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DOES SIZE OF OPERATED AREA MATTER? EVIDENCE FROM MALAWI'S AGRICULTURAL PRODUCTION

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ABSTRACT

The objective of this paper was to examine the relationship between farm size and agricultural productivity using data from Malawi. This paper has examined the relationship using ordinary least squares regression with heteroskedasticity consistent covariance matrix (HC3) standard errors having confirmed absence of endogeneity of farm size. The major finding is that, contrary to the findings of earlier studies which reported a positive relationship, there is strong evidence that probably the post market liberalization period (1990s) became characterized by an inverse farm size productivity relationship. This finding suggests that well-thought-after land and credit market interventions or land redistribution from the rich to the land poor households would possibly raise total output thorough productivity gains.

Key words: Farm size, Productivity, Inverse Relationship, Malawi
JEL classification D13, Q12, Q15

1. INTRODUCTION

In Malawi, smallholder farmers face food insecurity due to several factors which include erratic rainfall, degraded and marginal soils, low propensity for crop diversification, high agricultural input prices, missing or less efficient credit and insurance markets and lack of enough farming land. Insufficient land holding is becoming a critical problem as the population of Malawi continues to soar. Furthermore, the low per capita land holdings in highly populated areas of Malawi make food security policies hard to achieve.

While other people have more than enough land, land trade is not conducted at levels that one could view as optimal, and, as a result some people still do lack enough land to earn a living (Otsuka and Place 2001). Indeed recent studies have reported very small per capita holdings with the national average settling around one hectare (2.5 acres) (NSO, 1998). Considering that a large proportion of Malawians has smaller land holdings, it is necessary to investigate the inverse farm size productivity relationship (IR) which seems to characterize agriculture in some countries.

For the benefit of appropriate policy formulation, knowledge of the existence of the relationship, would guide policy makers in approximating implications for skewed land holdings. If the inverse farm size productivity relationship exists in Malawi's farms, it might be necessary for policy to ensure redistribution of land from the land rich households to the land poor ones not only because the relationship might be due to poor households investing too much in production, a phenomenon which would degrade the soils in the long run, but also because in a such a situation, land redistribution has the potential of raising the overall productivity, equity and would promote rural growth and poverty alleviations (Eckstein et *al.,* 1978; Lipton, 1993; Singh, 1990). For instance, Heltberg (1998) considers the early land reforms in Japan, South Korea and Taiwan an important factor behind early economic transformation through their role in creating agricultural surplus, growing consumer demand and political stability needed to sustain rapid industrialization.

The inverse relationship may also have important repercussions for sustainable natural resource management. Farming practices emerging as a result of efforts to get more from small land holdings could exhaust soil resources through nutrient mining. Soil exhaustion has direct links with soil erosion as well as environmental degradation and deforestation. It follows then that theoretically, the IR could cost humanity its biodiversity besides perpetuating poverty of the landless among other possible effects.

In Malawi land pressure is severe in densely populated areas of the southern region due to increased migration from land scarce areas in Mulanje and Thyolo into the upland catchment areas for cultivation and other human activities. Land pressure is also about acute in the central region where the capital city is situated. In general however the whole country has dwindling sizes of per capita land holdings as can be appreciated from the table I below;

Table 1. Percentage of households with land-holdings of less than 0.5 hectares in Malawi

District	Holding size *of* <0.5 ha	Population (1998)
Chitipa	38	126000
Karonga	53	194000
Rumphi	58	128000
Mzimba	12	610994
Nkhotakota	44	229460
Kasungu	22	480659
Ntchisi	18	167880
Mangochi	39	610239
Salima	46	248214
Mwanza	51	138,015
Nsanje	52	194924
Machinga	39	369614
Chikwawa	34	356682

Source: NSO Smallholder land household Composition Survey Report (1992/3), *1998 Malawi Population and housing census*

Table 1 shows the proportion of the population whose farm sizes were less than half a hectare in early 1990s and it can be seen from this table that many places were characterized by low average land holdings. There is no data at present to show the recent changes in land holdings but there is no reason to think that land holdings may have improved because, land is constant while population has grown.

Column three in the table shows population by district by 1998 and, assuming that there has been no change in land holdings, these figures are indicative of the extent of land pressure in Malawi and the table is suggestive of the need for careful studies geared towards underpinning policies which would result in rural people being able to produce enough for a living out of small land holdings.

To follow the argument of Adesina and Djato, (1996), any context specific studies in Malawi on the productivity topic could be very useful because evidence from other countries is mixed and, even if it was not, it would be fallacious to simply rely on results from other countries for purposes of agrarian reforms in Malawi. What is unfortunate is the reality that owing to data limitations, there are not many studies in Malawi on the topic to permit well-informed policy formulation.

The objective of this paper is to test for the presence of an inverse relationship between farm size and productivity in rural areas of Malawi using data collected by International Food Policy Research Institute (IFPRI) and Agricultural Policy and Research Units (APRU). At present, productivity of agriculture is very crucial for economic growth since the economy is agrarian and today, there are several debates within the ministries responsible for agriculture and land as to whether it is land consolidation rather than redistribution which might help reduce the low productivity of agriculture.

2. THE INVERSE RELATIONSHIP

The farm size productivity inverse relationship is defined as average grain yields fall when the size of a farm increases (Chen, 2003). Chayanov (1926) is recognized with first noticing this relationship in Russian agriculture, but according to literature, Sen (1962) is believed to be the earliest modern reference on this subject. Berry and Cline (1979) reviewed the early empirical evidences on farm size and productivity and econometric issues and they also found a significant inverse relationship. There are several proposed explanations for the IR as follows.

2.1 Labour Costs

Sen (1962) explained the inverse relationship with labor dualism, where given the same technology, small-scale farmers have a lower opportunity cost of their labor than operators of large farms, a condition which makes labour productivity to be higher on small farms than on large farms. The differential opportunity cost dimension has also been explored by Deininger and Feder (2001) who used agency theory to explain it. In the context of agency theory, it is argued that, unlike the larger farm case, when labor markets are functioning, small sized farms use only family labor (Taylor and Adelman, 2003) which has stronger incentives to work because they share directly in the farm output and, moreover, in the long run can expect to inherit the farm. In this case, labour input does not really have to be monitored as all factors being equal, family members are interested in high productivity. On the other hand, large farms with high land to labour ratios are rocked by high labour supervision costs as there are no incentives for hired labour to input as high quality labour as they would on their farms.

The differential labour cost perspective seems to be supported by the suggestions that land markets may be imperfect in rural areas so that sometimes it may be hard for small land holders (with high labour to land ratios) to access extra land, and, by the suggestion that labour markets themselves are also not perfect. Imperfections in the labour markets result in large farmers not being able to access labour when needed leading to low labour input intensity on the farm. Indeed, arguing along the same lines, Feder (1985) showed that a necessity to supervise hired labor and capital market imperfections could lead to a systematic relationship between yields and farm size, and this relationship could be positive or negative.

Eswaran and Kotwal (1986) claimed that family labor availability would create advantages for small farms but indivisibility of capital would work in favor of large farms so that a possible outcome is that yields will be decreasing with farm size for relatively small farms and increasing with farm size above a certain size threshold. Some of the prominent authors on the imperfect labour market school and especially on the importance of family labour surplus include Mazumdar, (1965), Carter, (1984) Reardon et al., (1996) and Newell et al., (1997), Sen, (1975) and Bardhan, (1973).

The inability of large farms to adjust farm size to efficient levels may not only be due to the imperfections in the credit markets but also to the imperfections in the land markets for example due to poor property rights (Heltberg, 1998).

2.2 Land Quality

Some authors such as Sen, (1975), Bhalla and Roy (1988), Benjamin (1995) suggested that unobserved land quality is positively related to farm productivity but inversely related to farm size. Lamb (2003), studying the relationship along these lines rejected the hypotheses that there was an inverse relationship between farm size and land quality. It was argued that the relationship could vanish upon careful control of land quality differences across farms. Benjamin (1995) found that the IR vanished upon controlling for soil quality through instruments (population density, presence of a city, number of males and females of age 10-15 in a household). In the first stage, he predicted farm size using these instruments.

The land quality school of thought implies that in the course of land fragmentation individuals do retain smaller but fertile pieces of land. This implicitly assumes exogeneity of soil quality though it would also be argued that even soil quality itself may be endogenously dependent on farmer characteristics. Bearing this in mind, Kimhi (2003) studied productivity of maize in Zambian farms using a recursive framework and found the inverse relationship (IR). Adesina and Djato (1996) found no significant differences in terms of productivity between large and small farms using a profit function on data from the Ivory Cost. Bhalla and Roy, (1988) and Benjamin, (1995) have found that the inverse relationship weakens considerably after differences if land quality are taken into.

2.3 Capital Markets

The other factor deriving the relationship between farm size and productivity is believed to be the capital markets. It is believed that the imperfections in credit markets for example make it hard for household with plenty land to farm it efficiently because they are wealth constrained and they can not readily borrow money from the market. This dimension of the argument would favour the existence of the inverse relationship other factors being equal. On the other hand, if credit access is conditional on a household having larger land holdings, then land endowed households would enjoy farm credit access resulting in their farms being efficiently farmed than smaller farms which would not have high access to credit. This latter argument is in line with Feder, (1985), Feder and Onchon, (1988) who established an empirical link between credit access and collateral value of land and productivity of farms in Thailand.

Furthermore, Carter and Wiebe (1990) found a U-shaped effect of farm size on both farm output and family income, and attributed it to access to capital. Sawers (1998) attributed the lack of an inverse relationship in the Argentine interior to policy distortions and credit market imperfections. Arguing in favour of the credit market and farmer level unobserved heterogeneity, Assuncao and Ghatak, (2003) demonstrated theoretically that even in the absence of diminishing returns with respect to any input, the IR could still obtain as a result of imperfect credit markets and heterogeneity in farmer skills. Dorward (1999) found that farm size had a positive effect on productivity in Malawi due to land, capital and output market failures. Observations made by Nothale (1986) were also that farm size was associated with increasing productivity in Malawi agriculture.

Market imperfections in goods markets may also factor in price risks such that households would attempt to take this into consideration in their decision making. Pursuing this line of thought, Barrett, (1996) found some evidence that the IR may be a result of price risk which induced small holder farmers to input more labour on their small farms as the risky product prices made their future consumption of market goods uncertain. However some studies have failed to reject the IR despite having employed fixed effects and random effects models which would in theory control for household specific characteristics unobserved by the econometrician suggesting that market imperfections or farmer ability heterogeneity may not be the driving force of the relationship.

In American agriculture, farm size and productivity were found to be positively related or unrelated by Huffman and Evenson,(2001) and Hallam, (1993) while Ahearn, *et al.,* (2002) showed that average farm size in the U.S. was negatively related to multifactor productivity over 1960-1996. Helfand (2003), studying agriculture in Brazilian Centre West, found a nonlinear relationship using Data Envelope Analysis with productivity first falling and then rising with farm size.

2.4 Economies of Scale

It would be reasonable to argue that small land holdings may make mechanization of farms less meaningful and costly implying that only households with large farms would use certain technologies such that productivity differentials would be a result of differential technologies on small and large farms. Pursuing this line of thought, Deolalikar (1981) found evidence for productivity advantages for small farms in districts in which traditional technologies dominated, and the opposite in farms in which modern technologies dominated. On the other hand, Binswanger et al., (1995) suggested several sources of economies of scale that could create a productivity advantage for large farms. Zaibet and Dunn (1998) found that small farms faced a binding constraint in the use of mechanization in Tunisia. Kevane (1996) found that insurance and financing constraints created a positive relationship between wealth and yields in western Sudan.

2.5 Green Revolution

The green revolution would only favour large farms as input access would need credit which may be easy to get for large farm holders than not. On the other hand, some technologies may be hard to justify below some farm sizes (Deolalikar, 1981). This was evident in an Indian study by Deolalikar who found that farms that employed advanced technology (big ones) were more profitable than the others (the small ones). But green revolution maybe neutral to scale hence casting doubts that it might be a cause of any differentials in productivity across farms (Hazel and Ramasamy, 1991).

Some authors (see Heltberg, 1998) have argued that households with large farms might have now become more productive due to the effect of Green Revolution. It is argued that green revolution may have favoured large farms which by virtue of being large gets access to inputs easier. So, even if large farms were doomed to low productivity, due to labour costs, the impact of great revolution would be to raise productivity of the farms due to purchased input intensity thereby reducing the differences in productivity. But as others have also argued, technology may not be a plausible explanation for the phenomenon because many studies have found that technology is almost always constant returns to scale (Bardham, 1973, Berry and Cline, 1979, Carter, 1984 and Cornia, 1985).

2.6 High Conservation Effort

Byiringiro and Reardon (1996) find that the inverse relationship can also be explained by higher land conservation efforts on small farms. If this is the case then land redistribution in favour of smaller but manageable farms would have long term productivity improving effects.

In this paper effort has been made to control for many of the discussed factors and below we discuss the data used.

3. Data and Analysis

3.1 Data

Data used to estimate the model were collected by International Food Policy Research Institute (IFPRI) and Agricultural Policy and Research Unit (APRU) in Malawi between 1994 and 1995 from a sample of 404 farmers in villages from five districts drawn from all the three regions of Malawi namely, Dedza, Rumphi, Dowa, Nkotakota and Mangochi districts. The survey was conducted as part of a study of the determinants of access to and participation in existing formal and informal credit and saving programs. The wide coverage provides us enough data to draw reasonable conclusions about all the three parts of the country.

This paper is based on 374 cases out of the total owing to missing data within the other cases. It would also be important to mention at this stage that this is the most recent data set that contains the necessary variables to permit the analysis. The recent national surveys such as the Integrated Household Survey (IHS) for 1998 and 2004 would be very good alternatives but, they do not contain observations at plot level and hence cannot really be used for the purposes of this paper. Despite that the data set is old, it is the most recent that Malawi has and has the ability to provide policy makers there with recent evidence about the relationship under study.

The variables of concern here are output per acre (Produc) constructed as the total value of farm produce reported divided by the total acreage considered agriculturally useful (operated area); sex is coded as each household's proportion of female members in the household so that larger values of the proportion indicate high numbers of women relative to men in the household. Age as a factor is measures age of the head of the household; and, schooling is in terms of the highest number of years of schooling for the household head and would, among other roles proxy farmer abilities.

Dummies representing districts take the value of one for the district and zero otherwise, while in the theoretical models that follow, '*i*' stands for access to credit institutions and the more sources of credit (as indicated by where one got credit in the previous year) one has, the higher numbers this variable takes. Technology *(t)* is represented by inputs such as fertilizer, seeds and adoption of crops which have recently been associated with new varieties; *f* is total effective farm size in acres while soil quality (s) is controlled for by plot level soil characteristic scores that have been aggregated into a soil quality index which is monotonically increasing with better soil quality per acre while district dummies are thought to control weather differences across districts.

Then we have labour (*l*) hours and asset ownership approximating wealth as well as capital. It has to be said that studies where all these variables have been considered are indeed scanty and in Malawi, they are completely unavailable. It follows therefore that this study offers answers to some of the questions that have remained unanswered during policy debates in the ministries of lands, agriculture and natural resources.

3.2 The model

This paper estimates the farm size productivity relationship through the following basic model

$$\ln(\text{Produc})_i = \alpha + \beta \ln(f)_i + \delta h_i + \phi i_i + \varphi t_i + \gamma \ln(k)_i + \lambda s_i + \theta \ln(l)_i + \mu_i \quad (1)$$

Where, as stated in the data section, Produc imply output per acre for farm i.,; *h* represents household and location level variables, ln stands for natural logarithm, *i*., stands for available institutions, *t*, for technology, f is farm size, *s*, for site quality, *k* for capital and *l* for labour inputs.

Due to the non constant variance of the errors in all models, the results are accompanied by robust standard errors which are calculated using the Huber/White/sandwich estimator of variance instead of the traditional calculation. Heteroskedasticity consistent covariance matrices (HC3) specify an alternative bias correction for the robust variance calculation as well. The later corrects for heteroskedasticity by using the conservative heterskedasticity-consistent covariance matrix (Ω) (HCCME) (Davidson and MacKinnon 1993) and, these are also reported.

Table 2 provides interpretation of the various variable names that accompany the estimates.

Table 2 Variable description

Variable name	Description
Produc	Output per acre
logproduc	Logarithm of output per acre
famsize	Size of the operated farm
farmsizecubb	Log of (Farm size ^3)
logfamsize	Log of farm size
sex	Proportion of female members in the household.
logage	Logarithm of average age in the household
agesquare	Age^2
leveschool	Years spent at school by household head
labour	Log of labour hours invested in farming
totalferte	Log of total expenses on fertilizer acquisition
pestcidekg	Amount of pesticides converted to kg
logseedprice	Price of seed in log form
creditindex	Index of credit acquisition (the higher the number implies that a farmer accessed loans from different sources)
logassetva	Logarithm of value of assets
loplotquality	Plot quality index
hybrid41	Hybrid 41 variety dummy
hybrid18	Hybrid 18 dummy
hybrid17	Hybrid 17 dummy
hybrd16	Hybrid 16 dummy
hybrd12	Hybrid 12 dummy
tobaccco	Tobacco adoption dummy
ricce	Rice dummy
casava	Cassava dummy
cottton	Cotton dummy
dowaa	District dummy
rumphii	District dummy
nkhotakota	District dummy
mangocci	District dummy

Table 2 above describes the variables that have been used herein.

4. Empirical Results

4.1 Descriptive Statistics

The mean operative land holding is around 3.54 acres (2.47 acres=1ha) and operated holdings are generally large in Rumphi (4.1 acres) possibly due to lower population densities and therefore lower land pressure that characterizes the northern region. Farm sizes are also considerably above average in Nkhotakota, Dowa and Dedza which are districts in the central region which on average has lower land pressure compared to the south.

Finally, Mangochi, a district in the southern region with many people per land area has an average farm size of (2.35 acres) and this is below the sample average. In terms of output per acre , the total sample average is 350.6 Malawi Kwacha per acre while Dowa, Dedza and Rumphi are just above this average; Nkhotakota has the highest productivity average and Mangochi, with highest population density and the lowest farm size has the lowest average productivity.

With respect to the correlation between farm sizes and productivity the data suggests that there is no relationship between farm size and productivity with a positive correlation of 0.006 and not significant at any reasonable level. Mangochi reports a negative one alongside Nkotakota and Rumphi though these too are insignificant even at 10per cent. Dowa and Dedza have a positive relationship and this relationship is stronger in Dowa.

Though Dowa shows a close to significant positive relationship, the sample from Dowa is the smallest and that casts doubts as to whether this could be indicative of a real positive relationship because as Heltberg (1998) cautioned, small samples might sometimes increase the chances of a positive relationship being reported at the expense of the inverse one. This information is also summarized in the table below;

Table 3. Averages of the variables

	Rumphi	Dowa	Dedza	Nkhotakota	Mangochi	Total
PRODUCTIVITY	377.3	397.2	294.6	493.63	238.70	350.6
Farm size(acres)	4.1	3.78	3.77	3.71	2.35	3.537
(Farm size	-0.13	0.21	0.03	-0.15	-0.03	0.01
PRODUCTIVITY corr)	***(0.25)****	***(0.13)***	**(0.80)**	***(0.22)***	***(0.82)***	***(0.91)***
N	76	55	99	67	77	374
Ni/ N*100	20	15	26	18	21	100

** The brackets contain p-values associated with the respective correlation*

The table above provides a rough picture of what might be going on, but more meaningful analysis has to consider other factors and for that reason several regressions were fitted onto the data.

4.2 Regression results

Table 4 below presents results from the model where output per acre is regressed on several variables and, the right hand side columns show estimates and their p-values with OLS, Huber/White/ sandwich and HC3 standard errors.

Table 4. Ordinary Least Square Estimates

logProduc (dependent)	**Ols Beta**	**P>t**	**Robust Beta**	**P>t**	**HC3 Beta**	**P>t**
logfamsize	-0.297	0.000	-0.297	0.000	-0.297	0.000
sex	-0.052	0.251	-0.052	0.261	-0.052	0.315
logage	-0.122	0.159	-0.122	0.221	-0.122	0.370
agesquare	0.081	0.335	0.082	0.458	0.082	0.637
leveschool	0.149	0.006	0.150	0.005	0.150	0.009
labour	-0.007	0.971	-0.003	0.966	-0.003	0.972
totalferte	0.271	0.001	0.272	0.001	0.272	0.012
pestcidekg	0.146	0.001	0.147	0.000	0.147	0.000
logseedprice	-0.221	0.002	-0.224	0.001	-0.224	0.002
credit index	0.041	0.038	0.042	0.036	0.042	0.040
logassetva	0.035	0.550	0.036	0.549	0.036	0.590
loplotquality	0.031	0.579	0.031	0.534	0.031	0.558
hybrid41	0.143	0.054	0.143	0.065	0.143	0.085
hybrid18	0.197	0.003	0.198	0.003	0.198	0.005
hybrid17	0.205	0.000	0.206	0.000	0.206	0.001
hybrd16	0.146	0.001	0.147	0.002	0.147	0.095
hybrd12	0.064	0.225	0.065	0.279	0.065	0.334
tobaccco	0.072	0.145	0.073	0.143	0.073	0.189
ricce	0.092	0.046	0.093	0.183	0.093	0.263
casava	0.435	0.000	0.436	0.000	0.436	0.000
cottton	-0.063	0.231	-0.061	0.066	-0.061	0.100
dowaa	0.098	0.155	0.099	0.154	0.099	0.190
rumphii	0.024	0.735	0.024	0.703	0.024	0.726
nkhotakota	-0.101	0.143	-0.101	0.119	-0.101	0.152
mangocci	-0.231	0.006	-0.231	0.010	-0.231	0.022
_cons	0.480	0.018	0.520	0.035	0.520	0.118
Adj R-sq	0.45					

From table 4 the IR shows up with a negative beta of 0.29 and is highly significant. Interesting is also the observation that levels of schooling, adoption of modern varieties of maize and cassava, technology such as purchased seed prices and the use of pesticides are significant. The model has an r-square of 0.45. These results are in line with the findings of previous studies for example Adesina and Djato, (1996). At this stage however, the reliability of the estimates in table 4 is still questionable and many would raise questions about their statistical validity and, until such concerns are addressed in the following few paragraphs, a discussion of the implications of these results will not be held.

The findings imply that any move towards increasing farm parcels by the landless by one per cent may lead to a .29 per cent productivity gains.

4.2 Specification Issues

Some of the criticisms against the voluminous deal of work that has already taken place in an attempt to investigate the IR are that due to lack of enough data, disaggregation has generally been problematic and where it has been applied results are questionable as this brings issues of loss of degrees of freedom which leads to frequent rejection of the IR (Heltberg, 1998) and also that due to the difficulty in collection of data for soil quality variables, studies have generally not treated soil quality well in regressions.

Another criticism leveled has been related to some other unobserved household level or village level heterogeneity that is never accounted for in most studies. It has been argued that such an accounted for heterogeneity may be a misspecification and hence the very cause of the counterintuitive observation that the coefficient of land size is generally negative. Lack of soil quality data or good proxies is problematic because as pointed out by Sen (1973), and Bhalla and Roy (1988) unobserved soil quality may vary inversely with farm size and this might impact negatively on the coefficient of farm size in the productivity equation thereby yielding a negative beta. Considering the caution proposed by Heltberg about the loss of degrees of freedom and the frequent rejection of the IR this paper has not estimated district level regressions. Moreover with valid data of 374 cases any attempt to split it into five districts would render other regressions inestimable. The study however has data on soil quality in terms of an aggregated, monotonically increasing soil quality index comprising scores of soil type, soil depth and soil colour. So, unlike previous studies which did not control for soil quality while studying the relationship on Malawi data, this study has that advantage.

With respect to the last criticism about unknown unobserved heterogeneity, the implications depend on whether such heterogeneity which essentially comes from an omitted variable, comes from a variable that is related to one or more of our regressors because that will result in our regressors becoming correlated with the error term (Gujarati, 2003; Wooldridge, 2002). It therefore becomes important to consider regressors in a model as to whether they may be endogenous because if they are, then ordinary least square estimator breaks down as E (u|x) becomes non-zero.

If it is expected from theory or some a prior knowledge that some regressors might be correlated with the error term, then several procedures could be employed. For example if there are instruments, then one could use them to instrument the endogenous variable in a mult-stage set-up. Or one could run a Seemingly Unrelated Regression (SUR) type system to ensure that all information in the two equations is used. The problem is that good instruments are often lacking for example Benjamin (1995) instrumented farm size with population pressure, distance to the city, age groups of household dependants. Some authors including Heltberg (1998) have questioned the efficacy of such instruments whose predictive power(R-square) was less than 0.2, in achieving their purpose. On the other hand, instrumenting a variable when it is not actually endogenous may compromise efficiency of estimates and it is only reasonable to follow instrumental variable estimation after endogeneity test have yielded results pointing to endogeneity.

Wooldridge (2002) and Gujarati (2003) argue that one way to roughly test whether a suspected variable is endogenous or not is to realize that if the covariance of that variable and that of the error term for the model under consideration is zero then there is no correlation between it and the error hence ordinary least squares estimates may be relied upon. Some of the regressors used in this study are labour input, fertilizer input, farm size and sources of credit. Due to the awareness that these might be endogenous this paper tested for their correlation coefficients with the predicted residuals after an ordinary least square regression estimated and the results suggested no evidence of endogeneity. Correlation tests have shown that there is no evidence to advantage the argument that some of these variables may be endogenous and that such endogenity would bias our estimates.

In order to justify our use of farm size as it was without any instrumentation, a more formal test of endogeneity needed to be implemented. Accordingly, we performed a formal test due to Durbin, Wu and Hausman (DWH test). The results from this test showed no evidence of endogeneity (with a test statistic of 0.84 and $p<.45$) as well again supporting the arguments we made earlier that in this case no endogeneity exist with respect to farm size and OLS results with robust variance are valid. This test follows Davidson and MacKinnon (1993) who suggest an augmented regression test (DWH test), which can easily be formed by including the residuals of each endogenous right-hand side variable, as a function of all exogenous variables, in a regression of the original model.

The implied exogeneity of farm size choice may ensue owing to land transfer systems in Malawi which some authors have argued they primarily follow traditional inheritance other than rents in other parts of the country.

If the OLS results were from a mis-specified model, this would ensue in specification tests but in all the models fitted above the Ramsey's RESET test showed that there was no omitted variable problem thereby reinforcing the DWH results as well. We also tried to fit a model with the cube of the farm size variable following the proposal by Royston and Altman (1994) (implicitly applied by Heltberg (1998)) on the usefulness of polynomials in the event of nonlinearities, but, even this could not reverse the IR.

Moreover, though not reported here, results from GLS fixed effects and random effects estimators upheld the IR relationship. So, correlation tests, the third polynomial specification, Ramsey's Reset test, DWH tests, GLS and HC3 confirmed that the found relationship was not spurious. The GLS FE would control for unobserved heterogeneity in land quality and farmer ability and the results show that the IR is not driven by these factors. The DWH tests dispel any thoughts that the findings were due to measurement errors in farm size and even soil quality.

4.3 Discussion of Results

In sum, this paper finds that adoption of different types of modern crop varieties is significant across the models and in all models hybrid maize adoption is associated with increased output per acre. The price of seeds in general negatively affects output per acre and is highly significant again underscoring the importance of technology to productivity. Fertilizer use and schooling affect productivity positively and are generally highly significant across the models underpinning the pertinence of education and technology in any efforts to boost agricultural sector through productivity gains.

The most interesting result is the impotency of methodologies employed herein in nullifying the existence of the inverse relationship between farm size and agricultural productivity. At this juncture, there is absolutely no reason to think that farm size in the rural areas of Malawi had a positive relationship with output per acre. In fact if there was a relationship at all then it was not negative, nor is there any reason to suggest a case for omitted variables.

This implies that if previous authors found a positive relationship in the past, then that relationship changed towards the turn of the 1990's. Since one of the theoretical reasons for a positive relationship between farm size and productivity has to do with economies of scale in lumpy inputs on the large farms as well as the preferential treatment enjoyed by large farms in terms of subsidies (Kimhi, 2003; Helfand, 2003), it could be the case that after the agricultural market liberalization that took place in the 1980's large farms stated getting disciplined by high farm input prices thereby compromising on their overall productivity.

The liberalization came in with removal of subsidies on farms and later government started encouraging small holder farmers through fertilizer revolving funds and other means. This very turn of events might have led to the inefficiency of large farms. If that is indeed the case it is only reasonable then to suggest that any land reforms aimed at increasing farm sizes of the land poor households would be pro-poor and developmental as they would increase productivity. It may be that land quality accounted for some portion of productivity (though may not necessarily vary with farm size) but given that we have controlled for land quality at two levels that is by including district dummies and the land quality variable, it could be that its effects are sandwiched within district level dummies and cannot be observed through the beta of the later variable. Whatever the case, the IR result did not seem to vanish.

The results do not show any evidence that the observed relationship may be due to measurement error in the farm size variable or due to omission of the land quality variable or due to unobserved farmer heterogeneity as this did not show up in the endogeneity tests. There was also no evidence to support the claim that the relationship may be driven by labour market imperfections.

If the relationship was due to imperfect labour markets which work in favour of those with smaller land to labor ratios (the small holder farmers), then we would expect labour input to be significant in the above models but as it turns out none is. Similarly, if it is land quality that drives the relationship then we would equally find a significant land quality variable.

If we also argue that it is economies of scale that drives the relationship then we would be arguing in favour of larger land holdings and therefore a positive relationship unless we have grounds to argue that there has been a major change in the agricultural sector in Malawi such that economies of scale exist on small and not large farms. This is so unlikely and for sure economies of scale might not be the explanation after all as argued earlier, constant returns to scale technology may be a reasonable assumption following the many studies that have found results offering support for this.

However, credit markets may actually be the driving force here but in a novel manner. There are chances that credit access may not necessarily be dependent on farm size but other characteristics related to a household's social capital for example. This social capital does not vary with farm size and this may imply that on average individuals may have the same access to credit in terms of amounts loaned from the rural economy.

Considering that farm sizes are varied, those with large farms will have low credit per unit of land and hence inputs per land area and this would generate the inverse farm size relationship. To finally ensue, we also would postulate that land cannot readily be sold due to imperfections in the land market but also leaving land unfarmed poses a real danger of losing it to landless. So, the imperfections in the land and credit market may very well be the driving forces of the relationship.

This phenomenon could also be explained by a case where due to credit market imperfections credit is generally scarce and any equity enhancing government programmes that sought to issue handouts would not discriminate households according to farm size. This would give farmers with different farm sizes equal access to inputs and the land rich ones would be disadvantaged if evaluated in the context of input per land area. From the present data, assuming equality of sample variances, independent sample t-tests revealed no significant departure in terms of credit access between large and small farms[*].

Alongside other previous studies, Place and Otsuka, (2001) have found some evidence asserting that land markets are not existent in some places and where they take place it is unlikely that they do so in sufficient levels to permit flexible transfer of land across individuals of different farming abilities and opportunities. This imperfection is further reinforced by the possible inefficiencies in the credit market which tends to restrict credit access based on other factors but possibly not land sizes.

The logical implication of this finding is that ultimately, other factors being equal; some farmers remain with land they cannot use efficiently while others who would do with larger farming sizes end up devoting all their effort in terms of resources heavily onto their small farming holdings. This would lead to land poor households (who, through their social relations in society and, through interventions that target the poor would also have received equal amounts of farm credit on average), producing more per hectare (owing to the relatively high credit per land area ratio which may translate to a proportionately high input per area ratio) than the others with larger farms whose land constraints are relaxed but must try farming third land entirely due to poor land markets and possibly land tenure rights. This would give us the inverse relationship.

If the IR was due to soil quality differences, then redistribution would be useless for productivity and incomes. If the IR was due to labour markets imperfections then an intervention in those markets would be worthwhile and redistribution would improve production potential of a nation as redistribution would possibly generate efficient farm sizes which could be managed even in the absence of hired labour. If it was due to farmer

[*] The independent sample test yielded a t-statistic of 1.8 which was not significant at 5per cent.

heterogeneity then unless the capable farmers were identified, it would be hard to postulate how land redistribution would positively impact production potential of a nation.

The deductions in this paper are that since credit access index seems to positively affect productivity but also inputs have been found to be highly significant, then the IR in Malawi may be due to credit market imperfections in which case interventions in the credit market would have the potential of reversing the relationship.

According to the previous discussion, this paper postulates (though due to data unavailability we can not test the land tenure and claims and those related to determinants of credit acquisition) that if there were interventions in the credit and land markets that sought to increase the facility with which land got moved between farmers of different farming abilities and at the same time if there were interventions in the credit markets (e.g. through any moves to encourage financial institutions to reliably reach the rural areas) which would encourage the collateral nature of land (e.g. through titling, registration or enhancement of rural tenure systems etc), the IR would vanish. The IR would vanish under the stated assumptions because households with more and titled land would acquire enough credit for their farm needs or would rent some out thereby only operating efficient sizes and this would increase overall productivity.

On the other hand, in the absence of any efforts to correct the imperfections in the said markets, redistribution would move land from the resource constrained but land rich farmers to farmers who would manage just to inject enough resources to operate the land acquired from redistribution thereby increasing overall production and possibly productivity. For example a finding that fertilizer expenditure is positive and significant would imply that those on large farms have not yet reached the optimum level of fertilizer application because they face liquidity constraints while those on small farms, may face a tight budget which just meets their input costs.

5 Conclusions

Our major finding is that, contrary to previous findings which found a positive relationship between farm size and productivity, there is strong evidence that probably the 1990s became characterized by an inverse farm size productivity relationship. Apart from the inverse relationship the other findings are that credit access inputs and modern varieties are in general the factors that enhance productivity.

Earlier findings based on data generated in the 1980s a period which saw larger farms enjoy high access to credit and high value crops than small land holders were suggestive of a positive relationship. The change in agricultural policy towards the 1990's possibly meant no preferential treatment of large land holders such that the conspicuous differentials in credit access that existed vanished. This would imply that in per land area terms, large land holders would be receiving less credit with the consequence of low input intensity per land area and this might have reversed the positive relationship and possibly resulting into the IR.

We argue that since credit access index seems to positively affect productivity but also inputs have been found to be highly significant, then the IR in Malawi may be due to credit market imperfections in which case interventions in the credit market would have the potential of reversing the relationship. According to the previous discussion, this paper postulates (though due to data unavailability we can not test the land tenure and claims and those related to determinants of credit acquisition) that if there were interventions in the credit and land markets that sought to increase the facility with which land got moved between hands and at the same time if there were interventions in the credit markets (e.g. through any moves to encourage financial institutions to truly reach the rural areas) which would encourage the collateral nature of land (e.g. through titling, registration or enhancement of rural tenure systems etc), the IR would vanish. The IR would vanish under the stated assumptions because households with more and titled land would acquire enough credit for their farm needs or would rent some out thereby only operating efficient sizes and this would increase overall productivity.

We therefore conclude that the IR may be due to credit and land market imperfections which make it hard for land transfers and land investment financing for large farms thereby making smallholder farmers look more productive. Redistribution, of land from large land holders to small land holders would increase equity and productivity while careful interventions in the credit (through creation of enabling rural business environment) and land markets (possibly through enhancement of land rights) would also improve land productivity as large farms would equally be farmed effectively with increased access to inputs.

Future studies should try to directly incorporate information on land tenure (which the present data set does not have) and other factors that determine credit access in analyses of the relationship as these may be enlightening.

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