enhanced institutional coordination (Program 6). More information available at: http://mofa.gov.gh/site/?page_id=2754

1997; Fang and Beghin 2000; Pearson, Gotsch, and Bahri 2003; Nguyen and Heidhues 2004; Yercan and Isikli 2007). More recently, it has been shown that important additional insights might be obtained using PAM analysis if farmers' efficient behavior is considered, in addition to their observed behavior (Reig-Martinez et al. 2008).

In a recent study, Winter-Nelson and Aggrey-Fynn (2008) studied maize and rice production systems in Ghana by using a conventional PAM. The findings of that study suggest that all existing maize and rice farming systems contribute to economic growth and private income generation among farmers. Maize returned a lower cost/benefit ratio than rice production, possibly suggesting higher efficiency in maize systems than rice systems. However, the authors recognize that these results could be explained, at least in part, by the high prices prevailing in 2007 when the data were collected. Sensitivity analyses conducted by the authors suggest that lower prices found in other periods would make rice systems unprofitable. The main finding of their study is that more intensive use of inputs, such as fertilizer, could help to make the two crops more profitable. For rice, the study identifies post-harvest losses and lack of processing capacity as two main constraints. The study also recommends further exploration of the constraints faced by farmers to using fertilizer more intensively.

Overall, Winter-Nelson and Aggrey-Fynn (2008) assessed the profitability of maize and rice farming in Ghana by dealing with observed average farmers' behavior, implicitly assuming that all farmers behave efficiently. But, how might their results and recommendations change if the current farming practices of some individual farmers were seen to be inefficient when compared to best practices under currently available technologies? The answer to this question has important policy implications. The impact of agricultural policies on farmers' income might be widely different under observed average versus efficient behaviors.

In this paper, following Reig-Martinez, Picazo-Tadeo, and Estruch (2008), we go one step beyond traditional PAM analysis. This allows us to examine what farmers could do in order to rise to the challenge posed by market competition and become more efficient producers instead of limiting the analysis to a purely static perspective based on what farmers are currently doing. Farmers will have to adjust in the coming years to a more uncertain market environment by using their productive assets more efficiently, thereby improving their profitability in the face of greater market volatility. Hence, we draw a clear distinction between observed and efficient farming behavior. The estimates of the efficient levels of input use, outputs, revenues, and profits are computed using DEA. Our results show that profit-efficient farmers earn higher revenues because they have significantly higher yields. The efficient farmers earn more profits because, in addition to higher revenues, they also have lower per unit of output costs than the average observed farmer in the sample because they manage their inputs more efficiently. Further, the efficient farmers depend more on family labor than hired labor, especially in rice cultivation.

The rest of the paper is organized as follows. Section 2 briefly describes the methodology. Section 3 discusses data and descriptive findings. Section 4 reports the results. The final section of the paper provides conclusions and discusses policy implications of the main findings.

Methodology

A policy analysis matrix (PAM) is a budget-based method for quantitative economic policy analysis, which allows for the evaluation of public investment projects and government policies in the agricultural sector (Monke and Pearson 1989; Pearson, Gotsch, and Bahri 2003). Budgets are calculated to assess private and social profitability of the production systems employed in different farming systems. Private budgets are based on current market prices faced by farmers, while social budgets are based on social prices that account for government policies that may influence market prices such as taxes and subsidies.

The conventional PAM consists of two accounting identities: one defining profit as the difference between revenues and costs and the other measuring the effects of divergence (distorting policies and market failures) as the difference between observed market prices and prices that would exist if the distortions were removed. 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). Table 1 depicts a typical PAM.

Table 1. Policy analysis matrix

	Revenue	**Costs**		**Profit**
		Tradable inputs	**Domestic factors**	
Private Prices	A	B	C	D
Social Prices	E	F	G	H
Divergence	I	J	K	L

Source: Monke and Pearson 1989.

The first (private prices) row 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). The second row measures the social profitability of the same cropping system in terms of social prices (H+E-F-G). The social profitability is calculated at shadow prices for inputs and outputs that are calculated by taking into account such market influencing policies as taxes, subsidies, tariffs, and import duties. For instance the shadow prices for tradable goods are their parity prices. The export parity price for rice, for example, will be the FOB price minus the cost of processing and transporting the rice to the border. The valuations therefore measure the comparative advantage or efficiency in the crop commodity farming system. Socially acceptable outcomes are achieved when resources are employed such that maximum possible levels of output and profits are generated (Monke and Pearson 1989).

The columns of the PAM illustrate revenues, costs, and profits. The costs are divided into two components – tradable inputs and domestic production factors. We further divide tradable inputs into three subcomponents – seed, fertilizer, and chemicals. Likewise, domestic cost factors are divided into capital, labor, and contracted services. Further, labor input is disaggregated into hired labor and family labor. All budget items are denominated in local currency units per unit of land (Ghanaian Cedi per hectare) for consistency and comparability.

The third row in the PAM table shows divergences, which reflect the transfers in the economy due to policy distortions. This allows for the capturing of the differences between private and social profitability of a given cropping system. In the PAM context, social profitability is measured in conventional terms by adopting international prices in the valuation of tradable inputs without considering redistribution of income, food security, or some other societal objectives. The valuations of tradable inputs as well as domestic cost factors can also be affected by government taxes and subsidies.

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 Ghana 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).

The second method applied in this analysis is data envelopment analysis (DEA), which is used 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 conditions are achievable for most maize, rice, and soybean farmers and represent the productive plans that would prevail if farmers were optimally operating under existing conditions in terms of profit-efficiency. Thus, we use DEA to compute maize, rice, and soybean production plans that maximize short-run profit for producers for given sets of input and output prices. In general, DEA allows evaluation of the performance of peer farmers by constructing a surface over the data that allows the observed behavior of a given farmer to be compared with the best observed practices (Reig-Martinez, Picazo-Tadeo, and Estruch 2008).

In doing these computations, we assume that maize, rice, and soybean farmers in Ghana follow a profit-maximizing strategy and then evaluate their relative performance. However, one may argue that smallholder farmers would not actually follow a profit-maximizing strategy, but rather a strategy aimed at maximizing output if they are subsistence farmers and food security is their main concern. This issue is discussed later following the presentation of the findings of the empirical analyses.

Data and descriptive findings

Smallholder farmers dominate the agricultural sector in Ghana, particularly in the production of food crops, and on average cultivate about 2 hectares of land using traditional farming practices. They usually obtain seeds from the previous harvest and intercropped cultivation systems are preferred, partly to reduce the risk of total crop failure (Seini 2002). Large farms and plantations do not commonly cultivate food crops, including maize, rice, and soybean. The productivity of the smallholder cropping systems in Ghana largely depends on inherent soil fertility and prevailing weather conditions, since only limited amounts of fertilizer and agrochemicals are applied and irrigation systems are very rare (MoFA 2010).

This paper uses survey data that was collected in May–June 2011 from four districts in three regions of Ghana (IFPRI 2011). The districts are Sissala East in Upper West region, Tolon Kumbungu and Yendi in Northern region, and Nkoranza in Brong Ahafo region. Sixty-one farmers were surveyed in Sissala East, 60 in Tolon Kumbungu, 64 in Yendi, and 71 in

Nkoranza, for a total of 256 farm households. Data for crop budgets for the three different crops – maize, rice, and soybean – were collected from each farmer. In total, 417 crop budgets were collected, 201 for maize, 130 for rice, and 86 for soybean. Data for the crop budgets were collected on a plot basis.

In each district, with the help of a staff from MoFA, a list of communities where the crops of interest were grown was obtained, and then the district team chose three communities randomly. A contact person from each community assisted in drawing up a household list of farmers involved in the cultivation of maize, rice, or soybean. Out of this list, at least 20 farmers were randomly selected for the survey. The questionnaire was designed to obtain a maximum of two crop budgets of maize, rice, or soybean for each farmer and, therefore, from 20 farmers, a maximum of 40 crop budgets could be obtained. Interviews with the farmers were conducted on a one-on-one basis with the help of a translator.

The survey obtained data on one output and six inputs for maize, rice, and soybean production. Output is measured in kilograms of crop production. The only fixed input is cultivated land, measured in hectares. Variable inputs are labor, capital, contracted services, fertilizers, seeds, and agrochemicals, all of which are measured in cedis (GHC), the national currency of Ghana.[2] Tradable inputs include seed, fertilizer, and agrochemicals. Domestic cost factors include labor, capital, and contracted services. Labor input includes both the on-farm labor of the farmer and his or her household and hired labor. Capital inputs include the cost of use of farm-owned machinery, equipment, and tools. It is important to note that farmers in the sample use limited capital, mainly hand tools. Tables 2 to 4 present sample descriptions for the maize, rice, and soybean data, respectively. Average sizes of sown areas for maize, rice, and soybean are 2.4, 1.5, and 1.4 hectares, respectively. The average total output for maize, rice, and soybean are 3.4, 2.6, and 1.6 ton, respectively. The reported average prices of maize, rice, and soybean have been calculated at GHC 0.39, 0.40 and 0.50 per kilogram, respectively.

Observed average and profit maximizing production plans

As mentioned earlier, we use data envelopment analysis to estimate profit-maximizing production plans for maize, rice, and soybean production. These computations show that 22 maize farmers (11 percent of all maize farmers), 13 rice farmers (10 percent of all rice farmers), and 10 soybean farmers (about 12 percent of all 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 profit-maximizing production plans for maize, rice, and soybean are reported in Tables 5 to 7, respectively. The observed average production plans for the respective crops are also provided in these tables. Overall, achieving profit efficiency for all three crops involves, on average, an increase in crop yields and a reduction in the use of hired labor and tradable inputs. However, there are some differences across the three crops.

Table 5 shows that the profit maximizing (efficient) maize producers produce about 20 percent more output per hectare (yield) while spending nearly 30 percent less in tradable inputs and domestic factors as compared with an observed average maize producer. The DEA analysis for maize also suggests that achieving profit efficiency involves, on average, significant reduction in

[2] USD 1 = GHC 1.42 in June 2011.

the use of hired (wage) labor, fertilizer, and agrochemicals. However, there is virtually no difference in the use of capital when moving from average to efficient productive plans.

Likewise, Table 6 indicates that rice yields per hectare are higher by 17 percent for efficient rice farmers. There is no significant difference in total costs per hectare of sown area between profit-efficient and average farmers. Again, achieving profit efficiency in rice production generally involves significant reductions in the use of hired labor, capital, fertilizer, and contracted services. Conversely, the use of family labor doubles when moving from observed average to efficient rice production. This suggests that efficient rice farmers mainly depend on family labor and use very little hired labor.

Finally, Table 7 shows that profit-maximizing soybean farmers produce nearly 70 percent more output per hectare than the average farmer. However, the total costs per hectare of sown area for the profit-efficient soybean farmers is almost 20 percent lower than an average farmer's total costs per hectare. The results also suggest that reaching profit efficiency involves, on average, a significant reduction in the use of contracted services. In addition, efficient soybean farmers achieve significantly higher yields per hectare while considerably reducing the use of hired labor, fertilizer, and capital.

Computation of the PAM matrices for average and profit-efficient farmers

We have constructed the PAM matrices for maize, rice, and soybean using two alternative profit functions. In the first, we included family labor in the domestic cost factor. In the second alternative, we excluded family labor from the domestic cost factor, effectively including it in the profit. In this case, we assume that net farm profit is the return to family labor and management. This can be considered an operating profit for farm households.

The PAM matrices were initially constructed on the basis of average outputs and costs for maize, rice, and soybean producers as observed in the data. Output prices and unit costs of tradable inputs and domestic cost factors, corresponding to the private profitability row of the matrix, were also derived from the survey data. Calculations of social prices use respective international prices (CIF prices for imports) as efficiency benchmarks following standard practices in the literature (Monke and Pearson 1989; Pearson, Gotsch, and Bahri 2003). Following Winter-Nelson and Aggrey-Finn (2008), we used expert information, past studies, post-farm costs from the Ministry of Food and Agriculture and data on import duties and fees from the Ministry of Trade and Industry to calculate social prices for maize, rice, and soybean. The social prices, calculated in Table 8, are the import prices of the respective crop adjusted for divergences due to import duties and fees, transportation and processing costs, post-harvest losses, and quality differences between imported and domestic crops. Maize, rice, and soybean imports into Ghana are subject to the following duties and fees (USDA 2011 and official sources):

- Import duty – 20 percent (10 percent for soybean)
- Value added tax (VAT) – 12.5 percent
- National Health Insurance Levy to be collected by the VAT Secretariat – 2.5 percent
- Export Development Fund levy – 0.5 percent
- ECOWAS levy – 0.5 percent
- Inspection fee – 1 percent
- Ghana Customs Network fee – 0.4 percent.

It is worth noting that the import duty, Export Development Fund levy, ECOWAS levy, and inspection fee are calculated on the CIF price, while the VAT and National Health Insurance Levy are calculated after adjusting the CIF price for import duty. In addition, we adjusted prices for real exchange overvaluation. Our analysis indicates that the real exchange rate of Ghana's national currency is slightly (2 percent) overvalued (IMF 2008, Bank of Ghana 2012).

The analysis was completed by incorporating government support mechanisms for maize, rice, and soybean, which alter the social profitability of these crops. The government of Ghana runs a fertilizer subsidy program on the assumption that the subsidy will make fertilizer more affordable to smallholder farmers, thereby increasing fertilizer access and application rates, which will ultimately increase crop yields. The goal of the fertilizer subsidy program is to increase the national average rate of fertilizer use from 8 kg per hectare to 20 kg per hectare. The program was initially introduced in 2008 in the form of vouchers with a 50 percent subsidy (Banful 2009). The program is currently implemented in the form of a waybill system by subsidizing the fertilizer at the entry port and making the subsidy available to all types of farmers that can afford the subsidized price. The current subsidy rate is estimated at about 35 percent (Benin et al. 2012). Thus, we used a fertilizer subsidy rate from 30-50 percent in the calculations of the social profitability of maize, rice, and soybean. Finally, we assumed social costs of labor and land to be equal to their private costs. The analytical price calculations were comparable to reported market prices. Figure 1 shows the trend of recent monthly market prices.

Further, computing profit maximizing production plans using DEA allows us to construct virtual representative producers of maize, rice, and soybean that are labeled efficient. The efficient farmers obtain higher revenues than the average observed farmers, because their yields per hectare are increased by about 20 percent, 17 percent, and 70 percent for maize, rice, and soybean, respectively. The efficient maize farmers also have lower costs than the respective average farmer in the sample, because they manage their inputs more efficiently. The main savings come from a 30 percent reduction in labor costs. Similarly, the efficient soybean farmers also have lower costs than the average farmer in the sample. However, the main savings here come from a 48 percent reduction in the costs of contracted services. It is important to note that we do not observe a considerable reduction in the efficient rice farmers' costs. But our data indicate that efficient rice farmers use more family labor and less hired labor and tradable inputs. In general, the efficient farmers for all three crop types depend more on family labor than hired labor, but this phenomenon is more evident in efficient rice farmers. One explanation for this observation is that substituting hired labor with family labor allows for a more efficient use of the workforce and saves in management and agency costs. Overall, revenue increases and reduced costs result in a much stronger financial situation for efficient maize, rice, and soybean farmers.

The obtained revenue and cost figures of the efficient maize, rice, and soybean farmers are used to build crop-specific PAM matrices. The respective cells of these new PAMs have been computed by using the same price and cost adjustments and decomposition into tradable and non-tradable (domestic factors) intermediate inputs as in the construction of the conventional PAMs.

The private and social profitability of maize, rice, and soybean farming computed under observed average productive plans are shown in Tables 9 to 11 (Panels A), respectively. Similarly, the private and social profitability of maize, rice, and soybean farming computed under production plans that maximize profits are shown in Tables 9 to 11 (Panels B), respectively.

As mentioned earlier, we have constructed the PAM matrices for maize, rice, and soybean using two alternative profit functions – with and without family labor included in the domestic cost factor. Tables 9 to 11 include all labor in the domestic cost factor. In contrast, the private and social profitability of maize, rice, and soybean production computed under observed average (Panels A) and profit-efficient (Panels B) productive plans with a profit function that excludes family labor from the domestic cost factor are shown in Tables 12 to 14, respectively.

Main results

The first finding comes from the conventional PAM analysis for maize with a profit function that includes family labor in domestic cost factor. This 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 show 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 labor from domestic cost factor and effectively assumes that the net operating profit of the farm is the return to family labor and management shows that maize farming is profitable for both observed average and profit-efficient farmers in both private and social prices.

The computation of PCR and DCR for maize farming illustrates the basic weaknesses and strengths of this farming system (Table 15). First, the remuneration of the domestic cost factors per hectare exceeds the value added per hectare by 34 percent when computed at social prices with a profit function that includes family labor in domestic cost factor. Nevertheless, in all other cases both the PCR and the DCR remain significantly below one, pointing to the ability of the maize farming system to create value for the growers 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 20 percent for observed average and profit-efficient maize farmers, respectively.

Turning to rice farming, the conventional PAM analysis with a profit function that includes family labor in domestic cost factor shows that rice farming is not profitable for the observed average farm both in private and social prices. Moreover, the results from the PAM analysis with profit-efficient data show that rice farming is profitable under production plans that maximize profits in private prices, but is not profitable in social prices. Moreover, PAM analysis for rice farming with a profit function that excludes family labor 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 computation of PCR and DCR for rice farming suggests that the rice farming system is not able to add to the national income at social prices when family labor is included in the domestic cost factor (Table 16). For example, the remuneration of the domestic cost factors per hectare for the observed average farmer exceeds the value added per hectare by 20 percent, when computed at private prices, and by 63 percent when computed at social prices. Likewise, the remuneration of the domestic cost factors per hectare exceeds the value added per hectare by 20 percent when computed at social prices even for profit-efficient rice farmers. However, if we exclude family labor from the domestic cost factor, both the PCR and the DCR become significantly less than one, pointing to the competitiveness of the rice farming system to create value for the growers 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 average and profit-efficient rice farmers, respectively.

Finally, conventional PAM analysis for soybean production with a profit function that includes family labor in domestic cost factor shows that soybean farming is not profitable for both observed average and profit-efficient farms 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 is not profitable in social prices. Further, PAM analysis for soybean production with a profit function that excludes family labor 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.

The computations of the PCR and DCR explain the basic weaknesses and strengths of soybean farming under observed average production plans (Table 17). The compensation of the domestic factors per hectare exceeds the value added per hectare by 5 percent, when computed 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 conditions. Further, if we assume that net operating profit is a return to family labor, 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 15 percent to Ghanaian soybean producers mainly through taxes and subsidies.

Conclusions and policy implications

This paper carried out a modeling exercise on the private and social profitability of the maize, rice, and soybean farming systems in Ghana. In doing so, two analytical methods, namely, the policy analysis matrix and efficiency analysis based on data envelopment analysis were combined. This allowed us to generate average and profit-efficient productive plans for each crop farming system. Further, we considered two alternative profit functions. In the first alternative, we included family labor in the domestic cost factor. In the second alternative, we excluded family labor from the cost, effectively including it in the net farm profit and assuming it as a return to family labor.

Our findings suggest that the maize farming system is mainly profitable under both average and profit-efficient production plans. This conclusion holds under both alternative profit functions. The conventional PAM results suggest that the soybean farming system is not viable under the observed average production plan. However, soybean production becomes profitable under production plans that maximize profit. Further, the rice farming system is mainly not profitable if we include family labor in domestic cost factor. Thus, one may argue that, in the long run, the survival of Ghana's rice farming system is clearly compromised because of its lack of international competitiveness.

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

With regard to the argument that, contrary to our assumption, farmers may be maximizing output instead of profit, the findings above show that the methodology used in this study is not contradicted by the alternative assumption. Profit maximization implicitly assumes output maximization for the available combination of inputs. Further, considering that subsistence oriented farmers are resource constrained, those farmers would employ more family labor, which is a flexible resource (as opposed to tradable inputs). Our findings show that profit-efficient farmers produce significantly more output per hectare (20, 17, and 69 percent more per hectare for maize, rice, and soybean, respectively – see Tables 5 to 7) and they employ significantly more family labor than hired labor. This lends further credibility to the assumption of profit maximization. Finally, the study aims to establish the profitability and competitiveness of farming maize, rice, and soybean, so an objective function based on profit maximization is appropriate.

The findings of the study have some important policy implications. First, policies based on dissemination of best practices could improve overall efficiency of maize, rice, and soybean farming systems in Ghana. 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 GHC 300 per hectare. The main question here, however, is to identify 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-efficient farmers compared with the observed average farmers.

Table 2. Sample description: maize

Variable	Units	Quantities		Price
		Mean	SD	(GHC per unit)
Output	kg	3,400.8	3745.1	0.39
Cultivated land	ha	2.36	3.04	***
Total labor	GHC	515.4	943.9	***
Capital	GHC	29.1	30.6	***
Seeds	GHC	21.8	49.1	0.56
Fertilizer	GHC	325.3	367.7	***
Agrochemicals	GHC	55.4	81.5	6.42[a]
Contracted services	GHC	341.7	471.9	***

Source: IFPRI 2011.
[a] Price per 1 liter bottle of herbicides

Table 3. Sample description: rice

Variable	Units	Quantities		Price
		Mean	SD	(GHC per unit)
Output	kg	2630.1	2966.1	0.40
Cultivated land	Ha	1.46	2.41	***
Total labor	GHC	592.9	516.6	***
Capital	GHC	33.8	48.0	***
Seeds	GHC	41.3	60.1	0.56
Fertilizer	GHC	216.3	385.9	***
Agrochemicals	GHC	56.4	122.1	6.67[a]
Contracted services	GHC	284.2	523.4	***

Source: IFPRI 2011.
[a] Price per 1 liter bottle of herbicides

Table 4. Sample description: soybean

Variable	Units	Quantities		Price
		Mean	SD	(GHC per unit)
Output	kg	1628.3	2863.2	0.50
Cultivated land	Ha	1.44	2.88	***
Total labor	GHC	394.7	597.1	***
Capital	GHC	29.6	51.8	***
Seeds	GHC	42.1	106.8	0.69
Fertilizer	GHC	56.2	275.1	***
Agrochemicals	GHC	34.0	86.0	6.98[a]
Contracted services	GHC	150.6	284.9	***

Source: IFPRI 2011.
[a] Price per 1 liter bottle of herbicides

Table 5. Observed average and production plans for maize (averages per hectare)

Variable	Units	Average	Profit-maximizing	Variations (%)
Output	kg	1614.6	1939.5	20.1
Inputs				
Labor	GHC	254.4	179.4	-29.5
Family labor	GHC	165.0	137.5	-16.7
Hired labor	GHC	89.4	41.9	-53.1
Capital	GHC	25.0	24.5	-2.0
Seeds	GHC	10.7	9.3	-13.1
Fertilizer	GHC	126.8	57.4	-54.7
Agrochemicals	GHC	28.9	16.5	-42.9
Contracted services	GHC	161.0	145.2	-9.8

Source: Authors' computations based on IFPRI 2011.

Table 6. Observed average and profit-maximizing production plans for rice (averages per hectare)

Variable	Units	Average	Profit-maximizing	Variations (%)
Output	Kg	2278.5	2656.4	16.6
Inputs				
Labor	GHC	659.3	831.8	26.2
Family labor	GHC	376.3	772.0	105.2
Hired labor	GHC	282.9	59.8	-78.9
Capital	GHC	27.1	14.8	-45.4
Seeds	GHC	32.3	23.2	-28.2
Fertilizer	GHC	113.2	10.6	-90.6
Agrochemicals	GHC	42.1	34.8	-17.3
Contracted services	GHC	185.6	127.1	-31.5

Source: Authors' computations based on IFPRI 2011.

Table 7. Observed average and profit-maximizing production plans for soybean (averages per hectare)

Variable	Units	Average	Profit-maximizing	Variations
Output	Kg	1109.4	1874.5	69.
Inputs				
	GHC	363.2	318.2	-12.4
Labor	GHC	253.6	237.2	-6.5
	GHC	109.6	81.0	-26.1
Capital	GHC	25.3	19.3	-23.7
Seeds	GHC	26.2	30.1	14.9
Fertilizer	GHC	27.5	20.0	-27.3
Agrochemicals	GHC	22.3	19.6	-12.1
Contracted services	GHC	113.4	59.1	-47.9

Source: Authors' computations based on IFPRI 2011.

Table 8. Price calculations

	Private prices			Social prices		
	Maize	Rice	Soybean	Maize	Rice	Soybean
CIF Price Accra, US$/MT	**407**	**560**	**406**	**407**	**560**	**406**
Exchange rate	1.42	1.42	1.42	1.45	1.45	1.45
CIF Price Accra, GHC/MT	**577.9**	**795.2**	**576.5**	**590.2**	**812.0**	**588.7**
Import duty	115.6	159.0	57.7	0.0	0.0	0.0
ECOWAS levy	2.9	4.0	2.9	0.0	0.0	0.0
EDFL	2.9	4.0	2.9	0.0	0.0	0.0
Processing fee	5.8	8.0	5.8	5.9	8.1	5.9
Cost before VAT & NHIL (CIF+Import duty)	**693.5**	**954.2**	**634.2**	**596.1**	**820.1**	**588.7**
VAT	86.7	119.3	79.3	0.0	0.0	0.0
NHIL	17.3	23.9	15.9	14.9	20.5	14.7
CIF+duty+tax+fees	**809.1**	**1113.3**	**740.8**	**616.9**	**848.7**	**609.3**
Port fees and charges[a]	238.8	328.6	238.2	243.9	335.5	243.3
Cost landed into storage in Accra	**1047.9**	**1441.9**	**979.0**	**860.7**	**1184.3**	**852.6**
Haulage to shared market	130.0	130.0	130.0	130.0	130.0	130.0
Cost in shared market	**1177.9**	**1571.9**	**1109.0**	**990.7**	**1314.3**	**982.6**
Haulage to production zone	170.0	170.0	170.0	170.0	170.0	170.0
Value in production zone (import quality)	**1007.9**	**1401.9**	**939.0**	**820.7**	**1144.3**	**812.6**
Quality adjustment	453.6	841.1	281.7	369.3	686.6	243.8
Value in production zone (local quality)	**554.4**	**560.7**	**657.3**	**451.4**	**457.7**	**568.8**
Haulage to farm	120.0	120	120.0	120.0	120	120.0
Farm-gate price (calculated)	**434.4**	**440.7**	**537.3**	**331.4**	**337.7**	**448.8**
Reported price	390.0	400.0	500.0	---	---	---

Source: Authors' calculations.
[a] Includes inspection fees, service charges, and fees to the Ghana Shippers Council

Table 9. PAM for maize: including family labor in domestic cost factor

Panel A. PAM under observed productive plans: Maize (GHC/ha)								
		Costs						
		Tradable inputs			**Domestic factors**			
	Revenue	**Seed**	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	**Profits**
Private value	629.7	10.7	126.8	28.9	254.4	25	161	22.9
Social value	537.5	10.9	167.4	29.5	254.4	25	161	-110.7
Transfers	92.2	-0.2	-40.6	-0.6	0.0	0.0	0.0	133.6

Panel B. PAM under profit-efficient productive plans: Maize (GHC/ha)								
		Costs						
		Tradable inputs			**Domestic factors**			
	Revenue	**Seed**	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	**Profits**
Private value	756.4	9.3	57.4	16.5	179.4	24.5	145.2	324.1
Social value	645.7	9.5	75.8	16.8	179.4	24.5	145.2	194.5
Transfers	110.7	-0.2	-18.4	-0.3	0.0	0.0	0.0	129.6

Source: Authors' computations based on IFPRI 2011.

Table 10. PAM for rice: including family labor in domestic cost factor

Panel A. PAM under observed productive plans: Rice (GHC/ha)								
	Revenue	Costs						Profits
		Tradable inputs			Domestic factors			
		Seed	Fertilizer	Chemicals	Labor	Capital	Services	
Private value	911.4	32.3	113.2	42.1	659.3	27.1	185.6	-148.2
Social value	759.2	32.9	149.4	42.9	659.3	27.1	185.6	-338.1
Transfers	152.2	-0.6	-36.2	-0.8	0.0	0.0	0.0	189.9
Panel B. PAM under profit-efficient productive plans: Rice (GHC/ha)								
	Revenue	Costs						Profits
		Tradable inputs			Domestic factors			
		Seed	Fertilizer	Chemicals	Labor	Capital	Services	
Private value	1062.6	23.2	10.6	34.8	831.8	14.8	127.1	20.3
Social value	885.1	23.7	14.0	35.5	831.8	14.8	127.1	-161.7
Transfers	177.4	-0.5	-3.4	-0.7	0.0	0.0	0.0	182.0

Source: Authors' computations based on IFPRI 2011.

Table 11. PAM for soybean: including family labor in domestic cost factor

Panel A. PAM matrix under observed productive plans: Soybean (GHC/ha)								
		Costs						
		Tradable inputs			Domestic factors			
	Revenue	Seed	Fertilizer	Chemicals	Labor	Capital	Services	Profits
Private value	554.7	26.2	27.5	22.3	363.2	25.3	113.4	-23.2
Social value	492.1	26.7	36.3	22.7	363.2	25.3	113.4	-95.5
Transfers	62.6	-0.5	-8.8	-0.4	0.0	0.0	0.0	72.3
Panel B. PAM under profit-efficient productive plans: Soybean (GHC/ha)								
		Costs						
		Tradable inputs			Domestic factors			
	Revenue	Seed	Fertilizer	Chemicals	Labor	Capital	Services	Profits
Private value	937.3	30.1	20	19.6	318.2	19.3	59.1	471.0
Social value	831.5	30.7	26.4	20.0	318.2	19.3	59.1	357.8
Transfers	105.7	-0.6	-6.4	-0.4	0.0	0.0	0.0	113.1

Source: Authors' computations based on IFPRI, 2011.

Table 12. PAM for maize: excluding family labor from domestic cost factor

Panel A. PAM under observed productive plans: Maize (GHC/ha)								
		Costs						
		Tradable inputs			Domestic factors			
	Revenue	Seed	Fertilizer	Chemicals	Labor	Capital	Services	Profits
Private value	629.7	10.7	126.8	28.9	89.4	25	161	187.9
Social value	537.5	10.9	167.4	29.5	89.4	25	161	54.3
Transfers	92.2	-0.2	-40.6	-0.6	0.0	0.0	0.0	133.6
Panel B. PAM under profit-efficient productive plans: Maize (GHC/ha)								
		Costs						
		Tradable inputs			Domestic factors			
	Revenue	Seed	Fertilizer	Chemicals	Labor	Capital	Services	Profits
Private value	756.4	9.3	57.4	16.5	41.9	24.5	145.2	461.6
Social value	645.7	9.5	75.8	16.8	41.9	24.5	145.2	332.0
Transfers	110.7	-0.2	-18.4	-0.3	0.0	0.0	0.0	129.6

Source: Authors' computations based on IFPRI, 2011.

Table 13. PAM for rice: excluding family labor from domestic cost factor

Panel A. PAM under observed productive plans: Rice (GHC/ha)								
	Revenue	**Costs**						**Profits**
		Tradable inputs			**Domestic factors**			
		Seed	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	
Private value	911.4	32.3	113.2	42.1	282.9	27.1	185.6	228.2
Social value	759.2	32.9	149.4	42.9	282.9	27.1	185.6	38.3
Transfers	152.2	-0.6	-36.2	-0.8	0.0	0.0	0.0	189.9
Panel B. PAM under profit-efficient productive plans: Rice (GHC/ha)								
	Revenue	**Costs**						**Profits**
		Tradable inputs			**Domestic factors**			
		Seed	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	
Private value	1062.6	23.2	10.6	34.8	59.8	14.8	127.1	792.3
Social value	885.1	23.7	14.0	35.5	59.8	14.8	127.1	610.3
Transfers	177.4	-0.5	-3.4	-0.7	0.0	0.0	0.0	182.0

Source: Authors' computations based on IFPRI 2011.

Table 14. PAM for soybean: excluding family labor from domestic cost factor

Panel A. PAM under observed productive plans: Soybean (GHC/ha)								
	Revenue	**Costs**						**Profits**
		Tradable inputs			**Domestic factors**			
		Seed	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	
Private value	554.7	26.2	27.5	22.3	109.6	25.3	113.4	230.4
Social value	492.1	26.7	36.3	22.7	109.6	25.3	113.4	158.1
Transfers	62.6	-0.5	-8.8	-0.4	0.0	0.0	0.0	72.3
Panel B. PAM under profit-efficient productive plans: Soybean (GHC/ha)								
	Revenue	**Costs**						**Profits**
		Tradable inputs			**Domestic factors**			
		Seed	**Fertilizer**	**Chemicals**	**Labor**	**Capital**	**Services**	
Private value	937.3	30.1	20	19.6	81	19.3	59.1	708.2
Social value	831.5	30.7	26.4	20.0	81	19.3	59.1	595.0
Transfers	105.7	-0.6	-6.4	-0.4	0.0	0.0	0.0	113.1

Source: Authors' computations based on IFPRI 2011.

Table 15. Private and social profitability indicators for maize

Indicator	Including family labor in domestic cost factor		Excluding family labor in domestic cost factor	
	PAM on observed data	PAM on profit-efficient data	PAM on observed data	PAM on profit-efficient data
Private cost ratio	0.95	0.52	0.59	0.31
Domestic cost ratio	1.34	0.64	0.84	0.39
Subsidy ratio to producers	0.25	0.20	0.25	0.20

Source: Authors' computations based on IFPRI 2011.

Table 16. Private and social profitability indicators for rice

Indicator	Including family labor in domestic cost factor		Excluding family labor from domestic cost factor	
	PAM on observed data	PAM on profit-efficient data	PAM on observed data	PAM on profit-efficient data
Private cost ratio	1.20	0.98	0.68	0.20
Domestic cost ratio	1.63	1.20	0.93	0.25
Subsidy ratio to producers	0.25	0.21	0.25	0.21

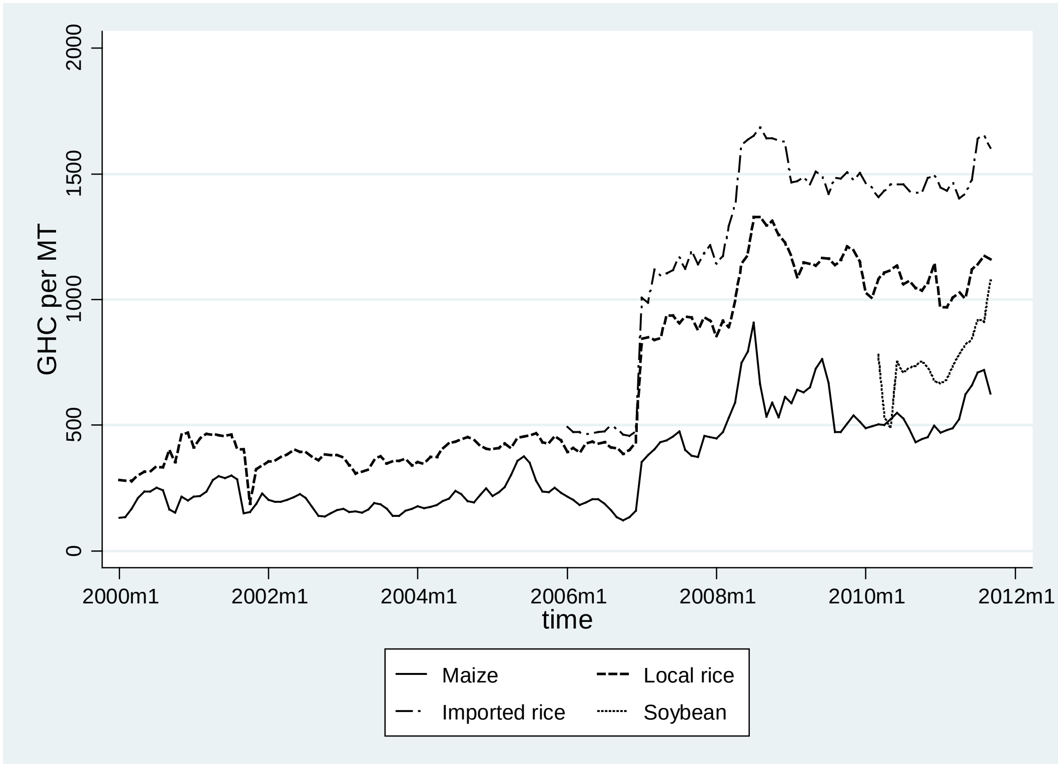
Source: Authors' computations based on IFPRI 2011.

Table 17. Private and social profitability indicators for soybean

Indicator	Including family labor in domestic cost factor		Excluding family labor from domestic cost factor	
	PAM on observed data	PAM on profit-efficient data	PAM on observed data	PAM on profit-efficient data
Private cost ratio	1.05	0.46	0.52	0.18
Domestic cost ratio	1.24	0.53	0.61	0.21
Subsidy ratio to producers	0.15	0.14	0.15	0.14

Source: Authors' computations based on IFPRI 2011.

Figure 1. Monthly wholesale prices of maize, rice, and soybean in Ghana (2000–2011)



Source: Authors' calculations using official data.

Note: Soybean is a relatively new crop in Ghana and only available data are graphed above.

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