Essays on Energy Demand and Efficiency Analysis

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Abstract

This thesis consists of four papers focusing on the issues of energy demand and efficiency analysis in the agricultural and environmental sectors. The first paper examined the long-run relationship among rainfall distribution, electricity consumption and economic growth (GDP) in Ethiopia using time series data between 1981 and 2014. Results indicated the existence of unidirectional Granger causality from rainfall to real GDP, and bidirectional Granger causality between capital stock and real GDP. There was also evidence of unidirectional Granger causality from real GDP to electricity consumption but not *vice versa*. The second paper estimated national and regional-level gasoline and diesel demand elasticities in Sweden using county-level panel data for the period 2001-2015. National-level elasticity estimates from a partial adjustment model indicated that *per capita* income, own and substitute prices, and *per capita* vehicle stocks were statistically significant in determining gasoline demand, and *per capita* income and own price were statistically significant in diesel demand case. Furthermore, regional elasticity estimates were computed from the national estimates, revealing a variation between counties, with the highest being approximately 40% greater than the lowest in absolute terms. The third paper evaluated cost efficiency associated with hydropower-related biodiversity restoration projects in Sweden based on a survey data from 245 projects. The results provided evidence of cost inefficiency with an average efficiency score of 55%, suggesting the potential to minimise cost efficiency loss by up to 45%. Factors such as project duration, project owner and restoration measure type were statistically significant determinants of cost inefficiency score. The fourth paper estimated farmers' level of technical efficiency score and examined its connection with commercialisation using a survey data in rural Ethiopia. Estimates from the stochastic frontier production function showed that farmers had a mean technical efficiency score of 51%. The variables related to educational level and radio and mobile telephone access were positively linked to farmers' technical efficiency. Furthermore, farmers with a higher level of commercialisation were technically more efficient than those with lower market participation.

Keywords: Rainfall, electricity consumption, economic growth, fuel demand, elasticity, technical efficiency, stochastic frontier, biodiversity restoration, Ethiopia, Sweden.

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Dedication

To my beloved father and mother, Tafesse Tirkaso (*Tafe*)
and Bizunesh Chamiso (*Anaye*)

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I Tirkaso, W.T. (2018). Dynamics of rainfall, electricity consumption and economic growth in Ethiopia. (manuscript).

II Tirkaso, W.T. (2018). Gasoline and diesel demand elasticities in Sweden (manuscript).

III Tirkaso, W.T. and Gren, I-M. (2018). Evaluation of cost efficiency in hydropower-related biodiversity restoration projects in Sweden: A stochastic frontier approach (Manuscript).

IV Tirkaso, W.T. and Hess, S*. (2018). Does commercialisation drive technical efficiency improvements in Ethiopian subsistence agriculture? African Journal of Agricultural and Resource Economics, 13(1), pp. 44-57

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1 Introduction

This thesis consists of four (4) research papers dealing with energy demand and efficiency analysis in the agricultural and environmental sectors. The first paper on energy demand investigated the long-term relationship between electricity consumption and economic growth by considering the potential effects of rainfall distribution. The second paper estimated national and regional-level gasoline and diesel demand elasticities in Sweden and examined their implications for the distributional impact of fuel taxes across regions. The third paper evaluated the level of cost efficiency linked to hydropower related biodiversity restoration projects in Sweden and identified the determinants of cost inefficiency. The final paper estimated farmers' technical efficiency level in Ethiopia and examined its connection with commercialisation level. Overall, the content of the thesis covers the context of developed and developing countries in Sweden and Ethiopia respectively.

The long-term relationship between electricity consumption and economic growth has been widely examined (*e.g.*, Kraft and Kraft, 1978; Asafu-Adjaye, 2000; Wolde-Rufdael 2006; Solarin, 2013). However, most of these studies do not consider the potential impact of rainfall distribution in their modelling, given that rainfall has a potential effect on electricity generation and economic performance, primarily in developing counties. This study examined the long-run relationship between rainfall distribution, electricity consumption and economic growth. Its contribution is to show that consideration of rainfall distribution when examining the nexus between electricity consumption and economic growth is vital, mainly in developing countries such as Ethiopia.

With respect to fuel demand, studies show that gasoline and diesel consumption accounts for 35% of total CO_2 emissions in OECD countries alone (IEA, 2017). In connection, various climate policy instruments, such as fuel taxes, have been recommended in order to reduce emissions from the transport sector. Therefore, the second paper estimated gasoline and diesel demand elasticities at a national and regional level in Sweden and examined their impact on the design of fuel taxes. The main contribution of this study was to estimate reliable gasoline and diesel demand elasticities in Sweden, and calculate the corresponding regional level elasticities considering the relative variation in each fuel type's share in the total fuel consumption at a national and regional level. Furthermore, results from the study offer a contribution to policy by examining the implications of adopting elasticities on a national and regional level in order to achieve emission reduction targets in the transport sector.

Applications of stochastic frontier analysis (SFA) have become popular in measuring performances in production economics (Aigner *et al.*, 1977; Battese and Corra, 1977; Meeusen and van Den Broeck, 1977; Førsund *et al.*, 1980; Schmidt and Lin, 1984; Greene, 2008). In this regard, the third paper evaluated whether costs associated with hydropower-related biodiversity restoration measures were technically efficient. This study employed the so-called frontier eco-efficiency (FEE) model, which relates the costs of different measures to their corresponding ecological effect (see Robaina-Alves *et al.*, 2015). The main contribution of this study is the application of the FEE model to evaluate the cost efficiency of hydropower related biodiversity restoration projects, hence providing policy-relevant information for the cost-effective implementation of such projects. The fourth paper estimated the technical efficiency level of smallholder farmers in Ethiopia and identified the potential causal relationship between technical efficiency and commercialisation. Applying more reliable empirical strategy, this study mainly contributed to literature by investigating the causal relationship between farmers level of technical efficiency and commercialization in the context of predominantly subsistence agriculture.

Overall, the papers included in this thesis cover topics related to energy demand and efficiency analysis in the environmental and agricultural sectors, with each paper attempting to address core issues in the corresponding thematic areas. Furthermore, the studies also provided empirical evidence that could be relevant for sustainable agricultural development and environmental protection policies. A brief summary of each paper is presented in the subsequent section.

2 Summary of papers

2.1 Paper I: Dynamics of rainfall, electricity consumption and economic growth in Ethiopia

There have been a large number of studies examining the relationship between economic growth and electricity consumption (Kraft and Kraft, 1978; Asafu-Adjaye, 2000; Wolde-Rufdael 2006; Solarin, 2013). However, most of these studies do not consider rainfall in their modelling despite the evidence that fluctuations in rainfall have a significant effect on economic performance and electricity generation, particularly in developing countries context (Muñoz and Sailor, 1998; Sharma and Shakya, 2006; Miguel and Satyanath, 2010; Barrios *et al.*, 2010; Yamba *et al.*, 2011; Wagena *et al.*, 2016). Such interdependence implies that the dynamics of economic performance and electric power consumption are subject to the long term rainfall distribution.

This study examined the long-term relationship among rainfall distribution, electricity consumption and economic growth in Ethiopia. The empirical framework was based on the augmented Cobb-Douglas production function at aggregate level, which explicitly includes labour force, capital stock *i.e.* gross fixed capital formation, electricity consumption and rainfall as separate inputs. Inclusion of electricity consumption as an additional input was justified by the growing contradictory view on the neutrality hypothesis that energy use is expected to be a limiting factor to economic growth when energy costs constitute a substantial proportion of GDP, *i.e.* a high level of energy intensity (Stern, 2000; Ghali and El-Sakka, 2004). In this regard, there is evidence that greater electricity intensity has commonly been observed in most low-income countries (Sun, 2003; Sadorsky, 2013). The inclusion of rainfall in the production framework is due to its detrimental effect on aggregate output if the economy is highly dependent on rainfall (Sharma and Shakya, 2006; Ali, 2012; Robinson *et al.*, 2012). Furthermore, the level of investment in an economy could also be affected by rainfall that unfavourable rainfall distribution could results in a reduction of capital stock, lower GDP, and in most cases, a reduction in consumption *per capita* in the long run (Fankhauser and Tol, 2005).

In light of this, bounds testing for cointegration developed by Pesaran *et al.* (2001) and the Toda Yamamoto (TY) non-Granger causality test (Toda and Yamamoto, 1995) were applied. The bounds testing for cointegration was chosen due to its applicability when there is a mixed order of integration in the series. Therefore, three possible cases of Granger causality tests were examined: non-Granger causality between GDP and electricity consumption, between rainfall and GDP, and between rainfall and electricity consumption. The corresponding test results have implications for energy policy choice scenarios. For example, if there is feedback from GDP to electricity consumption or no Granger causality in either direction, a policy of energy conservation should be recommended since additional power consumption will not have an incremental effect on aggregated output. Conversely, Granger causality going from electricity consumption to GDP implies a positive multiplier effect on GDP, and thus a policy directed at increasing electric power capacity to match consumption should be suggested. In the case of bidirectional Granger causality, both electric power conservation and energy infrastructure expansion policies could be recommended. These policy options have been widely explored in previous empirical works (*e.g.* Asafu-Adjaye, 2000; Odhiambo, 2009; Adom, 2011; Solarin, 2011).

In the analysis, this paper used annual data on GDP (billion constant 2010 US$), electricity consumption (billion kWh), mean annual rainfall (mm), aggregate capital stock denoted by gross fixed capital formation (billion constant 2010 US$) and the number of people in the active labour force (million) in Ethiopia in the period 1981-2014. Real GDP, electricity consumption and total number of labour force (population between ages 15-64) were obtained from the World Bank Development Indicators (WDI) (World Bank, 2015), data on aggregate capital stock was taken from EconStats, WDI and Ethiopia’s Ministry of Finance and Economic Development (MoFED) (EconStats, 2016, MoFED, 2011, World Bank, 2015), and the distribution of mean annual rainfall in Ethiopia was taken from the United Nations Development Programme’s (UNDP) constructed dataset (McSweeney *et al.*, 2010).

The study’s results confirmed the existence of a long-run relationship among rainfall, electricity consumption and GDP. Specifically, there was evidence of unidirectional Granger causality from rainfall to real GDP, suggesting the presence of a long-run linkage between rainfall and aggregate output. Such a finding indicates the economy's reliance on rain-fed agriculture where unfavourable rainfall could have an adverse effect. Furthermore, there is an evidence of long-run Granger causality from GDP to capital stock in Ethiopia. Unlike most developed countries where capital accumulation is considered an engine for GDP growth (*e.g.* see Bond *et al*., 2010; Swan, 1956; Barro *et al*., 1992; Lucas, 1993; Romer, 1994), this study found that growth in GDP leads to long-run capital accumulation in Ethiopia. This could be linked the case that fast GDP growth creates high profit expectations, which then encourages business owners to invest more in the economy (e.g. see Uneze, 2013).

The result of a unidirectional Granger causality from real GDP to electricity consumption implies that growth in GDP creates electricity demand in Ethiopia. With regard to policy options, the evidence of unidirectional Granger causality from GDP to electricity consumption suggests an electric power conservation policy scenario in Ethiopia. However, given that only 43% of the total population have access to electricity (see, World Bank, 2016), a policy of electricity conservation cannot be recommended since the growing energy-intensive industrial sector and urbanisation, coupled with the government's rural electrification programme, could trigger greater electric power demand. Therefore, the government should speed up electric power coverage in the country by increasing its power-generation capacity and making the sector more efficient.

2.2 Paper II: Gasoline and diesel demand elasticities in Sweden

Gasoline and diesel consumption account for 35% of the total CO_2 emissions in OECD countries alone (IEA, 2017). In connection, a fuel tax has been recommended as an effective policy instrument to reduce the corresponding emissions level. Generally, such policy instrument has been well regarded as cost effective to achieve certain emission reduction target. Several studies have examined the incidence of fuel taxes, in particular to gasoline, based on homogenous elasticity estimates, *i.e.* estimates obtained from pooled data at the national level (Sterner, 2007; Kim *et al*., 2011; Lin and Li, 2011). Meanwhile, this approach might not be effective in achieving the desired emission reduction for a number of reasons.

First, pooled estimates may not represent cross-sectional or regional heterogeneity. For instance, the study by Wadud *et al*. (2009) demonstrates that elasticities from aggregate data are limited at capturing detailed cross-sectional heterogeneity. Second, the assumption of identical slopes for all cross-sectional units in a dynamic panel data model could overestimate the speed of adjustment parameters, while the mean effects of exogenous covariates could be underestimated (Robertson and Symons, 1992; Maddala *et al*., 1997). The implication is that a tax-based climate policy using elasticities from pooled models could be biased when regional distributional effects are of concern (Verde and Tol, 2009; Grainger and Kolstad, 2010; Jiang and Shao, 2014; Vandyck and Van Regemorter, 2014).

Therefore, the purpose of this paper was twofold: to estimate gasoline and diesel demand elasticity in Sweden both at the national and regional level, and to derive the necessary national tax to achieve a consumption or emission reduction target and associated responses at a regional level. Fixed effects and generalised method of moments (GMM) estimators were used to derive the national-level homogenous elasticity estimates. Graham and Glaister (2006) developed a framework to derive regional elasticity estimates from the national level and this method was used in the study. The regional level gasoline and diesel demand elasticities were then computed for each regions represented by the counties of Sweden. The main contribution of this study was to estimate consistent gasoline and diesel demand elasticities in Sweden and derive the corresponding regional level elasticities considering the relative variation of each fuel type's share in the total fuel consumption at a national and regional level. Generally, most of the previous studies have estimated gasoline and diesel demand elasticities for Sweden based on nationally aggregated time series data (*e.g.* Dahl, 2012; Brännlund, 2013), which may not capture the potential effect of spatial heterogeneity. In addition, the empirical results make a policy contribution by examining the implications of adopting elasticities from a national and regional level to achieve the emission reduction target in the transport sector.

To realise these objectives, this study used annual aggregated data on the quantity of gasoline and diesel consumption, real *per capita* income, gasoline and diesel prices, and *per capita* vehicle stock to estimate gasoline and diesel demand. The data covers a panel of 21 Swedish counties between the year 2001 and 2015. Furthermore, the study used data on the shares of each fuel type in the total fuel consumption at a national and regional level to compute regional level elasticity estimates following the approach given by Graham and Glaister (2006) and Crôtte *et al*. (2010). The datasets were collected from multiple sources. County-level deliveries of annual gasoline and diesel products to final consumers (1000 m^3) were obtained from the Swedish Statistical Agency (SCB, 2016), annual real prices for gasoline and diesel (SEK/litre) were collected from the Swedish Energy Agency (SEA, 2016), and county-level *per capita* income (1000 SEK) were obtained from the Swedish Statistical Agency (SCB, 2016). The nominal values were converted into real values using the 2010 consumer price index (2010 =100).

The elasticity estimates at a national level showed that *per capita* income, the price of gasoline, diesel price, and *per capita* vehicle stock had the expected sign in the gasoline demand model with a relatively higher magnitude for gasoline price in absolute term. Similarly, the included variables in the diesel demand model had the expected sign with diesel and gasoline prices having a statistically significant coefficient. The short and long-run price elasticities of gasoline were in the same order of magnitude as several other studies, but the corresponding price elasticities of diesel were in the upper range (in absolute values). The chosen method for deriving regional estimates implied that the differences could be explained by the share of regional fuel consumption of each fuel type in relation to the national shares. A relatively high regional share implies greater elasticity at the regional than the national level, and *vice versa*. The calculations showed that regional gasoline and diesel elasticities could deviate by 30% from national level.

As a member of the EU's comprehensive climate change mitigation plan, Sweden has developed long-term emission reduction targets. Among them, a 70% reduction in emissions from the transport sector by 2030 from the 2010 level is a key target. This study calculated the required price change at a national level to achieve this target, and examined the associated effects on county-level demand. The calculated differences in price elasticities implied differences in demand responses to the introduction of the price increase at a national level, with a northern county, Norrbotten, showing the lowest response and the region of the capital in Sweden, Stockholm, the highest response. A price increase would therefore have different welfare effects in the counties as measured by reductions in consumer surplus.

2.3 Paper III: Evaluation of cost efficiency in hydropower-related biodiversity restoration projects in Sweden: A stochastic frontier approach

Hydropower is a vital source of energy in Sweden, supplying nearly 61 TWh of power in 2016 alone, which corresponds to 41% of total electricity production (SEA, 2015). Despite its importance, there has been a growing criticism of power-generating hydropower dams due to their distortion of ecological conditions in the riverine landscape. For instance, streams can be entirely or partly desiccated, thereby destroying habitats and migration pathways for fish species. In this regard, approximately 2,000 water bodies in Sweden do not meet the requirement of sufficient ecological status (EU, 2000). Furthermore, fish species such as eel and salmon, which are protected under the EU Habitat Directive (Council Directive 92/43/EEC 1992), are affected by hydropower plants (HaV, 2014). Therefore restoration measures aimed at improving biodiversity, such as stabilisation of channels and improvement of riparian and in-stream habitats and water quality around hydropower plants, have been implemented in various parts of Sweden.

This study evaluated whether the costs associated with biodiversity restoration measures were technically cost-efficient in view of the desired environmental targets. In the present analysis, the so-called frontier eco-efficiency (FEE) model was used, which relates the costs of different measures to their corresponding ecological effect (see Robaina-Alves *et al.,* 2015). Accordingly, the cost frontier model was specified and estimated considering ecological output and input prices, *i.e.* wage and interest rate as factors explaining biodiversity restoration costs. For each hydropower plant, the survey data contained responses on several indices of perceived ecological effect. One was the effect on the primary target of the project, such as improvements in trout, salmon or eel, while others comprised five additional ecological effects. Two different ecological effect variables were then constructed: *Targeffect*, which only included the effect on the target for the restoration, and *Toteffect*, which added the constructed index on other effects to the index on the targeted effect. Two models were specified – *Targeffect* and *Toteffect* models – corresponding to each ecological output. Consequently, a frontier cost function associated with restoration projects was specified based on a twice-differentiable Cobb-Douglas frontier cost function (*e.g.* see Battese and Corra, 1977; Kumbhakar *et al.*, 2015). The main contribution of this study was the application of the FEE model to evaluate the cost efficiency of hydropower-related biodiversity restoration projects, hence aiding policy design for the cost-effective implementation of such projects.

To realise the study objectives, data from two main sources were used: the national database for restoration measures (CBJ, 2016) and a survey of 275 hydropower plants in Sweden (Sandin *et al.,* 2017). The official database included information on types of measures (construction of technical natural fishways, road culverts, instream and spawning area restoration, and dam removal), project timing, the principal (county board, municipality, non-governmental organizations (NGO’s), private firm or others) and cost. The projects were implemented over a 30-year period between 1985 and 2015, but all the costs were adjusted using the 2016 consumer price index. The survey by Sandin *et al*. (2017) included questions on the ecological effects of different biodiversity restoration measures. Data on costs were obtained from CBJ (2016) and included the principal's total operating costs for implementing and managing the measures. Data on the ecological effects of the projects would require measurements of ecological status before and after the implementation of the restoration project. These data are not available, and therefore the results from a survey of experts at county boards were used, which included questions on the perceived ecological impact of restoration projects (Sandin *et al*., 2017). The responses were scaled from -10 to 10, where 10 is the best achievement.

The results of the analysis produced some interesting outcomes. The null hypothesis of no cost inefficiency was rejected, suggesting the presence of cost inefficiency across all the biodiversity restoration projects studied. The *Targeffect* and *Toteffect* models produced similar results with respect to the estimated coefficients and significance level. Furthermore, the main variables of interest that represented ecological outputs *Targeffect* and *Toteffect*, were both positive and statistically significant in all specifications. The results for the determinants of cost inefficiency across projects are estimated jointly with the frontier cost function and variables representing project management by NGO's and private principals, were negative and statistically significant. This suggests that biodiversity restoration projects owned and managed by NGO's and private parties have a greater likelihood of being more cost-efficient than those projects operated by municipalities. However, the results also indicated that projects implemented by *others*, such as the Swedish Forestry Agency and the Swedish Transport Agency, had a higher probability of being cost-inefficient compared to those projects operated by municipalities. When the effect of project duration on the technical inefficiency level was taken into account, it was found that the estimates became positive and statistically significant, indicating that a lengthy project duration results in greater cost inefficiency.

The conclusion based on the results in this study was that costs associated with hydropower related biodiversity restoration in Sweden could be reduced by reallocating measures and project ownership. However, the data on ecological effects remained the subjective evaluation of experts on a Likert scale, without any instructions as to how to assess the effect. It is therefore unclear if and how differences in spatial and dynamic scales of the ecological effects between restoration measures can be considered. This highlights the need for data based measurements and assessments of ecological status at the sites before and after implementation of the restoration projects.

2.1 Paper IV: Does commercialisation drive technical efficiency improvements in Ethiopian subsistence agriculture?

The empirical relationship between commercialisation and technical efficiency has been at the heart of policy debate under various farming regimes, including commercial, semi-commercial and subsistence farming (Binswanger & Von Braun 1991; Pingali & Rosegrant 1995; Barrett 2008). Traditionally, farmers in commercial and semi-commercial regimes tend to supply surplus produce to the market with the aim of maximising profit, subject to input constraints. However, this may not be the case with subsistence farming, in which households primarily produce for their own consumption but still supply a certain proportion of their output to the market, despite their own food consumption needs not being fully met (Gebre-ab, 2006).

This paper sought to estimate a farmer's technical efficiency score and examine the potential causal relationship between commercialisation and technical efficiency, focusing on the main crop producers in Ethiopia. The analysis followed the following steps. First, a stochastic frontier production function with a one-step specification that includes the determinants of technical inefficiency was estimated. Second, factors influencing the level of commercialisation for the main crops were estimated by including the predicted technical efficiency score as one of the exogenous variables.

Given the existence of a potential reverse causal relationship between commercialisation and technical efficiency, the two-stage least squares (2SLS) regression analysis was implemented using the household head's years of schooling as an instrument for the technical efficiency score. The identifying assumption behind the instrument was that, conditioned on the exogenous distribution of educational level, a household head with more years of schooling had a greater probability of being technically efficient. Essentially, the instrument validity test shown by first stage result and weak exogeneity test statistics suggests that education affects commercialization through technical efficiency, implying that the exclusion restriction assumption is not violated. The effect of farmers' educational levels and technical efficiency has been well documented in the literature (*e.g.* Kebede 2001; Nisrane *et al.* 2011; Tirkaso, 2013).

To realise the goal, this study used the 2009 Ethiopian rural household survey data collected by the International Food Policy Research Institute (Hoddinott & Yohannes 2011). This survey compiles household characteristics, agriculture and livestock information, food consumption, health and women's activities, as well as data on community-level electricity and water, sewage and toilet facilities, health services, education, NGO activity, migration, wages, and production and marketing. Hence, the study used 540 households selected from seven villages in the sample. These villages are known for their production of agricultural crops, including wheat, teff (*Eragrostis tef*), sorghum, khat (*Catha edulis*), coffee, barley, maize and enset (*Ensete ventricosum*).

The results from the study revealed interesting outcomes. First, the stochastic frontier production function showed that farm size, fertiliser use, oxen and hoe were statistically significant in determining farm output. Importantly, the hypothesis of no technical inefficiency was rejected, confirming the existence of technical inefficiency as the statistics representing variation in inefficiency, *i.e.* σ_u became statistically significant at the 1% level. Further, the predicted efficiency score from the stochastic frontier production function showed that the farmers had a mean technical efficiency score of 51%, implying that their output could be substantially increased if improvements were made to existing input mixes. The variables related to the educational level of the household's head, mobile telephone access and level of commercialisation became statistically significant in determining a farmer's technical inefficiency score.

The estimates representing the effect of commercialisation showed that a greater degree of market participation had a significant effect in reducing technical inefficiency among farmers. Furthermore, the corresponding 2SLS regression result indicated that technical efficiency was endogenous and did not cause commercialisation. This coincided with the argument put forward by Gebre-ab (2006) that surplus production, or being productive, is not a main driver of market participation in a largely subsistence agriculture. This is due to smallholder farmers still being able to supply a certain proportion of their produce to the market with the objective of covering other household requirements (or basic needs, such as medicine).

In conclusion, this study identified the existence of technical inefficiency, and analysed the prevalence of the potential link between smallholder commercialisation and technical efficiency, with the former playing a significant role in improving the latter. Specifically, the stochastic frontier estimates indicated that increasing the level of market participation could enhance a farmer's level of technical efficiency, supporting the argument that commercialisation improves smallholders' productivity by increasing their income and thereby improving access to healthy and nutritious food (Pingali & Rosegrant 1995). This implies that any policy effort aimed at creating an efficient tie between the farm sector and the market will improve the performance of agricultural production. Thus policy measures directed at increasing the market participation rate of farmers by providing improved education, sufficient access to ICT tools such as radios and mobile telephones, improved transport infrastructure and access to transportation services will significantly contribute to improvements in agricultural productivity.

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