On the Farm Size and Returns to Productivity Relationship: Evidence from Ghana

Charles Ackah[1], Michael Tuffour[1], Francis Dompae[1] and Fred Dzanku[1]

[1]Institute of Statistical, Social and Economic Research

Abstract

The old and controversial debate on the inverse relationship found between farm size and productivity has led some authors to throw in cautions and insights for further research. There is some empirical evidence that suggest that the inverse relationship have been removed by the green revolution technology which invalidates the relative output superiority of small farms. Differences in empirical studies on the farm size-productivity relationship due to variations in crop, technology and market structures shaping agricultural systems in different countries might be expected. On this premise, this study sought to contribute a new country (Ghana) level evidence to the relationship between farm size and productivity. measured in yields and net returns. The Ghana Living Standard Survey Round 6 data, collected from a nationally representative sample of households was used. We explored for such possible explanations at both crop and aggregate levels using two main priority food security crops which are maize and rice. Informed by the popularity of the inverse relationship, the study hypothesized an inverse relationship between farm size and crop productivity at both aggregate and individual crop levels. Ordinary Least Squares (OLS) regression was used for the estimation of the relationship between farm size and returns to productivity in addition to other variables. Two main models were specified for the regression which were linear and double log functions. The study discovered that farm size is the most important variable in the IR debate and the relationship proved positive with respect to all the models, crops and regressions. The study therefore calls for three main actions. One, a review in Ghana's land use for agriculture policy, two, the use of sustained and improved technologies for agriculture and three, a review of the IR debate by considering input use intensity, credit market dynamics, and soil quality in Ghana.

Keyword: Inverse relationship, productivity, returns to productivity, Ghana

1.0 Introduction

The old and controversial debate on the inverse relationship (IR) between farm size and productivity prompted this study to investigate the relationship in Ghana. Gaurav and Mishra's (2014) revisited the debate in recent times using data from India where the debate in the modern era started with Sen (1962). Studies on this controversy persistently call for new evidence on the debate. This study in following that tradition seeks to contribute evidence from a recent nationally representative survey of households in Ghana where the status of the relationship has not been adequately investigated. Given the fact that Ghana has not yet achieved the green revolution, this study constitutes an important contribution to complement the literature on the

subject largely drawn from India and countries from other regions that achieved the green revolution. The study also adds a complementary dimension for the sub-Saharan African region where the farm size and returns to cultivation relationship is examined in some countries. These countries include Rwanda (Byiringiro & Reardon, 1996; Ali & Deininger, 2014), Malawi (Dorward, 1999; Holden & Fisher, 2013), Uganda (Carletto et al., 2011), Kenya (Muyanga & Jayne, 2014), Zambia (Kimhi, 2006) and Madagascar (Barrett et al. (2010). Results generated from the study have yielded mixed results; some which show a positive relationship on one hand and others showing a negative one. Larson (2014) hints that differences in empirical studies on the farm size and returns to cultivation relationship might be expected due to variations in crop, technology and market structures; which shapes agricultural systems in different countries.

In the history of the debate so far, explanation gaps and conflicts in the relationship include the possibility of the existence of measurement errors, sample selection bias and omitted variable bias, among others. These the study recognizes as some of the challenges in the IR debate. Notwithstanding that the study, apart from seeking to contribute to some of these gaps and conflicts as permitted by our data set, attempts a search for the type of relationship between farm size and productivity that exists in Ghana's agriculture and any new alternative explanations that may apply to the relationship in the country. We explored for possible explanations using two main priority food security crops among which two (maize and rice) are in production deficit and two (cassava and yam) in production surplus which might give some new dimensions. To the best of our knowledge, this relationship has not been examined in Ghana which will be investigated with two main staple crops. Whilst the result may not be new per se, it will contribute or add a country level dimension to the already hazy and blurred empirical evidence of the relationship in Sub Sahara Africa (SSA). Unlike in the other regions

of the developing world where the inverse relationship empirically dominates the literature, neither a negative nor a positive relationship has clearly emerged in SSA. Different dimensions of labour has been examined in the relationship but the number and gender composition of the labour used in farms have not been adequately investigated which this study seeks to contribute to.

The paper is organized in six main sections including this introductory section. In section two, the hypothesis to be addressed in the study is presented. In section three, relevant literature explaining the farm size-productivity relationships are reviewed. The methodology used in generating the data and addressing the hypothesis is presented in section four whilst section five discusses the results obtained. Section six constitutes the last section in which conclusions are drawn and policies are recommended.

2.0 Main hypothesis

The inverse farm size-productivity relationship has generated enough controversy over time leading many authors to throw in cautions and insights for further research. Deolalikar (1981) found some evidence that suggest that the inverse relationship have been removed by the green revolution technology, thus invalidating the relative output superiority of small farms. But the green revolution is scale-neutral and Africa (except Malawi) not achieving it makes an interesting proposition to further understand this dimension of the relationship in SSA. Lamb (2003) recommends the need to reexamine the inverse farm size-productivity relationship with weaker assumptions on farmer behavior (p.74). Gaurav and Mishra (2014) also recommend a detailed comparative analysis of the factors associated with the inverse relationship including exploring the relationship at crop level. Following these recommendations, the main research question this paper examines is how farm size influence crop productivity in Ghana and what factors drive the relationship? In line with the evidence on the subject of this study so far and

the popularity of the inverse relationship, this study hypothesized that there is an inverse relationship between farm size and crop productivity. Since Ghana is yet to achieve the green revolution, this hypothesis is also justified by the studies that show that the yield superiority of small farms diminishes and in fact reverses with the use of the green revolution technology.

3.0 The Farm size-productivity relationship and its explanations

Whilst the inverse relationship dominates the literature, some positive relationships also appear strongly in some empirical studies. The review of these studies highlights the geographical distribution (region and country) of empirical studies that identify the inverse relationship, the time fames in which the studies were conducted, the nature of the data set and the analytical methods used.

3.1 Summary of current food crop production performance in Ghana

Crop specific estimates in single studies have been rare, and where multiple crops are involved their productivity is often aggregated. The background of the two crops studied in this paper offer interesting prospects for interpretation. In terms of acreage cultivated, maize (18.1% of the land area classified as suitable for farming) and cassava (12.9%) are the second and third most important crops respectively (GSS, 2014). Whilst cassava production meets the nation's consumption needs, there is a maize production deficit/gap of 49 per cent (MoFA, 2013). Maize again emerged as the most important crop among the major cereals cultivated, accounting for 69.8 per cent of the land cultivated with cereals, with rice as the third crop accounting for 11.4 per cent of the total acreage under cultivation for cereals (GSS, 2014). Under root, tuber and plantain total land area under cultivation, cassava is the dominant crop with a share of 46.6 per cent of the acreage cultivated, followed by yam with 31.3 per cent (GSS, 2014). The four crops also feature among five crops identified as important to the diet of the Ghanaian population (MoFA, 2013). These four crops are therefore consistent with their tag as the food security of

the nation, emerging as leading crops both in the diet of the population and in the hectares under cultivation.

The production of some important staple food crops have been unstable but mostly in deficit for a while. Information on which farmers are recording the highest yields remains scanty especially with respect to the scale of farming which is classified into three in Ghana – small, medium and large. In recent times, the acquisition of land for livelihood activities has become more difficult for majority of the population due to rapid population growth and urbanization, resulting in competition for land especially for mining, housing, industrial development and commercial agriculture (ISSER, 2013). Ghana's land governance system has been viewed as unlikely to help the poor and vulnerable population who largely depend on the land as their source of livelihood. These developments are likely to be particularly harmful to agriculture and food crop farmers who are classified as the poorest segment of the population (GSS, 2014). The emerging land scarcities and insecurities can reduce farm sizes, induce intensification and can erode the chances of increasing productivity. The type of land entitlement of farmers, including the quantity of land smallholders have, can influence their ability and choice of parcels of lands in their plots for farming where land quality as an explanation of the inverse relationship is embedded. This relates to the choice of producing in the most fertile lands, a choice that large scale farmers are assumed to lack in accounting for the inverse relationship between farm size and productivity.

3.2 The Farm Size-Productivity Literature

The inverse relationship between farm size and productivity has generated controversy since its discovery by Sen (1962) in the pre green revolution era. Prior to Sen' study, the inverse

relationship between farm size and output was first discovered in Russian agriculture by Chayanov (1926). This relationship has continued to dominate research findings with results indicating positive relationships are comparatively sparse empirically. The emergence of the green revolution has influence the relationship in some studies conducted after its emergence.

Deolalikar (1981) found the inverse relationship using cross-sectional regional data but observed that the yield superiority of small farms diminishes and in fact reverses with the use of the green revolution technology. Making reference to the literature and informed by a prior judgment, he indicated that the findings may have resulted from the reduction in the importance of labour in small farms and the increased importance or use of improved seeds and fertilizers which smallholders could not afford because it is credit intensive. An important factor in understanding the inverse relationship and its reversal is the fact that the study took place in the post-green revolution India. If we infer from the relationship between farm size and adoption of technology which Just and Zilberman (1983) found to be influenced largely by risk attitudes and per hectare returns, there should be no inverse relationship between farm size and yields. Technology adoption and risk-aversion are thus factors that can possibly explain the inverse relationship since yield levels are determined to a large extent by the use of technology especially the green evolution technology. The role of credit and land tenure arrangement on the relationship between farm size and technology adoption proposed for further examination by Just and Zilberman (1983) are equally important factors that can be fundamental to the inverse farm size-productivity relationship.

Carter (1984) used a pooled village cross-sectional farm management survey data and shows a strong inverse relationship between farm size and productivity. The author acknowledged it as a strong relationship and admitted that it the strength of the relationship is surprising given that

the data used postdate the green revolution which was shown to have wiped out the relationship in the literature. The results further specifically indicate that as farm size doubles, productivity per hectare declined up to nearly 40%. The author also acknowledged that this elasticity was on the high side compared with figures reported in the literature including the pre-green revolution era, but on the contrary the estimates are comparable to estimates from other studies using data in the 1950s. These surprising results were attributed to sample selection bias as a non-random approach was used to select the study area and farmer selection rule based on literacy. The strong inverse relationship still persisted after correcting for this sample selection bias. This invariably makes farmer education an important variable in examining the inverse relationship between farm size and productivity.

After assessing the relevance of factors such as mode of production, locality (village) and farm level factors in explaining the inverse relationship, Carter (1984) came to the conclusion that farm characteristics differences, soil quality differences, per hectare input use differences, labour use differences, other specific characteristics such as behavioural rules and market position, and perhaps smallholder adaptation to technical change due to growing pressure on land explain the inverse relationship (P. 144). On the technical change, given that the green revolution has been observed to be scale neutral (Mosley, 2002) large farms which have been reported to have better access to technology and are technically efficient compared to the smallholder farms (Barrett et al, 2010) should rather explain a positive relationship.

The inverse relationship has been more dominant in and more associated with India. Studies elsewhere tend to show more mixed results as compared to the case of India in particular and East Asia in general where the inverse relationship has also been found in Bangladesh, Indonesia and Philippines (see Ahmad et al, 1999). Most of these studies took place in the

1960s up to the early 1980s. In a relatively new study in Bangladesh, Banik (1994) found no significant relationship between farm size and productivity whether positive or negative. Rather than farm size, land elevation was found to explain the differences in land productivity. Favourable land elevation which favours access to irrigation resulted in cropping intensity. Thus, cropping intensity, aided by access to irrigation was also found to be an important factor in the land productivity differences. This is an indication that irrigation and water management could be relevant in explaining differences in land productivity.

From the Island of Java where rice is the most important crop, Benjamin (1995) found the inverse relationship between farm size and rice productivity from a 1980 sample survey of 5,605 farmers. However, the inverse relationship was eliminated after controlling for omitted variable bias using instrumental variables. Land quality was investigated as an omitted variable, showing that it is a possible explanation of the inverse farm size-productivity relationship. A similar pattern is shown in China's case of the inverse relationship. Chen et al (2011) observed the inverse relationship between the cultivated area of land and grain output in China which however disappears after controlling for unobserved land quality using an instrumental variable estimation procedure. They concluded that on the basis of the data used which is from a survey in the late 1980s the inverse relationship is due to land heterogeneity and therefore is not inherent in China's agriculture.

In the case of Pakistan, Ahmad et al (1999) observed that the data sets used in the studies in Pakistan are old, and thus used a newer data set at the time. Their study followed few studies in Pakistan on the farm size-productivity relationship such as Khan (1979) who found a positive relationship. Chaudry et. al. (1985) were the first to find the inverse relationship. Ahmad et al (1999) also found the inverse relationship but with different crops exhibiting opposite

relationships. Higher levels of cropping intensity among smallholders and a more intensive use of inputs per acre were identified as the causal factors of the inverse relationship (p. 1148).

Using 1995/1996 agricultural census data in Brazil, Helfand and Levine (2004) examined the relationship between farm size and efficiency and indicate that differences in efficiency across farms exist and are determined by type of land tenure, access to institutions such as markets and use of modern inputs. Their study did not find the inverse relationship, citing preferential access to efficiency enhancing institutions and services such as electricity, access to markets and extension services for technical support by large farms. Another explanation advanced is that the large farms also had a more intensive use of productivity increasing inputs and technologies compared to the smaller farms. The point is made in the paper that the small to medium size farms could still have been more efficient producers if they benefited from access and use of the institutions and inputs that gave the large scale farms the advantage which wiped out the inverse relationship. The authors draw the conclusion that differences in access to institutions, inputs and technologies can alter the inverse relationship between farm size and productivity. They suggest that if the inverse farm size-productivity holds, land reforms could be important for achieving efficiency (as well as equity) in agricultural production.

Smallholder farming has driven Asia and Latin America to the Green Revolution and the predominance of the inverse farm size-productivity relationship may have contributed to (fit the tenets of) the green revolution in these regions. As Africa remains the only continent to miss the green revolution, evidence of the inverse relationship in African agriculture needs to be clear to forge understanding of what role smallholders can play in achieving the green revolution. In a policy-oriented study on whether Africa's rural development strategies should focus on smallholder farming premised on the inverse size-productivity relationship, Larson et al (2014) found and admit technology/input use variations such as fertilizer application across

and within countries. By (farm) scale, the variations are less within countries compared to across countries. The latter reflected in fertilizer use in Kenya and Malawi where majority of farmers applied fertilizer to their farms irrespective of farm scale whereas in Tanzania and Uganda farmers rarely apply fertilizer. In contrast to the input type or technology use variations found across countries, within country variations stem from the intensity of input use. This was observed with household labour use intensity which was less obvious in Malawi where the study also found little variation in farm sizes. Two inverse relationships were found between farm size and maize yields at plot level and between farm size and household labour use. Despite finding the inverse relationship in these four countries, other studies found positive relationships in some of the same countries. In Kenya there is an indication of a positive relationship between farm size and measures of agricultural productivity especially for households when farms measuring between 0 and 50 hectares are considered (Muyanga & Jayne, 2014).

In Malawi, Dorward (1999) used a linear programming farm household model and found a positive relationship between farm size and productivity. He explained that the absence of an inverse relationship is accounted for by land, capital and produce markets. Buttressing this explanation for the positive relationship, the author observed that smallholder farming is performed as a part time activity whilst larger farmers have better access to credit and capital. Apart from the input and output markets determining the positive relationship found which is consistent with suspicions of other studies (Lamb, 2003; Helfand and Levine, 2004) that the inverse relationship between farm size and productivity is determined by imperfect markets, the study was based on smallholder agriculture (farm sizes categorized into seven with half a hectare intervals with the largest scale farms being over 3 ha) which means that large scale farm holdings were likely to be few in the data.

Dorward (1999) and Henderson (2014) observed that interpretations of the inverse farm size-productivity relationship are not always straightforward despite most empirical studies observing the relationship. To this end, Dorward questioned why the inverse relationship does not hold in some studies and whether the relationship results from correlation or causality. Reviewing the explanations for the inverse farm size-productivity relationship, he observed that during the early days of the green revolution, the relationship appeared to be weakened and differential access to credit by large scale farmers appeared to be responsible. This observation in the literature appears to be applicable to areas where the green revolution has been achieved. In SSA where the green revolution has not yet been achieved and where his study originated using aggregate farm survey data collected in the 1980s, the inverse relationship could be applicable holding the green revolution technology use constant.

Before Larson et al (2014) found that fertilizer use is rare in Uganda and that yield and family labor use declines with the plot size indicating inverse relationships, Carletto et al (2011) found the inverse relationship stronger after controlling for errors of measurement of land size using Global Position System (GPS) devices. This contradicts what Lamb (2003) found in India where the inverse relationship disappears after controlling for measurement errors in land size. In a similar study in Malawi by Holden and Fisher (2013) farm size measurement error accounts for more than 60% of the inverse relationship in the overall sample of their study. The relationship is explained differently when the sample was disaggregated by land size, the inverse relationship is accounted for most by market imperfections (land and labour) and food security motives in farms less than a hectare. The results of this study which used panel survey data of households and GPS and farmers' reported measurement of land size in which a stronger inverse relationship is found with the GPS measurement of farm size contradict the absence of the inverse relationship in Malawi by Dorward (1999). Holden and Fisher (2013) based on their results suggest that studies that are based on farmers' self-reported farm sizes are unable

to detect an inverse relationship. Comparing these results to Lamb (2003) also show the contradiction at the aggregate level but the results on farms less than one hectare are consistent in both studies.

Two studies observed a strong inverse relationship in Rwanda. An examination of land and labour productivity outcomes from a nationwide cross sectional survey of 1,240 households in Rwanda revealed the inverse relationship. A strong inverse relationship was found between farm size and land productivity whilst a positive relationship was found between farm size and labour productivity by Byiringiro and Reardon (1996). Allocative inefficiency was observed in smaller farms which is attributed to factor market constraints where access to inputs tend to be a challenge for smallholders relative to large scale farmers. They also found that smaller farms have three times higher land yields in value terms, use four times more labour per hectare and have farmed on their lands fewer times compared to the larger farms (p. 131). These patterns could explain the main results of the relationships between farm size and productivity but within the context of the farm size considered large in the study (average of large scale farms being 2.38ha) the variations seem stark. In another study in Rwanda, a robust inverse relationship between farm size and gross output per hectare was found caused by intensive labour use by smallholder farmers (Ali & Deininger, 2014). This labour use intensity by smallholder farmers is in line with the inverse relationship found between farm size and household labour use by Larson et al (2014). These findings show a strong case for labour market imperfections as the explanation for the inverse relationship. In both studies, unobserved factors or measurement errors such as heterogeneous land quality were not associated with the inverse relationship as observed in other studies.

In recent times, Lamb (2003), Barrett et al. (2010) and Gaurav and Mishra (2014) have all found the inverse relationship in their studies in India and Madagascar but with varying

explanations. In response to concerns in the literature on the omission of soil quality measurements and reference to market imperfections as explanations of the inverse farm size-productivity relationship, Lamb (2003) examined the role that land quality and labour and land market imperfections play in the relationship. Employing panel data that contains land quality data from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) on India, the results indicate that differences in land quality largely explain the inverse relationship using a random effect profit regression. However, from labour demand regressions, land quality does not play any role in the inverse relationship. Further varied methodological assessment indicates the inverse relationship to be much stronger in fixed effects than in random effects estimates which together with results obtained from instrumental variable estimates suggest the likelihood of measurement error in the farm size variable also playing a role in explaining the relationship. Controlling for market imperfections in land and labour and land quality removed the inverse relationship, leading to the conclusion that land quality and market imperfections drive most of the inverse relationship from random effects estimates.

Barrett et al (2010) observed that research on the relationship between farm size and productivity do not often have soil quality data which leads to an omitted variable bias. Using a cross-sectional data set that includes soil quality measurements at plot level from Madagascar with a single crop (rice), they first tested the inverse relationship hypothesis, and then tested the two prominent explanations for the relationship, which include soil quality and factor market imperfections. Their findings confirm the existence of the inverse relationship and reveal that market imperfections account for about one-third of the relationship. Contrary to the explanation that that differences in soil quality explain the inverse relationship as indicated by Lamb (2003), their results show that none of the inverse relationship could be attributed to soil quality. Using instrumental variable techniques to account for omitted variable bias, Benjamin (1995) found that land quality which has been omitted in most studies is a possible

explanation of the inverse relationship. He therefore emphasized that cross-sectional variation in estimates of the relationship is important in explaining the inverse relationship. Since the studies of Benjamin (1995) and Lamb (2003) originate from Asia, this conflict in the role of land quality may be caused by differences in geographical areas of the study but could also be random. Barrett et al (2010) concluded that most of the inverse relationship possibly resulted from measurement error or allocative inefficiency within households.

Gaurav and Mishra (2014) offer the latest accounts of the debate on the inverse farm size-productivity relationship, but as routinely as has been the case, with data from India. They measured productivity in terms of net returns and found the inverse relationship between farm size and productivity which was still present after correcting for sample selection bias, controlling for the farm household characteristics and introducing fixed effects. The use of family labour which has been widely noted in the literature as an explanation of the inverse relationship was associated with productivity. Other variables associated with productivity include age of household head as a proxy for farming experience, use of irrigation and membership of a Farmer Based Organization (FBO). These findings were generated from data collected in a crisis period within the farming context (drought and rising levels of farmers' suicide) but the methodological robustness makes them a good basis for comparison using other new data sources.

This review has highlighted diversity and conflicts in how farm size influence productivity. The dominant relationship has been the inverse relationship which is explained by various factors including labour, land and input market imperfections (Feder, 1980), farmers' response to risks and uncertainties (Srinivasan, 1972; Barrett, 1996), size-sensitive cropping patterns (Ahmad et al, 1999), variable soil quality (Benjamin, 1995; Lamb, 2003), input use intensity (Carter, 1984; Ahmad et al, 1999), among others. The review has also shown the inverse farm size-productivity relationship to be weakened with technical change such as the green

revolution. Most importantly (to this study) is also the evidence from the literature that the inverse relationship between productivity and farm size is weaker or less pronounced in Africa compared to the other developing regions. These empirical evidences uphold the observation of Dorward (1999) that explanations of the inverse relation between farm size and productivity is not straightforward. This therefore calls for more studies on the subject in an attempt to confirm or refute what is known so far, or establish new evidence about the relationship between farm size and productivity. It is in this context that this study has been carried out.

3.0 Methodology

The methodology of the study involves the data source and description; and method of data analysis which includes the various model specifications and description of variables.

3.1 Data Source

The Ghana Living Standards Survey round six (GLSS6) was designed to obtain nationally and regionally representative data across a wide range of socioeconomic indicators using a two stage stratified sampling design. Using a probability proportional to size to allocate the primary sampling units which constituted census enumeration areas to the 10 regions of the country, the PSUs (Enumeration Areas) were further categorized into urban and rural localities of residence. Households were systematically selected from the selected PSUs in the second stage of sampling to obtain a nationally representative sample of 18,000 households from 1,200 out of a total 3,000 EAs in the country. The survey was conducted over a one year period between October 2012 and October 2013.

The data on agricultural production was captured using a house household questionnaire, one of three instruments used in the survey. The data set contains information on the ownership and operation of farms and farm equipment, quantity of land owned, crops grown, physical

access to inputs, source of inputs, use of credit, use of labour, farm expenditure, harvest, sales value of harvest and consumption of own produce. The data set accounts for a number of data limitations which some contributors to the inverse relationship (Benjamin, 1995; Lamb, 2003; Barrett et al, 2010) attribute for the inverse relationship such as small sample and village level data sets. Like many other studies, one limitation of the data set is the lack of land quality data food security motives, behaviour variables and closeness to market. Most importantly however, our data set brings two new dimensions to the discussion on the inverse relationship, coming from a very recent survey and bringing urban dimensions for exploration.

3.2 Method of Analysis

The study used regression as its method of analysis since it is the most famous method of estimation in the IR relationship. Besides studies like Darwood *et al.* (1999), Thapa (2007), Lamp (2003), Barret et al (2010), Chen et al (2011) and Gaurav and Mishra (2014) have used regression models for the estimation of the relationship between farm size and productivity.

3.2.1 Empirical Model Specifications

The study used two main forms of model specification following the approach of Gaurav and Mishra (2014). These were the linear and double log simple regression. These three equations were both in simple and multiple regression forms. Below is how the following regression model where specified.

Linear Functions

This simple linear regression was specified in the form:

$$y = \beta_0 + \beta_1 x + \varepsilon \qquad (1)$$

Where y is the dependent variable, β_0 is the y – intercept , β_1 is coefficient of the independent variable x , which is the farm size and ε which is the error term of the regression.

This multiple linear regression model was specified in the form:

$$y = \beta_0 + \beta_i \sum_{i=1}^{n} x_i + \varepsilon \qquad (2)$$

y, β_0 and ε have already been indicated in equation (1) but the set of β_is are the coefficients of the independent variables which are made of up of the farm and farmers' characteristics.

Double Log Functions

The double log function of the study are in two forms. The first one (3) establishes a relationship between the dependent variable which is either returns to cultivation I, returns to cultivation II or output which in general terms referred to as y. The independent variable is the farm size (x). The simple regression model of the double log function is given in the form:

$$Iny = \beta_0 + In\beta_i x_i + \varepsilon \qquad (3)$$

The multiple regression double log function is given in the form:

$$Iny = \beta_0 + \beta_1 Inx_1 + \beta_i \sum_{i=2}^{n} z_i + \varepsilon \qquad (4)$$

Here, the independent variables in Equation (4) are a combination of farm size which is logged, farm and farmers' characteristics (z) which are not logged, and the error term of the regression (ε). With respect (3), Thapa (2007) and argues that it is the conventional approach in the debate for estimating land size and returns to productivity. Base on this, the study chose the double log function as one of the functions in its analysis. Notwithstanding that the study employed (4) due to its application in Thapa (2007) and Gaurav and Mishra (2014) in the IR debate.

In estimating the relationship between farm size and returns to cultivation, the study did not consider the soil quality and relative input use as predictor for returns to productivity. This was partly due to the lack of available data for such a study. Therefore the study in its estimation followed Thapa (2007) were these variables were not considered. Though the IR debate considers some main hypothesis such as risk, imperfect labour markets, returns to scale and soil quality (Newell *et al.,* 1997), this study did not focus on them though it assumed labour imperfections, risk and acknowledged possible variations in soil quality. Similar to the study of Sial *et al.* (2012), the study did not consider the heterogeneity that exist among farmers in terms of expertise quality in farming but overlooked it. On the issue of irrigation, the study did not factor that into its analysis. This was further supported by Fan (2003) where it was discovered that irrigation does not really contribute to the economies of scale in farming in Asia. Besides the two crops in Ghana are rain dependent (Asante and Amuakwa –Mensah, 2014) especially in the production of maize and irrigation may not play much of a role in their production.

3.2.2 Description of Variables

The dependent variables (DVs) for the study were in three categories and they were separately regressed on the respective independent variables (IVs). These were yield in measured in kilogrammes, returns to cultivation I (value of sale of yield minus cost of production in Ghana cedis) and returns to cultivation II (value of total value of yield minus cost of production in Ghana cedis). Besides the DVs were at both individual levels of rice and maize, and also at the aggregate level. The IVs for the study were farm size measured in hectares, age of household head measured in years, male and female labour measured in man-days, education which was dummied as no, basic, education or higher education (as reference point), location of farm

which dummied as rural and urban, distance to extension services, measured in Kilometers, farm rights which was dummied and household size which was a continuous a variable and measured in counts.

4.1 Results and Discussion

Table 1: Returns to cultivation and factors influencing it

	(1)	(2)	(3)	(4)
VARIABLES	**Returns1**	**Returns1**	**lnReturns1**	**lnReturns1**
farmsize	31.42***	29.27***		
	(3.449)	(3.523)		
Age of Household head		3.633*		-0.00107
		(1.887)		(0.00148)
Male labour		9.727***		0.00933**
		(3.166)		(0.00363)
Female labour		-7.750**		-0.0114***
		(3.308)		(0.00266)
No education		233.8**		0.262***
		(91.92)		(0.0713)
Basic Education		280.7***		0.305***
		(64.86)		(0.0497)
Distance to Extension service		6.779***		0.00299*
		(2.346)		(0.00179)
Location of Farm is Rural (Dummy)		205.8**		-0.108*
		(80.64)		(0.0656)
Farm rights (Dummy)		468.7***		0.448***
		(59.08)		(0.0451)
Household size		-3.529		0.00591
		(10.09)		(0.00809)
Lnfarmsize			0.816***	0.808***
			(0.0252)	(0.0272)
Constant	315.9***	-391.6***	5.286***	5.038***
	(31.12)	(136.5)	(0.0330)	(0.108)
Observations	8,361	8,361	4,043	4,043
R-squared	0.010	0.024	0.206	0.241

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In table 1, returns to cultivation is actually in two forms. Returns I is value of sale of yield minus cost of production and returns to cultivation II is value of total value of yield minus cost of production. Beginning with returns 1, the simple linear regression results indicate that there is a significant positive relationship between farm size and returns to production. This is at a significant level of 1%. The higher the farm size, the higher the returns to output and vice versa with an R – square of 0.010; which is very low per the GLSS data. With the exception of household size, all the other factors determined returns to cultivation in Ghana when regressed with farm size. With the exception of female labour, age of farmer, male labour, level of education, distance to extension services, location of farm and farm ownership rights have a positive relationship with returns to cultivation, whether I or II. Household size however was not significant when it when it comes to its effect on returns to productivity. Farm size, male labour, basic education and farm rights were significant at 1% whiles, no education and location of farm were significant at 5% with the age of the farmer significant at 1%.

When the double log function was used with farm size being the only independent variable, the latter was significant at one percent and has a positive relationship with return to productivity. When the double log function was with only farm size logged, farm size still remained significant; having a positive relationship with returns to productivity. With the same double log function, female labour and location of farm had a negative significant relationship with returns to productivity whiles male labour, no education, basic education, distance to extension services and farm rights still have a positive relationship with farm productivity. Out of the factors that influenced returns to productivity, female labour, no education, basic education, and farm rights are significant at 1% with male education significant at 5% while distance to extension services are significant at 10%.

It is clear from the four (4) different regressions there are some variables that have not changed either in their significance level or direction. These variables are farm size, basic education and farms rights. This implies, with respect to the focus of the study farm size is very key in determining returns to output in Ghana and this has a positive relationship with returns to agricultural production. Therefore in Ghana, the larger the farm size the larger the returns to output, all things been equal.

Table 2: Returns to cultivation (harvest minus cost) and factors influencing it

VARIABLES	(4) Returns II	(5) Returns II	(6) InReturnsII	(7) InReturnsII
farmsize	80.18***	60.34***		
	(11.87)	(12.17)		
Age of Household head		-5.126		-0.00478***
		(6.517)		(0.000951)
Male labour		35.13***		0.00740***
		(10.94)		(0.00154)
Female labour		8.785		0.00885***
		(11.43)		(0.00161)
No education		-81.47		0.0302
		(317.5)		(0.0465)
Basic Education		0.457		0.0347
		(224.0)		(0.0332)
Distance to Extension service		-4.555		-0.00126
		(8.103)		(0.00119)
Location of Farm is Rural (Dummy)		491.0*		0.0899**
		(278.5)		(0.0424)
Farm rights (Dummy)		689.6***		0.166***
		(204.0)		(0.0302)
Household size		146.7***		0.0155***
		(34.84)		(0.00524)
Lnfarmsize			0.790***	0.722***
			(0.0155)	(0.0166)
Constant	982.0***	-319.8	5.733***	5.693***
	(107.1)	(471.4)	(0.0190)	(0.0694)

Observations	8,361	8,361	7,102	7,102
R-squared	0.005	0.013	0.268	0.287

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2 shows how returns to agricultural production (value of yield minus cost) is determined by farm size and the other factors already mentioned. Under this form of returns to productivity, four (4) different regressions were considered. With respect to the first regression, a simple linear regression was used where only farm size was regressed on returns to production. The results indicated that farm size positively influences returns to production at a 1% significant level. With the second and multiple regression which added other variables to the farm size, farm size still remained significance at a 1% level. The other factors which were significant at 1% were male labour, farm right and house hold size. Location of farm was significant at 10%. All the factors that had a positive significant relationship with returns to production. With respect to the third regression, the double log function which had only farm size as its independent variable, there was a significant positive relationship between farm size and returns to production. With respect to the fourth regression, which is a double log function, farm size still remained 1% significant in addition to age of household head, male labour, female labour, farm rights and household size. In addition, location of farm was significant at 5% level of significance. From the four different regressions farm size has a positive influence on returns to production at a 1% significant level.

This is an indication, the farm size is a clear predictor of returns to production. Therefore, in Ghana's case, the larger the farm size the higher returns to the value of yield. The findings of the study is similar to the observation made by Mahmmod *et al*. (2014) where farm sizes and gross returns had a positive relationship as well as margins. The findings of this study is also different to that of Gaurav and Mishra (2014) and Masterson (2007) where they discovered in

India and Paraguay respectively there exist an inverse relationship between returns to productivity in the form of net returns and farm size.

Table 3: Aggregated Crops Output vrs farm size,

Variables	(1) Aggregate I **Output**	(2) Aggregate II **Output**	(3) Aggregate III **LnOutput**
Farmsize	17.34***	14.74***	
	(4.407)	(4.532)	
Sex of household head		139.7	
		(97.51)	
Loan for farm		67.08	
		(109.1)	
Farm rights		202.8***	
		(75.90)	
Basic Education		200.7**	
		(84.04)	
No education		43.89	
		(118.1)	
Age of household head		2.223	
		(2.456)	
Household size		8.480	
		(13.23)	
Distance to Extension service		0.821	
		(3.016)	
Male Labour		14.74***	
		(4.075)	
Female Labour		-8.009*	
		(4.251)	
Location of Farm is Rural (Dummy)		-172.9*	
		(103.7)	
LnFarmsize			0.745***
			(0.0171)
Constant	251.6***	-66.12	3.946***
	(39.77)	(191.1)	(0.0211)
Observations	8,361	8,361	7,349
R-squared	0.002	0.006	0.205

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The study also considered the factors which influenced the output of rice and maize combined (in the aggregated form) among over seven thousand (7000) households in Ghana. In Table 3, all the four (4) different regressions were considered. Farm size had a positive relationship with aggregate output and at a 1% significant level in the simple linear regression analysis (aggregate I). In the multiple regression analysis (aggregate II), farm size was still significant at 1% level and had a positive relationship with output. Farm right and male labour where also significant at 1%. Basic education was significant at 5% whiles female labour and location of farm are significant at 10%. With respect to the second regression, all the variables had a positive relationship with output except female labour and location of farm. With the double log regression of aggregate output and farm size, there was still a positive relationship between the two variables at a 1% significant level.

The findings of this study are similar to that of Khan (1979) who found a positive relationship between farm size and productivity in Pakistan. Though Dorward (1999) used a linear programming farm model which has a different form of estimation compared to this study, he found a positive relationship between farm size and productivity in Malawi. This finding is similar to Ghana's situation though he explained that that large farm sizes have access to credit and market which our study did not go further to look at. Muyanga & Jayne (2014) also found out that the positive relationship between farm size and agricultural productivity holds in Kenya especially for household farms measuring between 0 and 50 hectares. The findings is similar to that of Cornia (1985) who after studying 15 developing countries of the world found out that there is a positive relationship between farm size and productivity in countries of Bangladesh, Peru and Thailand.

Carletto et al. (2013) followed the old debate of the actual farm size and yields of farmers. After using both farmers' report and using the Geographical Positioning System Debate to estimate farm size and yields of Ugandan farmers, they concluded that the IR debate holds for both cases and it is even steeper with the case of the GPS. Similar to Mahmood *et al.* (2012), Sial *et al.* (2012) observed that IR holds in Pakistan in all the six districts investigated. The relationship studied between land size and productivity for all the individual districts proved negative using the log linear model for the regression estimation. The results was no different for the relationship when all the six districts were combined. Notwithstanding the observation made by Sial *et al.* (2012), Khan (1979) had earlier been proven otherwise in the IR debate in Pakistan, a finding similar to the observation made by this study.

Table 4: Individual Crops, Output vs farm size

Variables	Maize Output1 **Qkg**	Maize Output2 **LnQkg**	Rice Output1 **Qkg**	Rice Output2 **LnQkg**
Farmsize	102.7***		15.12***	
	(2.679)		(1.012)	
Lnfarmsize		0.712***		0.632***
		(0.0168)		(0.0325)
Constant	6.538	4.148***	17.41***	2.788***
	(5.360)	(0.0152)	(2.163)	(0.0338)
Observations	4,898	4,898	1,664	1,664
R-squared	0.231	0.270	0.118	0.185

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows regression results involving two individual crops; which are maize and rice. Two separate regressions for each crop were run. Each regression had a simple linear regression and one with a double log function. With respect to maize, regression results from both functions revealed a 1% significant positive relationship between farm size and output. This direction and level of significance between farm size and output were the same for the rice.

Conclusion and Recommendation

The GLSS data has proven that the IR debate in Ghana's case does not hold. There is therefore a positive and significant relationship between farm size and productivity which could be in the form of quantity of yield, value of yield and net returns at both the aggregate and the individual crop levels for maize and rice. There are other significant relationships between output or returns to productivity and other variables like labour, farm size and education. Notwithstanding that farm size is the overarching significant variable that relates with returns and productivity in IR debate in Ghana with respect to models used, though it proved to otherwise. The study recognizes that in Ghana's debate, it did not consider some factors compared to other works. Some these are factor are input use intensity compared to Newell 1997) and Dyer (1996), labour use dynamics like Verma and Bromley (1987) and Dyer (1996), credit market dynamics like (Cornia, 1985), and soil quality like (Bhalla and Roy, 1988).

The study suggests land plays an important role in Ghana's agriculture. Therefore the higher the land size, the higher the returns to productivity in agriculture, all things being equal. This calls for a serious review and action in the land policy for agriculture in Ghana especially in the face of emerging land scarcity which is caused by urbanization, increased mining activities and general population increase. Where the situation of dealing with land scarcity becomes too difficult, policies towards achieving the green revolution must be directed towards sustainable agriculture intensification and use of modern agriculture technology in the farming of maize and rice. The study also calls for further research into the IR debate in Ghana by factoring in labour imperfections, soil quality, behavioural rules, food security motives and market position.

References:

Ahmad, M., Qureshi, S. K., & Hussain, Z. (1999). Recent Evidence on Farm Size and Land Productivity: Implications for Public Policy [with Comments]. *The Pakistan Development Review*, 1135-1153.

Ali, D. A., & Deininger, K. (2014). Is there a farm-size productivity relationship in African agriculture? Evidence from Rwanda. *Evidence from Rwanda (February 1, 2014). World Bank Policy Research Working Paper*, (6770).

Asante, F., & Amuakwa-Mensah, F. (2014). Climate Change and Variability in Ghana: Stocktaking. *Climate*, *3*(1), 78-99. doi:10.3390/cli3010078

Banik, A. (1994). Farm Size, Factor Productivity and Returns to Scale under Different Types of Water Management. *Economic and Political Weekly*, A175-A182.

Barrett, C. B. (1996). On price risk and the inverse farm size-productivity relationship. *Journal of Development Economics*, *51*(2), 193-215.

Barrett, C. B., Bellemare, M. F., & Hou, J. Y. (2010). Reconsidering conventional explanations of the inverse productivity–size relationship. *World Development*, *38*(1), 88-97.

Benjamin, D. (1995). Can unobserved land quality explain the inverse productivity relationship? *Journal of Development Economics*, *46*(1), 51-84.

Byiringiro, F., & Reardon, T. (1996). Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. *Agricultural economics*, *15*(2), 127-136.

Carletto, C., Savastano, S., & Zezza, A. (2011). Fact or artefact: The impact of measurement errors on the farm size-productivity relationship. *World Bank Policy Research Working Paper Series, Vol*.

Carter, M. R. (1984). Identification of the inverse relationship between farm size and productivity: an empirical analysis of peasant agricultural production. *Oxford Economic Papers*, 131-145.

Chaudhry, M. G., Gill, M. A., Chaudhry, G. M., & Aslam, M. M. (1985). Size—Productivity Relationship in Pakistan's Agriculture in the Seventies [with Comments]. *The Pakistan Development Review*, 349-361.

Chen, Z., Huffman, W. E., & Rozelle, S. (2011). Inverse relationship between productivity and farm size: The case of China. *Contemporary Economic Policy*, *29*(4), 580-592.

Cornia, G. A. 1985.Farm Size, Land Yields and the Agricultural Production Function: An Analysis for Fifteen Developing Countries. *World Development* 13(4): 513–34.

Deolalikar, A. B. (1981). The inverse relationship between productivity and farm size: A test using regional data from India. *American Journal of Agricultural Economics*, *63*(2), 275-279.

Dorward, A. (1999). Farm size and productivity in Malawian smallholder agriculture. *The Journal of Development Studies*, *35*(5), 141-161.

Dyer, G. (1991). "Farm Size–Farm Productivity Re-Examined: Evidence From Rural Egypt." *Journal of Peasant Studies* 19(1): 59–92.

Shenggen, F. and Chan-Kang, C. (2003), Is Small Beautiful? Farm Size, Productivity and Poverty in Asian Agriculture. July 17, presented at the 2003 *International Association of Agricultural Economists*, Durban, South Africa.

Feder, G. (1980). Farm size, risk aversion and the adoption of new technology under uncertainty. *Oxford Economic Papers*, 263-283.

Gaurav, S., & Mishra, S. (2014). Farm Size and Returns to Cultivation in India: Revisiting an Old Debate. *Oxford Development Studies*, 1-29.
Ghana Statistical Service (GSS) (2014). *Ghana Living Standards Survey Round 6.* Accra: GSS.

Helfand, S. M., & Levine, E. S. (2004). Farm size and the determinants of productive efficiency in the Brazilian Center-West. *Agricultural Economics*, *31*(2-3), 241-249.

Holden, S. T., & Fisher, M. (2013). *Can area measurement error explain the inverse farm size productivity relationship?* (No. 12/13). Centre for Land Tenure Studies, Norwegian University of Life Sciences.

Institute Statistical Social and Economic Research (ISSER) (2013). *Ghana Social Development Outlook 2012.* Accra: ISSER

Just, R. E., & Zilberman, D. (1983). Stochastic structure, farm size and technology adoption in developing agriculture. *Oxford Economic Papers*, 307-328.

Khan, M. H. (1979). Farm Size and Land Productivity Relationships in Pakistan. *The Pakistan Development Review*, 69-77.

Kimhi, A. (2006). Plot size and maize productivity in Zambia: Is there an inverse relationship? *Agricultural Economics*, *35*(1), 1-9.

Lamb, R. L. (2003). Inverse productivity: Land quality, labor markets, and measurement error. *Journal of Development Economics*, *71*(1), 71-95.

Larson, D. F., Otsuka, K., Matsumoto, T., & Kilic, T. (2014). Should African rural development strategies depend on smallholder farms? An exploration of the inverse-productivity hypothesis. *Agricultural Economics*, *45*(3), 355-367.

Mahmood H. Z., Qasim, M., Khan, M. and Husnain, M. I. U. (2014). Re-Examining the Inverse Relationship between Farm Size and Productivity in Pakistan. *The Journal of Animal & Plant Sciences. 25(4),* 1537 – 1546.

Masterson, T. (2007). Productivity, Technical Efficiency, and Farm Size in Paraguayan Agriculture. *Levy Economics Institute Working Paper Collection*. Working Paper No. 490.

Ministry of Food and Agriculture (MoFA) (2013). *Performance audit report on MoFA's support to farmers to increase food crop production.* Accra: MoFA.

Mosley, P. (2002). The African green revolution as a pro-poor policy instrument. *Journal of International Development*, *14*(6), 695-724.

Muyanga, M., & Jayne, T. S. (2014). Is small still beautiful? The farm size-productivity relationship revisited.

Newell, A., K. Pandya, and J. Symons. 1997. "Farm Size and the Intensity of Land Use in Gujarat." *Oxford Economic Papers* 49(2): 307–15.

Sen, A. K. (1962). An aspect of Indian agriculture. *Economic Weekly*, *14*(4-6), 243-246.

Sial, M. H.; Iqbal S. and Sheikh A. D. (2012). 'Farm Size – Productivity' Relationship Recent Evidence from Central Punjab. *Pakistan Economic and Social Review*, 50 (2), 139-162.

Srinivasan, T. N. (1972). Farm size and productivity implications of choice under uncertainty. *Sankhyā: The Indian Journal of Statistics, Series B*, 409-420.

Thapa, S. (2007).The relationship between farm size and productivity: Empirical evidence from the Nepalese mid-hills. 106th Seminar of the EAAE. Pro-poor development in low income countries: Food, Agriculture, Trade, and Environment 25-27 October, Montpellier, France

Verma, B. and D. W. Bromley (1987). 'The Political Economy of Farm Size in India: The Elusive Quest." *Economic Development and Cultural Change* 35(4): 791–808.