2011

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Working Paper

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Working Paper 2011-31

UNIVERSITY OF MASSACHUSETTS AMHERST

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Abstract

Access to land and particularly its distribution has reemerged as an important part of both academic and policy discussions in the last decade, leading to the resuscitation of the debate on the relationship between size of holdings and output per land unit. Across the world, studies have suggested the existence of a decreasing relationship between land size and output per unit of land. The most-widely accepted explanation for this relationship is that households with smaller holdings tend to be labor rich relative to land, and therefore can achieve higher output through the increased application of labor. Despite the rich literature on this topic there has been little work on whether this relationship is valid for female-headed households, particularly in the case of African countries. Past African studies have found female-headed households to be smaller by close to one adult in comparison to male-headed households. Given this difference one would expect there to be a difference in the outcome of land redistribution for different types of households, ceteris paribus. Additionally, the aggregate impact in African countries could be substantial, as female-headed households comprise in several cases up to 30 percent of the rural households. In this paper we will examine empirically whether the inverse size and output relationship is different between female and male headed households in the case of Kenya, using the Kenya Integrated Household Budget and Expenditure Survey of 2006, which includes modules on agricultural holdings and agricultural output in addition to the standard demographic characteristics. By controlling for the endogeneity of crop choice and fertilizer use we are able to find that cash crop production and human capital, and not differences in household size, determines the differences in male and female headed land productivity. Hence, our study goes beyond the simple discussion of the inverse relationship between land size and output per unit and the potential impact of redistribution. Specifically we will be able to address the kind of broad rural development policies in addition to land redistribution that would allow female headed households to do at least as well as (if not better than) male headed households.

Keywords: Agriculture, Gender, Kenya, Africa, Crop Choice, Land Productivity

JEL Code: J16, O13, Q15

Introduction

The role of women in African agriculture is a well-studied topic, and it is accepted as a stylized fact that female-headed households are less productive than male-headed households, as measured by value of output per unit of land (FAO 2011). In this paper we revisit this issue in the Kenyan context using a newly available national data set the Kenya Integrated Household Budget and Expenditures Survey (2006) which includes modules on agriculture.

There are a number of reasons why it is important to revisit these questions at this particular time. The first is the international context; the last thirty years have seen globalization and neoliberal policies greatly expand the reach of the market. This has occurred across economies both in the rural and urban areas. Rural households which in the past were somewhat insulated from market phenomena are today much more integrated. In situations where production occurs at the household level, differently structured households have potentially been impacted in different ways. Further given the difference in resources, powers and placement, households may themselves adjust differently to these forces (Tsikata, 2010). Beyond extending the market, the process of globalization and the neoliberal policies impact land issues in African economies by consciously attempting to promulgate western perspectives on ownership and management of land under the guise of land reform. Immediately after independence land reform, including specifically land redistribution, was attempted in a number of African countries. With the oil crisis of the 1970s, land issues took a back burner to correcting macro-economic imbalances. Land reform resurfaced in the late 1980s and early 1990s led by the World Bank and bilateral donors. This second round of discussion and implementation of land reform often focused on tenurial reform and the imposition of private property. While claiming that security of tenure was essential for small farmers to be more productive (despite little evidence) they were in many ways preparing the ground to allow large investors to make safe large capital intensive investments in African land (Manji 2006).

Hence, Africa is now being hailed as the new land of opportunity by the World Bank and global capitalists have been engaging in a process of land grab through large scale acquisitions of land (see Deininger and Byerlee 2011).

There have also been a number of changes in the local context of Kenya which make the topic worth revisiting. After somewhat of a hiatus during the previous regime, the present Kenyan government has speeded up the issuance of land titles across the country. Additionally, it has increased support of agriculture with an emphasis on market related activities such as contract farming as the key to improving the welfare for

rural populations. To implement the *Strategy for the Revitalization of Agriculture* the Government of Kenya planned to increase budget resources from 2.5 percent in 2004/05 to 3.5 percent of GDP in 2008/09 (Government of Kenya 2008). The tremendous growth of the urban market means that there is now a market for products which in the 1960s to the 1980s were seen as subsistence crops. At independence in 1964 Kenya's urban population comprised 8 percent of the total population with just over 700,000 of whom 50 percent were located in Nairobi. The overwhelming majority of Kenyans (92 percent of the population) were living in rural areas, mostly engaged in various forms of agriculture. The capital city was effectively the only large market for food crops and even that market was limited because the low population density of the city at the time allowed a significant proportion of urbanites to be engaged in substantial farming activities. Based on estimates by Freeman (1991) and the Mazingira institute (1987) as cited in Gĩthĩnji (2000 pg. 132) approximately 29 percent of urban households farmed on their own private properties. This group represented only 32 percent of all urban farmers, suggesting that in the late 1980s over 80 percent of all urban households engaged in some self-provisioning of farm products.

By 2006 the picture is completely different. Although Kenya is still predominantly a rural society with 79 percent of the population living in rural areas, the urban population now numbers 7.8 million of whom only 3 million live in Nairobi, indicating the existence of a large number of urban agglomerations across the country (See Table 1). Thus, most rural areas are now in close proximity to markets for agricultural products. This development is of particular importance: contrary to the dominant traditional story of exports driving agricultural development, Wiggin (2005) found that success stories in African agriculture more recently have been propelled by the expansion of internal demand.

Table 1: Population Structure in Kenya 1964-2006

	1964	1970	1975	1980	1985	1990	1995	2000	2005	2006
Urban population in millions	0.76	1.2	1.7	2.5	3.3	4.3	5.2	6.1	7.4	7.8
Population in the largest city (% of urban population)	50	46	39	34	33	32	34	36	38	38
Rural population (% of total population)	92	90	87	84	83	82	81	80	79	79

This trend in growing urbanization along with a concurrent increase in demand for the products of agriculture has been accompanied by a decrease in the availability of land per capita for agriculture. This is caused both by the rapid population growth and the failure of the non-farm sector to provide enough jobs to absorb the increasing population (Gĩthĩnji 2010). Both the demand effect (for products of agriculture) mentioned above and the supply effect (land availability) have increased the value of land and its commoditization. We believe that this increased pressure on land via commoditization, in the context of a patriarchal society is likely to weaken the position of female-headed households, in the same way that the penetration of capitalism via

colonialism weakened the position of women farmers in the 19th and 20th. centuries (Boserup 1970). A further motivation for the study is that female headed households continue to be poorer on average than male headed households. Gĩthĩnji (2000) finds that female-headed households only made 58 percent of the income made by male-headed households in rural areas, whereas Place et al (2007) find that in Western Kenya women were more likely to be chronically poor both in terms of protein intake and non food expenditure. Since female-headed households make up close to one third of rural households, understanding the reasons behind female headed households' lower output per unit of land would go a long way in helping us eradicate poverty in rural areas.

Beyond addressing the gender gap in agricultural productivity, our work also contributes to the literature on the inverse relationship (IR) between land size and productivity per unit area. Despite the large number of studies examining IR, relatively few have been carried out in African economies (Sender and Johnston 2004, Gĩthĩnji *et al*/2011). In the past work on this relationship the kind of household has rarely been taken into account. Even when they were controlling for the sex of the head of household, gender dimensions were not central to the story[1].

Explaining the Gap

In the literature there are three basic strands that explain the difference in output per unit of land area between male and female-headed households. The most common strand which also coincides with the explanation for the IR effect is the access to and control of labor. As noted above households headed by women tend to be smaller than male-headed households and are thus less able to increase output per land unit by increasing the amount of labor added per unit of land. We would add that in a patriarchal society female heads may also have less control over adult male labor in their household. Udry (1996) for example in a study in Burkina Faso attributes the difference in productivity between male- and female-controlled plots to the differential (and inefficient) allocation of resources within the household between male and female plots. Hence, female plots receive less labor as well as other inputs such as fertilizers than male-managed plots. Holden *et al*(2001) find that in cereal production in the Ethiopian highlands male-headed farms had 50 percent higher yields than their female counterparts. This difference is attributed both to the lack of access to labor and draught animals. Finally, in a study of Nigerian rice farmers, Oladeebo and Fajuyigbe (2007) show that female farmers command less family labor than their male counterparts, despite being technically more efficient than their male counterparts (see also Peterman et al., 2010).

[1] Deere and Leon (2001) and Masterson (2007) constitute exceptions to the rule. Their work however focuses on Latin America while our focus here is Africa.

The second strand of reasoning given for the difference is tenure insecurity, which may occur at two different levels. The first is the general lack of title for small farmers particularly in many African countries. This is a result both of the existence of indigenous forms of ownership and assigning of rights that do not neatly fit into western notions of private property and therefore the titling regime. The lack of title is also due to the limited capacity of governments to complete cadastre surveys of the rural areas. The argument made in this context is that lack of titles and insecurity lead to fewer long-term investments by farmers who are not assured of reaping the returns on their investment. Female-headed households are less likely to have titles and therefore would in this context be expected to invest less and thus have lower output per land unit. Boserup (1970) points out how the basis of titling in a number of African countries under the British for example titled only in men's names, creating insecurity for married women. Alene et al. (2008) find that, in addition to lower education, the less secure tenure for women has resulted in lower productivity. Goldstein and Udry (2008) point to how exclusion from socio-political networks in Ghana leads to women being insecure about the land they farm and thus, for fear of losing control over their land, unwilling to leave it fallow with detrimental consequences for soil fertility and land productivity. In the context of Kenya, Dolan (2001) finds that women are excluded from contract farming in the vegetable export sector because of a lack of titles. As is clear here what has become an opportunity for male farmers with titles has not been one for women; in fact the resources previously used by women for vegetable farming for family consumption and local markets have been taken over by men. Hence, to the extent that contract farming can be considered an opening occasioned by globalization, it is one primarily for male farmers, often at the expense of women farmers.

The second part of the security of tenure argument is that since women get access to land through their relationship to a male, even if titles exist their permanence on the allocated plot is not a given. In fact there is plenty of evidence that titles may decrease security for women as men (in whose name most titles are given) may dispose of the land. Here the ability of an individual male to dispose of land given private property may actually increase insecurity for women compared to indigenous systems that often do not allow a single individual to dispose of land without consultation - even if only of other men. For example Lesorogol (2005) finds that privatization of communal pastoral lands in Kenya resulted in a market for leasing of the lands in which the men alone controlled the revenue. The leases are an outcome of the process of privatization which has resulted in women effectively having less access to land and its products than they did under communal tenure. In the same context, Mwangi (2007) notes that both women and the youth did not receive parcels when the pastoral lands were subdivided, on the grounds that they were not collective ranch members during the period of collective property rights.

The third type of argument revolves around lack of access to farming support in particular credit, extension, and input support, because of various forms of discrimination against women. There are a number of studies

that point to the lack of access in inputs as a cause of lower productivity. Boserup (1970) is among the first to point out how a western perspective of farming with the male head of household as the principal farmer led in the African colonies to extension services that supported only male farmers, with the assumption that female farmers were not as good as their male counterparts. This practice continues in post-colonial Africa. Staudt (1978) finds that extension was channeled to men in Kenya. Bindlish *et al*(1993) find that women farmers have less access to extension in Burkina Faso and that having female extension workers makes a difference in the productivity of women farmers. Saito *et al*(1994) find that extension contributes to productivity increases on male manage plots but not on female managed ones in Kenya. Gĩthĩnji (2011) reports that fewer extension visits and demonstrations take place on female headed household farms. A number of studies (Ongaro 1990; Saito 1994; Udry et al. 1995; Udry 1996; Deininger and Olinto 2000; Tiruneh et al. 2001; Ouma *et al*2006; Wanjiku *et al*2007) point to the gap in credit, fertilizer and capital use and technological adoption between female and male-headed households.

New Explanations

Whereas most studies which address the gender gap in productivity utilize small datasets, our study makes use of a national survey, the Kenyan Integrated Household Budget Survey, which was conducted by the Kenya National Bureau of Statistics in 2006. This survey includes a detailed agricultural module which among other things captures the size of land, number of plots, characteristics of plots, as well as inputs and credit. Hence, we are able to examine possible discriminations against female-headed households in Kenya as a whole.

Quisumbing (1996) notes that often the difference in productivity may be accounted for by the choice of crops which is not accounted for in single equation models due to its endogeneity. In our work we begin with a single equation model and follow that up with a reduced form two stage least square (2SLS) models to estimate the impact of choice of crops. By controlling for the likelihood the farm would be producing cash crops we are able to explain most of the gap between female and male headed households.

Our work presents several other advantages over many other studies. The first is that unlike most previous studies which treat *de jure* and *de facto* female headed households the same, we are able to separate households by marital status into; married, never married and widowed. By doing this we potentially control for support via transfers that may accrue to *de facto* female headed households that are a product of male migration for employment. Additionally we are able to control for both soil and slope characteristics of the land. While studies have often noted the importance of soil fertility due to data limitations they often have had to use proxies such as village or regional fixed effects to capture this important variable. Since our data contains self-reported descriptions of soil types we are able to improve on this control. In addition we are able to control for the slope of the land. This is particularly important in Kenya where much of the best land is at relatively high altitudes and is inclined. In these kinds of conditions a novel explanation for IR and

productivity of small farms may be the limited possibility of exploiting returns to scale in the use of large capital machinery such as tractors (Gĩthĩnji *et a*l2011). Our third innovation is the way we treat human capital in farming. In all previous studies of this type both quantity and quality of human capital as measured by literacy or education are thought to be important. In most studies quality of human capital has been captured either via the education or literacy status of the head of household. The implicit assumption in this approach being that farming is a top down activity in which the human capital of the manager dominates. Implicit in this is a view that any knowledge the manager acquires about farming can be easily passed to other members of the household regardless of their own human capital. We instead assume that farming is a somewhat collective activity in which human capital of each member is complementary (Gĩthĩnji *et a*l2011). We do this by using the degree of literacy within the household as a proxy for the human capital of the entire household.

The Data

This survey includes a detailed agricultural module which among other things captures the size of land, number of plots, characteristics of plots, as well as inputs and credit. The survey is national and representative to the district level which is the second level of disaggregation after the province. The total number of households covered is 13,212 with 66,725 individuals. For our purposes we drop Nairobi, the capital which is 100 percent urban as well as the sparsely populated North Eastern province (< 5% of total population) in which the rural population was under sampled. We restrict ourselves only to farming households leaving us with 6,630 households and 37,802 individuals.

Presented in Table 2 are some basic descriptive statistics on household, land characteristics and output by type of household. As in many African countries a little over 30 percent of farming households are female-headed. Most of the female heads (close to 60 percent) are widows while the rest are married with the exception of 3 percent who have never been married. Although given the longer life expectancy of women, one expects the number of widows to be greater than widowers the difference is striking. In real terms there are six times as many widows as they are widowers. The large number of widows contrasted to the small number of widowers suggests that on death of a spouse men are able to get remarried relatively easily while women are not if we assume that death rates are comparable. On the other hand it could be the reflection of a much higher death rate in men than women. The slightly higher average age of the head of female-headed households is consistent with there being a larger group of widows among the female-headed households. As we expect the female-headed households are smaller by just over one individual. This difference means that these households have less labor available. Given the roughly equal dependency ratio the difference is

proportionately shared in a drop in both the number of children and adults. Another striking difference is the feature is the greater number of seniors (above 65) living in female-headed households. In a patriarchal society in which assets are transferred to sons, we would expect that there was an obligation for the sons to look after the elderly parents; however, this does not seem to be the case. Depending on the health of the elderly it may also mean that female-headed households' capacity to work in farming or outside the house may be restricted. In terms of assets male-headed households land holdings are 15 percent larger than those of their female counterparts. Because of the smaller household size however there is no difference in the per capita measure of land. This relationship has been fairly stable over time. Gĩthĩnji (2000) found the same relationship held twenty years ago. Assuming that no other differences exist (our examination of slope and soil characteristics shows little variation depending on who is the head of the household), and given roughly equal per capita land sizes and the same number of plots, we would expect there to be little differences in output per acre if labor is the main input. In fact this is not the case: male-headed households' output on average is 81 percent larger than female-headed households. This gap begs explanation.

Table 2 Basic Household and Farm Characteristics

	Male-headed	Female-headed
Percent of Population	69.9	31.1
Married (%)	93.9	38.5
Never Married (%)	1.6	3.1
Widowed (%)	4.5	58.4
Household size	6	4.9
Average age of Head	47.4	50.3
Dependency Ratio	0.39	0.38
% senior members of HH	5.4	9.9
Land Size in acres	2.57	2.24
Land size per capita in acres	0.43	0.46
Number of Plots	3.1	3
Output per acre in Shillings	34,684	19,161

An examination of the inputs to farming begins to suggest a story that may partially explain the difference in output. Table 3 presents the differences in male- and female-headed households' access to inputs and transfers. We notice that male-headed households are more likely to be using inorganic fertilizer (60 percent of male-headed households use inorganic fertilizer versus 50 percent of female-headed households), to be receiving seeds or fertilizer from agricultural cooperatives (4 percent vs 2 percent). Since inorganic fertilizer use can be considered a proxy for technological adaption, it may also suggest a gap between men and women in the use of other capital inputs – for which unfortunately we do not have good direct measures. Furthermore, we notice that the percentage of male-headed households using organic fertilizer, receiving transfers from the government or from NGOs, and having access to government resources is higher than their female counterparts. Even where women seem to do better, as in the case of access to credit, the complete

story suggests otherwise. Despite receiving more credit the variation in the interest rates they pay is higher resulting in a higher (23% p.a. vs 18% p.a.) though not statistically significant average.

Table 3 Farming Inputs and Transfers

	Male Headed	Female-headed
% of households using Inorganic Fertilizer	60.4	50.2
% of households using Organic Fertilizer	45.5	43.0
% of households receiving Government transfers	22.2	20.4
% of households receiving Nonprofit transfers	12.5	11.4
% of households receiving Credit	30.9	31.7
% of households receiving seeds or fertilizer from Govt	4.1	2.9
% of households receiving seeds or fertilizer from Coops	4.1	2.3
% of households farming Land for cash crops	13.3	8.4
% Income from cash crops	20.3	13.8

The Model

We begin with the basic standard model used in the IR literature. Y_i is the total farm output per acre of farmland for household *i*. L represents the size of the farm in acres and H is a vector of control variables which include household demographic characteristics, marital status, educational characteristics, and plot characteristics (soil and slope types of the plots a household operates on). F is a vector of fixed effects which controls for the district in which household *i* is located and ε is the error term.

The model takes the form:

$$logY_i = \beta logL_i + \gamma H_i + \delta F_i + \varepsilon_i \, .$$

The demographic characteristics are marriage status, which includes married (monogamous and polygamous), never married, whereas the omitted variable is not married (which includes widowed, divorced and separated). We control for household size and household size squared, in order to capture non-linear effects of additional household members on output per acre. We define the dependency ratio as the fraction of children under 15 years of age over the number of household members. We also control for the age of the head of the household and its square, in order to capture possible benefits of experience. Finally, our demographic characteristics include educational characteristics. Thus, we control for the years of education

the head of the household received and a square term, to allow for non-linear returns to education. We also control for the percent of literate members of the household, as captured by the number of household members who are able to both read and write. Our rationale is that agriculture is not an individual enterprise, conducted by the head of household alone. Hence, the number of literate members of a household might impact the productivity of the output in a way that cannot be captured by looking at the education of the head alone.

Turning to the plot characteristics, we include three types of controls. The number of plots allows us to capture the effect of fragmentation on output. Although more land fragmentation could potentially obstruct the expansion of mechanized methods of production, it could also serve as a safety net for agricultural production and allow differentiation of product. We also control for the types of soil and slope on which the household operates, by looking at the relative shares of different types of soil and slope, on which the household operates. The different types of soil are loamy, sandy, between sandy and clay, clay, or other type, whereas slope is classified into flat, slight slope, moderate slope, steep/hilly, and other type. We choose to omit the percent of loamy land and the percent of flat land, as they are the most common types.

We estimate a series of models beginning with the most basic which includes just land size and a dummy variable for female-headed households. We proceed by adding demographic and household controls in regression two and then number of plots controlled by a household, soil, slope of the plots (as percentages and district fixed effects controls in regression three. Regressions four and five are two stages least squares models (2SLS) used to control for crop choice and fertilizer use that we will return to in the next section. The first 2SLS regression is run with household demographic controls which we then remove for the final 2SLS regression, to see whether household size is important in cash crop production.

In the first two regressions we focus on household demographic and human capital characteristics. In our first regression, both of our control variables are strongly significant, statistically and economically. Smaller farms are more productive in terms of output per acre (a 1% increase in farm size decreases output by 0.36%), whereas the output per acre of female-headed households is 41% lower than that of their male counterparts, *ceteris paribus*.

Table 4: Results

	(1) OLS	0 OLS	(3) FE	(4) 2SLS	(5) 2SLS
Log Land	-0.3642***	-0.3814***	-0.3233***	-0.4770***	-0.4578***
	(0.0365)	(0.0403)	(0.0358)	(0.0393)	(0.0394)
Female Headed	-0.4106***	-0.2058**	-0.1536*	-0.0305	-0.0382
	(0.0516)	(0.0679)	(0.0600)	(0.0579)	(0.0495)
Married		0.1056	-0.0184	-0.0453	
		(0.0904)	(0.0803)	(0.0730)	
Never Married		0.2454	0.0507	-0.0905	
		(0.2009)	(0.1713)	(0.1945)	
HH Size		0.0708*	0.0804**	0.0926***	
		(0.0323)	(0.0264)	(0.0281)	
HH Size Sq.		-0.0053**	-0.0033*	-0.0041**	
		(0.0018)	(0.0015)	(0.0016)	
Dependency Ratio		-0.3383*	-0.2958*	-0.1385	
		(0.1527)	(0.1276)	(0.1196)	
Age of Head		0.0300*	0.0053	-0.0041	0.0121
		(0.0118)	(0.0099)	(0.0105)	(0.0093)
Age of Head Sq.		-0.0002	-0.0000	0.0001	-0.0001
		(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ed. of Head		0.0689*	0.0309	0.0262	0.0270
		(0.0333)	(0.0272)	(0.0258)	(0.0260)
Ed. of Head Sq.		-0.0010	-0.0000	0.0000	-0.0000
		(0.0019)	(0.0016)	(0.0016)	(0.0016)
Percent Literate		0.6153***	0.4039***	0.3924***	0.3824***
		(0.1296)	(0.1078)	(0.1001)	(0.0906)
Plots			0.1659***	0.1219***	0.1233***
			(0.0226)	(0.0208)	(0.0209)
Sandy Soil			-0.3621***	-0.1063	-0.1028
			(0.0985)	(0.0929)	(0.0933)
Between Soil			-0.1817*	0.0180	0.0132
			(0.0888)	(0.0815)	(0.0824)
Clay Soil			-0.0778	0.0049	0.0021
			(0.1205)	(0.1455)	(0.1474)
Other Texture			-0.1080	0.1960	0.2192
			(0.1814)	(0.1950)	(0.1954)
Slight Slope			0.1021	0.0431	0.0449
			(0.0649)	(0.0648)	(0.0652)
Moderate Slope			0.2777**	0.0295	0.0316
			(0.0930)	(0.0832)	(0.0837)
Steep Slope			0.5656***	0.1403	0.1405
			(0.1593)	(0.1210)	(0.1211)
Other Slope			1.6370*	0.2913	0.2932
			(0.7401)	(0.3654)	(0.3655)
Cash Crop				4.5348***	4.5258***
				(0.4135)	(0.4200)
Inorganic Fert.				0.3852	0.4019
				(0.2410)	(0.2424)
Constant	9.2436***	7.4403***	7.7481***	7.5417***	7.4076***
	(0.0537)	(0.3203)	(0.3419)	(0.3656)	(0.3502)
Observations	6037	4463	4463	4433	4450
Adjusted R^2	0.061	0.088	0.350	0.402	0.399

Standard errors in parentheses are adjusted for 768 survey clusters.
Regressions 3-5 are estimated with district fixed effects which are not reported.
* p<0.05, ** p<0.01, *** p<0.001

In Regression 2 we add household demographic controls. The gender gap in productivity appears to be closing down to around 21%. We notice that there is an inverted U relationship between household size and land productivity, as the coefficients on household size and household size squared are positive and negative respectively; an increase in the household size will increase land productivity until having around 7 household members, *ceteris paribus*. The dependency ratio is negative as expected, as the increase of dependent household members increases the requirements for care, thus capturing some of the time that could otherwise be spent on agricultural production. We notice that the educational attainment of the head of household, which is the variable, used most often to capture human capital characteristics, is positive but doesn't have a very strong effect on productivity. On the other hand, the percentage of literate household members has a very strong effect on agricultural productivity: a household with only literate members would be 62% more productive per acre of land than a household comprised out of only illiterate people, ceteris paribus.

In equation 3 we add controls for for soil types, slope and number of plots, as well as fixed effects for each district. In many studies of the IR phenomenon, critics have pointed to the lack of any direct controls for soil types as potentially resulting in an omitted variable bias (Cornia 1985, Bhalla and Roy 1988, Sen 1999). Whereas most studies have relied on fixed effects as controls for soil quality, our soil category provides new information, particularly as we use it in conjunction with fixed effects at the district level. We find three important results. The first is that the type of soil matters, as the increase in the share of sandy land or land between sandy and clay (versus the default loamy soil) decreases output per acre. The second is that the slope of land is important. Farms on slopes tend to be more productive than those on flat land. Third, and perhaps most striking, is that the degree of land fragmentation is correlated with higher output per acre. Dividing the same acres of land into more plots , while assuming the same household and the same soil and slope characteristics, is correlated with a 17% increase in agricultural productivity (an estimate which is positive and statistically significant). In this specification the gender gap in productivity has fallen to 15% and now is only significant at the 95 percent confidence level. In the next section we work at disentangling the effect of the differences in female and male-headed farms from the effects from the differences in input and crop choice

The Choice of Crop

One of the major differences between most poor and rich households in rural Kenya is access to cash crop farming. Gĩthĩnji (2000) for example found that farms which were described as mainly cash crop producing had higher land and labor productivity than the subsistence or mixed farms (both cash crop and subsistence farming) despite being surprisingly similar in terms of land endowments in size terms. In terms of labor, cash

crop farms were 2.3 times and 1.3 times as productive as subsistence and mixed farms respectively and 2.5 and 1.8 times in terms of land respectively.

Numerous other studies have found that female-headed households are also much less likely to engage in cash crop farming (Dey 1981, Chipande 1987, Due and Gladwin 1991, Masterson 2007). This is the case here, as well. While 11.9 percent of land under the control of males headed households is used for growing cash crops that is the case for only 7.8 percent of land under female headed households.

Female headed household's crop choice could be the result of outright discrimination in access to inputs or to the markets required to sell the cash crops. Prima facie evidence of this can be seen by examining where households obtain seeds and fertilizer; 3.4 percent of male headed households receive at least some of their fertilizer or seeds from a cooperative, compared to only 2 percent of female headed households. Additionally 3.8 percent of male headed households received seeds or fertilizer from a government source, compared to only 2.4 percent of female headed farms. In both cases the difference between males and female headed farms is significant at the 95% confidence level.

However discrimination is not the only possible explanation; there are numerous reasons why female headed households might be more likely to choose subsistence crops. Female headed household could be more risk averse to price fluctuations; lower access to credit might require subsistence crops for consumption smoothing; or cultural barriers might define certain crops as "male" crops. We can think of the problem as the presence of an unobserved variable "A". The variable A would be both correlated with growing cash crops and would influence the error term of our regression. Using X to designate all of the other regressors we get:

$$Y = \beta_1 X + \beta_2 CC + \epsilon$$
$$= \beta_1 X + \beta_2 CC + (\alpha A + \mu)$$

And:

$$Cov(A_i CC_i) \neq 0$$

To separate out the exogenous component of variation in cash crop production and fertilizer use from the endogenous element of crop choice we use a two stage least squares regression. In the first stage regressions we use the percent of other households in the same cluster that receive seeds or fertilizer from an agricultural cooperative as instruments to predict the percent of land devoted to growing cash crops and we utilize the percent of other farmers in the district using fertilizer to instrument a household's fertilizer use. Subsequently, we use the regression coefficients to predict the percent of land we would expect each farm dedicate to cash crops and likelihood of using fertilizer. The predicted values are then used in our second stage regression estimating land productivity. So our first_1 stage is:

$$\widehat{CC} = \pi_{11} X + \pi_{12} I + n_1$$

$$\widehat{Fert} = \pi_{21}X + \pi_{22}I + n_2$$

And our second stage:

$$Y = \beta_1 X + \beta_2 \widehat{CC} + \beta_3 \widehat{Fert} + \epsilon$$

There are two key assumptions in this model. The first key assumption in this model is that the presence of a cooperative does not increase productivity on a farm unless the cooperative increases the likelihood that the farm produces cash crops. Additionally, the use of fertilizer by other farmers does not increase a household's production other than through increasing the likelihood that the farmer uses fertilizer. The second key assumption is that the correlation between our instruments and what they instrumenting is not zero. This second assumption we can empirically test. The R-squared scores for these regressions are .30 and .47 respectively and the instruments are all statistically significant in the first stage regressions.

In the first 2sls model (Regression 4), the percentage of land devoted to cash crops becomes a prime explanation of higher productivity. We notice that, once we calculate the likelihood that a farm will produce cash crops, the gender gap in agricultural productivity falls to a mere 3 percent and is statistically insignificant. The inverted U relationship between household size and agricultural productivity still holds. The percent of the household that is literate is still highly significant; a move from a household with only illiterate members to a household where all its members can read and write increases output per acre by 39 percent. Fragmentation still has a positive impact on productivity, whereas type of land, slope or the fertilizer use of the household cease being statistically significant.

However we must add an important caveat to this story: the household size variables have increased in their significance from the OLS FE models. It is possible that in order to take advantage of opportunities for cash crop production the labor advantage of a larger household becomes even more important. To test for this in our final regression – number 5 – replicates our 2sls model above but with all of the household size variables removed. The gender gap of productivity remains less than 4 percent and statistically insignificant despite no controls for their smaller average size. At the same time, the inverse relationship between farm size and productivity still holds true, while the positive impacts of household literacy, fragmentation and cash crop choice remain.

Discussion

There are four key results from our estimations that bear some discussion. The first is that the inverse relationship between land size and output per acre holds even when controlling for female headed households who are close to 30 percent of farming households and who on average have lower gross output per acre than their male-headed counterparts. Given this result policies that facilitate land concentration may result in lower overall agricultural land productivity. Part of the reason that the IR result holds is our second key finding which is that in a model inputs and crop choice are controlled for being a female-headed household does not result in lower output per unit of land. This fits in with the findings by Nyariki (2011) who finds that female headed households are more efficient in the use of the limited resources that they control. In addition to female-headed households not being statistically significant, marital status has no explanatory power.. This finding is consistent with Gĩthĩnji 's (2000) simple calculation that showed given the largest possible remittances from urban areas, given the difference in population size between the urban and rural populations were not large enough to close the gap between male and female headed households. Our third key finding is the importance of human capital at the household level, i.e. there is complimentarity in household human capital in farming. Literacy of all members of the household has greater impact that the education of the head of the household.

The fourth key finding is the role of soil, slope, inputs and crop choice in the context of rainfed agriculture. In our OLS equation we find that soil and slope are key determinants of productivity, however their significance is lost in the context of a model that includes crop choice and fertilizer use. This is consistent with a story of where soil and slope characteristics determine crop choice (Gĩthĩnji et al 2011). The importance here vis-à-vis female headed households is that on average they have less access to standard crop cooperatives than do male households. In a simple logistic regression predicting access to cooperatives we find that for similar farm characteristics, the control for female-headed is negative and significant at the 10 percent level. For a farm with similar characteristics, switching the head of the farm from male to female decreases the probability of the farm using a cooperative by 43 percent.

This leads us to our final finding: the differences in male and female productivity are largely determined for by differences in crop choice. A full study of the gendered differences in cash crop production is beyond the scope of this paper; however we can put forward a few hypotheses. If female headed households are less able to access credit or insurance markets, or are closer to subsistence limits in their access to food, they may choose to produce subsistence crops despite their lower returns in order to lower the risk of price shocks. If this is the case policies that reduce these risks - such as food assistance, credit or insurance interventions, or food price stabilization - could increase female household participation in cash crop production and hence

overall productivity. Alternatively it is possible that female headed farms might desire to produce cash crops just as much as male farmers, but are being discriminated against in access to cooperatives and other markets for inputs and outputs. Policies to encourage more female participation in the cooperatives could have important impact in increasing female farm productivity.

CONCLUSIONS

Female-headed farms (de jure or de facto) are not less productive than male-headed farms: in fact, the difference in output per acre which appears in the initial (naïve, if you will) specifications can be attributed to the impact of the fact that they do not produce cash crops. However, this result is hardly a choice: it is rather an exclusion from agricultural cooperatives, government support, and networks in general, which would allow female-headed households to do equally well with female-headed households. In fact, once the different cash crop choice has been accounted for in the first stage of the estimation female-headed households are not less productive than their male-headed counterparts.

What is the import of our findings in the existing context of expanding markets and globalization? First, our finding of the IR effect and the non significance of female-headed households suggests that land redistribution would be beneficial for all poor rural households with limited access to land regardless of the sex of the household head. In addition however policy must go beyond redistribution and education and ensure that all households have equal access to the key inputs in farming. This would mean a complete reconsideration of both extension services and cooperatives which are the key ways that most successful small farmers receive support. Extension services must both become more gender sensitive in terms of provision of services, farmers chosen for demonstration and visits as well as in the makeup of extension officers. Crop cooperatives can no longer have a monopoly on supporting and marketing cash crops without them showing an ability to support female-headed households. In the absence of restructuring that force them to take gender into account then hybrid women organizations will be a necessity to ensure that women have equal opportunities in farming.

Although the above steps seem fairly obvious and straightforward, they essentially call for a reevaluation of the entire infrastructure of capital accumulation in rural areas, beginning with the redistribution of land, and then the creation of institutions that give small farmers including female-headed households equal access to

key inputs. In the context of expanding markets and globalization it will be only with such a regime change that female-headed households and other small farmers will have a chance to thrive.

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