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# INTRA-HOUSEHOLD GENDER DIFFERENTIALS IN SMALLHOLDER AGRICULTURE PRODUCTIVITY IN FOOD AND NON-FOOD CROP COMMERCIALISATION PATHWAYS: EVIDENCE FROM ZIMBABWE

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# ACRONYMS

| | |
|---|---|
| **FAC** | Future Agricultures Consortium |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FH** | female-headed |
| **ha** | hectare |
| **MH** | male-headed |
| **NEPAD** | New Partnership for African Development |
| **OLS** | Ordinary Least Squares |

# ABSTRACT

This study examines the intra-household gender differentials in smallholder agriculture productivity in Zimbabwe in the context of two different pathways to household commercialisation. It uses household plot-level data drawn from two rural Zimbabwe sites of highly commercialised smallholder farmers in maize and tobacco production. Most empirical studies have examined gender differentials in terms of gender of plot managers. This study contributes to the literature by classifying female plot managers into those from female-headed and male-headed households. Overall, we find evidence of gender differentials in agricultural productivity by plot manager as well as when female plot managers are distinguished by household type. The aggregate output results show that the gender bias in agricultural productivity is more pronounced in plots managed by females in male-headed households, underscoring the importance of distinguishing household types in gender analysis.

# 1 INTRODUCTION

The problem of low agricultural productivity and the marginal increases in agricultural productivity over time in Africa compared to other developing countries is well known and documented (NEPAD 2013). African agriculture continues to rely on farming systems based on family resources, with smallholder farmers forming the bulk of the agricultural sector (NEPAD 2013). Although in terms of agricultural output, the sector has shown growth and has been the main driver of economic growth, productivity in agriculture has not risen significantly compared to other developing regions. Cereal yields in Africa are less than half of the yields obtained in Asia (NEPAD 2013). Agricultural intensification has also not occurred in Africa, due to a combination of factors which includes low uptake of modern technologies and an unfavourable policy environment to incentivise production (Nin-Pratt and McBride 2014). According to the World Bank (2007), for instance, cereal yields per hectare moved from a little over 1 tonne per hectare in 1960 to 4.5 tonnes per hectare in 2005 in South Asian countries, compared to about 0.9 tonnes per hectare in 1960 to a little over 1 tonne per hectare in 2005 in sub-Saharan Africa.

Although there are myths[1] surrounding women's role in agriculture (Doss *et al*. 2018), women are estimated to provide a significant proportion of labour in agricultural activities in Africa and play a critical role in agricultural production. For instance, Palacios-López, Christiaensen, and Kilic (2017) find that women contribute 40 per cent of agricultural labour to household crop production in six African countries, while Mukasa and Salami (2015) note that women account for almost 50 per cent of the agricultural labour force. However, women still face numerous social, political, economic, and cultural barriers which impinge on their ability to improve their agricultural productivity and to effectively participate in agricultural commercialisation processes. Yet, women's participation in agricultural production and commercialisation is crucial for their empowerment and economic independence. The FAO (2011) notes that access to resources such as land, education, modern inputs, technology, and financial services is a critical determinant of agricultural productivity, but women or female farmers tend to have disproportionate access to these resources compared to their male counterparts.

In Zimbabwe, earlier studies have found that *de facto* female-headed households tend to have smaller landholdings and limited access to farm machinery and labour resources (Horrell and Krishnan 2007). Such systematic differences in access to resources can lead to gender differentials in productivity and the impacts of agriculture on welfare. Besides negatively affecting agricultural productivity, gender inequalities regarding access to productive, human, and social capital assets can exacerbate the poverty situation among female-headed households in rural communities. Several studies have identified gender gaps in agricultural productivity among smallholder farmers in Africa (Aguilar *et al*. 2015; Ali *et al*. 2016; de la O Campos, Covarrubias and Parton 2016; Mukasa and Salami 2015; Slavchevska 2015; Kilic, Palacios-López and Goldstein 2015; Palacios-López and López 2015; Horrell and Krishnan 2007).

Although there is a growing number of empirical studies on gender differentials in agricultural productivity and its decomposition, these studies have not considered the commercialisation contexts and the issues of intra-household resource allocation which may affect the productivity of female plot managers; for instance, whether female plot managers belong to female-headed or male-headed households (Doss 2002; Chirwa *et al*. 2011). An earlier study on gender and productivity in Zimbabwe finds productivity differentials in female-headed households only in the cultivation of cotton but not food crops (Horrell and Krishnan 2007). In order to address these issues, our study is set in the contexts of two agricultural commercialisation pathways in two study areas among smallholder farmers in Zimbabwe: a) a study area largely driven by non-food crop (tobacco) commercialisation and b) another study area driven by food crop (mainly maize) commercialisation.

Our study, therefore, contributes to the empirical evidence on gender differentials in smallholder agriculture productivity in two ways. First, our data allow us to group households into commercialisation pathways; one group in which plot managers belong to households with at least a plot manager involved in tobacco (non-food crop) production (the non-food crop commercialisation pathway), and another group in which plot managers belong to households who are only involved in purely food crop commercialisation (the food crop commercialisation pathway).

Secondly, we consider intra-household resource allocation issues by distinguishing female plot managers into two groups: female plot managers in female-headed households and female plot managers in male-headed households. To our knowledge, these issues have not been studied in Zimbabwe in the context of land resettlement programmes for smallholder farmers. We test the hypotheses that a) there are no gender differences in productivity in female- and male-managed plots, b) there are no differences in productivity between female plot managers from male- and female-headed households and male plot managers, and c) gender productivity differentials do not depend on the commercialisation pathway chosen by the farming household.

The rest of the paper is organised as follows. The next section reviews the theoretical and empirical literature on gender and agricultural productivity in general and specifically the emerging evidence from African agriculture. Section 3 outlines the data sources and the methodology used in assessing agricultural productivity differentials and intra-household effects. Plot-level and crop-specific data are used to understand the gender differentials in agricultural productivity. We use both statistical analysis of differences between female plot managers and male plot managers and econometric analysis which controls for managers' and plot-level characteristics. Section 4 presents the empirical results and discusses the main relationships between gender, intra-household effects, and agricultural productivity. Finally, Section 5 provides concluding remarks.

# 2 GENDER DIFFERENTIALS IN AGRICULTURAL PRODUCTIVITY: LITERATURE REVIEW

There are several theoretical strands on how gender issues affect development based on gender roles in household socioeconomic activities, as well as household resource allocation to different socioeconomic activities. One strand of reasoning comes from the marginalisation theories on the triple roles or burdens of women, which point to the differential access to resources and opportunities against women or female decision makers. It is noted that women relative to men tend to face challenges in access to resources and this restricts their participation and undermines their productive potential in economic activities (FAO 2011). Empirical work has tested the marginalisation theories from the perspective of the gender of the household head, explaining differences between male-headed households and female-headed households.[2] This, however, assumes a unitary model of the household, in which there is a unique decision maker in the household who internalises the preferences of all other members to maximise a common welfare function.

However, collective bargaining models suggest that resources are negotiated within the households and the outcomes result in Pareto efficiency in the allocation of resources to various economic activities pursued by household members (Udry *et al*. 1995; Quisumbing and Maluccio 2000; Bourguignon, Browning and Chiappori 2009). In the context of agricultural resources, the gender differentials in productivity can therefore be explained by inefficient resource allocation. This has given rise to the shift in focus from the gender of household head to the gender of the plot manager or the gender of the person in the household who is responsible for most farming decisions or outputs on the plot (Doss 2018). However, gender differences in the outcomes have been interpreted as a result of Pareto-inefficient resource allocation, without determining the sources of such inefficiencies, such as the relative bargaining strengths of members within the households. Doss (2003) notes that control of resources within a household has implications for the relative bargaining power of individual members of the household, and development outcomes may depend on women's power to bargain for intra-household allocation of resources (Doss 2013).

Doss (2018) reviews some of the evidence on gender differentials in many aspects of agricultural performance including agricultural land and labour productivity, production and profitability, technical efficiency, and studies that decompose such gender differentials. There are a number of empirical studies in Africa on gender differentials on agricultural productivity.[3] More recent studies have gone a step further by focusing on the decomposition of the gender bias in agricultural productivity to distil sources of bias and distinguish between structural constraints and gender bias. Using the gender of plot manager, several authors find gender differentials in productivity in favour of male plot managers after accounting for plot managers' characteristics and other covariates. Aguilar *et al*. (2015) find a 34.5 percentage point productivity differential in favour of male plot managers in Ethiopia. Ali *et al*. (2016) find a gender productivity differential of 17.5 per cent before controlling for other characteristics, and a gap of 34.9 per cent after controlling for household and community seasonal effects, plot characteristics, farmer characteristics, and input intensity in Uganda. Another study in Uganda using gender of household head, gender of plot holder, and gender of plot manager finds only a 10 per cent productivity differential only when using female plot managers (de la O Campos *et al*. 2016).

Mukasa and Salami (2015) in a cross-country study, after controlling for other covariates, find gender productivity differentials of 8.5 per cent, 17.5 per cent, and 50.8 per cent in Tanzania, Uganda, and Nigeria, respectively. Similarly, Slavchevska (2015) finds evidence that female plot managers are consistently less productive than their male counterparts, conditional on other covariates. Kilic *et al*. (2015) find a 25 per cent productivity differential against female-managed plots in Malawi while Karamba and Winters (2015) find that female plot managers' participation in the agricultural subsidy programme in Malawi did not help them overcome the gender productivity gap. Horrell and Krishnan (2007) find that female-headed households were less productive than male-headed households only when cultivating cotton, but there were no differences in maize and groundnut cultivation after accounting for input use in Zimbabwe. Desiere and Jolliffe (2018) also find evidence of gender productivity differentials among smallholder farmers in Ethiopia, with male-headed households being 8 per cent more productive than female-headed households. Similarly, Ragasa *et al*. (2013) only find gender productivity differentials in the cultivation of barley among smallholder farmers in Ethiopia.

Although the shift in empirical studies has focused on the gender of the plot manager, one aspect that has been ignored in the analysis of gender differentials in agriculture productivity is the recognition that Pareto-inefficient resource allocations may depend on whether the plot manager belongs to a female-headed or male-headed household. This distinction of female plot managers by household type unmasks the balance of power within the household in allocation of resources. Chirwa *et al*. (2011) in the context of the farm input subsidy (fertiliser) use on plots managed by different individuals in the household find less bias in intra-household use of subsidised fertilisers although male-headed households were more likely to receive subsidised fertilisers than female-headed households. This study departs from previous studies on gender differentials in agricultural productivity by analysing these differentials through the lens of female plot managers in female-headed households and female plot managers in male-headed households compared with male plot managers. As noted by Horrell and Krishnan (2007), the society in Zimbabwe is deeply patriarchal, particularly in Shona-speaking areas. In such societies, women in the household may enjoy little power in bargaining for resources for enhancing agricultural productivity.

# 3 DATA AND METHODS

The data for this study are from a randomly selected sample of 647 households drawn from smallholder farmers in the Mvurwi and Concession areas of Mazowe District in Zimbabwe. These smallholder farmers are A1 resettlement farmers who were beneficiaries of the country's fast-track land reform programme which started in 2000. Under the land reform programme, each household was allocated about 5 hectares (ha) of land to pursue agricultural livelihoods. Prior to 2000, the Mvurwi study area was occupied by large-scale mainly white commercial farmers involved in mixed farming activities. However, after 2000, most of the study area farms were acquired and subdivided into small- (about 5ha) to medium-scale (30 to 100ha) units.

Most farmers initially, particularly prior to 2007, engaged in maize production for sale to traders in nearby Mvurwi and Concession towns. Since 2007, there has been rapid growth in tobacco production for sale through Harare-based auction floors and other crops such as vegetables, groundnuts, and soya beans. The A1 smallholder resettlement areas have been a focus for agricultural commercialisation in the past 17 years. Mvurwi has seen increased participation of smallholder farmers in tobacco production engaging in non-food crop commercialisation while in Concession, maize cultivation for food and sale still plays a dominant role in the agricultural system. Mutyasira and Sukume (2020) find that smallholder farmers in these study areas sell at least 74 per cent of their agricultural output, and participation in input markets is also high.

The area has high levels of participation of private sector contracting companies, bulk traders, and aggregators (for maize and horticulture products) and links to auction markets (for tobacco) and spot markets locally (for horticulture and maize). There is increased competition among traders and contracting companies, and we expect a greater number of households engaging with various markets.

The study uses plot-level data from 647 sampled households. For each plot, within a household, a plot manager was identified as the person who makes most farming decisions on the plot. This allows us to identify the plot managers by gender and whether these female plot managers belong to female- or male-headed households. In the plot-level analysis, we use data from 1,294 plots on which tobacco was cultivated on 406 plots and maize on 503 plots. In the crop-level analysis, we use data for 863 plots where maize (480 plots) and tobacco (383 plots) output was reported by the households.

Our plot-level econometric analysis is in two parts. First, we follow the most widely used approach of estimating the gross value of harvested output per unit of land on each plot as the dependent variable. Most studies which have looked at gender differentials in agricultural productivity use the gross value of output per unit land size in local currency or US dollars as a measure of productivity (such as Kilic *et al*. 2015 and de la O Campos *et al*. 2016). This approach deals with issues of intercropping which are typical in smallholder agricultural systems (Doss 2015). The key contribution in our approach is to categorise plot managers into those belonging to households that cultivate some tobacco and other crops (including food crops) and those from households cultivating purely maize and other food crops. To investigate gender differentials and intra-household resource allocation in this context, we estimate the following plot-level general model:

$$log\ GVO_{ijk} = \alpha_o + \alpha_1 FPM_{ijk} + \alpha_2 CP_{ik} + \sum_m \beta_m X_{ijk} + \sum_m \gamma_m Z_{ijk} + \sum_m \tau_m H_{ik} + \varepsilon_{ijk}$$

*Equation 1*

where $GVO_{ijk}$ is the gross value of output harvested in US$ per hectare for all crops on the plot *i* managed by individual *j* in household *k*, $FPM_{ijk}$ is the dummy representing female plot manager *j* on plot *i*, $CP_{ik}$ is a dummy representing the commercialisation pathway for the household *k* to which the plot manager *j* belongs, $X_{ijk}$ are plot manager's characteristics, $Z_{ijk}$ are plot-level characteristics, $H_{ijk}$ are household-level characteristics for household *k* to which the plot manager *j* belongs, and $\varepsilon_{jk}$ is the error term on the plot *i* managed by individual *j* in household *k*. Intra-household resource allocation issues are estimated by including the gender of the plot manager as female plot managers in female-headed and male-headed households.

Second, we analyse crop-level productivity for all maize and tobacco plots. Doss (2015) observes that many studies on gender differentials have focused on staple crops relative to cash crops. This provides opportunities to assess the relative gender productivity differentials in smallholder food and non-food crops. We therefore specify the following regression model for maize and tobacco plots, separately:

$$log\, Y_{ijkc} = \alpha_o + \alpha_1 FPM_{ijk} + \sum_m \beta_m X_{ijk} + \sum_m \gamma_m Z_{ijk} + \sum_m \tau_m H_{ik} + \varepsilon_{ijk}$$

*Equation 2*

where for crop *c* (*c*=1, 2) $Y_{ijk}$ is the yield calculated as output harvested in kilogrammes per hectare on the plot *i* managed by individual *j* in household *k*, $FPM_{ijk}$ is the dummy representing female plot manager *j* on plot *i*, $X_{ijk}$ are plot manager's characteristics, $Z_{ik}$ are plot-level characteristics,  are household-level characteristics for household *k* to which the plot manager *j* belongs and $\varepsilon_{jk}$ is the error term on the plot *i* managed by individual *j* in household *k*. We estimate variants of the above models, first with the gender of plot manager entering the model assuming Pareto efficiency outcomes of resource allocation. Secondly, we consider intra-household resource allocation biases and test the relative bargaining of female plot managers in female-headed and male-headed households. Thirdly, we exploit the fact that some of the smallholder farmers in the non-food commercialisation pathway also cultivated maize; we test the gender differentials in maize productivity in households classified as pursuing a food-based commercialisation pathway compared to those that are pursuing a non-food-based commercialisation pathway.

The dependent variables in the models are the logarithms of gross value of agricultural output per hectare and crop yield as measures of land productivity. For the plot-level model in (1), we estimated agricultural productivity by computing the gross value of harvested output per hectare of cultivated plot as the crop output harvested on the plot valued at median prices in US dollars, and divided this by the size of the plot. In equation (2), yields for maize and tobacco were computed as the total quantity of output for each crop per hectare of cultivated plot.

The variables used in this study to explain gender differentials in agricultural productivity are similar to those used in the literature (for example, Kilic *et al*. 2015; de la O Campos *et al*. 2016; Aguilar *et al*. 2015; Ali *et al*. 2016). Our key explanatory variables in the models are gender of plot manager and household commercialisation pathways while controlling for other covariates. In both models, the gender variable enters the model at two levels: gender of the plot manager and as an intra-household variable in which the gender of the female plot manager is interacted with the gender of the head of the household. The gender of the plot manager is measured as a dummy variable equal to 1 if the plot manager is female, otherwise it is equal to zero. An alternative specification of the model with respect to gender is the creation of two dummy variables, one representing female plot managers in female-headed households and another representing female plot managers in male-headed households.

The evidence on gender differentials in agricultural productivity is rather mixed (Doss 2015, 2018), though recent studies point to the existence of gender biases (Aguilar *et al*. 2015; Slavchevska 2015; Ali *et al*. 2016). The commercialisation pathway variable only enters in model (1) as a dummy variable equal to 1 if the household has a plot manager cultivating tobacco in addition to other food and non-food crops. The inclusion of this variable is one of the innovations in the study, considering that under the same land reform programme, households can make different crop choices as they commercialise their agricultural production. Greater market participation is expected to create incentives for improved agricultural productivity (Rios, Masters and Shively 2008; Benfica *et al*. 2017). Such choices may have implications for intra-household resource allocation and resultant gender differentials in agricultural productivity.

We also control for plot manager's characteristics, plot characteristics, and household characteristics. With respect to the characteristics of the plot manager, two variables enter the models: age of plot manager and education of the plot manager in terms of years of schooling. The level of education is expected to be positively associated with productivity. The plot-level characteristics included in the models are the size of the cultivated plot in hectares in logarithm form, distance of the plot from the household in kilometres, dummy for intercropping on the plot as a soil fertility-improving practice, dummies representing farmers' own perception on the quality of soil on the plot, dummy representing application of organic fertiliser on the plot, quantities of inorganic fertilisers, hired labour, and family labour used on the plot, and a dummy representing use of tillage services.

Intercropping, and the application of organic and inorganic fertilisers are included as soil fertility-improving practices which can lead to improved agricultural productivity and are expected to be positively associated with this (FAO 2013). However, if intercropping is not properly done, competition for nutrients increases, leading to a reduction in productivity of one or all crops on the plot. Quantities of inorganic fertilisers, hired labour, and family labour are measured per hectare of cultivated plot size and enter the models in logarithm form. The models also control for household-level variables including household size, a dummy representing a household's access to extension services, a dummy representing access to market information, a dummy representing a household's access to non-farm income sources, and a wealth index following previous studies (for example, Aguilar *et al*. 2015 and Kilic *et al*. 2015).

# 4 DISCUSSION OF RESULTS

## 4.1 Descriptive analysis

Table 4.1 shows the mean differences of variables at plot level by gender of plot manager. The t-test results are for the difference in female plot managers and male plot managers, with a negative difference showing means in favour of female plot managers. Overall, 76.5 per cent of the plots were managed by men compared to only 23.5 per cent managed by women. With respect to plot manager characteristics, female plot managers are on average 1.59 years older and have 1.56 years less of schooling than male plot managers and the differences are statistically significant at the 10 per cent and 1 per cent level, respectively. All the variables representing the characteristics of the household head are statistically significant at the 1 per cent level between male plot managers and female plot managers. Female plot managers are likely to come from households who are mostly female-headed, with the household heads being on average 3.66 years older and 1.33 years less educated compared to household heads of male plot managers. Similarly, male plot managers belong to male-headed households.

Of the seven household characteristics, we find statistically significant differences between female plot managers and male plot managers in five categories, with three in favour of male plot managers – household size, wealth index, and contract farming. Households to which female plot owners belong tend to have statistically significantly higher dependency ratios (at the 1 per cent level) compared to those of male plot managers. Households of female plot managers also tend to be visited more frequently by extension agents compared to households of their male counterparts. However, there are no gender differences in access to non-farm incomes and access to extension services.

Most of the plot characteristics are statistically different between female-managed plots and male-managed plots. Female managers are likely to cultivate plots which are 0.36ha smaller than their male counterparts. However, if the inverse farm size–productivity relationship holds (Barrett 1996), then larger sizes of male-managed plots may become a disadvantage for their agricultural productivity. Female plot managers cultivate fewer plots and their plots are on average farther away (by 0.12 kilometres) from their homesteads compared to male-managed plots. There are no statistically significant differences in the proportion of female-managed plots and male-managed plots on which maize is cultivated. However, tobacco cultivation is in favour of male plot managers, and the differences in the proportion cultivating tobacco is statistically significant at the 1 per cent level.

With respect to input use, the differences in female-managed plots and male-managed plots are statistically significant in all but three variables. Family labour use per hectare is significantly higher in male-managed plots than in female-managed plots. We also find use of inorganic fertiliser, use of pesticides, herbicides, tractor tillage services, and animal tillage services to be significantly higher in male-managed plots compared to female-managed plots. These mean differences are statistically significant at that 1 per cent level. However, while there are statistical differences in most of the market-sourced agricultural inputs, with respect to hired labour intensity there is no statistical difference. It seems female plot managers compensate the relatively high dependency ratio (low household labour supply) by hiring more labour.

The unconditional mean also reveals that agricultural productivity is higher among male plot managers compared to female plot managers. We find that female plot managers are less productive, earning US$750 per hectare in gross value of agricultural output less than their male counterparts. The difference in mean productivity is statistically different at the 1 per cent level. The high use of market-based inputs among male plot managers observed above suggests the role of the markets in driving productivity in smallholder agriculture and potentially leading to differences in gender differentials in agricultural productivity.

## 4.2 Econometric analysis

We estimate two models in our econometric analysis using two measures of agricultural productivity at plot- and plot-crop levels, gross value of output for all crops per hectare as in model (1), and crop-specific yields as specified in model (2). Table 4.2 presents descriptive statistics of the variables used in the models. The

Table 4.1 Mean differences in characteristics by gender of plot manager

| Characteristic | Pooled sample | Male managers | Female managers | Difference |
|---|---|---|---|---|
| **Manager characteristics** | | | | |
| Age | 49.19 | 48.82 | 50.41 | -1.59* |
| Education | 9.10 | 9.47 | 7.91 | 1.56*** |
| **Household-head characteristics** | | | | |
| Age | 51.29 | 50.43 | 54.09 | -3.66*** |
| Female-headed | 0.16 | 0.025 | 0.601 | -0.58*** |
| Education | 9.11 | 9.41 | 8.12 | 1.30*** |
| **Household characteristics** | | | | |
| Household size | 6.18 | 6.26 | 5.89 | 0.37** |
| Dependency ratio | 1.06 | 1.01 | 1.21 | -0.96*** |
| Access to extension | 0.869 | 0.869 | 0.871 | -0.003 |
| Frequency of extension contacts | 18.79 | 17.78 | 22.06 | -4.28* |
| Wealth index | 0.31 | 0.39 | -0.09 | 0.48*** |
| Access to non-farm income | 0.685 | 0.685 | 0.688 | -0.003 |
| Contract farming | 0.40 | 0.43 | 0.32 | 0.11*** |
| **Plot-level characteristic** | | | | |
| Plot size (cultivated) | 1.65 | 1.73 | 1.37 | 0.36*** |
| Distance to plot | 0.52 | 0.49 | 0.61 | -0.12*** |
| Intercropping | 0.02 | 0.02 | 0.04 | -0.02** |
| Soil is of good quality | 0.71 | 0.70 | 0.75 | -0.05* |
| Maize is cultivated | 0.39 | 0.39 | 0.37 | 0.02 |
| Tobacco is cultivated | 0.31 | 0.35 | 0.20 | 0.15*** |
| Groundnuts are cultivated | 0.05 | 0.03 | 0.12 | -0.09*** |
| Common bean is cultivated | 0.05 | 0.04 | 0.09 | -0.05*** |
| Soya bean is cultivated | 0.14 | 0.14 | 0.12 | 0.02 |
| Number of plots cultivated by plot manager | 2.72 | 2.78 | 2.50 | 0.29*** |
| **Plot-level input use** | | | | |
| Family labour use per hectare (person-days) | 6.24 | 6.71 | 4.70 | 2.01*** |
| Hired labour use per hectare (person-days) | 69 | 69.37 | 67.82 | 1.55 |
| Inorganic fertiliser use | 0.85 | 0.88 | 0.78 | 0.10*** |
| Organic fertiliser use | 0.070 | 0.07 | 0.065 | 0.005 |
| Irrigation use | 0.03 | 0.03 | 0.02 | 0.01 |
| Pesticide use | 0.49 | 0.52 | 0.39 | 0.12*** |
| Herbicide use | 0.45 | 0.48 | 0.34 | 0.15*** |
| Tractor tillage use | 0.50 | 0.54 | 0.35 | 0.18*** |
| Animal tillage use | 0.14 | 0.14 | 0.12 | 0.02*** |
| **Agricultural productivity** | | | | |
| Gross value of output per hectare (USD) | 2,466.44 | 2,642.65 | 1,892.60 | 750.04*** |

Note: *** Statistical significance at the 1 per cent level. ** Statistical significance at the 5 per cent level.
* Statistical significance at the 10 per cent level.
Source: Authors' own.

statistics for all crops show that 23.5 per cent of the plots are female managed and of these 14.1 per cent are managed by female plot managers living in female-headed (FH) households and 9.4 per cent are managed by female plot managers living in male-headed (MH) households. The figures also show that 86.9 per cent of plot managers were in households that had access to extension services and 81.5 per cent were in households that had access to market information. Non-farm income sources are also important in the study areas, with 68.5 per cent of plot managers coming from households that had received incomes from non-farm sources. Tractor tillage services are also highly used among smallholder farmers, with 49.6 per cent using such services. On average, a plot manager cultivates 2.7 plots. We also find that a high proportion of plot managers (71.6 per cent) come from households who are pursuing the non-food crop commercialisation pathway. Most plots are under maize cultivation (38.9 per cent), followed by tobacco (31.4 per cent), and soya beans (13.8 per cent). Soya beans are emerging as an important cash crop among smallholder farmers in Zimbabwe.

With respect to maize plots, 22.3 per cent of the plots are managed by female managers, of which 16.3 per cent of the plots are managed by female managers from female-headed households and only 6 per cent from male-headed households. For plot managers cultivating maize, there is high access to extension services and market information services at 85 per cent and 78.5 per cent, respectively. For tobacco plots, 15.1 per cent of the plot managers are female, with 11 per cent of plots being managed by female managers from female-headed households and 4.2 per cent of plots managed by female managers from male-headed households. Fertiliser use intensity, hired labour intensity, and family labour intensity are all higher on tobacco plots compared to maize plots, though cultivated plot sizes are higher for maize than for tobacco. The use of tractor tillage services is roughly the same on maize and tobacco plots, a reflection of high levels of commercialisation in the study areas.

### a) Agricultural crop productivity

The first set of results are based on equation (1) above, where the output values for all the crops harvested on the plot were aggregated to obtain the gross value of output per hectare. This is a proxy of agricultural productivity. We assess gender differentials in productivity while controlling for the pathway to commercialisation pursued by the household. Table 4.3 presents Ordinary Least Squares (OLS) regressions for four models: (1) specifies the gender in terms of the female plot manager regardless of the type of household and controls for the commercialisation pathway; (2) accounts for the gender of household head in the household the female plot manager belongs to and controls for the commercialisation pathway; (3) is similar to model 1 but we replace the commercialisation pathway and intercropping with crop dummies and an interaction variable between the commercialisation pathway and maize cultivation; and (4) is similar to model 2 but we replace the commercialisation pathway and intercropping with crop dummies and an interaction variable between the commercialisation pathway and maize cultivation. Our discussion is mainly based on models 1 and 2 as the key variables of interest perform consistently in all the four models.

The results consistently show that there are gender differentials in agricultural productivity among smallholder farmers. Plots managed by female managers are on average 11–20 per cent less productive compared to plots managed by male managers. The coefficients of the female plot manager are statistically significant at the 1 per cent level. These results are consistent with previous studies in smallholder agriculture in other countries in Africa (Ali *et al*. 2016; Kilic *et al*. 2015; de la O Campos *et al*. 2016).

In model 2, splitting the female plot manager variable into the type of household, we further find evidence of a gender productivity gap which is more pronounced in female plot managers belonging to male-headed households. The coefficient of the female plot manager in female-headed households is negative and insignificant, but the coefficient of the female plot manager in male-headed households is statistically significant at the 1 per cent level. The gender productivity gap against female plot managers in male-headed households increases to 33.3 per cent compared to the productivity of all male plot managers, regardless of whether they are in female-headed or male-headed households. This relationship is consistent regardless of the specification. The results reveal the importance of recognising the type of household in assessing the impact of gender on productivity. Female plot managers are highly disadvantaged when they belong to male-headed households, suggesting weak countervailing power over bargaining of resources that may be productivity enhancing on their plots. This may be particularly important in patriarchal societies such as Zimbabwe.

With respect to plot manager's characteristics, we find a negative and statistically significant relationship between the age of the plot manager and productivity. The coefficient is statistically significant at the 10 per cent level in models 1 and 3, and at 5 per cent level in models 2 and 4, with one additional year in age reducing productivity by 0.3 per cent. While the plot manager's age could be used as a proxy for farming experience and hence potentially have a positive effect on productivity, it can also be noted that age of the farmer also influences the propensity to adopt new and improved technologies (Teklewold, Kassie and Shiferaw 2013; Mutyasira *et al*. 2018).

Number of years of schooling have a positive effect on productivity, but the coefficient is only statistically significant at the 1 per cent level in models 3 and 4. Household size has a positive and consistent statistically significant relationship with agricultural

**Table 4.2 Descriptive statistics of variables in regression models**

| Variables | All crops | | | | Maize plots | | | | Tobacco plots | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min | Max | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Log of gross value of output per hectare | 7.422 | 892 | 5.30 | 9.87 | - | - | - | - | - | - | - | - |
| Log of yields | - | - | - | - | 8.146 | 0.543 | 6.91 | 9.24 | 7.159 | 0.380 | 6.40 | 8.29 |
| Female plot manager (0/1) | 0.235 | 0.424 | 0.00 | 1.00 | 0.223 | 0.417 | 0.00 | 1.00 | 0.151 | 0.359 | 0.00 | 1.00 |
| Female plot manager in FH household (0/1) | 0.141 | 0.349 | 0.00 | 1.00 | 0.163 | 0.369 | 0.00 | 1.00 | 0.110 | 0.313 | 0.00 | 1.00 |
| Female plot manager in MH household (0/1) | 0.094 | 0.291 | 0.00 | 1.00 | 0.060 | 0.239 | 0.00 | 1.00 | 0.042 | 0.200 | 0.00 | 1.00 |
| Age of plot manager (years) | 49.19 | 13.12 | 19.0 | 86.0 | 49.95 | 13.17 | 20.0 | 86.0 | 48.80 | 12.85 | 19.0 | 86.0 |
| Plot manager's years of schooling (years) | 9.104 | 2.683 | 0.00 | 15.0 | 9.110 | 2.711 | 0.00 | 15.0 | 8.990 | 2.789 | 0.00 | 15.0 |
| Household size | 6.175 | 2.609 | 1.00 | 15.0 | 6.008 | 2.575 | 1.00 | 15.0 | 6.493 | 2.664 | 1.00 | 15.0 |
| Soil quality is good (0/1) | 0.709 | 0.455 | 0.00 | 1.00 | 0.683 | 0.466 | 0.00 | 1.00 | 0.684 | 0.465 | 0.00 | 1.00 |
| Soil quality is fair (0/1) | 0.252 | 0.434 | 0.00 | 1.00 | 0.271 | 0.445 | 0.00 | 1.00 | 0.266 | 0.443 | 0.00 | 1.00 |
| Access to extension services (0/1) | 0.869 | 0.337 | 0.00 | 1.00 | 0.850 | 0.357 | 0.00 | 1.00 | 0.862 | 0.346 | 0.00 | 1.00 |
| Wealth index | 0.277 | 2.178 | -9.50 | 7.00 | 0.188 | 2.258 | -9.50 | 7.00 | 0.332 | 1.971 | -9.50 | 5.85 |
| Access to market information (0/1) | 0.815 | 0.389 | 0.00 | 1.00 | 0.785 | 0.411 | 0.00 | 1.00 | 0.804 | 0.397 | 0.00 | 1.00 |
| Distance to plot (km) | 0.519 | 0.895 | 0.00 | 8.00 | 0.531 | 0.946 | 0.00 | 8.00 | 0.486 | 0.877 | 0.00 | 8.00 |
| Access to non-farm income (0/1) | 0.685 | 0.465 | 0.00 | 1.00 | 0.692 | 0.462 | 0.00 | 1.00 | 0.650 | 0.478 | 0.00 | 1.00 |
| Organic fertiliser applied on plot (0/1) | 0.070 | 0.254 | 0.00 | 1.00 | 0.133 | 0.340 | 0.00 | 1.00 | 0.005 | 0.072 | 0.00 | 1.00 |
| Log of inorganic fertiliser applied per hectare | 4.808 | 3.403 | -3.00 | 8.52 | 5.748 | 1.235 | -0.51 | 8.73 | 6.205 | 0.828 | -0.51 | 8.73 |
| Log of hired labour person-days per hectare | 1.641 | 0.838 | -1.32 | 4.30 | -0.024 | 2.439 | -4.00 | 3.09 | 1.565 | 2.027 | -4.00 | 4.30 |
| Log of family labour person-days per hectare | 3.247 | 1.582 | -1.80 | 7.23 | 2.401 | 1.132 | -2.00 | 5.55 | 4.691 | 0.968 | -2.00 | 7.00 |
| Log of cultivated plot size in hectares | 0.196 | 0.851 | -4.82 | 2.94 | 0.591 | 0.667 | -1.83 | 2.94 | 0.194 | 0.571 | -1.77 | 1.61 |
| Intercropping system on plot (0/1) | 0.024 | 0.153 | 0.00 | 1.00 | 0.025 | 0.156 | 0.00 | 1.00 | 0.003 | 0.051 | 0.00 | 1.00 |
| Use of tractor tillage services on plot (0/1) | 0.496 | 0.500 | 0.00 | 1.00 | 0.529 | 0.500 | 0.00 | 1.00 | 0.540 | 0.449 | 0.00 | 1.00 |
| Number of plots cultivated by plot manager | 2.716 | 1.082 | 1.00 | 7.00 | - | - | - | - | - | - | - | - |
| Commercialisation pathway – non-food (0/1) | 0.716 | 0.451 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Maize cultivated on plot (0/1) | 0.389 | 0.488 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Tobacco cultivated on plot (0/1) | 0.314 | 0.464 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Groundnuts cultivated on plot (0/1) | 0.053 | 0.223 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Common bean cultivated on plot (0/1) | 0.053 | 0.223 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Soya bean cultivated on plot (0/1) | 0.138 | 0.345 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Maize x commercialisation pathway (0/1) | 0.247 | 0.432 | 0.00 | 1.00 | - | - | - | - | - | - | - | - |
| Number of observations | 1,294 | | | | 480 | | | | 383 | | | |

Note: FH stands for female-headed, MH stands for male-headed, and (0/1) indicates dummy variable.
Source: Authors' own.

productivity. The respondents' own evaluation of soil quality is also associated with higher agriculture productivity with good and fair soils being 34.3 per cent and 26.6 per cent more productive than plots classified as having poor soils by the households. The wealth index is consistently positive and statistically significant at the 1 per cent level. The results show that plots managed by members from wealthier households tend to have higher productivity, consistent with previous studies that have included this variable (Kilic *et al.* 2015; Karamba and Winters 2015) but contrary to the findings in de la O Campos *et al.* (2016).

However, access variables produced mixed results. Similar to findings in Ragasa and Mazunda (2018) in the case of Malawi, and Mukasa and Salami (2015) in the case of Nigeria and Uganda, we do not find evidence of a statistically significant relationship between access to extension services and agricultural productivity. The results from Ragasa and Mazunda (2018) suggest that extension messages are mostly productivity-improving only when farmers evaluate them to be useful. However, access to market information is positive but weakly significant at the 10 per cent level in models 3 and 4. Distance to plot is consistently negative but weakly significant in two of the four models.

With respect to input use, application of organic fertilisers on the plot reduces productivity and the coefficient is consistently negative. The proportion of plots with organic fertilisers generally low, and the negative effect may suggest that these farmers are using inefficient combinations of organic and inorganic fertilisers. This is in contrast to other studies examining gender differentials in productivity (such as Ali *et al*. 2016; Kambara and Winters 2015) but similar to findings in Aguilar *et al*. (2015) in the case of Ethiopia. We find market-sourced input use intensity to be positively related to agricultural productivity, suggesting the role of market incentives to driving productivity improvements in smallholder agriculture. The coefficients of quantities of inorganic fertilisers and amount of hired labour on the plot are statistically significant at the 1 per cent level in all the four models, giving elasticities in the range of 0.05–0.08 and 0.08–0.19, respectively. Similarly, the use of tractor tillage services on the plot is positively associated with productivity and the coefficients are statistically significant at the 1 per cent level, further suggesting market incentives as one of the drivers of productivity. Although family labour is statistically significant, its sign is sensitive to specification.

The inverse land size–productivity relationship is also highly and significantly supported in smallholder agriculture in Zimbabwe with coefficients being statistically significant at the 1 per cent level. This is consistent with many studies in smallholder agriculture either using farmer estimates or GPS measures of plot size (Palacios-López and López 2015; Horrell and Krishnan 2007; Kilic *et al*. 2015; de la O Campos *et al*. 2016; Karamba and Winters 2015; Mukasa and Salami 2015). However, Desiere and Jolliffe (2018) argue that the negative relationship may be driven by systematic measurement errors of farmers overstating output on smaller plots, and the authors find a positive relationship when production was estimated using crop-cut methods and a negative relationship using farmers' own estimates of production using data from Ethiopia.

The pathway to commercialisation which households pursue is weakly associated with plot-level agricultural productivity. The coefficient is positive and statistically significant at the 10 per cent level, suggesting that plots managed by members from households pursuing non-food crop commercialisation tend to be about 10 per cent to 12 per cent more productive than plots managed by members from households pursuing food crop commercialisation. Models 3 and 4 replace the commercialisation pathway variable with crop dummies, and we find statistically significant evidence of higher productivity on plots with tobacco consistent with non-food crop commercialisation pathway results. Much lower levels of productivity are found on plots with common beans, groundnuts, and soya beans.

Table 4.4 report OLS regression results of models by household commercialisation pathways. Models 1 and 3 specify the gender of plot manager as in previous studies while models 2 and 4 distinguish female plot managers by household type. The results show significant gender agricultural productivity gaps among plots managed by members in the non-food crop commercialisation pathway, but an insignificant relationship among plots managed by members in the food crop commercialisation pathway. In the non-food crop commercialisation pathway, the gender productivity gap is 20.1 per cent in model 3 and increases to 34.8 per cent in plots managed by females in male-headed households. This suggests that the gender productivity differentials are more pronounced when households are pursuing non-cash crop commercialisation, but even worse when female plot managers belong to male-headed households. These differential results are similar to earlier findings in Zimbabwe by Horrell and Krishnan (2007) using the gender of household head as a gender indicator, who found differences in cotton (non-food crop) cultivation compared to food crops. Our analysis suggests that the conditions of resource allocation in female-headed and male-headed households may be different and Pareto inefficiencies may be propagated by the dominant positions of male-headed households over female members, situations that are socially and culturally embedded in most patriarchal societies in sub-Saharan Africa.

### b) Maize and tobacco productivity

The second set of models focuses on plots with maize and tobacco using yields for each crop based on equation (2). Table 4.5 presents regression estimates of the effect of gender of plot manager and other socioeconomic factors on the yields of all maize and tobacco plots. Firstly, we followed the traditional way of using the gender of the plot manager as the gender identifier in models 1 and 3. Secondly, in models 2 and 4, we distinguish female plot managers into two groups to assess the bargaining power over resource allocation within households: female plot managers in female-headed households and female plot managers in male-headed households. In both crop plots, female plot managers are less productive compared to male plot managers but the relationship is weak, with the coefficient being statistically significant at the 10 per cent level.

**Table 4.3 OLS regression estimates of agricultural productivity (all crops)**

| Dependent variable is gross value of output US$/hectare | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat |
| Female plot manager (0/1) | -0.1960 | -4.21*** | - | - | -0.1079 | -2.65*** | - | - |
| Female plot manager in FH household (0/1) | - | - | -0.1065 | -0.1065 | - | - | -0.0674 | -1.14 |
| Female plot manager in MH household (0/1) | - | - | -0.3330 | -0.3330 | - | - | -0.1765 | -2.26** |
| Age of plot manager (years) | -0.0031 | -1.75* | -0.0036 | -0.0036 | -0.0026 | -1.78* | -0.0028 | -1.98** |
| Plot manager's years of schooling (years) | 0.0128 | 1.53 | 0.0137 | 0.0137 | 0.0189 | 2.40** | 0.0191 | 2.85*** |
| Household size | 0.0312 | 4.21*** | 0.0335 | 0.0335 | 0.0270 | 3.16*** | 0.0282 | 4.31*** |
| Soil quality is good (0/1) | 0.3431 | 3.88*** | 0.3562 | 0.3562 | 0.3458 | 4.16*** | 0.3512 | 3.12*** |
| Soil quality is fair (0/1) | 0.2659 | 2.55*** | 0.2864 | 0.2864 | 0.3080 | 3.52*** | 0.3168 | 3.02*** |
| Access to extension services (0/1) | 0.0836 | 0.93 | 0.0687 | 0.0687 | 0.0199 | 0.21 | 0.0142 | 0.19 |
| Wealth index | 0.0587 | 5.06*** | 0.0621 | 0.0621 | 0.0641 | 5.81*** | 0.0656 | 7.55*** |
| Access to market information (0/1) | 0.0281 | 0.42 | 0.0385 | 0.0385 | 0.1006 | 1.70* | 0.1042 | 1.85* |
| Distance to plot (km) | -0.0362 | -1.44 | -0.0390 | -0.0390 | -0.0368 | -1.59 | -0.0385 | -1.82* |
| Access to non-farm income (0/1) | 0.0636 | 1.24 | 0.0656 | 0.0656 | 0.0123 | 0.30 | 0.0135 | 0.33 |
| Organic fertiliser applied on plot (0/1) | -0.3002 | -3.21*** | -0.2948 | -0.2948 | -0.1601 | -1.86* | -0.1588 | -1.75* |
| Log of inorganic fertiliser applied per hectare | 0.0767 | 11.0*** | 0.0751 | 0.0751 | 0.0452 | 5.73*** | 0.0453 | 4.64*** |
| Log of hired labour person-days per hectare | 0.1891 | 7.95*** | 0.1889 | 0.1889 | 0.0751 | 2.88*** | 0.0754 | 3.02*** |
| Log of family labour person-days per hectare | 0.1087 | 6.86*** | 0.1073 | 0.1073 | -0.1019 | -5.86*** | -0.1023 | -5.27*** |
| Log of cultivated plot size in hectares | -0.1941 | -4.35*** | -0.2006 | -0.2006 | -0.3354 | -9.08*** | -0.3354 | -8.63*** |
| Intercropping system on plot (0/1) | -0.1954 | -1.19 | -0.2046 | -0.2046 | - | - | - | - |
| Use of tractor tillage services on plot (0/1) | 0.3351 | 6.69*** | 0.3309 | 0.3309 | 0.2739 | 7.24*** | 0.2732 | 6.90*** |
| Number of plots cultivated by plot manager | -0.0309 | -1.46 | -0.0421 | -0.0421 | -0.0057 | -0.32 | -0.0111 | -0.54 |
| Commercialisation pathway – non-food (0/1) | 0.1075 | 1.82* | 0.1216 | 0.1216 | - | - | - | - |
| Maize cultivated on plot (0/1) | - | - | - | - | -0.1883 | -1.44 | -0.2081 | -1.50 |
| Tobacco cultivated on plot (0/1) | - | - | - | - | 0.7360 | 6.25*** | 0.7220 | 5.71*** |
| Groundnuts cultivated on plot (0/1) | - | - | - | - | -0.5434 | -3.26*** | -0.5316 | -3.69*** |
| Common bean cultivated on plot (0/1) | - | - | - | - | -0.6231 | -4.72*** | -0.6236 | -5.56*** |
| Soya bean cultivated on plot (0/1) | - | - | - | - | -0.5319 | -4.42*** | -0.5469 | -4.05*** |
| Maize x commercialisation pathway (0/1) | - | - | - | - | -0.0717 | -1.15 | -0.0653 | -1.00 |
| Constant | 5.7360 | 28.3*** | 5.7636 | 5.7636 | 6.7482 | 28.5*** | 6.7746 | 30.8*** |
| Number of observations | 1,294 | | 1,294 | | 1,294 | | 1,294 | |
| Replications | 50 | | 50 | | 50 | | 50 | |
| Wald chi2 (17) | 988.73 | | 3332.42 | | 1980.1 | | 3075.08 | |
| Prob > chi2 | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| R-squared | 0.3656 | | 0.3687 | | 0.4949 | | 0.4956 | |
| Adjusted R-squared | 0.3556 | | 0.3583 | | 0.4853 | | 0.4856 | |

Note: Standard errors were obtained by bootstrapping up to 50 replications. (0/1) indicates dummy variable. *** Statistical significance at the 1 per cent level. ** Statistical significance at the 5 per cent level. * Statistical significance at the 10 per cent level.
Source: Authors' own.

The results show a gender productivity gap of 9.2 per cent considering all maize plots and 8.3 per cent considering all tobacco plots. With respect to maize plots, we also find maize yields to be much lower among plots managed by female managers in female households, with the coefficient being statistically

**Table 4.4 OLS regression estimates of gross value per hectare by household commercialisation pathway**

| Dependent variable is log of gross value per hectare | Food crop commercialisation | | | | Non-food crop commercialisation | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat |
| Female plot manager (0/1) | -0.0762 | -0.91 | - | - | -0.2005 | -2.78*** | - | - |
| Female plot manager in FM household (0/1) | - | - | -0.0549 | -0.66 | - | - | -0.0722 | -0.74 |
| Female plot manager in MH household (0/1) | - | - | -0.1349 | -0.91 | - | - | -0.3481 | -3.96*** |
| Age of plot manager (years) | -0.0025 | -0.70 | -0.0028 | -0.82 | -0.0021 | -1.05 | -0.0026 | -1.28 |
| Plot manager's years of schooling (years) | 0.0340 | 2.45** | 0.0333 | 2.23** | 0.0133 | 1.11 | 0.0160 | 1.29 |
| Household size | 0.0243 | 1.76*** | 0.0249 | 1.47 | 0.0304 | 3.31*** | 0.0333 | 3.95*** |
| Soil quality is good (0/1) | -0.0429 | -0.14 | -0.0415 | -0.16 | 0.4259 | 4.24*** | 0.4440 | 4.12*** |
| Soil quality is fair | -0.1417 | -0.45 | -0.1323 | -0.46 | 0.3702 | 3.32*** | 0.3910 | 3.65*** |
| Access to extension (0/1) | 0.0219 | 0.11 | 0.0166 | 0.12 | 0.0734 | 0.66 | 0.0549 | 0.52 |
| Wealth index | 0.0627 | 3.45*** | 0.0643 | 3.63*** | 0.0531 | 3.65*** | 0.0565 | 4.44*** |
| Access to market information (0/1) | 0.2162 | 1.34 | 0.2197 | 1.80* | -0.0321 | -0.35 | -0.0189 | -0.22 |
| Distance to plot (km) | -0.0115 | -0.27 | -0.0129 | -0.38 | -0.0546 | -1.86* | -0.0571 | -2.07** |
| Access to non-farm income | -0.0755 | -0.90 | -0.0792 | -0.91 | 0.0863 | 1.62 | 0.0941 | 2.14** |
| Organic fertiliser was used (0/1) | -0.0693 | -0.47 | -0.0635 | -0.49 | -0.3378 | -3.54*** | -0.3433 | -3.33*** |
| Log of inorganic fertiliser applied per hectare | 0.0676 | 7.82*** | 0.0669 | 8.57*** | 0.0880 | 8.95*** | 0.0858 | 6.72*** |
| Log of hired labour person-days per hectare | 0.1398 | 2.50** | 0.1400 | 2.45** | 0.1750 | 5.90*** | 0.1748 | 5.95*** |
| Log of family labour person-days per hectare | -0.0615 | -1.93* | -0.0613 | -1.96** | 0.1542 | 6.34*** | 0.1522 | 6.81*** |
| Log of cultivated plot size in hectares | -0.2867 | -4.18*** | -0.2887 | -4.63*** | -0.1922 | -3.36*** | -0.1987 | -3.78*** |
| Use of tillage tractor services (0/1) | 0.1810 | 1.76* | 0.1774 | 2.10** | 0.3493 | 7.23*** | 0.3474 | 6.63*** |
| Number of plots cultivated | -0.0322 | -0.70 | -0.0366 | -0.73 | -0.0191 | -0.98*** | -0.0317 | -1.15 |
| Constant | 6.4883 | 14.24*** | 6.5229 | 16.04*** | 5.5257 | 19.79*** | 5.5440 | 23.37*** |
| Number of observations | 367 | | 367 | | 927 | | 927 | |
| Replications | 49 | | 50 | | 50 | | 50 | |
| Wald chi2 (17) | 183.73 | | 265.50 | | 690.74 | | 542.69 | |
| Prob > chi2 | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| R-squared | 0.3064 | | 0.3070 | | 0.3487 | | 0.3529 | |
| Adjusted R-squared | 0.2706 | | 0.2691 | | 0.3358 | | 0.3394 | |

Note: Standard errors were obtained by bootstrapping at 50 replications. (0/1) represents dummy variables
*** Statistical significance at the 1 per cent level. ** Statistical significance at the 5 per cent level. * Statistical significance at the 10 per cent level.
Source: Authors' own.

significant at the 10 per cent level. Thus, there is an 11.1 per cent maize yield gap when the female plot manager is in a female-headed household compared to male plot managers. However, there are no statistical differences between plots managed by female managers in male-headed households compared to male plot managers. In the tobacco plots, the type of households from which female plot managers originate does not matter, though the overall effect of gender of plot manager is weakly significant and biased against female plot managers.

The number of years of schooling of the plot manager is positively associated with maize productivity and the coefficient is statistically significant at the 1 per cent level, suggesting that an additional year of schooling increases productivity by 3 per cent. This relationship holds even in the case where female plot managers are distinguished by the head of the household. Surprisingly, education has a perverse sign and is statistically insignificant in the tobacco plot models. Farmers' own assessment of soil quality

**Table 4.5 OLS regression estimates of crop yields of all maize and tobacco plots**

| | All maize plots: Dependent variable is log of plot maize yield | | | | All tobacco plots: Dependent variable is log of plot tobacco yield | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat |
| Female plot manager (0/1) | -0.0917 | -1.91* | - | - | -0.0832 | -1.64* | - | - |
| Female plot manager in FH household (0/1) | - | - | -0.1105 | -1.67* | - | - | -0.0539 | -0.78 |
| Female plot manager in MH household (0/1) | - | - | -0.0455 | -0.65 | - | - | -0.1545 | -1.60 |
| Age of plot manager (years) | 0.0009 | 0.50 | 0.0011 | 0.52 | -0.0019 | -1.38 | -0.0019 | -1.10 |
| Plot manager's years of schooling (years) | 0.0299 | 3.05*** | 0.0299 | 2.55*** | -0.0041 | -0.47 | -0.0039 | -0.41 |
| Household size | 0.0082 | 0.95 | 0.0074 | 0.77 | 0.0061 | 0.85 | 0.0065 | 0.99 |
| Soil quality is good (0/1) | 0.1759 | 2.05** | 0.1730 | 1.59 | 0.1789 | 2.68*** | 0.1844 | 2.92*** |
| Soil quality is fair (0/1) | 0.0997 | 1.07 | 0.0946 | 0.79 | 0.1681 | 2.69*** | 0.1736 | 2.49** |
| Access to extension services (0/1) | 0.0712 | 0.77 | 0.0746 | 0.72 | -0.1513 | -1.87* | -0.1565 | -2.22** |
| Wealth index | 0.0600 | 5.65*** | 0.0596 | 5.03*** | 0.0572 | 5.48*** | 0.0578 | 5.41*** |
| Access to market information (0/1) | 0.0245 | 0.32 | 0.0223 | 0.27 | 0.1904 | 2.53*** | 0.1933 | 2.70*** |
| Distance to plot (km) | -0.0326 | -1.60 | -0.0320 | -1.30 | 0.0101 | 0.41 | 0.0099 | 0.37 |
| Access to non-farm income (0/1) | -0.0547 | -1.10 | -0.0567 | -1.30 | -0.0144 | -0.50 | -0.0108 | -0.29 |
| Organic fertiliser applied on plot (0/1) | -0.1209 | -1.66* | -0.1212 | -1.84* | 0.3715 | 2.10** | 0.3678 | 2.08** |
| Log of inorganic fertiliser applied per hectare | 0.0752 | 2.83*** | 0.0761 | 3.68*** | 0.0895 | 2.05** | 0.0911 | 2.87*** |
| Log of hired labour person-days per hectare | 0.0224 | 2.18** | 0.0225 | 2.24** | -0.0106 | -1.07 | -0.0107 | -1.13 |
| Log of family labour person-days per hectare | -0.0576 | -2.15** | -0.0574 | -2.10** | -0.0439 | -1.85* | -0.0440 | -1.67* |
| Log of cultivated plot size in hectares | -0.1573 | -4.69*** | -0.1581 | -4.64*** | -0.2165 | -5.44*** | -0.2168 | -4.72*** |
| Intercropping system on plot (0/1) | -0.5121 | -4.78*** | -0.5102 | -5.05*** | - | - | - | - |
| Use of tractor tillage services on plot (0/1) | 0.1415 | 2.69*** | 0.1403 | 2.60*** | 0.0388 | 1.13 | 0.0406 | 0.90 |
| Constant | 7.3706 | 25.96*** | 7.3662 | 29.91*** | 6.7420 | 23.14*** | 6.7232 | 25.73*** |
| Number of observations | 480 | | 480 | | 383 | | 383 | |
| Replications | 50 | | 50 | | 44 | | 44 | |
| Wald chi2 (17) | 296.96 | | 289.71 | | 121.74 | | 216.92 | |
| Prob > chi2 | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| R-squared | 0.2962 | | 0.2968 | | 0.2158 | | 0.2179 | |
| Adjusted R-squared | 0.2687 | | 0.2677 | | 0.1793 | | 0.1792 | |

Note: Standard errors were obtained by bootstrapping at 50 replications. (0/1) indicates dummy variable.
*** Statistical significance at the 1 per cent level. ** Statistical significance at the 5 per cent level. * Statistical significance at the 10 per cent level.
Source: Authors' own.

is also positively associated with crop productivity, although only highly significant in the tobacco models. Household access to extension services is statistically significant in the tobacco models, but has a perverse sign which suggests that tobacco productivity falls with access to extension services. Other studies such as Ragasa and Mazunda (2018) find access to extension services to be insignificant in explaining productivity but a statistically significant relation when extension services enter the model as a dummy of usefulness of the messages as evaluated by the household. We also find evidence that wealthier households tend to be more productive in both maize and tobacco models, with the coefficient statistically significant at the 1 per cent level.

With respect to input use intensity, we find evidence of a positive relationship between inorganic fertiliser and crop productivity in both maize and tobacco plots. The coefficient is statistically significant at the 1 per cent level in the maize model and at the 5 per cent level in the tobacco model. The estimated elasticity

**Table 4.6 OLS regression estimates of maize plots by household commercialisation pathway**

| Dependent variable is log of plot maize yield | Food crop commercialisation | | | | Non-food crop commercialisation | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | (2) | | (3) | | (4) | |
| | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat | Coef. | z-stat |
| Female plot manager (0/1) | -0.0208 | -0.26 | - | - | -0.1372 | -1.70* | - | - |
| Female plot manager in FH household (0/1) | - | - | -0.0497 | -0.48 | - | - | -0.1658 | -1.65* |
| Female plot manager in MH household (0/1) | - | - | 0.1100 | 0.56 | - | - | -0.0919 | -1.31 |
| Age of plot manager (years) | -0.0011 | -0.42 | -0.0008 | -0.29 | 0.0020 | 0.95 | 0.0022 | 0.96 |
| Plot manager's years of schooling (years) | 0.0393 | 2.23** | 0.0406 | 2.57*** | 0.0281 | 2.69*** | 0.0275 | 2.05** |
| Household size | 0.0374 | 1.92* | 0.0360 | 2.23** | -0.0007 | -0.06 | -0.0015 | -0.13 |
| Soil quality is good (0/1) | 0.0794 | 0.26 | 0.0775 | 0.26 | 0.2001 | 1.21 | 0.1949 | 1.85* |
| Soil quality is fair (0/1) | 0.0679 | 0.23 | 0.0534 | 0.18 | 0.0948 | 0.62 | 0.0887 | 0.80 |
| Access to extension services (0/1) | 0.1889 | 0.81 | 0.2043 | 0.95 | 0.0174 | 0.17 | 0.0198 | 0.20 |
| Wealth index | 0.0674 | 2.76** | 0.0670 | 3.82*** | 0.0525 | 2.94*** | 0.0522 | 3.08*** |
| Access to market information (0/1) | -0.0780 | -0.36 | -0.0930 | -0.47 | 0.0890 | 0.95 | 0.0883 | 0.94 |
| Distance to plot (km) | -0.0334 | -0.87 | -0.0314 | -0.86 | -0.0368 | -1.86* | -0.0359 | -1.06 |
| Access to non-farm income (0/1) | -0.1955 | -2.35** | -0.1969 | -2.13** | 0.0045 | 0.08 | 0.0008 | 0.01 |
| Organic fertiliser applied on plot (0/1) | -0.2122 | -1.75* | -0.2171 | -1.63 | -0.0445 | -0.63 | -0.0423 | -0.52 |
| Log of inorganic fertiliser applied per hectare | 0.0686 | 2.09** | 0.0724 | 2.25** | 0.0881 | 2.12** | 0.0879 | 1.85* |
| Log of hired labour person-days per hectare | 0.0427 | 2.04** | 0.0448 | 1.94** | 0.0222 | 1.78* | 0.0220 | 1.97** |
| Log of family labour person-days per hectare | -0.0631 | -1.53 | -0.0608 | -1.62 | -0.0529 | -1.24 | -0.0531 | -1.41 |
| Log of cultivated plot size in hectares | -0.0860 | -1.25 | -0.0881 | -1.27 | -0.2031 | -3.63*** | -0.2051 | -4.03*** |
| Intercropping system on plot (0/1) | -0.3390 | -1.80* | -0.3264 | -1.46 | -0.5981 | -4.70*** | -0.5945 | -3.99*** |
| Use of tractor tillage services on plot (0/1) | -0.0518 | -0.45 | -0.0596 | -0.52 | 0.1746 | 3.40*** | 0.1732 | 2.99*** |
| Constant | 7.5226 | 14.50*** | 7.4841 | 16.83*** | 7.2395 | 21.62*** | 7.2513 | 21.40*** |
| Number of observations | 172 | | 172 | | 308 | | 308 | |
| Replications | 49 | | 50 | | 50 | | 49 | |
| Wald chi2 (17) | 92.77 | | 138.61 | | 236.36 | | 175.93 | |
| Prob > chi2 | 0.000 | | 0.000 | | 0.000 | | 0.000 | |
| R-squared | 0.3659 | | 0.3687 | | 0.3042 | | 0.305 | |
| Adjusted R-squared | 0.2913 | | 0.2898 | | 0.2609 | | 0.2591 | |

Note: Standard errors were obtained by bootstrapping at 50 replications. (0/1) indicate dummy variable. *** Statistical significance at the 1 per cent level. ** Statistical significance at the 5 per cent level. * Statistical significance at the 10 per cent level.
Source: Authors' own.

of productivity with respect to quantity of inorganic fertiliser is 0.08 for maize and 0.09 for tobacco. Quantity of hired labour in person-days is positively associated with maize productivity, with a statistically significant coefficient, but shows a perverse but insignificant sign in the case of tobacco plots. The higher the number of family labour days used on the plot, the less productive are maize and tobacco cultivation among smallholder farmers. We also find the familiar inverse relationship between plot size and agricultural productivity, with the coefficient being statistically significant at the 1 per cent level. This finding is consistent with many other studies in smallholder agriculture (Kilic *et al.* 2015; Mukasa and Salami 2015; Ali *et al.* 2016; de la O Campos *et al.* 2016). Use of tractor tillage services on maize plots tends to be significantly associated with higher productivity, but there is no significant relationship on tobacco plots.

The farming households in the study were classified based on whether they are pursuing commercialisation led by food crop production or non-food crop production. Since farmers who are in the non-food crop commercialisation pathway also grow a significant amount of maize, we investigate the gender differentials in productivity conditional on the commercialisation pathway. Table 4.6 presents regression results of maize yields in plots managed by plot managers in food crop commercialisation and non-food crop commercialisation pathways. Models 1 and 3 specify gender of plot manager in the traditional way while models 2 and 4 distinguish female plot managers by their household type.

The gender productivity differentials are only observed among plots managed by those from households pursuing non-food crop commercialisation, with an estimated gap of 13.7 per cent against female plot managers and 16.6 per cent against female plot managers in female-headed households. Similar to the maize model above, education and wealth index are consistently positive and statistically significant. Plot managers from households that received income from non-farm sources tend to have lower productivity of maize in the food crop commercialisation pathway. The coefficient is statistically significant at the 5 per cent level. Such a significant negative relationship between productivity and access to non-farm income is evident in similar studies (for instance, Kilic *et al*. 2015; Karamba and Winters 2015).

We also find that both inorganic fertiliser and hired labour use intensity are associated with increased maize productivity regardless of the commercialisation pathway pursued by the household. The estimated elasticities of maize yields with respect to quantity of inorganic fertiliser applied on the plot range from 0.07 to 0.09, and with respect to number of hired person-days, elasticities range from 0.02 to 0.04. Although the coefficient of plot size is consistently negative, it is only statistically significant at the 1 per cent level when households are pursuing commercialisation based on non-food crops. Intercropping is negatively associated with maize productivity, with a statistically significant coefficient in three of the four regression models, suggesting the impact of competition for crop nutrients in intercropping systems.[4]

The use of tractor tillage services is associated with increased productivity only among plots managed by members from households pursuing non-food crop commercialisation and the coefficient is statistically significant at the 1 per cent level. Plots managed by members from non-food crop commercialising households that use tractor tillage services are about 17.2 per cent more productive in maize production compared to those that do not use tractor tillage services. In contrast, as we observed above in the tobacco plot model, use of tractor services was not statistically significant, suggesting that tractor services are more beneficial in maize cultivation.

# 5 CONCLUSIONS

Improving productivity in smallholder agriculture is key in facilitating structural change from semi-subsistence to commercial agricultural activities. Increased smallholder farmer engagement with markets, that is, both input and output markets, can provide further impetus in improving labour and land productivity, leading to increased incomes and wellbeing. However, smallholder agriculture commercialisation can have varying effects on different households. This study set out to investigate gender differentials in agricultural productivity, by focusing on intra-household resource bargaining and allocation, in the context of smallholder commercialisation in resettlement areas of Zimbabwe. Our contribution to the empirical evidence on gender differentials is recognising that analysing the different pathways of household commercialisation and the type of household to which female plot managers belong, can capture intra-household resource bargaining and allocation. This in turn can reveal different implications for agricultural productivity.

Our results on gender productivity differentials among plot managers are broadly consistent with most existing empirical studies (such as Horrell and Krishnan 2007; Aguilar *et al*. 2015; Ali *et al*. 2016; Kilic *et al*. 2015; and de la O Campos *et al*. 2016) which find that plots managed by female members of the household are relatively less productive compared to plots managed by male members of the household. This implies that resource allocation towards agriculture-improving investments within the household are Pareto-inefficient, and agricultural production cannot be maximised with such gender gaps. The gender productivity gap is estimated at 10–20 per cent against female plot managers.

In addition, when we account for the type of household for female plot managers in terms of whether they belong to female-headed or male-headed households, plots managed by female managers in male-headed households are 17–33 per cent less productive than plots managed by male managers regardless of the household type. These reveal the low countervailing bargaining power over resources of female plot managers in male-headed households as a source of Pareto inefficiency in resource allocation for agricultural development. The evidence underscores the importance of the household structure when analysing the impacts of the gender of decision makers in development outcomes, particularly in societies where matriarchal and patriarchal systems are culturally and socially embedded, such as in many sub-Saharan African countries.

Our evidence also contributes to the findings of Horrell and Krishnan (2007) in the context of a patriarchal society in Zimbabwe who found evidence of gender productivity differentials in a non-food crop but no differentials in food crop production. Our results also suggest that 20–35 per cent gender productivity differentials exist in plots managed by members whose households are classified as pursuing a non-food crop commercialisation pathway, with no gender differentials among plots managed by members from households pursuing a food crop commercialisation pathway. Thus, when it comes to food production, that is, households who are commercialising through this pathway, there seems to be efficient allocation of resources to agricultural activities regardless of the gender of the plot manager. This suggests that a gender equity approach should be applied which aims to close the gap in agricultural productivity in smallholder commercial agriculture, and attempts to address the balance of power of female plot managers in male-headed households. Our results from maize and tobacco yield analysis weakly show gender productivity differentials in both crops, but results of maize yields by a commercialisation pathway show that gender productivity differentials in maize only exist if households are also cultivating tobacco. Hence, there may be a bias in resource allocation in households who are pursuing a non-food crop commercialisation pathway.

Our study has also demonstrated that there is high market participation in input markets, such as inorganic fertilisers and labour markets, which provides further incentives for increased productivity among smallholder farmers regardless of the commercialisation pathway and type of crop. However, tractor tillage services that are used by nearly half of the sample are productivity-improving for aggregate plot productivity but crop-level analysis shows that such services are more productive in maize cultivation, particularly in tobacco-producing households but not as productive in tobacco cultivation *per se*. This suggests that potentially high incomes from tobacco sales may be allowing these households to hire tractor tillage services on maize production while compensating for their time and effort on non-cash crop production.

Overall, our results demonstrate the need for better understanding of gender differentials in agricultural productivity or development outcomes by recognising the importance of household structures and inheritance systems. It is within these structures and systems that female decision makers have to bargain for equity in the allocation of scarce resources, particularly in societies where gender biases are socially and culturally embedded. It is quite evident that gender productivity gaps exist in the smallholder farming systems of Zimbabwe, and hence the need for appropriate policies and interventions to redress the inequalities in access to land, human, and social capital assets which limit women's productive capacity and ability to actively participate in agricultural commercialisation processes. Options for availing appropriate technologies and affordable financing for women-managed enterprises need to be explored.

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# ENDNOTES

1 Traditionally, women have been treated as dependants of men, who passively participate in agriculture as through subsidiary roles such as tobacco grading. However, due to the migration of men to work in towns, commercial farms, and mines, women in most rural communities in Zimbabwe have become the *de facto* heads of households, and are increasingly involved in agricultural production and overseeing the production and consumption decisions of those households (Muir-Leresche 2006).

2 Doss (2013) reviews both the theoretical frameworks and existing empirical studies on issues of intra-household resource allocation, bargaining, and decision-making within households.

3 Mukasa and Salami (2015) review some of the evidence emerging from earlier studies.

4 The effect of intercropping has been mixed in empirical studies. Ragasa and Mazunda (2018) also find a negative but insignificant relationship between productivity and intercropping systems. Others such as Desiere and Jolliffe (2018), Palacios-López and López (2015), Kilic *et al.* (2015) and Ali *et al.* (2016) find a positive and significant relationship between productivity and the plot being intercropped.

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