



## Back to the Plough: Women Managers and Farm Productivity in India

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*In India the role of women as farm managers has been veiled behind the image of men as primary decision makers on farms. Data shows that approximately 8% of farm households had women farm managers in India in 2004 and this number increased to 11% in 2011. This rising phenomenon of farm management by women begets an in depth understanding of these farms, including, differentials in productivity levels across men and women managed farms. This paper uses three measures to capture productivity – production value, profit value and crop specific yields. The results show that production value is lower by approximately 7% in women managed farms even with all controls. The difference in profitability is of the same magnitude, albeit, insignificant. There are two possible channels behind the result – unobservable soil quality or differences in managerial efficiency as a result of inexperience. While we cannot test explicitly for the first channel, the paper provides suggestive evidence on the second channel using crop specific yields. This study makes two contributions to the literature – one, it is the first study in the Indian context and second, it employs semi-parametric decomposition techniques to look at the productivity differentials along the entire distribution.*

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# **Back to the Plough: Women Managers and Farm Productivity in India**

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## **Abstract**

In India the role of women as farm managers has been veiled behind the image of men as primary decision makers on farms. Data shows that approximately 8% of farm households had women farm managers in India in 2004 and this number increased to 11% in 2011. This rising phenomenon of farm management by women begets an in depth understanding of these farms, including, differentials in productivity levels across men and women managed farms. This paper uses three measures to capture productivity – production value, profit value and crop specific yields. The results show that production value is lower by approximately 7% in women managed farms even with all controls. The difference in profitability is of the same magnitude, albeit, insignificant. There are two possible channels behind the result – unobservable soil quality or differences in managerial efficiency as a result of inexperience. While we cannot test explicitly for the first channel, the paper provides suggestive evidence on the second channel using crop specific yields. This study makes two contributions to the literature – one, it is the first study in the Indian context and second, it employs semi-parametric decomposition techniques to look at the productivity differentials along the entire distribution.

## 1. Introduction

Economists have been interested in gender gaps in employment, wages, access to resources and productivity to understand the sources of disadvantage faced by almost half the world's population. An extensive literature within this looks at the difference in female and male productivity in agriculture. Doss(2015) and Quisumbing(1996) provide a detailed review of this literature. There are two strands within this literature. One looks at the gender difference in labour productivity in cultivation of a crop. Second looks at the crop productivity of lands either owned or managed by female and male operators. Udry (1996) was one of the earliest studies which examined the productivity of plots controlled by men and women within the same households, and growing the same crop in Africa. Most studies find that productivity of female held plots is lower than those controlled by males, and this difference either becomes very small or vanishes when access to productive resources is controlled for.

A large body of literature has developed in the last two decades, that looks at this question for Sub-Saharan Africa (recent studies include de la O Campos et al (2016) for Uganda, Ali et al (2015) for Uganda, Aguilar et al (2015) for Ethiopia, Kilic, Palacios-Lopez and Goldstein (2015) for Malawi, Oseni et al (2015) for Nigeria, Slavchevska (2015) for Tanzania, Guirkinger et al. (2015) for Mali, wa Githinji et al. (2014) for Kenya, Kaziana and Wahhaj (2013) for Burkina Faso, Peterman (2011) for Nigeria and Uganda, Matshe, Zikhali and Chilonda (2010) for Zimbabwe). But there are few studies that look at this dimension of gender gap in other regions. There is only one study on rice production in Philippines by Koirala, Mishra and Mohanty (2015) which analyzes the difference in productivity of male and female headed farm households. On the basis of a review of many such studies FAO State of Food and Agriculture Report (2010-11) states that "If women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent."

This is the first study that provides estimates of gender differences in agricultural productivity for India. Given that agriculture is still the predominant provider of employment and income in rural areas of India, from the perspective of both gender and food security this question assumes importance. This study contributes to the literature in two ways – first by providing estimates for India, for which none currently exist and secondly, by undertaking a non-parametric decomposition along the entire distribution, and not only at the mean levels of productivity. Apart from productivity, we also analyse differences in farm profits since efficiency requirements on farm should ideally relate to profitability and not yield as output

and input decisions are taken to maximize profits and not output. We also provide suggestive evidence for the mechanisms behind the observed effects.

Increasing smallholder agricultural productivity is one of the tools for poverty reduction in rural areas and agricultural policy in India needs to be reshaped to cater to the emerging needs of the farmers. Currently there is no space in the policy to make provision for differential needs of women who manage their farms. This is largely because of the invisibility of these women as primary decision makers on farm matters from the discourse. A part of it is attributable to paucity of data regarding this facet of cultivator households in India. Globally, shares of women farm operators range from a high of 18% in Latin America and the Caribbean to a low of 4% in Oceania. South Asia shows a proportion of 12%.

As per the Indian agriculture census 2010-11, women farmers operate 12.78% of operational land holding and 10.34% of the operational area in India. In 1995-96, these figures stood at 9.5% of land holdings and 7.2% of operational area. According to Indian Human Development Survey, women managed farms in 8.3% of the households in 2004 which increased to 11% in 2011. Clearly, women are gaining ground in farm management in India. Mahajan (2017) looks at the determinants of this rise in incidence of women farm managers and finds that male migration is one of the important reasons behind the observed growth in their numbers over time. There is no evidence of what might be the implications of this on food security.

This is the first paper which looks at farm productivity differentials between men and women farm managers in India. The paper is organized as follows. Section 2 presents a brief literature review on existing evidence for other countries and the Indian context. Section 3 elucidates the data used in the analyses and the empirical strategy, along with a description of variables. The empirical strategy is detailed in Section 4 and the results are discussed in Section 5. Section 6 presents a discussion of possible mechanisms behind the obtained results and checks for their robustness using a semi-parametric decomposition. The conclusions are gathered in Section 7.

## **2. Background**

### *2.1 Literature Review*

A look at the literature shows that there are two types of methodologies which are generally used to assess the gender differential in agricultural productivity. The first uses household-level information and outcomes and relates it to either the gender of the household head or gender of the person who makes farm management decisions in the household

(Quisumbing 1996; Doss 2015; Peterman et al. 2011). Using data on household head is more common since most surveys capture this information. These studies make the assumption that decision making within the households follows a unitary setting and soil quality differences across household in a study area are negligible (Schultz 2001).<sup>1</sup>

The second set of studies use plot level information within a household. This is due to prevalence of differential management of plots within a household by men and women in Sub-Saharan Africa. Such a setting allows one to control for household-crop level heterogeneity in a regression framework. The causal estimate is identified using within household variation in productivity differences across male and female managed plots cultivated with the same crop. These have been the most influential studies in terms of bringing out pareto-inefficiency within household allocation of resources to production. Recent studies use Oaxaca-Blinder decomposition to decompose the difference in productivity into an endowments part (due to inputs and other household characteristics) and the second part due to structural differences (unexplained part).

A few studies in the second strand find that gender differentials are significant even after controlling for input usage (Guirkinger et al. 2015 for Mali; Saito et al. 1994 for Nigeria; Udry 1996 for Burkina Faso; Quisumbing et al., 2001 for Ghana; Peterman et al., 2011 for Uganda) while others find that the differential disappears after input controls are included (Kaziana and Wahhaj (2013) for Burkina Faso; Saito et al. (1994) for Kenya; Gilbert et al., (2002) for Malawi; Akresh (2005) for Burkina Faso; Goldstein and Udry (2008) for Ghana). Most of these studies look at yield and very few examine profits (Adesina and Djato 1997; Goldstein and Udry 2008). The mediating factors usually are crop choice, input usage, credit access, market access and human capital differences.

## *2.1 The Indian Context*

The contribution of women to agriculture in India has been studied along the dimensions of unpaid family labourers and agricultural labourers. Around 73% of the rural workforce in India is engaged in agriculture (Census 2011). In terms of gender composition, about 80% (69%) of the female (male) workforce in rural India is engaged in agriculture (Census 2011). Female agricultural labourers constitute 55% of the female agricultural workforce. But there is no study that looks at women as farm managers and its implications

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<sup>1</sup> We do not attempt a complete literature review here and interested readers can look at Quisumbing (1996), (Croppenstedt, Goldstein, & Rosas (2013) and Doss (2015) for a look at all the studies which have looked at this question.

for farm productivity. Importance of farm management in the Indian context cannot be disputed since at least 50% of households in rural areas cultivate some land. Also, rising farm management by women, due to male migration, has direct implications for food security. In 2011, approximately 11% of households report that women are the primary decision maker of farm decisions. Additionally, the Indian context is very different from Sub-Saharan Africa. Unlike Africa where within households plots are managed by men and women, such a division of plots is not observed in India. Usually, there is one person in the household who takes most agricultural decisions, which can be in consultation with other family members.

Almost all studies in this literature, including this study, are not a causal analysis of whether a women farm manager has a negative effect on farm productivity. Such a policy experiment would involve giving the same access to inputs and quality of land to men and women farm operators and then infer if productivities on the two types of plots are different. From a policy perspective what are the implications of these studies? In general, literature tells us that women have lower output levels than men managed/headed households and most of it disappears when input usage is accounted for. If productivity gap disappears after input accounting, does it mean that providing more inputs will increase farm output? Perhaps not if women are using inputs commensurate with quality of land, which is an unobservable. In instances where gender residual remains, there are again concerns about whether the residual is due to managerial ability, varying by gender of the farm manager or due to an unobservable variable like soil quality. If the former is due to inadequate training and information due to inexperience then policy intervention has a role to play by providing the necessary extension services to women farm operators.

The aim of many government programs is to increase agricultural productivity of farmers by imparting them training. Do these programs need to have special component which explicitly involves catering to women? The economic rationale behind such targeting would come if returns to these efforts are greater i.e. if there is a greater increase in marginal productivity of women farm managers through these programs. This will lead to an overall increase in agricultural production as well as an increase in income generation for women.

### **3. Data**

Data from the Indian Human Development Survey (IHDS) is used for analyses. It is a nationally representative survey conducted by the University of Maryland and the National Council of Applied Economic Research (NCAER) in 2004-05. It covers 41,554 households across 382 districts of India. It covers all States and Union Territories except Andaman and

Nicobar Islands and Lakshadweep. The primary sampling units are villages in rural areas (1503 villages) and the number of rural households surveyed is 27,010. A second round of the survey in 2011-12 re-interviews the original households and also includes new households. It covers 384 districts in the second round and includes 42,152 households. The number of villages included in the rural areas is 1503. Around 83% of the households in IHDS I (2004-05) were re-interviewed in IHDS II (2012). However, the crop production schedule for IHDS II is not yet publicly available and we do not incorporate it in this version of the paper. Once the second round is available one can incorporate household fixed effects to control for household level unobservables which do not change over time.

The survey enquires about agricultural production details in households which report cultivating land in the past year. Approximately 55% of the rural households report cultivating agricultural land. The survey then asks the identification details of the member who primarily makes decisions regarding farm cultivation matters. The crop production schedule is canvassed for households that report cultivating some land in the past one year. When interviews were conducted before December 2004 the crop year was July 2003-June 2004. For households where interviews were conducted in 2005 the crop year was December 2003-November 2004.<sup>2</sup> Each crop grown in *Kharif*, *Rabi* and Summer were recorded for each season. Other information on the crop (whether it is cultivated on irrigated land, how much area is planted under it, total production, the price at which it is sold) were also recorded. Information on inputs was recorded at the household level (man-days of labour hired, value of seeds purchased, money spent on fertilizers and manures, pesticides, water purchased for irrigation, hiring farm equipment, repayment of agricultural loan) and not at the plot level. Additionally, measurement of inputs is prone to error since the survey does not capture exact usage in quantity. To deal with this we create indicator variables in the regression analyses for input controls.

## 4. Empirical Strategy

### 4.1 Main Specification

Equation below is estimated to arrive at the differential effect of a woman farm manager on agricultural productivity:

$$\ln O_{hv} = \beta_0 + \beta_1 \text{Woman FM}_{hv} + \beta_2 \ln N_{hv} + \beta_3 C_{hv} + \beta_4 F_{hv} + \beta_5 H_{hv} + \beta_6 I_{hv} + V_v + u_{hv}$$

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<sup>2</sup> More than 90% of the villages were interviewed in the same window. Controlling for village fixed effects will in the analyses hence controls for village specific weather shocks that may be correlated across households.

Here subscript 'h' refers to a household and 'v' refers to a village. Variables are defined as below:

O: Value of output per hectare of land

Woman FM: Indicator variable for the farm manager in household 'h' being a woman

N: Gross cultivated area

C: Crop choice (proportion of area under each crop)

F: Farm decision maker characteristics like age, education, marital status

H: Other household characteristics like asset ownership of the household, caste, religion, demographic composition of the household (number of adult men)

I: Input used (these include: (a) fertilizer/manure, herbicide/pesticide, hiring water for irrigation; hiring tractors or animals for farm; repayment of loan as proxy for credit access; ownership of tube-well, electric pump, diesel pump, bullock cart, tractor by the household; use of purchased seed; (b) Proportion of land irrigated; hired labour days per acre; household labour days per acre (adult male, adult female, child (10-14 age))

V: Village Fixed effects

The main coefficient of interest in the above regression is the coefficient of the indicator variable 'Woman FM'. If it is negative then it shows that the value of output produced on women managed plots is lower than that of men. It must be noted, that the above does not imply that women managed farms are less efficient since differences in crop choice and input intensity could be one of the driving factors for the difference in value of productivity. Here, it must be noted that crop choice is endogenous and so are other input choices. We condition the estimates on village fixed effects. To the extent that agro-climatic variation across geographies drives the choice of crops and inputs, we are able to control for the observables which can affect both crop/input choice and the value of production at the village level. However, household level unobservables can still result in the correlation of these variables with the error term (u). The results on coefficients of inputs should at best be viewed as correlations and not causal due to this possibility.

#### *4.2 Construction of variables*

(a) Dependent variable: This is the total value of output aggregated over all the crops which were cultivated by a household in the reference year. Each household that reports cultivation on land also reports the total production of each crop and the price at which each crop in a particular season was sold in the market. This price is used to impute a value to the part of

produce which may have been used by the household for self consumption. A very small proportion of households (1.4%) report no price for sale of crop or zero output. In another specification we consider value of profit as the dependent variable. The value of profit is obtained by subtracting total input expenses paid in the reference year from the total value of production in the year.<sup>3</sup> Table 1 below shows the difference between men and women managed farm households in value of production and profits. On an average we find no significant difference between men and women managed farm households in either production value or profits.

(b) Gender of the Farm Manager: This is the main variable of interest which is an indicator variable that takes a value of one if in a household a woman is the primary decision maker of farm matters. The question asked of the head of the household is “Who is the primary decision maker about farm matters in your house?” There are other ways of defining the gender variable by taking the gender of the household head and not the farm manager. The data shows that amongst women farm managers around 77% and 81% are household heads. We prefer to use the reported farm manager’s sex to define the gender variable since management is likely to be different from headship. Studies that use headship usually find that the differences are negligible but these differences become starker when the sex of the actual farm manager is used (Doss 2015).

(c) Crop choice: One of the important mediators in most studies is the type of crop cultivated on a particular land. In our analyses a household could be growing multiple crops over a year. The composition of these crops is controlled for in the analyses. Table 1 shows the difference between men and women managed farm households in cultivated area and crop choice. It can be seen that women grow more cereals whereas men grow more non-food crops in India.

(d) Input usage: The mean level of input usage by men and women cultivators is shown in Table 2. Plot level input information is only available for irrigation. Data for other inputs is available for all the crops combined. The survey does not capture on which plots these inputs were used and in what quantity. To this extent our analysis about actual usage of these inputs is restricted. We use the information available on usage of inputs to ascertain some basic differences which may exist across men and women managed farm households. Table 2

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<sup>3</sup> Around 15% of the households report negative or zero profits. Currently, we drop these households from the analyses since we are taking a log transformation of the profits as the dependent variable.

shows that in 2004, women farmers have significantly lower access to all inputs except hired equipment. Women managed farm households hire more equipment largely because their ownership of equipment (reflected in proportion of women managed farm households which own tube wells, pumps and ploughing equipment) is significantly lower than that of men managed farms households.

(e) Other controls: A description of other household level control variables in the regression analyses is given in Table 3. The statistics show that women on average have lower education levels than men farm managers, which is largely due to overall lower schooling levels of women in rural India. There is no difference in average age of men and women farm managers and it is approximately equal to 47 years. There is a stark difference across the farm households in terms of marital status of the farm manager. Men farm managers are likely to be currently married and living with their spouse, whereas women farm managers are more likely to be widowed. The proportion of women farm managers who are currently married and living with their spouse in the village are 28%. A substantial proportion of women farm managers (13%) are married but their husbands have migrated from the village. In terms of wealth deciles, there is no consistent difference across men and women farm managed households. If anything, women managed households are significantly greater in upper wealth deciles than lower wealth deciles.<sup>4</sup> The household demographic composition in terms of number of men is also significantly lower in women managed farm households. This is in line with women farm managers more likely to be widowed or with a husband who has migrated.

## **5. Results**

### *5.1 Value of Output*

Table 4 shows the results for the main specification with village fixed effects and controls for crop composition. In the summary statistics there was no difference in the production value between men and women managed farms but when area under cultivation is controlled for in specification (1) the estimates show that value of production is lower on women managed farms by 11% conditional on cultivated area. Table 1 shows that cultivated area is smaller in women managed farm households. Literature shows that there is an inverse relationship between farm size and farm yield. Smaller farms on an average have larger

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<sup>4</sup> We first create an assets index (Filmer and Pritchett, 2001) and then compute deciles of this index. These deciles are created for all households in rural areas.

yields. This is reflected in the overall higher value of production on women managed farms as the farm size is smaller. However, the results show that for the same farm size, the value of production on these farms is lower. Controlling for crop composition the value of production is 7.7% lower on women managed farms. Further adding controls for farm manager characteristics (Table 5, specification 1) like age, education and marital status reduces the difference in productivity between men and women managed farm households and it becomes insignificant. When household demographic controls like wealth deciles, caste, religion and number of male household members, the difference again becomes significant (Table 5, specification 2). This is because yield is larger in higher wealth decile households and women are over represented in the upper deciles. Once controls are added for wealth, we find that for the same wealth women managed farm households have lower value of production. This implies that women farm managers despite residing in wealthier households are not able to reap the benefits in terms of output value in comparison to men farm managers belonging to similar wealth status households. Addition of input controls reduces the productivity gap by one percent. Overall, women have a lower on farm productivity and the magnitude is approximately 7%.

We next consider the heterogeneity in the effects on value of farm productivity by area cultivated, age and whether or not the manager is the household head. This is done to shed light on possible sources of disadvantage that women farm manager face. The results are shown in Table 6. The results show that value of production is lower in small farm sized women managed farm households than for the ones that have larger farm size. In terms of age, women aged 38 or above show smaller productivity on their farms in comparison to younger women. Lastly, women who are also household heads show a larger and significantly negative effect on their productivity in comparison to women who are not household heads.<sup>5</sup> On the whole these results show that older women, who are also more likely to be the head of the households, having small landholdings are likely to have lower productivity levels than men managed farm households.

## 5.2 Profits

As discussed earlier a better measure of farm efficiency is its profitability since farms with lower yields may be so due to un-observables like soil quality. To the extent that the farm manager takes into account these while making production and input decisions, it may

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<sup>5</sup> A further heterogeneous effect by *de facto* headship and *de jure* headship is conducted but the results are omitted for brevity. There is no significant difference between these two type of households.

then not be necessary that increasing inputs or better information will necessarily increase productivity. The farmer maybe doing the best in terms of productivity given profits are maximized.

Table 7 shows the results for farm profits when village fixed effects and crop choice is controlled for. It can be seen that on an average women earn 11% lower profits on their land for the same cultivated area and this negative effect increases to 13% when village effects are added as controls. A large part of this lower profit on women managed farms is explained by crop choice since this negative gap reduces to 10% when controls for crop choice are included. When further controls for characteristics of the farm manager, household demographics and inputs are added in Table 8, the magnitude of the negative difference does not change much. It remains around 8% but it turns insignificant. The results with respect to heterogeneity are not presented for brevity. The estimates show that women who are head of households having larger landholdings have lower profits. However, the results are not statistically significant.

## **6. Possible Mechanisms and Discussion of Results**

### *6.1 Mechanism*

There are two important factors that act as mediators in our analyses. One is the crop choice of the farmer and second is the input usage. But even after controlling for them and other demographic characteristics, farm households where women manage farms have 7% lower production (significant) and profits (insignificant). The question of crop choice also is related to the extent to which men and women are producing for market or home consumption. When producing partly or entirely for home consumption, farmers may not be maximizing profits (or production) but may instead be pursuing a range of more complex objectives. If there is limited access to markets, with a high wedge between prices farmers receive as producers and the amount that they pay as consumers, it can be economically rational for them to produce lower-value crops for home consumption rather than more valuable crops for the market.

The policy relevant question is if women face constraints in terms of inadequate knowledge, experience and training and if these can be overcome through policy interventions. For suggestive evidence in this direction we use the existing qualitative evidence on gender roles across crops. It has been well documented in the literature that rice cultivation involves greater demand for women's labour (Boserup 1970). In the Indian context studies have shown that women's involvement is greater in rice cultivation due to

tasks like transplanting and weeding which are predominantly performed by women (Bardhan 1974). Equipped with this evidence, studies compare female labour force participation rates across rice and wheat growing regions (Agarwal 1986; Chen 1989; Chin 2011).<sup>6</sup> They find that regions where rice cultivation was intensive, the involvement of women in agriculture activities was greater and still persists. If involvement of women has been historically greater in rice cultivation then one would expect that they are likely to have greater experience and knowledge about best cultivation practices for rice crop. Crop specific differences in agriculture productivity can then throw some light on whether experience, which is acquired through involvement in production process, is one of the channels through which lower average value of productivity plays out conditional on crop choice.

We estimate the main specification with the dependent variable as crop specific yields. The two crops we consider are rice and wheat. Table 9 shows the results for rice yield and Table 10 shows the results for wheat yield. Women managed farms which cultivate rice show a lower rice yield by 7% in comparison to male managed farms. This becomes small and insignificant when controls for manager characteristics and inputs are added. On the other hand, wheat yields are lower by 13% on women managed farms and this difference does not reduce when other controls are included.

These results are in line with the hypothesis that women have more experience due to their historical involvement in rice cultivation in India. Insufficient involvement in crop cultivation prior to taking up management, as in the case of wheat crop, can be one of the channels through which the productivity gap between men and women plays out.<sup>7</sup> Other confounding factors to this hypothesis may be that women in wheat growing areas have lower quality lands. At the outset there does not seem to be an economic reason why this should be the case unless men in rice growing areas are more convinced with the skills of their wives and leave farm management in their hands when they migrate or take up non-farm jobs. This again rests on the assumption that women in rice growing areas may have better management abilities due to their experience in crop cultivation.

## *6.2 Discussion and Semi-parametric decomposition*

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<sup>6</sup> Rice and wheat are the two most important cereal crops in India and still account for more than 70% of area cultivated

<sup>7</sup> A direct test of the hypothesis could have been a measure of women's experience in cultivation. However, the data does not capture any such measure. An indirect construction of the measure through husband's death or the year of migration is also not captured in the data. We can only identify whether the husband is a migrant currently or the woman is a widow.

The above results show that on an average, women managed farm households have lower value of output, lower profits albeit insignificant and lower wheat yields. These results persist even after all controls are included in the regression. We generalize the analyses to construct counterfactual distributions i.e. what would have the distribution of say value of output for men managed farms if they had the same characteristics as the women managed farms and plot the density estimates along the entire distribution (DiNardo, Fortin and Lemieux 1995).

The main objective in a semi-parametric decomposition is to construct a counterfactual density of productivity measures that would prevail for men if they had women's distribution of characteristics (and vice versa). The former assumes men as the reference group while the latter assumes women as the reference group. In this analysis we assume men as the reference group. The counterfactual density can then be estimated by applying nonparametric kernel density estimation techniques to a re-weighted sample of men. We describe briefly the method for constructing the counterfactual density and use the below notation. The density functions for productivity for men and women are written as:

$$f(y|G = M) = \int g(y|x, G = M)h(x|G = M)dx$$

$$f(y|G = F) = \int g(y|x, G = F)h(x|G = F)dx$$

Here  $G$  is the gender of the farm manager and  $g(y|x, G = F)$  refers to density of the productivity evaluated at productivity level 'y' given the characteristics of the individual farmer is 'x' and the gender of the farm manager is 'Female'. Intuitively, it is a function that translates attributes to productivity.  $h(x|G = F)$  refers to the density of attributes 'x' when the gender is female. In a parametric Oaxaca Blinder decomposition,  $h(x|G = M)$  is analogous to endowments,  $g(y|x, G = F)$  would be return to those endowments and  $f(y|G = F)$  would be the productivity of women farm managers. The counterfactual that we want to construct is: density of productivity measures that would prevail for men if they had the same characteristics as women.<sup>8</sup> This is given by:

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<sup>8</sup> It is possible to construct other counterfactual, for example what would have been the density of productivity measures for women if they had the same characteristics as men

$$=f_c^F(y)=\int g(y|x, G = F)h(x|G = M)dx$$

$$\begin{aligned}
f_c^M(y) &= \int g(y|x, G = M)h(x|G = F)dx \\
&= \int g(y|x, G = M)h(x|G = M) \frac{h(x|G = F)}{h(x|G = M)} dx \\
&= \int g(y|x, G = M)h(x|G = M)\varphi(x)dx
\end{aligned}$$

The above counterfactual can be constructed by using the below identity given by Bayes' Theorem:

$$\frac{h(x|G = F)}{h(x|G = M)} = \frac{\Pr(G = F|X = x)}{(1 - \Pr(G = F|X = x))} \frac{\Pr(G = M)}{\Pr(G = F)}$$

In the above expression  $\varphi(x)$  is also called the re-weighting function. The counter-factual can then be computed using a weighted density estimate of productivity measures where weights are given by  $\varphi(x)$ . The re-weighting function can be simply obtained by using the predicted probabilities from a logit/probit that predicts the probability that a particular observation belongs to a woman managed farm managed on the basis of observed characteristics (X) from the pooled observations. This gives an estimate for  $\Pr(G = F|X = x)$ . An estimate for  $\Pr(G = M)$  can be obtained by computing the proportion of farm households where men manage farms.

Figure 1 shows the kernel density plots for production value for women managed farms and the counterfactual distribution for men managed farms (after controlling for area, crop choice, demographics, location and inputs). It can be clearly seen that even if men managed households had the same characteristics as women managed farms they would still have larger output values and this difference is stark at the lower to mid level of the production value distribution. Hence, differences in observables cannot completely explain the higher output value in men managed farms. The actual distribution of profits for women managed farm households and the counterfactual distribution for men managed farm households is shown in Figure 2. Here, the differences between the two distributions are less stark and only at the mid value of profit distribution do we observe significant differences.

Figure 3 shows the kernel density plots for actual rice yield on women managed farms and the counterfactual distribution of the rice yield on men managed farms if they had the characteristics of women managed farms. Lastly, Figure 4 shows the same distributions for wheat yield. The two distributions for rice yields are again closer to each other except for in the middle part of the distribution. The counterfactual distribution of wheat yields on men

managed farms is however, significantly and consistently, larger along the entire distribution till the middle value of wheat yields (small value of density at lower end and larger values at the higher end for the counterfactual men's distribution). This shows that difference in characteristics between wheat growing farms which are managed by men and women do not explain the differences at least at the lower to mid end of the distribution. There is no significant difference in wheat yields at the upper end of the distribution once all the controls have been added. These counterfactuals show that if anything women at the lower end of the value distributions of production, profits and yields per acre have lower productivity measures than men.

## **7. Conclusion**

This paper looks at men and women farm managers in India and the possible differences in their agricultural productivity. Notably, women manage smaller farms and on average the production value, profits and yields per acre on small farms is larger. But conditional on the cultivated area, production value and profits per acre on women managed farms is lower. The production value on women managed farms is lower than men managed farms by approximately 7% even after controls for area, crop composition, farm manager and household characteristics and inputs are included. In terms of profitability we find that profits on women managed farms are lower but this difference is insignificant in our sample once all controls are included.

To shed some light on the possible mechanisms that may be driving the obtained results, the paper exploits existing evidence in the literature on gender roles across crops. Women have been more involved in rice cultivation in India and wheat has been predominantly regarded as a male crop. We examine the yield differences across rice and wheat crop. The results show that there is little difference between men and women managed farms in rice productivity once area, season and farmer characteristics have been controlled for. However, wheat yields on women managed farms are lower by almost 16% even when all controls are included. This evidence is suggestive of lack of managerial knowledge and experience in cultivation practices in wheat cultivation due to gendered roles.

## References

- Adesina, Akinwumi A, and Kouakou K Djato. 1997. "Relative Efficiency of Women as Farm Managers: Profit Function Analysis in Cote d'Ivoire." *Agricultural Economics* 16: 47–53.
- Agarwal, B. 1986. "Women, poverty and agricultural growth in India." *The Journal of Peasant Studies*, 13(4), 165–220.
- Aguilar, Arturo, Eliana Carranza, Markus Goldstein, Talip Kilic, and Gbemisola Oseni. 2015. "Decomposition of gender differentials in agricultural productivity in Ethiopia." *Agricultural Economics* 46, no. 3: 311-334.
- Akresh, Richard. 2005. "Understanding Pareto Inefficient Intrahousehold Allocations." IZA Discussion Paper no. 1858, Inst. Study Labor, Bonn.
- Ali, Daniel Ayalew, Derick Bowen, Klaus Deininger, and Marguerite Duponchel. 2015. "Investigating the gender gap in agricultural productivity: evidence from Uganda." *World Bank Policy Research Working Paper* 7262.
- Backiny-Yetna, Prospere, and Kevin McGee. 2015. "Gender differentials and agricultural productivity in Niger." *World Bank Policy Research Working Paper* 7199.
- Bardhan, P. 1974. "On life and death questions." *Economic and Political Weekly*, 9(32/34), 1293–1304.
- Chen, M. A. (1989). "Women's work in Indian agriculture by agro-ecologic zones: Meeting needs of landless and land-poor women." *Economic and Political Weekly*, 24(43), WS79–WS89.
- Chin, Y.M. 2011. "Male backlash, bargaining, or exposure reduction?: Women's working status and physical spousal violence in India." *Journal of Population Economics*, 25(1), 175–200.
- de la O Campos, Ana Paula, Katia Alejandra Covarrubias and Alberto Prieto Patron. 2016. "How Does the Choice of the Gender Indicator Affect the Analysis of Gender Differences in Agricultural Productivity? Evidence from Uganda." *World Development* 77: 17-33.
- DiNardo, John, Nicole M. Fortin, and Thomas Lemieux. 1995. "Labor market institutions and the distribution of wages, 1973-1992: A semiparametric approach." No. w5093. National Bureau of Economic Research.
- Doss, Cheryl. 2014. "If women hold up half the sky, how much of the world's food do they produce?." In *Gender in Agriculture*, pp. 69-88. Springer Netherlands.
- Doss, Cheryl R. 2015. "Women and Agricultural Productivity: What Does the Evidence Tell Us?." *Yale University Economic Growth Center Discussion Paper* 1051.
- Filmer, Deon, and Lant H Pritchett. 2001. "Estimating Wealth Effects Without Expenditure Data—Or Tears: An Application To Educational Enrollments In States Of India." *Demography*, Vol 38, No 1, pp 115–132.

Gilbert, Robert. A. Sakala, Webster D., & Todd D. Benson. 2002. "Gender analysis of a nationwide cropping system trial survey in Malawi." *African Studies Quarterly*, 6(1-2), 223–243.

Kazianga, Harounan, and Zaki Wahhaj. 2013. "Gender, Social Norms and Household Production in Burkina Faso." *Economic Development and Cultural Change* 61 (3): 539–76.

Kilic, Talip, Amparo Palacios-Lopez, and Markus Goldstein. 2015. "Caught in a productivity trap: a distributional perspective on gender differences in Malawian agriculture." *World Development* 70: 416-463.

Koirala, Krishna H., Ashok Mishra, and Samarendu Mohanty. 2014. "The Role of Gender in Agricultural Productivity in the Philippines: The Average Treatment Effect." In *2015 Annual Meeting, January 31-February 3, 2015, Atlanta, Georgia*, no. 195705. Southern Agricultural Economics Association, 2014.

Mahajan, Kanika. 2018. "Changing Roles: Women as Farm Managers." Mimeo.

Matshe, Innocent, Precious Zikhali, and Pius Chilonda. 2010. "Education and agricultural inputs use by female farmers in Zimbabwe." *Agenda* 24, no. 86: 96-110.

Mbiti, Isaac. M. 2007. *Moving women: Household composition, labour demand and crop choice*. Dallas, TX, USA: Mimeo, Department of Economics, Southern Methodist University.

Oseni, Gbemisola, Paul Corral, Markus Goldstein, and Paul Winters. 2015. "Explaining gender differentials in agricultural production in Nigeria." *Agricultural Economics* 46, no. 3: 285-310.

Palacios-López, Amparo, and Ramon López. 2015. "The gender gap in agricultural productivity: the role of market imperfections." *The Journal of Development Studies* 51, no. 9: 1175-1192.

Peterman, Amber, Agnes Quisumbing, Julia Behrman, and Ephraim Nkonya. 2011. "Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda." *Journal of Development Studies* 47, no. 10: 1482-1509.

Quisumbing, Agnes R. 1996. "Male-female differences in agricultural productivity: Methodological issues and empirical evidence." *World Development* 24, no. 10: 1579-1595.

Saito, Katrine Anderson, Hailu Mekonnen, and Daphne Spurling. 1994. *Raising the productivity of women farmers in Sub-Saharan Africa*. Vol. 230. World Bank Publications.

Schultz, T. P. 2001. Women's role in the agricultural household bargaining and human capital investments. In B. Gardner, & G.Rausser (Eds.), *Agricultural and resource economics handbook* (pp. 383–456). Amsterdam, Netherlands: Elsevier.

Slavchevska, Vanya. 2015. "Gender differences in agricultural productivity: the case of Tanzania." *Agricultural Economics* 46, no. 3 (2015): 335-355.

Udry, Christopher. 1996. "Gender, agricultural production, and the theory of the household." *Journal of political Economy*, 1010-1046.

wa Githinji, Mwangi, Charalampos Konstantinidis, and Andrew Barenberg. 2014. "Small and Productive : Kenyan Women and Crop Choice." *Feminist Economics* 20 (1): 101–29.

Goldstein, Markus, and Christopher Udry. 2008. "The Profits of Power: Land Rights and Agricultural Investments in Ghana." *Journal of Political Economy* 116 (6): 981–1022.

Table 1. Differences between men and women managed farms: Output and Crop choice

Variable	Variable Definition	Men	Women	Difference	
Production	Ln(production value per acre)	8.378	8.332	-0.046	
Profit	Ln(profit value per acre)	7.873	7.826	-0.047	
Area	Ln(gross cultivated area)	0.987	0.482	-0.506	***
Cereal	Proportion of area under Cereals	0.671	0.73	0.059	***
Pulses	Proportion of area under Pulses	0.079	0.071	-0.008	***
Oilseeds	Proportion of area under Oilseeds	0.092	0.06	-0.032	
Spice	Proportion of area under Spices	0.017	0.017	0	
Fruits & Veggies	Proportion of area under F&V	0.07	0.081	0.011	
Non-food	Proportion of area under Non-food crops	0.067	0.039	-0.028	***
Others	Proportion of area of cultivation under others	0.004	0.003	-0.002	*

*Note:* The sample includes all households which report a positive value of production in the last year.

*Source:* Author's calculations, IHDS I (2004)

Table 2. Differences between men and women managed farms: Input Usage

Input	Definition	Men (N=13105)	Women (N=971)	Difference	
Irrigation	Proportion area cropped which is irrigated	0.469	0.403	-0.066	***
Household adult male labour	Mandays of household adult male labour per acre	88.793	49.109	-39.684	***
Household adult female labour	Mandays of household adult female labour per acre	47.399	147.477	100.078	*
Household child labour (10-14)	Mandays of household child labour per acre	1.958	4.421	2.463	**
Hired labour	Mandays of labour hired per acre	13.079	20.629	7.55	
Fertilizer	Percentage households who purchased fertilizer/manure	0.893	0.835	-0.058	***
Pesticide	Percentage households who purchased pesticide	0.536	0.398	-0.138	***
Hired Equipment	Percentage households who hire any tractors/equipments/animals for working on farm	0.635	0.653	0.018	
Irrigation water purchase	Percentage households who purchased irrigation water	0.284	0.254	-0.029	*
Credit	Percentage households who repaid some agricultural loan last year	0.084	0.035	-0.049	***
Own Tube-well	Percentage households who own tube well	0.182	0.108	-0.074	***
Own Electric Pump	Percentage households who own electric pump	0.164	0.113	-0.051	***
Own Diesel Pump	Percentage households who own diesel pump	0.107	0.054	-0.053	***
Own Bullock Cart	Percentage households who own bullock cart	0.162	0.06	-0.102	***
Own Tractor	Percentage households who own tractor	0.052	0.028	-0.024	***

*Note:* The sample includes all households which report a positive value of production in the last year.

*Source:* Author's calculations, IHDS I (2004)

Table 3. Differences between men and women managed farms: Demographic Characteristics

Demographic characteristics	Definition	Men	Women	Difference
Age	Age of farm manager	46.931	47.268	0.337
Education	Number of years of education of farm manager	4.914	2.179	-2.735 ***
Marital Status	Proportion Unmarried	0.023	0.027	0.004
	Proportion Currently Married	0.937	0.287	-0.65 ***
	Proportion with spouse not living in house	0.001	0.133	0.132 ***
	Proportion widowed	0.036	0.537	0.501 ***
	Proportion separated/Divorced	0.003	0.016	0.014 ***
Asset Deciles	Decile 1 for assets score	0.076	0.064	-0.012
	Decile 2 for assets score	0.089	0.104	0.016
	Decile 3 for assets score	0.091	0.088	-0.002
	Decile 4 for assets score	0.098	0.077	-0.021 **
	Decile 5 for assets score	0.101	0.092	-0.01
	Decile 6 for assets score	0.1	0.071	-0.029 ***
	Decile 7 for assets score	0.097	0.089	-0.007
	Decile 8 for assets score	0.103	0.108	0.005
	Decile 9 for assets score	0.108	0.135	0.028 **
	Decile 10 for assets score	0.138	0.171	0.032 ***
Adult males	Number of adult males in household	1.833	1.164	-0.669 ***

*Note:* The sample includes all households which report a positive value of production in the last year.

*Source:* Author's calculations, IHDS I (2004)

Table 4. Production: Differences across men and women managed farms (Village and crop controls)

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.114***	(0.036)	-0.105***	(0.027)	-0.077***	(0.026)
ln (Area)	-0.134***	(0.010)	-0.045***	(0.009)	-0.061***	(0.009)
Cereal					-0.366**	(0.180)
Pulses					-0.497***	(0.186)
Oilseeds					0.001	(0.187)
Spice					0.888***	(0.244)
Fruits & Veggies					0.947***	(0.193)
Non-food					0.591***	(0.197)
Village Fixed Effects	No		Yes		Yes	
Crop Composition	No		No		Yes	
Characteristics FM	No		No		No	
Demographics HH	No		No		No	
Inputs	No		No		No	
Observations	14,076		14,076		14,076	
R-Square	0.022		0.577		0.614	

Note: The sample includes all households which report a positive value of production in the last year. Robust standard errors are in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 5. Production: Differences across men and women managed farms (All controls)

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.036	(0.032)	-0.087**	(0.034)	-0.073**	(0.032)
ln (Area)	-0.078***	(0.009)	-0.130***	(0.011)	-0.182***	(0.011)
Cereal	-0.346*	(0.178)	-0.346*	(0.183)	-0.354**	(0.180)
Pulses	-0.488***	(0.183)	-0.502***	(0.188)	-0.388**	(0.186)
Oilseeds	0.011	(0.185)	0.027	(0.192)	0.034	(0.188)
Spice	0.894***	(0.240)	0.823***	(0.246)	0.686***	(0.238)
Fruits & Veggies	0.937***	(0.191)	0.837***	(0.196)	0.722***	(0.193)
Non-food	0.600***	(0.194)	0.679***	(0.203)	0.611***	(0.199)
Age	0.002***	(0.001)	0.001	(0.001)	0.001**	(0.001)
Education	0.017***	(0.002)	0.008***	(0.002)	0.007***	(0.002)
Married	0.079*	(0.042)	0.067	(0.045)	0.057	(0.043)
Spouse migrated	0.069	(0.075)	0.036	(0.080)	0.005	(0.078)
Widowed	0.094*	(0.052)	0.116**	(0.055)	0.091*	(0.053)
Separated/Divorced	0.024	(0.116)	-0.048	(0.098)	-0.004	(0.089)
Irrigation					0.288***	(0.027)
Village Fixed Effects	Yes		Yes		Yes	
Crop Composition	Yes		Yes		Yes	
Characteristics FM	Yes		Yes		Yes	
Demographics HH	No		Yes		Yes	
Inputs	No		No		Yes	
Observations	14,007		12,314		12,314	
R-Square	0.619		0.636		0.663	

Note: The sample includes all households which report a positive value of production in the last year. Robust standard errors are in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 6. Production: Differences across men and women managed farms (Heterogeneous effects, All Controls)

Variable	Area Cultivated		Age		HH Head	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.094**	(0.039)	-0.045	(0.120)	-0.053	(0.063)
ln(Area)	-0.185***	(0.011)	-0.182***	(0.011)	-0.181***	(0.011)
Woman FM*ln(Area)	0.041	(0.030)				
Age	0.001**	(0.001)	0.001**	(0.001)	0.001**	(0.001)
Woman FM*Age			-0.001	(0.002)		
HH Head					0.012	(0.026)
Woman FM*HH Head					-0.029	(0.076)
Null: Woman FM+Woman FM*Area=0                      Reject below 3 acre						
Null: Woman FM+Woman FM*Age=0                                              Reject at age 38 & above						
Null: Woman FM+Woman FM*HH Head=0                                                                      Reject						
Other Controls						
Village Fixed Effects	Yes		Yes		Yes	
Crop Composition	Yes		Yes		Yes	
Characteristics FM	Yes		Yes		Yes	
Demographics HH	Yes		Yes		Yes	
Inputs	Yes		Yes		Yes	
Observations	12,314		12,314		12,314	
R-Square	0.663		0.663		0.663	

*Note:* The sample includes all households which report a positive value of production in the last year. Robust standard errors in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 7. Profit: Differences across men and women managed farms (Village and crop controls)

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.107**	(0.050)	-0.132***	(0.041)	-0.098**	(0.040)
ln (Area)	-0.125***	(0.012)	-0.013	(0.013)	-0.033***	(0.012)
Cereal					-0.534*	(0.291)
Pulses					-0.505*	(0.298)
Oilseeds					-0.066	(0.302)
Spice					1.121***	(0.360)
Fruits & Veggies					0.955***	(0.306)
Non-food					0.708**	(0.311)
<b>Other Controls</b>						
Village Fixed Effects	No		Yes		Yes	
Crop Composition	No		No		Yes	
Characteristics FM	No		No		No	
Demographics HH	No		No		No	
Inputs	No		No		No	
Observations	12,059		12,059		12,059	
R-Square	0.013		0.488		0.519	

*Note:* The sample includes all households which report a positive value of profit in the last year. Robust standard errors in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 8. Profit: Differences across men and women managed farms (Village and crop controls)

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.080*	(0.048)	-0.082	(0.050)	-0.079	(0.050)
ln (Area)	-0.041***	(0.013)	-0.074***	(0.015)	-0.102***	(0.016)
Cereal	-0.520*	(0.293)	-0.544*	(0.312)	-0.526*	(0.319)
Pulses	-0.509*	(0.299)	-0.576*	(0.318)	-0.458	(0.326)
Oilseeds	-0.060	(0.303)	-0.089	(0.325)	-0.033	(0.330)
Spice	1.134***	(0.360)	1.025***	(0.381)	0.916**	(0.383)
Fruits & Veggies	0.955***	(0.308)	0.834**	(0.328)	0.744**	(0.334)
Non-food	0.714**	(0.312)	0.775**	(0.334)	0.762**	(0.340)
Age	0.001	(0.001)	0.000	(0.001)	0.000	(0.001)
Education	0.007***	(0.002)	0.003	(0.003)	0.003	(0.003)
Married	0.058	(0.063)	0.050	(0.066)	0.040	(0.066)
Spouse migrated	-0.019	(0.116)	-0.046	(0.124)	-0.055	(0.123)
Widowed	0.077	(0.076)	0.072	(0.080)	0.047	(0.080)
Separated/Divorced	-0.034	(0.169)	-0.071	(0.152)	-0.044	(0.152)
Irrigation					0.323***	(0.040)
Village Fixed Effects	Yes		Yes		Yes	
Crop Composition	Yes		Yes		Yes	
Characteristics FM	Yes		Yes		Yes	
Demographics HH	No		Yes		Yes	
Inputs	No		No		Yes	
Observations	11,998		10,609		10,609	
R-Square	0.521		0.534		0.548	

*Note:* The sample includes all households which report a positive value of profit in the last year. Robust standard errors in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 9. Rice Yield: Differences across men and women managed farms

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.076***	(0.028)	-0.038	(0.034)		
ln (Area)	-0.122***	(0.011)	-0.136***	(0.011)		
Irrigated plot			0.141***	(0.021)		
Age			0.001**	(0.001)		
Education			0.013***	(0.002)		
Fertilizer						
Season	Yes		Yes		Yes	
Village Fixed Effects	Yes		Yes		Yes	
Characteristics FM	No		Yes		Yes	
Demographics HH	No		No		Yes	
Inputs	No		No		Yes	
Observations	8,241		8,200		7,584	
R-Square	0.645		0.653		0.673	

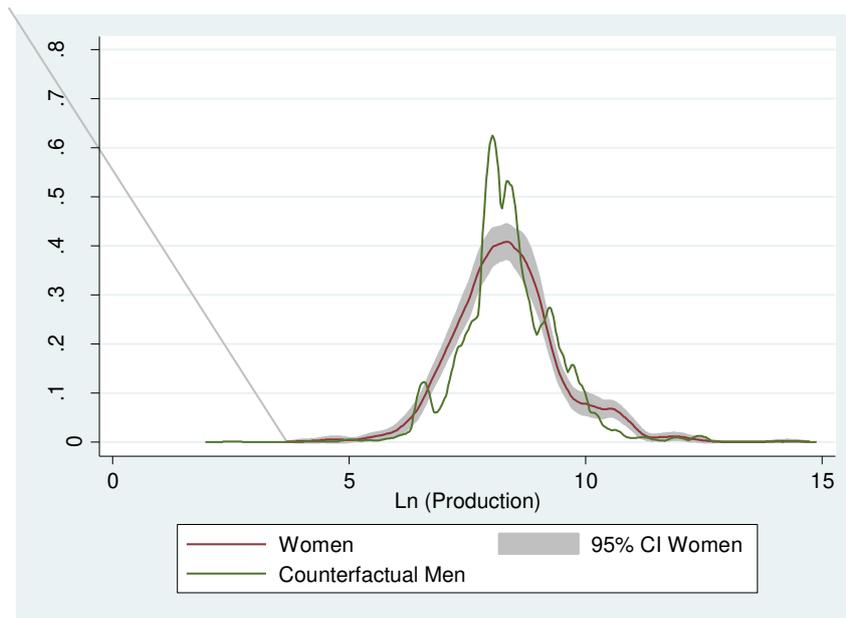
*Note:* The sample includes all plots on which a household reports rice cultivation in the last year. The controls for season include indicator variables for whether the crop was cultivated in Kharif, Rabi or Summer season. Input controls include all the input controls in Table 2 except measures of labour used on land since these are likely to suffer from measurement error as they are not crop specific. Robust standard errors in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Table 10. Wheat Yield: Differences across men and women managed farms

Variable	(1)		(2)		(3)	
	Coeff	S.E.	Coeff	S.E.	Coeff	S.E.
Woman FM	-0.133***	(0.033)	-0.130***	(0.044)	-0.159***	(0.044)
ln (Area)	-0.107***	(0.011)	-0.122***	(0.012)	-0.179***	(0.014)
Irrigated plot			0.234***	(0.040)	0.186***	(0.041)
Age			0.001	(0.001)	-0.001	(0.001)
Education			0.010***	(0.002)	0.003	(0.002)
Season	Yes		Yes		Yes	
Village Fixed Effects	Yes		Yes		Yes	
Characteristics FM	No		Yes		Yes	
Demographics HH	No		No		Yes	
Inputs	No		No		Yes	
Observations	6,253		6,223		5,618	
R-Square	0.587		0.592		0.624	

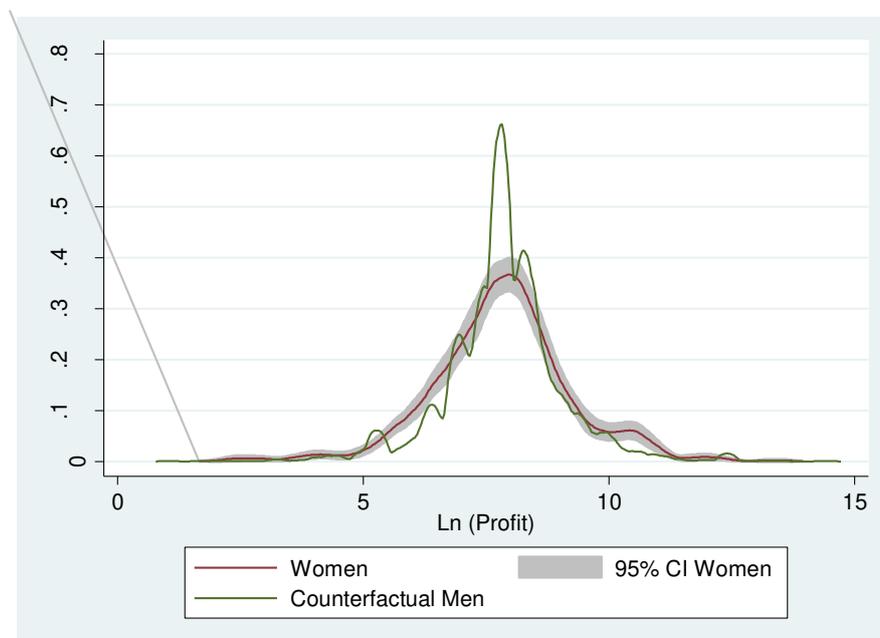
*Note:* The sample includes all plots on which a household reports wheat cultivation in the last year. The controls for season include indicator variables for whether the crop was cultivated in Kharif, Rabi or Summer season. Input controls include all the input controls in Table 2 except measures of labour used on land since these are likely to suffer from measurement error as they are not crop specific. Robust standard errors in parentheses. \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels respectively.

Figure 1. Distribution of Production: Actual and Counterfactual Distribution



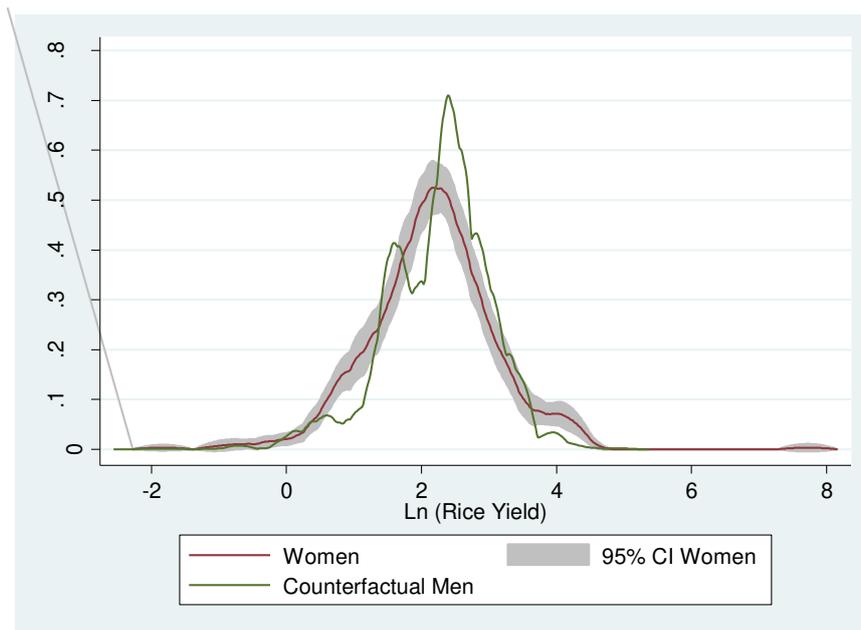
*Note:* The sample includes all households which report a positive value of production in the last year. The controls used for generating the reweighting function include cultivated area, district fixed effects, crop composition, farm manager characteristics, household characteristics and all input variables (excluding own household labour).

Figure 2. Distribution of Profits: Actual and Counterfactual Distribution



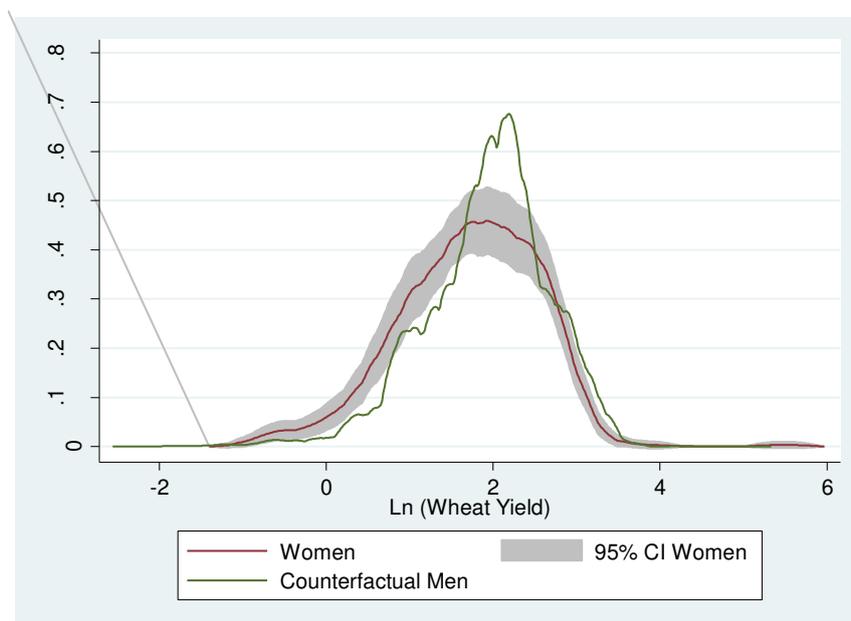
*Note:* The sample includes all households which report a positive value of production in the last year. The controls used for generating the reweighting function include cultivated area, district fixed effects, crop composition, farm manager characteristics, household characteristics and input variables (excluding own household labour).

Figure 3. Distribution of Rice Yield: Actual and Counterfactual Distribution



*Note:* The sample includes all plots on which a household reports rice cultivation in the last year. The controls used for generating the reweighting function include cultivated area, crop season, district fixed effects, farm manager characteristics, household characteristics and all input variables excluding labour inputs.

Figure 4. Distribution of Wheat Yield: Actual and Counterfactual Distribution



*Note:* The sample includes all plots on which a household reports wheat cultivation in the last year. The controls used for generating the reweighting function include cultivated area, crop season, district fixed effects, farm manager characteristics, household characteristics and all input variables excluding labour inputs.