Gender Differences in Agricultural Productivity

A cross-sectional household survey data collected in 2006 in Peru

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Abstract

According to the Food and Agriculture Organization of the United Nations (FAO), in developing countries, rural women act as a keystone of small-scale agriculture and daily family subsistence. The recognition of their crucial roles has recently increased as well as the recognition of their contribution in agricultural production. Regardless of the fact that the roles and needs of female farmers are recognized in policy, agricultural policies still do not address the needs of women farmers satisfactorily and tend not to be adequately translated into practice in agricultural development programs and planning. In almost all these countries households headed by females belong to the poorer level of society and often have lower incomes than households headed by males. Both of them lack access to agricultural resources but women are often claimed to have less access to resources in comparison to men. For instance, lack of land ownership is argued to limit women's ability to access credit, as land is often used as collateral. The situations they face may not only vary according to the degree of their lack of resources, but also according to different types of farming systems, social-ethnic groups and cultural institutions in general. Access to resources is often claimed to be essential to improving agricultural productivity of both male and female farmers. Studies have argued that male and female farmers are equally efficient as farm managers and attribute lower levels of inputs and human capital to explain women farmers' lower yields than men (Quisumbing, 1995).

This work aims to analyze gender characteristics and gender differences in agricultural productivity using a cross-sectional household survey data collected in Peru. I estimate log linear models that aim explaining differences in female and male household heads' values of production per hectare by plot, controlling for socio-economic characteristics of the household heads, agricultural inputs and regional variations in the Peruvian context. My results indicate there are no real effects of sex of the household head itself as well as no effects of sex of the household individuals on plot yield hectare. Furthermore, productivity differences are shown to be attributable to the several inputs male and female household heads use for their agricultural production. The inputs they use appear to be influenced by the different characteristics of the regions where the plots are located. Education and having Spanish as mother tongue were shown to be of high importance for agriculture in the Peruvian context. This suggests Spanish skills language and education, become a policy priority for female household heads to increase female household heads' productivity in comparison to

males', since the lack of these characteristics may describe a disadvantage of females to be more productive.

Preface

This research report is in concert with the project on land and gender in Peru by the Norwegian Institute for Urban and Regional Research (NIBR): *Closing the Gender Land Gap: The effects of land-titling for women in Peru,* financed by Norwegian Research Council Latin America program grant 196328. I would like to express my gratitude to the Institute for giving me the amazing opportunity for this learning process. In particular, I want to thank my supervisor Daniela Orge Fuentes, research fellow at NIBR, for her patience, guidance, valuable advice, and assistance throughout my work. Her personal efforts have helped me understand and organize my ideas properly and to achieve improvements throughout my working process. I also want to thank Henrik Wiig, senior researcher at NIBR, for his useful comments and important insights on the topic.

I am also grateful to Berhe Mekonnen Beyene, a Ph.D. student at the Economic Institute at UiO, for being always willing to share his knowledge in regarding data management using the STATA program. There is an extensive list of additional people I have already thanked and named in my heart who have been walked with me along this journey of personal and professional learning.

Last, but not least, infinite thanks go to my Colombian and Norwegian families for their love and support.

Claudia Carolina Cardona V.

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1 Introduction

Why do we pay attention to gender in agriculture?

Emphasis on the link between gender and agriculture has existed as long as the concept of gender itself. Today it is recognized that women in developing countries are important contributors in small-scale agriculture, rural workforce and daily family subsistence. Despite these important roles, women have greater difficulty than men accessing resources such as land, credit, agricultural inputs and services that increase the productivity of their parcels and thus also their possibility to enhance their own and their family's well-being (IFAD, 2009; Bank, 2009; Deere and Leal, 2001). Consequently, the productivity and economic empowerment of women is a logical priority of programs and policies aimed at promoting agricultural development. The priority is justified, as it considers women's agricultural production as a source of economic growth and as a benefit of rural livelihood and poverty reduction. None of this is news for the professionals involved in development issues and specializing in gender analysis and its applications to policy and program design. Yet recent analysis suggests that gender issues are explicitly integrated in less than 10% of official development assistance (Bank, 2009).

The perspective of economic empowerment of rural women in developing countries can be understood in terms of three interrelated key issues: (i) increasing access to key assets and control over them (property), (ii) increasing their influence in decision-making processes (iii) and improvement of their well-being and ease of their workload (Deere and Leal, 2001). In Latin America, different countries have shown that direct ownership of productive assets by women reduces the risk of poverty (Deere and Leal, 2001). Specifically, land ownership is the best guarantee rural women have to be able to provide food for their families. Moreover, land ownership is often seen as a precondition for increasing the productivity of peasant women, as it enhances their access to other resources needed for production (Deere and Leal, 2001).

This paper thus aims at analyzing gender conditions and gender differences in agricultural production in the Peruvian context. What is important in this work is the evaluation of what may affect agricultural productivity of rural Peruvian women and under which conditions. My results indicate there are no real effects of sex of the household head itself as well as no effects of sex of the household individuals on plot yield hectare. Furthermore, productivity differences are shown to be attributable to the several inputs male and female household heads use for their agricultural production.

I use a household data survey collected by Peruvian research institute Cuanto[1] in collaboration with the research institute Grade[2] in 2004 and 2006. The survey design was formulated by Grade while the actual collection in the field was done by Cuanto. According to the Grade's final report (Grade, 2007), panel data of the same households was collected, but it was not possible to identify the same plots in the two difference years. This means that a plot-to-plot comparison between the two years was not possible. After reviewing both questionnaires, I decided only to use the data collected in 2006, as it provided insight that is the most complete for the study at hand. I will estimate log linear models that may explain differences in female and male household heads in the value of output per hectare by plot, controlling for socio-economic characteristics of the household heads, agricultural inputs and regional variations. I use STATA 11 software for the calculations.

This paper is further organized as follows: Chapter two presents the research questions and hypotheses. Chapter three gives the theoretical framework and overview of gender and agriculture in the Peruvian setting. Chapter four describes the data used and the methods and the empirical model to be applied, while chapter five shows both the results achieved as well as the discussion of the main findings. Chapter six finally summarizes the overall conclusions.

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[1] The "Instituto Cuanto" is a Peruvian private civil and nonprofit research institute whose mission is to foster research that is intended to educate society on issues of national life with emphasis on quantitative aspects. It performs household surveys with national coverage in both urban and rural areas. See http://www.cuanto.org/

[2] "Grade" Grupo de Análisis para el Desarrollo is a private research center that conducts applied research on economic, educational, environmental, social areas relevant to the development for Peru and other Latin American countries. See http://www.grade.org.pe/.

2 Research Questions

My first research question is as follows:

1. Which features affect agricultural productivity for female household heads?

Studies addressing gender differences in agricultural production include attempts to measure differences between men and women. Quisumbing (1996) reviewed a number of studies related to male and female managed farms or plots. These studies used a dummy variable of the head of household's sex as proxy for farm management, assuming that the significance of the sex dummy variable supports the argument of socio-cultural discrimination between male and female workers in agriculture. In general, these studies found that female and male farmers are equally efficient as farm managers. Women farmers' lower yields are attributable to lower levels of inputs and human capital than men.

Although it has been claimed that the dummy variable for the sex of the household head may not fully capture the decision making process of a household head, the headship may contribute (Quisumbing, 1995). Assuming that a female household head that also hold a document that guarantee the property to plot as a proxy for management, I will attempt to explain gender features that may affect agricultural productivity in the Peruvian setting. The data at hand enables me to assume the presence of landownership through land property certification as a proxy of tenure security. It is expected that the presence of land ownership may improve status, power and wealth of female households as well as their productivity.

Land tenure security and women's access and control over land have also been associated with production efficiency (Fuentes and Wiig, 2009). It is expected that women's landownership should result in their having and improved position within the community and more participation in decision making process. Increasing women's access to land is often claimed to be a powerful tool to fight poverty, in particular, hunger, children's health and low levels of education showing that women tend to use wealth and income in a different manner than men (FAO, 2012).

My other next research question is as follows:

2. Does the gender household composition explain agricultural productivity?

This question relates to measuring the effects of household demographics on agricultural production. Thus, the cultural context will be taken at once. The gender asset gap in Latin America is often claimed to be a consequence of male preference in inheritance and gender bias in land markets as well as in the community (Deere, 2005). Assuming the presence of these male advantages over women, it may be expected that the number of males relative to females in the household may influence the way the household chooses to produce on its land. This could be due to the fact that male labor may be considered more productive in farming or because households in which the number of males is greater than females inherit the land with high quality for farming, and men may be more concerned to improve the quality of land that they expect to pass through inheritance to sons or another male family members (Chen et al., 2011; Jacoby, 1992).

However, there is evidence of a trend towards feminization of agriculture in developing countries (Deere, 2005; Ellis, 2000). In Latin America, the dominant trend over the past decades has been towards the feminization of smallholder production. The numbers of rural women being the principal farmers have increased as well as the proportion of rural female household heads (Deere, 2005). It has been often claimed that this phenomenon is due to the male absence from the farm. The reasons are related to male migration and/or employment in off-farm activities as well as the splitting of couples and divorce or widowhood in the case of households with couples.

Although inheritance of land tends to favor men, it is the principal mode by which rural women acquire land (Deere and Leal, 2003). It has been argued that rural women in Latin America value land ownership for reasons other than the prospect of being successful commercial farmers: “land offers to rural women security in covering their family’s minimum food requirements” (Deere, 2005, p. 58). Assuming male absence, it may be expected that the introduction of females relative to males in the household leads to a female inheritance also in the case of female heads.

3 Background and Theoretical Framework

3.1 Theoretical Framework

The literature on the intersection of gender and agricultural productivity is growing. I thus attempt to summarize its main points as they apply to the subject at hand.

The significance of women's participation in agricultural production in developing countries has been recognized since the publication of '*Women's role in Economic Development'* by Ester Boserup in 1970. According to Boserup (1970), it is possible to estimate gender differences related to efficiency in farming systems in which men and women manage separate plots. Boserup (1970) presented a threefold classification of farming systems according to the varying degrees of women's engagement in farm work. She uses the following classifications: (i) high female participation combined with low technology in sub-Saharan Africa; (ii) low female participation associated with animal draft technology, hired labor and cultural proscriptions on women's work outside the home; and (iii) sharing of farm work between women and men associated with intensive cultivation, land scarcity and small farm size. However, women's roles in agriculture may be much more heterogeneous than these classifications suggest (Deere, 1982; Ellis, 2000).

Measuring differences in agricultural productivity according to the sex of household head is complicated and may vary between different types of farming systems, social-ethnic groups and cultural institutions in general (Quisumbing, 1995). Gender differences may also change over time according to new pressures and opportunities and the way gender relations adapt to these in the rural livelihoods (Boserup, 1970).

Neoclassical economic theory first suggested models in which there were no individuals inside the household, but only a benevolent dictator or patriarch that made decisions on everyone's behalf. Several empirical studies have rejected the hypothesis that households act as if they are unitary (Quisumbing, 2003). Models in which the interaction occurs between individuals within the household have been created; many of them share the assumption that the allocation of resources is Pareto efficient (Quisumbing, 2003; Udry, 1996). Nevertheless, Udry (1996) shows in his study on Burkina Faso that resource allocations within the household are not Pareto efficient. Peterman and Quisumbing et al., (2010) explain that the asymmetrical distribution of productive inputs, rights and responsibilities may be more appropriate for gender differences in comparison to total technical efficiency. According to them, attaining allocative efficiency, which takes into account the distribution of household-level inputs among household members, "implies no reallocation of inputs within the household, which would result in an increase in total output, that is, yields" (Peterman, Quisumbing, et al., 2010, p. 2). This may be a reason that more recent examinations of household behavior have focused on decisions about resource allocation using models that (i) attempt to determine how decisions are made or (ii) examine the effects of decisions on production, as I will summarize below.

As stated by Quisumbing (1995), it is very difficult to isolate managerial efficiency differences in agricultural settings where plots are cultivated jointly by male and female household members and hired labor. The assumption that the farm manager is usually the male head of the household tends to neglect the actual contribution of women regarding decision- making and farm labor. For example, Boserup (1970) suggests that women's outstanding role in cultivation and harvesting in Sub-Saharan Africa is not complemented by ownership of resources, control over resource use or decision- making capabilities, all of which tend to be assumed within the male sphere. This setting has also been found in the male- run farming systems of Asia and Latin America (Quisumbing, 1995).

In agriculture, land may be the most important resource, but other notable examples include education, credit and technical assistance. Women's ability to obtain agricultural inputs is usually claimed to be constrained by gender discrimination. However, the indirect effect that differential access to resources (like credit, for example) has on women's ability to obtain inputs for production may be equally important. Women are much less likely to own land in different parts of the world, and Latin America is no exception. Deere and León (2003) claim that in Brazil, Mexico, Nicaragua and Peru, women are in the minority among landowners[3]. They study the sources and incidence of land ownership by women throughout Latin America, and they found that men are more likely to acquire land through markets. Due to gender bias in land markets, women are less competitive in the land market. Thus, women are more likely to inherit their land than buy it (ibid). Effective women's land rights are defined

[3] For instance, in Peru, 4.7 % of all women producers have a title properly registered compared 14.7 % of males, according to the national agricultural census CENAGRO, in 1994.

by Deere and León (2001) as requiring legal ownership of land by women, social recognition of that ownership, and effective control by women over land that they own. This definition imposes strong information requirements for a meaningful measurement of women's rights in an empirical investigation.

Quisumbing (1995) reviews econometric evidence on gender differences in agricultural productivity. According to Quisumbing (1995), in countries where it is possible to identify the gender of the plot manager, it is possible to estimate gender differences in technical efficiency. Her methodological overview includes an indirect measure of productivity by estimating earnings or wage functions. She claims that this method implies the heterogeneity of agricultural labor, since individual endowments influence labor market participation, earnings or wage and often provide evidence on returns to men's and women's schooling.

Production functions have also been used by different researchers to estimate female-male productivity differentials. This approach either estimates male and female production functions separately or estimates a pooled regression with a dummy variable for the gender of the farm manager or household head (Peterman et al., 2010). However, the use of separate production functions would not address the critical question of identifying the sources of female-male plot yield differentials (Peterman et al., 2010; Quisumbing, 2003). Another limitation of the production function approach is that it does not account for simultaneity bias introduced by ordinary least squares estimation of production functions. Studies conducted in sub-Sahara Africa, for example, have neglected the endogeneity of the input choice and the influence of resource allocation processes within the household, which in many cases are cultural and conducted under specific contexts on the division of labor and other resources of the plots managed by men and women (Peterman et al., 2010). According to Peterman (ibid), this kind of investigation has been criticized because it neglects the widespread phenomenon of crop cultivation by male and female individuals within the same household, whether practiced independently or jointly. These approaches are important to determine both how and why productivity differs by gender. For example, by estimating the productivity of men and women in the peasant agriculture of the Peruvian Sierra, Jacoby (1992) finds evidence that a sexual division of labor implies that male and female labor are not perfectly substitutable; women contribute more to livestock production and men contribute more to crop production.

A broad range of literature documents gender differences in productivity, and the findings from different studies has been summarized as follows: (i) Detailed data on decision- making control at the plot-crop level within agricultural households is claimed to be collected, and since the production of women seems to be underestimated (Ellis, 2000), detailed data on household work performed and a consistent way to assign value to it may be a priority for further research. (ii) Knowledge of all of the household production activities of women and men is also needed. Because rural households may engage in a number of productive activities, including wage labor, off-farm employment and nonagricultural self-employment, measures of agricultural productivity are only partial measures of the range of the household's productive activities (Peterman et al., 2010). Since detailed information about time use in all of their activities is not often available, it is difficult to know whether female inefficiency is due to inherent characteristics in women or depends on her distribution of time in other activities other than those relating to agriculture. (iii) Methods pose a challenge in this topic since collecting and analyzing data on gender in agriculture are inadequate (Quisumbing, 1996). The familial structure of households and cultural characteristics may be complex but necessary to be collected in agricultural surveys. As aforementioned, a number of possible factors may lead to agricultural productivity differences between men and women. Hence, more cross-cultural studies are needed, since context seems to be relevant in all of these issues.

3.2 Peru: Gender and the Agricultural Sector

Peru's economy reflects its varied geography: an arid coastal region, the Andes highlands further inland and tropical lands bordering Colombia and Brazil (Amazon). Agriculture, as in most Latin American countries, is still very important to the Peruvian rural areas (CIA., 2011). On one side is the local subsistence agriculture, using employing traditional techniques under poor conditions, and on the other side is the plantation agriculture which is export-oriented, using advanced technical tools. Traditional agriculture dominates the highlands where the main crops are corn and potato (CIA., 2011). Plantations are mainly found on the coast and the Amazon with industrial crops such as sugar cane, cotton and fruit trees. The coastal region, an arid but fertile land, has about two-thirds of Peru's irrigation infrastructure due to private and public investment aimed at increasing agricultural exports (CIA., 2011). The highlands and the Amazon regions, with abundant water resources but rudimentary irrigation systems, are home to the majority of Peru's poor, many of whom rely on subsistence or small-scale farming (ibid). The highlands have different agro climatic zones with different weather, some of which are not suitable for cultivating crops but good for grazing livestock (Escobal and Valdivia, 2004).

In terms of region, the coast and highlands have two thirds of the total agricultural surface as well as 83,23 % of the agricultural entities and 78 % of the rural population amounting to 6.6 million inhabitants (Escobal and Valdivia, 2004). At the national level, the average agricultural entity size is estimated to be 3.1 hectares (ibid). In the coast, however, the average size reaches 3.5 hectares, while the highlands are 2.3 hectares (ibid). In addition, the plots are more fragmented and spread in the highlands. This region is characterized by small-scale farming. Across the country, the number of plots by agricultural entity is 3.3; in the highlands it is 4.1 (ibid).

In most of the areas in the highlands, the land ownership is organized according to rural communities. There are 5,680 recognized rural communities, and the majority of them are located in the highlands (Escobal and Valdivia, 2004). This characteristic can be considered a cultural institution, as they have formally existed in Peru since the 16th century and play an important role in the agricultural sector.

One of the most important characteristics of Peruvian agriculture is the fragmentation of the property of land. This situation was reached during the 80s as a consequence of the division of the cooperatives created during the land reform process conducted during the 70s (Escobal and Valdivia, 2004) and probably due to more equalitarian inheritance regimes which allow for the splitting up of lands (Deere and Leal, 2001).

The Peruvian population was estimated at approximately 29,2 million people in July 2011 (CIA, 2011). It is a multiethnic country where around 45 % are Amerindian[4], 37 % are Mestizo (mixed Amerindian and white), 15 % are white and the remaining 3 % are black, Japanese, Chinese and other ethnic groups (ibid). As a consequence of a wide diversity, Peru has two official languages, Spanish as the main spoken language (84 %) and Quechua (13 %); however, it also offers a large number of other indigenous languages (ibid). The rural population amounts to approximately 24.1 % of the total population (INEI, 2007) and exhibits

[4] The term Amerindian denotes *American Indian*: a member of any of the peoples indigenous to the Americas except the Eskimos, Aleuts and Inuits. In principle, *American Indian* can apply to all native peoples throughout the Americas, but in practice it is generally restricted to the peoples of the United States and Canada. For native peoples in the rest of the hemisphere, usage generally favors *Indian* by itself or, less frequently, the contractions *Amerindian* or *Amerind*. See http://www.thefreedictionary.com/American+Indian.

the most precarious living standards[5]. Around 65 % of the labor force is allocated to the agricultural sector, and nearly one half of all incomes stem from agricultural activities (Escobal and Valdivia, 2004).

Avalaible data from Latin America provides an insufficiently accurate idea of the gender differences in the agricultural production process. Given the social construction of gender, in which agriculture is considered a predominantly male activity, it is common to assume that few women will answer the census questionnaire and declare themselves to be the main farmers; they only do so if they are in fact the owners or household heads in the cases in which there is no adult male resident in the household (Deere and León, 1982). Escobal and Valdivia (2004) pointed at the information gathered by the Ministry of Agriculture in the latest national agricultural census (CENAGRO) in 1994, that about 20.3 % of the principal farmers of the household in Peru were women. Women seem not to be considered agriculturists, despite their important role in the economy for subsistence and income-generating activities in agriculture and livestock tenure. Household work, which women are more likely to do, is not valued. This work may be productive in the sense of creating marketable value (i.e., processing agricultural products). Thus, bias is introduced against women in productivity measurements of neglecting this work (Deere and León, 1982). It is estimated that Peruvian women may represent as much as 80 % of a family's labor force (IFAD, 2009). Because of their productive activities, in addition to traditional household tasks and child care, women make it possible for their husbands to migrate in search of temporary work.

The majority of women of the rural population are poor, and nearly 70 % of them are extremely poor (INEI, 2009). Around 20 % of rural women are household heads with small-scale agricultural activities as their economic mainstay (MIMDES, 2008). They are generally poorer compared to those households headed by men. It is highlighted that rural, indigenous and Amazonian women specifically are the most affected by poverty because of their lower education levels, higher rates of illiteracy and high rates of maternal mortality (ibid). Access to agricultural inputs, credit and education may be limited by the diversity of languages; since men migrate in search of temporary work, one may think that men have more opportunities to become bilingual than women do (IFAD, 2009 ; Fuentes and Wiig, 2009). In 2009, the NGO Manuela Ramos revealed the situation of exclusion experienced by girls and teenagers aged

[5] According to the National Rural Households Survey (ENAHO) in 2010, the poverty rate reached 65.6 % in the rural highlands, 46.6 % in the rural Amazon and 34.8 % in the rural coast.

12 to 17 years. Their parents underestimate their attendance at school because at that age the opportunity costs of domestic work and support of farm production increase.

4 Data and Methodology

4.1 Description of the Data

The data used in this work comes from a household survey done by the two research institutes, Grade and Cuanto, in Peru between the years of 2004 and 2006. The survey was required by the land titling and cadaster program PETT[6] from the Peruvian Ministry of Agriculture. The main objective of the data collection was to evaluate the two main major economic impacts of the land titling and cadaster program PETT: (i) the investment demand effect and (ii) the credit supply effect. There are other effects expected through this evaluation, most of which focused on the economic outcomes that the implementation of the PETT can produce, including social, environmental and agricultural resource management, among others. This evaluation emphasizes the impacts of the second phase of the PETT (named PTRT2 2002-2006), on which the major PETT efforts in the Peruvian highlands are concentrated, with particular attention to the period 2004 - 2006. The survey contains baseline data that was collected between October and November 2004 and a final survey that was accomplished between October and November 2006 by Cuanto. Between these evaluations, the institutions conducted two more surveys, one in 2005 and another in 2006, monitoring and supervising the impacts of the PETT (Grade, 2007).

The implementation of the PETT program was expected to have positive effects on (i) investment, (ii) productivity and (iii) credit access of the beneficiary farmers. The impact evaluation comparing households and not parcels between the two survey rounds, done by Grade (2005), points at three important impacts of PETT: (i) increased participation in the land market, (ii) increased income of the households from non-agricultural activities (Zegarra et al., 2005) and (iii) increased access to formal land market, but this impact is rather marginal (ibid). The study also found no significant impacts on investment decisions of plot owners in

[6] The land titling and cadaster program PETT was initially a sub-division of the Ministry of Agriculture (MINAG), but on June 12, of 2007, it was integrated with the Organization for Formalization of Informal Property (COFOPRI) that was concerned with formalization of urban property (MINAG 2007). The PETT has had two components: (i) mapping lands and registering them in the cadaster, and (ii) titling them and registering the land plots in the National Superintendence of Registry Offices (SUNARP). According to the program, the PETT has targeted all peasants and expects to give peasants the population (ibid). The formalization of property rights is expected to give the peasants opportunities for seeking credits in banks by using land as collateral, to give them the facilities for applying for different types of aid programs from both public and private institutions, to reduce conflicts related to tenure, to increase tenure security and to contribute to the land markets.

the practices of conservation and soil improvement and agricultural profitability. It found no significant differences associated with establishing better female and male relations into the families during the PETT titling system that gives land titles named by both spouses. This means that low agricultural profitability of the eventually rural household's benefits from PETT may lead to the use of more resources and the creation of opportunities such as greater access to credit, greater legal certainty in non-agricultural activities and possibly in livestock (Escobal and Mediano, 2006). It is important to note that the identified impacts usually differ from the expected patterns in the literature on the subject, which is predicted to be through increased land productivity, increased investment in agricultural resources and land improvements.

The survey sample was randomly selected from the rural cadaster of PETT of the Peruvian coast and highlands. According to the final report published by Grade about the impacts of the PETT titling intervened areas in coastal and highland Peru (period 2004-2006), data on 2,207,109 plots at the national level was received. The information includes the geographical location of the land plots at the district and sector ("caceríos") levels but not about the owners. After removing plots that (i) had been inscribed before 1999, (ii) were from "selva" (Amazonas) and (iii) were from sectors with less than 21 land plots, the data base ended up with 1,639,421 land plots. It was established that a plot would be recognized as being titled as long as the plots were already registered in the public registry. Thus, this data was divided into 9,350 sectors under the geographical locations of coast and highland. By removing the districts with less than 8 sectors that had very low levels of cadastral coverage, the data ended up with 1,379,419 land plots (8,287 sectors). According to Grade (2007), one important criterion to consider in preparing the sample for the analysis was the strength of the titling coverage by PETT. They assumed that the effects of the PETT titling may systematically vary according to the degree of titling in each region. Therefore, titling density was used as stratification criteria.

These plots were stratified into five areas ("dominios") specified by geographic districts as follows: northern coast (DOM1-CN), south-central coast (DOM2-CCS), northern highlands (DOM3-SN), central highlands (DOM4-SC) and southern highlands (DOM5-SS). According to the final report, the leader of each selected plot has answered the questions. The survey is a questionnaire that contains both qualitative and quantitative data from 2.034 households in order to evaluate the second stage of the PETT. The sample includes the population already titled with the PETT in the first phase (1997-2002) and part of the second phase (2003-2004) as well as the non-titled population. After the final survey was conducted, data from 1,714 households and 8,410 land plots was obtained. Altogether, 141 households (or an attrition rate of 8.2 % of the original sample) located in highland areas could not be surveyed due to various reasons such as the absence of the informers, change of residence, houses that could not be found at this time and declinations (Grade, 2007).

4.2 Household Survey Data

The Grade data does not provide information on the explicit decision making within the household. Furthermore, the data at hand contains variables with missing observations, unclear values and plotting/typing errors. I assume that these errors occurred during the collection of the data as well as during its plotting into the spreadsheets. Because I neither participated in these activities nor had access to more detailed information, I can-not guarantee the correctness of my conclusions regarding the data quality.

Although both questionnaires lack at least some information, since they do not ask the same questions during both years, I determined the survey from 2006 to be the most complete and appropriate for use in my analysis. I use the final household survey collected in 2006. The main subjects addressed in the questionnaire are as follows: (i) household characteristics, (ii) housing characteristics, (iii) income generated outside the agricultural entity, (iv) information about plots inside the agricultural unit, (v) investment made on the plots, (vi) land transactions, (vii) household assets, (viii) agricultural and forestry production, (ix) access to credit and (x) participation in social programs.

For my analysis, I first removed all plots that did not show any production (not even zero), as I assume they were never planted. I thus removed 3.204, plots reducing the data set to 5.206 plot observations. After the first filter, I discovered a new condition with the data. The agricultural production data is given at crop level. After exploring the 144 different crops, I found 118 different measures of units of production. The majority of the sample is measured in kilograms (2.991 observations), and some observations are measured in other units of mass. However, I found 10 measures that are not units of mass in the International System of Units (SI); i.e., follow local subjective measurements. Since I did not find a way to convert these measures into units of mass of the SI or even find the price by unit or piece, I decided to remove these subjects (i.e., 1.069 plots) from my sample. After applying this second filter, I ended up with 4.137 plots.

I did a check on outliers in the variable indicating the size of the land plots and ended up removing 11 observations, as the size of their cultivable area was greater than the size of the plots. I believe these might discrepancies might indicate plotting errors, and if not, I consider them as little representative to the rest of the sample. After this, I had reliable data from 4.126 plots belonging to 1.395 households.

The questionnaire does not ask about labor from household members with respect to their plots. For the purpose of the analysis, following empirical studies (Deere and León, 1982, Figueroa, 1984), I thus will assume a proxy of labor force as follows: adult male labor above 19 years old, adult female labor above 19 years old, female and male teenager labor between 12 and 19 years old.

The set of plots deleted represents around half of the full sample. The largest percentage (i.e., 38.10 % of the full sample) refers to plots that, apparently to me, were not planted, while 12.71 % refers to the production without a monetary value. An additional discussion may address whether the fact that I remove certain observations affects my results. For instance, when the “availability of the data is influenced by a selection process that is related to the value of the dependent variable” (Stock and Watson, 2007, p. 322), selection sample bias occurs. This selection process can introduce correlation between the error term and one or more regressors, which leads to bias in the OLS estimator (Stock and Watson, 2007). “If the regressor is correlated with a variable that has been omitted from the analysis and that determines, in part, the dependent variable, then the OLS estimator will have omitted variable bias” (Stock and Watson, 2007, p. 187). Section 5.2.3 will present this discussion.

4.3 Empirical Model and Methods

Most of the empirical studies have followed the general approach to production analysis described by Quisumbing (1995). The direct method to estimate the production function of a farm manager *i* in household *j* is as follows:

$$Y_{ij} = f(V_i, X_i, Z_j) \tag{1}$$

"where Y_{ij} is quantity produced, V_i is a vector of inputs used by farm manager including land, labor, capital, and extension advice); X_i is a vector of individual attributes, including gender; and Z_j are household and community level variables. Correlation of input use with individual and household characteristics can be captured by interaction terms $V_i X_i$ and $V_i Y Z_j$" (Quisumbing, 1995, p. 6). Interaction terms describe a situation in which the simultaneous influence of two variables on a third is not compounding. In other words, if two variables of interest interact, the relationship between each of the interacting variables and a third "dependent variable" depends on the value of the other interacting variable.

Usually, gender productivity differences are estimated by using the Cobb-Douglas production function as most of the empirical studies on gender differences in agricultural productivity do (Quisumbing, 1995):

$$Y = \alpha_0 L^{\alpha_1} T^{\alpha_2} \tag{2}$$

" where Y is output, L is labor input (hired or family), and T is a vector of land, capital, and other conventional inputs" (Quisumbing, 1995). Constant returns to scale are often a reasonable assumption to make about technologies. If $\alpha_1 + \alpha_2 = 1$, the production function has constant returns to scale; doubling labor L and capital T will also double output Y. (Varian, 1992).

The relationship between two or more explanatory variables and a response variable is found by fitting a linear equation to the observed data (Verbeek, 2008). I make a log linear transformation of equation (2); i.e., *ln* on both sides of the equation (3) below which is hence a log-log model that can be estimated with the ordinary least squares (OLS) estimators,

$$lnY_i = \alpha_0 + \alpha_1 lnL_i + \alpha_2 lnT_i + \beta lnE_i + \delta Gender + \varepsilon \quad (3)$$

Assuming that Y_i is the dependent variable and represents the i^{th} plot gross value of output per hectare by plot. The variables L_i and T_i are defined as above; E_i is the indicator variable of schooling, Gender is the gender of the household head which was part of productivity indicator "alfa zero" in equation (2) and ε is the error term (Quisumbing, 1995). Explanatory variables in the specification model above include more dummy variables. Every value of independent variables is associated with a value of the dependent variable Y and "correlation between the gender of the household head and other inputs can be captured by interaction terms" (Quisumbing, 1995, p. 8). Interactions between the gender variable and other variables may be important in order to test for sex differences in input utilization; if, for instance, a significant interaction between the female dummy variable with education indicates whether female farm managers benefit less or more from education than farm managers as far as farm production is concerned (Quisumbing, 1995).

The differences in agricultural productivity between men and women do exist, but their measurement faces conceptual and methodological difficulties as the literature shows. The production function form already described has been used by many researchers to estimate male-female productivity differentials because it may be convenient to estimate since it is linear in parameters (Quisumbing, 1995). The data at hand was explored using scatter plots in order to determine whether there was a relationship between the dependent variable and different independent variables. When the data was subjected to a scatter plot, the relationship was not linear. The variables were log transformed and subjected to scatter plot again. Oval-shaped plots were obtained, indicating that there was an almost linear relationship between the natural logarithms of the variables. Although this approach seems convenient, it may not account for the simultaneity bias introduced by OLS estimation of production functions, particularly the endogeneity of input choice with respect to farmer characteristics (Quisumbing, 1996).

It should be noted that, in the analysis that follows, I do not explicitly model a true production function, which has intensive data requirements focusing on modeling all production factors. This affects the analysis of the coefficient of my key variables that I describe in the next section while controlling for other explanatory variables.

There exist different methods to compare two different groups of data and check if the difference is significant or if it is just a consequence of randomness. The decision on which models to use, concerns the distinction of variable types. In my work I use both t-test and chi2 tests.

4.4 Measurement of Key Variables

4.4.1 Value of Output per Hectare

The question of which measure of productivity to use remains open. However, it cannot be argued that gross value of output per hectare based on food crops alone is truly representative of a plot manager's efficiency (Peterman et al., 2010). Most studies have used output divided by a single input factor as a measure of productivity. A disadvantage of partial productivity measures is that they relate output to a single factor of production when factors of production do include an index of different inputs (O'Laughlin, 2007). In this sense, one condition of a productivity measure in this paper is the time frame of the available data that does not allow for analysis of long-run processes. According to the literature, rural households are engaged in a number of productive activities, including wage labor, off-farm employment, and non-agricultural self-employment; the measure I use here is only a partial measure of the set of the households' productive activities.

The dependent variable in this work is the gross value of plot production divided by the plot size. The first step is to calculate the value of output. This variable is calculated based on crop production. The data of agricultural production is available at crop level. After a review of the data, I found that one plot might have one or more crops harvested. Converting production into monetary terms by multiplying kilos of production by average prices in October 2006 (local currency), I first calculated the gross value of crop production. The plot production value is calculated by aggregating crop value per plot. I found the value of crop production in this setting to be the more appropriate measure than the crop yield, because many of the plots were planted with more than one crop. Using actual yield measures per crop when intercropping is practiced would be misleading, because individual crop yields will be artificially low (Peterman et al., 2010).

In order to make this study manageable, I have decided to aggregate the crops by eight groups taking into account the national importance given by the Ministry of Agriculture and The National Institute of Statistics and Informatics (INEI). I thus multiply the crop production (in kilograms) by the prices per kilogram (INEI, 2006)[7]. I use the exchange rate from October 2006 (Peru, 2006) and make the conversion to kilograms using the same equivalence table used by Cuanto. Table 1 below shows the calculations. Table 1 presents the summary for these calculations.

Table 1: Value of crop production per kilo in S/. and USD

Item	**Crop**	**U.M**	**Price in local currency per kilogram "Nuevos Soles" S/.**	**Price in USD[8] per kilogram**
1	Potatoes	Kilo	0,54	0,17
2	Rise	Kilo	0,55	0,17
3	Corn	Kilo	0,54	0,17
4	Wheat	Kilo	0,70	0,22
5	Vegetables, legumes, cereals and others[9]	Kilo	1,43	0,44
6	Fruit[10]	Kilo	0,53	0,17
7	Sugar Cane	Kilo	2,16	0,67
8	Coffee	Kilo	4,51	1,40

[7] Instituto Nacional de Estadistica e Informatica INEI (National Institute of Statistics and Informatics) in Información Económica. Sistema de Precios Promedio. Precios Agropecuarios. Agricolas Octubre 2006. See price average index in local currency S/. "nuevos soles" http://www.inei.gob.pe/.

[8] Calculating the price in USD, I use 1USD = 3,23 S/. in Octubre 2006. Source: Banco Central de la Reserva del Perú (The Central Reserve Bank of Peru). Política Monetaria. Tipo de Cambio. Octubre 2006. See http://www.bcrp.gob.pe

[9] Calculating the price, I did consider 10 randomly selected crops within 100 kinds of crops and take their average price. The sample is not representative of the population as I did not find official prices for all crops.

[10] Calculating the price, I did consider 10 randomly selected crops within 41 kinds of crops and calculate the average price.

4.4.2 Gender

A measure of the presence of plot ownership by household head sex will also be taken into account. It should be noted that this last measure in this paper is used as a proxy of presence of the household heads in agricultural production rather than a measure of effective rights (which would include direct control over land), which is outside of the scope of this paper. Because I am able to identify management only partially, this work faces different issues in terms of interpretation that are encountered by previous works in this vein. However, I will attempt to provide some insights and characteristics of the agriculture context in Peru.

The sex of the household head is used as a gender indicator of ownership to the plots, because no gender- disaggregated information on ownership was collected at the plot level. With regard to plots, two questions were asked: (i) “Do you have a PETT title for this plot?” and (ii) “What kind of certificate guarantees the property to the plot?” The coding of the question about the PETT title gives categories of ownership but does not specify an individual per se (response categories include household head, household head and spouse/cohabitant, household head and others, relative and no household head members). By matching these categories to the household roster, it is possible to determine the gender of the owner. Regarding the second question, several documents that guarantee the property of the land plot are mentioned. Since this work is intended to analyze the effects of neither specific property document ownership nor the PETT, a new variable that includes the PETT and all kinds of property documents was created. My variable attempts to capture male and female presence in agriculture production through ownership represented in the fact that the household heads do hold a property document to the plot, as the literature suggests is important in agriculture production but not the effectiveness of a specific institutional policy in this issue.

My second gender indicator is based on gender composition of the household. I thus classify the household members into three categories as follows: adults (19 years or older), teenagers (between 12 and 18 years old) and children (11 years or younger) among both females and males. This indicator is intended to measure gender presence in agriculture production from a demographic point of view since it takes into account the distribution of members inside the household.

Other variables used in this work will be explained as follows:

Socioeconomic indicators: This is a vector of the individual characteristics of men and women. The key variables include those that may be important in explaining the management skills of the individual. Although the sex of the household head has been criticized in the literature as a misleading factor for determining management of the plot, I still find it useful, since I expect the household head also to be a land owner. It has been argued that land ownership by itself is insufficient to ensure women's control over production and its output (Agarwal, 1994), but as was explained in Chapter 2, a woman's ownership of assets is expected to improve her bargaining position not only intra- household but within the community (Fuentes and Wiig, 2009).

Assuming that Peruvian women are "only" concerned with guaranteeing their family's minimum food requirement in other words, surviving the coefficient of the female household head variable should be a positive sign. However, reaching a certain conclusion is difficult since households can no longer sustain themselves from agricultural production alone (Deere, 2005). Education and age of the household head are also included to proxy management skills of the plot. Although women's level of education is expected to be lower in comparison to men's, it is expected that this variable have a positive sign regarding productivity. It is assumed that better educated individuals are more likely to adopt new technologies (Quisumbing, 1995). Other variables like migration and mother tongue may also be important to check, as was reviewed in the literature. The gender composition of the household already explained in Chapter 2 has been introduced as independent variable. It should be noted that gender composition variables are constructed on the base of number of individuals in the household disaggregated by sex and age. This is the same detailed household size. The variable labor is also constructed on the base of number of individuals of the household. Because these three variables are constructed on the same base and are highly correlated, I determined to use the household size variable only for descriptive statistics to give an overall description of the household as this variable is often to be used in these studies. Table 2 below presents the description of the socioeconomic indicators.

Table 2: Variables for socioeconomic indicators

Variable	**Variable description**	**Variable Name**
Female household head	*Dummy variable: 1=if household head is female, 0=otherwise.*	*fem_head*
Total number of female adults	*Continuous variable for the natural logarithm of the total number of female adults in the household if age>/= 19 years.*	*fem_adu (ln)*
Total number of male adults	*Continuous variable for the natural logarithm of the total number of male adults in the household if age>/= 19 years.*	*male_adu (ln)*
Total number of female teenagers	*Continuous variable for the natural logarithm of the total number of female teenagers in the household if age >/=11 years.*	*fem_teen (ln)*
Total number of male teenagers	*Continuous variable for the natural logarithm of the total number of male teenagers in the household if age >/=11 years.*	*male_teen (ln)*
Total number of female children	*Continuous variable for the natural logarithm of the total number of female children in the household if age < 11 years.*	*fem_chil (ln)*
Total number of male children	*Continuous variable for the natural logarithm of the total number of male children in the household if age < 11 years.*	*male_chil (ln)*
Household head schooling	*Dummy variable for schooling, specified by 1=If head has no schooling, 0=otherwise*	*school_head0*
	Dummy variable for primary schooling, specified by 1=If head has partial or completed primary schooling, 0=otherwise	*school_head1*
	Dummy variable for secondary education, specified by 1=If head has partial or completed secondary schooling, 0=otherwise	*school_head2*
	Dummy variable for postsecondary education, specified by 1=If head has postsecondary schooling, 0=otherwise	*school_head3*
Household head mother tongue	*Dummy Variable: 1= If household head speak Spanish as mother tongue, 0=If household head speak Quechua or other indigenous language.*	*head_tongue*
Household head land tenure	*Dummy variable: 1=If a household head hold a document that guarantee the property to the plot, 0=otherwise*	*doc_property*
Household head migration	*From the questionnaire "Has the household head migrated?": 1=yes, 0= no*	*head_migr*
Household head age	*Continuous variable for the natural logarithm of the age of the household head (years).*	*head_age (ln)*

Agricultural Inputs: The next vector of variables includes agricultural inputs. Assuming men to be privileged in comparison to women inside the household as well as in the community, it makes sense to expect men to own more and higher quality land. Other variables such as access to credit and technical assistance are expected to have positive signs. Expenditures for seeds, fertilizers and insecticides are also available. If we assume that inputs such as fertilizers and insecticides have a long- term effect so that they all sustain the fertility of the soil, it is expected that men do invest more than women, since they may be concerned with guaranteeing high quality of land for their sons. In the context of male advantages and the situation of scholar exclusion experienced by girls and teenagers aged 12 to 17 years, the labor force is assumed to refer to all household members older than 12 years of age. It should be noted that this variable is very similar to the variable of gender composition already described so that by running the regressions, one of them should be dropped to avoid bias.

Table 3: Variables for agricultural inputs and characteristics of the plots

Variable	**Variable description**	**Variable Name**
Size of the plot	*Continuous variable for the natural logarithm of the plot size in hectares*	*plot_size (ln)*
Size of the operational area of the plot	*Continuous variable for the natural logarithm of the operational area in hectares.*	*plot_oparea (ln)*
Size of the harvested area of the plot	*Continuous variable for the natural logarithm of harvested area of the plot.*	*plot_harvest (ln)*
Household head access to credit	*From the questionnaire "Do you or another household member receive credit from any state institution for agricultural activities, business, household construction, etc.? Dummy variable 1=yes, 0=no.*	*head_credit*
Household head access to technical assistance	*Dummy Variable: 1=If household head receives technical assistance, 0=otherwise.*	*head_techassi*
Expenses on seeds	*Continuous variable for the natural logarithm of the total expenses on seeds per plot in local currency.*	*exp_seed (ln)*
Expenses on fertilizers	*Continuous variable for the natural logarithm of the total expenses on fertilizers per plot currency.*	*exp_fert (ln)*
Expenses on insecticides	*Continuous variable for the natural logarithm of the total expenses on insecticides per plot in local currency*	*exp_insect (ln)*
Labor	*Continuous variable for the natural logarithm of number of household members by sex and age able to work: all members > 12 years old.*	*labor (ln)*

Sample regions: The set of regional variables are added in order to control for regional differences. A regional characteristic that includes the zone in which the plot is located may provide insights into the characteristics of the plots as well as the production process. According to the differences between the coastal and highland regions described in Chapter 3, it is expected that the so-called feminization of agriculture will be greater in the highlands than in the coast. According to their characteristics, the dummy variables for the highlands are expected to have negative signs, as poor areas may reflect low productivity. The coastal dummies may have a positive sign, as it would be argued that agroindustry areas reflect high productivity.

Table 4: Variables for regions

Variable	**Variable description**	**Variable Name**
Regions	*Dummy variable =1 for northern coast, 0=otherwise*	*reg1*
	Dummy variable =1 for southern and central coast, 0=otherwise	*reg2*
	Dummy variable =1 for northern highlands, 0=otherwise	*reg3*
	Dummy variable =1 for central highlands, 0=otherwise	*reg4*
	Dummy variable =1 for southern highlands, 0=otherwise	*reg5*

5 Analysis and Results

5.1 Descriptive Statistics

Descriptive statistics for the data are presented to give important insights into the sample under scrutiny. The tables in these sections give the breakdown of all regression variables for all 4.146 plots in the full sample and stratified by the sex of the household heads.

Table 5: Descriptive statistics for households and household heads characteristics

Variables	Full Sample N=4,146		Female headed N=854		Male headed N=3,292	
	Mean	SD	Mean	SD	Mean	SD
head_age (years)	60.17	(13.62)	63.35**	(13.27)	59.34**	(13.58)
household size (members)	4.50	(2.20)	3.88*	(2.34)	4.65*	(2.13)
fem_adu (members)	1.52	(0.85)	1.68**	(0.86)	1.48**	(0.84)
male_adu (members)	1.47	(0.86)	1.05**	(0.99)	1.58**	(0.79)
fem_teen (members)	0.32	(0.60)	0.27	(0.54)	0.34	(0.61)
male_teen (members)	0.36	(0.62)	0.25*	(0.56)	0.39*	(0.64)
fem_chil (members)	0.22	(0.49)	0.18*	(0.49)	0.23*	(0.48)
male_chil (members)	0.83	(1.32)	1.57**	(1.38)	2.36**	(1.25)
school_head1 (=1)	0.60	(0.48)	0.40**	(0.49)	0.65**	(0.47)
school_head2 (=1)	0.16	(0.37)	0.12*	(0.32)	0.18*	(0.38)
school_head3 (=1)	0.07	(0.26)	0.07	(0.26)	0.07	(0.26)
head_tongue (=1)	0.57	(0.49)	0.53*	(0.49)	0.58*	(0.49)
head_migr(=1)	0.12	(0.32)	0.19*	(0.39)	0.10*	(0.30)
doc_property (=1)	0.95	(0.21)	0.92*	(0.25)	0.95*	(0.20)

Source: GRADE 2006
Notes: Sample is stratified for gender of household head. Mean values reported with standard deviations are in parentheses. t-test and chi2 were conducted to check for significance. * indicates significant mean differences at the 5 percent level; ** significant at the 1 percent level.

Approximately 20.6 % (or 854 plots) are households that are headed by females, while the majority is households headed by males; that is, 79.4 %. Socio economic characteristics show that, on average, female household heads are significantly older than their male counterparts. Female heads have a mean age of 63 years, while male household heads are on average 59 years old. According to the data, the majority of the plots headed by females are unmarried or otherwise single; i.e., 86.42 %. With regard to the male subsample, the majority of the plots headed by males are married (90.09 %) or men who have a cohabitant.

Results from Table 5 shows that the number of individuals in the household is on average four for all plots. The average proportion of individuals is around four for plots headed by females and five for plots headed by males. Upon examination of the household composition and the gender of its individual members, it is possible to see a higher proportion of males among both female and male headed households. In particular, the average proportion of female adults is around two where plots are headed by women, while the proportion of male adults is one for plots headed by men. The average proportion of male adults is lower in the plots where the household is headed by women than in those where the household is headed by men; i.e., one vs. two. The civil status of female heads may be the reason for the lower presence of male adults and, in fact, lower presence of males and females of different ages. It may be argued that unmarried female heads may be widows or divorced and are more likely to become household heads at a much later stage in life.

According to Table 5, 84 % of the plots in the full sample belong to household heads that have at least some education. In particular, 60 % of the full sample has primary schooling (where 85 % are male heads) and the remaining 40 % has higher education levels by smaller proportions, including post-graduate education. The proportion of education among female heads among the plots is less than that of male heads; i.e., 61 % and 90 %, respectively. Escobal and Velandia (2004) claim the tendency for poor rural people in Peru to be older and less educated on average compared to rural non-poor people among both males and females. According to these researchers, the limitations in the educational Peruvian system that include poor infrastructure and resource endowments reflect the educational level of the household heads in rural Peru. Table 5 demonstrates this situation and is highlighted in terms of female head in a context in which the difference of the number of plots among both female and male subsamples is considerable.

Surprisingly, more than half of the plots in the full sample are among households headed by individuals who have Spanish as a mother tongue, that is to say, 57.03 %. In particular, 53 % of the plots headed by females are Spanish speakers, and around the same ratio applies for males; i.e., 58 %. Taking into account the low levels of household head’s education and the low levels of migration during the last 12 months prior to this data being collected, one may speculate the reasons related to the complex characteristics of ethnic diversity. According to *Truth and Reconciliation Commission (TRC) in 2003 (*“La Comisión de la Verdad y Reconciliación (CVR) 2003”), “…several phenomena such as media, military service, urbanization, industrialization and mass migration that changed the face of the country have broken down traditional barriers making social and ethnic identities more heterogeneous…"[11]. The commission reveals a relationship between ethnicity and exclusion: people who speak a native language usually prefer to hide their ethnic origin (CVR, 2003; Escobal and Velandia, 2004). This may explain why, under the limited conditions described above, household heads tend to be bilingual.

Finally, around 95 % of the plots with female and male household heads hold a property document to the plot indicating a presence of land ownership across almost the whole sample.

Table 6. Descriptive statistics for agricultural inputs variables and output

Variables	Full Sample N=4,146		Female headed N=854		Male headed N=3,292	
	Mean	SD	Mean	SD	Mean	SD
plot_size (hectares)	1.28	(2.69)	0.94**	(2.26)	1.37**	(2.78)
plot_oparea (hectares)	1.02	(1.97)	0.77**	(1.71)	1.08**	(2.03)
plot_harvest (hectares)	0.76	(1.51)	0.44**	(1.41)	0.84**	(1.53)
head_credit (=1)	0.09	(0.29)	0.09	(0.29)	0.09	(0.29)
head_techassi (=1)	0.02	(0.14)	0.03*	(0.18)	0.01*	(0.12)
exp_seed (nuevos soles)	110.53	(398.8)	58.33*	(161.4)	124.07*	(438.9)
exp_fert (nuevos soles)	210.37	(754.5)	101.89**	(420.5)	238.44**	(817)
exp_insect (nuevos soles)	72.77	(344.9)	24.61**	(108.5)	85.26**	(382.1)
labor (members)	3.70	(1.67)	3.26**	(1.82)	3.81**	(1.61)
output (yield per hectare)	3040.1	(14395)	2031.0*	(4575)	3301.9*	(15977)

Source: GRADE 2006
Notes: Sample is stratified for gender of household head. Mean values reported with standard deviations are in parentheses. t-test and chi2 were conducted to check for significance. * indicates significant mean differences at the 5 percent level; ** significant at the 1 percent level.

The second table presents descriptive statistics for the agricultural inputs used by households in the agricultural production process. The table includes information on size of the land, value of the inputs in local currency and the labor. Plot size is on average 1.28 hectares in the sample, where female heads seems to have smaller plots compared to men, i.e., 0.94 hectares vs. 1.37 hectares, respectively. It might be worthwhile to examine the operational area of the plots. On average, 1.02 hectares of the plot is cultivable in the full sample, where the area of

[11] CVR, 2003; Tomo VIII p. 89.

the plots belonging to female household heads is 0.77 hectares and for male heads is 1.08 hectares. The harvested area is 0.76 hectares on average where 0.44 hectares is the average harvested area for female heads and 0.84 hectares is the average for male heads. Note that the harvested area is less than the operational area for both female and male heads indicating they do not use all the area they could have used for harvesting.

It should be noted that only 9 % of the full sample, that is, 389 plots, of household heads had access to credit during the previous 12 months. The majority of the credits belong to plots that are located in northern coast, i.e., 114 plots. Not so different from the credits that belong to plots located in the southern highlands, i.e., 95 plots. At the same time, only 2 % of the full sample had registered technical assistance. Even though for both variables plots headed by males are in the majority, the absence of these two inputs seems to be very high for both males and females.

A comparison of expenses for seeds, fertilizers and insecticides between males and females tells us that, on average, male heads invest more in these inputs than females. This may be consistent with the fact that males have on average greater and larger plots than females. The high standard deviations may suggest extreme values of expenses. This may indicate the expenses on these inputs depending on the land: big land, more quantity of production, more agricultural inputs needed. The labor variable is consistent with what I found in the composition of the household. A high and significant correlation with female and male adults (i.e., 0.57 and 0.60, respectively) may indicate that more than half of the labor force is adult across the full sample.

Exploring the variable output, it is possible to see there are significant differences in the measurement of the dependent variable between male and female heads. Summary statistics indicate that the plot production value per hectare is 3.040 (s./ nuevos soles) on average with a standard deviation of 14.395 (s./ nuevos soles), where the maximum value of production by plot per hectare reaches 454.587 (s./ nuevos soles). The average gross value of production per hectare may indicate that in general, the plots of the full sample have low yields per hectare. Note that female heads' value of production per hectare is significantly lower than that of male heads. The high value of production compared with the mean suggests outliers in both of the variables, plot size and value of production per plot.

Table 7: Descriptive statistics for regional variables

Variables	Full Sample N=4,146		Female headed N=854		Male headed N=3,292	
	Mean	SD	Mean	SD	Mean	SD
reg1 (northern coast)	0.14	(0.35)	0.07*	(0.27)	0.16*	(0.36)
reg2 (southern and central coast)	0.04	(0.19)	0.05*	(0.22)	0.03*	(0.18)
reg3 (northern highlands)	0.25	(0.43)	0.18**	(0.38)	0.26**	(0.44)
reg4 (central highlands)	0.36	(0.47)	0.46*	(0.49)	0.32*	(0.46)
reg5 (southern highlands)	0.21	(0.40)	0.22	(0.41)	0.20	(0.40)

Source: GRADE 2006
Notes: Sample is stratified for gender of household head. Mean values reported with standard deviations are in parentheses. chi2 tests were conducted to check for significance * indicates significant mean differences at the 5 percent level; ** significant at the 1 percent level.

Upon examining the regional sample, I find that around 79 % of the plots are located in the highlands and only 21 % along the coastal region. In particular, 35 % of the plots of the full sample are located in central highlands, where 46 % of those plots are headed by females and 32 % headed by males. The main crops to be harvested in this region are wheat, corn and potatoes. Another difference may be observed in the northern highland, where the percentage of plots belonging to households headed by males is comparatively higher than that of those headed by females that is, 26 % and 18 % respectively. The main crops to be harvested are the same as in the central highlands, plus beans.

Although these results must be interpreted with caution, there are some clear trends that are worth commentary. Male heads are significantly younger than female heads. They have larger plots with bigger values of production in comparison to females, and this may be a reason for the males' higher expenses in agricultural inputs than female heads.

5.2 Empirical Results

This chapter presents the analysis as well as discussion on my results. All of the analysis is performed at the plot level.

After having removed the first check of outliers described in Chapter 4, I also found a new set of outliers, in my dependent variable. Some plots had a much larger value of production than the average. When looking for the characteristics of these plots, I found that the majority is located in the coastal region (exactly north), while just one plot is located in the highlands. It makes sense to consider these plots as belonging to enterprises rather than peasants. The reason may be found not only in the location but also in the fact that these plots are harvested with sugar cane and rice, two crops that, as I found in the literature, are products to be exported. Upon examining the plot size, I found that 6 plots are sized more than 30 hectares when the mean plot size is 1.28 hectare. When making a new data set without the outliers, the mean plot size was reduced to 1.22 hectares. Nevertheless, I decided to use my 4.126 sample, as all of my overall conclusions remain the same.

5.2.1 Analysis of Female and Male Household Head Agricultural Productivity

The first research question aims at determining what affects productivity for female household heads. Consider first an analysis of separate subsamples by female and male heads. I have constructed four models and separated them by pairs. Models 1 and 2 present plot productivity for female heads only. Models 3 and 4 present plot productivity for male heads only. Only models 2 and 4 introduce the set of regional variables in order to control for regional differences. Note that the *school_head0* (dummy for no education of the household head) and *reg5* (Southern highlands) variables in both models 2 and 4 were dropped to avoid multicollinearity. I also dropped the variable of the land ownership document as I can assume almost the whole sample with land tenure.

Each model represents a separate regression from left to right. All of the models are regressed under the assumption that the production function presents constant returns to scale. Sample sizes and pseudo R-squared values are reported at the bottom of each column. For construction of the variables see section 4.4. For descriptive statistics see section 5.1.

Table 8: Regressions for female household heads' plot productivity

Variables	**Model 1**		**Model 2**	
head_age (ln of years)	0.241	(0.326)	-0.225	(0.295)
school_head1 (=1)	0.0701	(0.182)	-0.0634	(0.170)
school_head2 (=1)	0.409	(0.276)	-0.0806	(0.257)
school_head3(=1)	0.0800	(0.519)	-0.423	(0.470)

head_tongue (=1)	-0.253	(0.163)	0.154	(0.216)
head_migr(=1)	0.0758	(0.240)	0.0844	(0.212)
labour (ln number of individuals)	0.0529	(0.140)	0.0352	(0.136)
plot_oparea (ln hectares)	-0.368***	(0.0613)	-0.389***	(0.0590)
head_credit (=1)	0.899***	(0.265)	0.836**	(0.252)
head_techassi (=1)	-0.00452	(0.382)	-0.0144	(0.332)
exp_seed (ln nuevos soles)	0.0687	(0.0445)	-0.00934	(0.0463)
exp_fert(ln nuevos soles)	0.203***	(0.0469)	0.171***	(0.0462)
exp_insect (ln nuevos soles)	0.142**	(0.0532)	0.142**	(0.0522)
reg1 (northern coast)			0.450	(0.512)
reg2 (southern and central coast)			0.103	(0.399)
reg3 (northern highlands)			-1.321***	(0.328)
reg4 (central highlands)			-0.562**	(0.209)
Constant	4.052**	(1.401)	6.618***	(1.251)
Observations	**844**		**844**	
Adj. R-sq.	**0.263**		**0.326**	

Notes: Standard errors in parentheses are clustered at the household level.* p<0.05 indicates significance at the 5 % level, ** p<0.01 indicates significance at 1 % level, *** p<0.001 indicating significance at the 10 % level.

The results of the estimation in Table 8, indicate that the value of R^2 is 0.263 for Model 1 and 0.326 for Model 2; both are significant as indicated by the significance of the F value 12.27 and 16.17, respectively for each model. This means that the variables in Model 1 only explain 26.3 % of the variation of the gross value of production per hectare. The variables in Model 2 explain 32.6 % of output per hectare. From the specified variables, the coefficients for operational plot area, access to credit expenses in fertilizers and insecticides are significant for both models. The variables for the northern and central highlands are statistically significant.

None of the individual attributes are statistically significant indicating no evidence of influence of female attributes on their productivity. The coefficient of operational plot area is significant at 10% level and takes negative sign. This indicates that an increase in operational land area lead to decrease output in 36.8 % while controlling by regions the decrease is 38.9%. An explanation of the negative relationship between operational area and yield may be the agricultural intensification associated with small farms and inefficient allocation of their inputs. For instance, an intra-household study by Udry et al., (1995) found that plots controlled by women are farmed much less intensively than similar plots controlled by men. His estimations implied that re-allocating the inputs used by male owned plots to female owned plots would increase productivity. This led us to speculate about the importance of inputs too. If we consider the low access to inputs and their high costs in the peasant farming system, increasing the operational plot area may imply a wider application of insufficient resources, (e.g., fertilizers and insecticides) that could lead to a reduction in the gross value of production per hectare.

Increase in access to credit led to an increase in the value of production per hectare. This is shown not only by the positive and highly significant coefficient in both regressions (89.9 % and 83.6 % respectively), but also the positive signs of both the fertilizers and insecticides. This means that expenses on fertilizers and insecticides lead to an increase in output. However, expenses on seeds and technical assistance service do not show the same pattern, indicating either (i) limitations to access to them or (ii) that women invest in other inputs that are missed in this model. The negative and high significant coefficient of the northern and central highlands dummies may confirm hypothesis (i) if we consider that 64 % of the plots that are headed by female are located between these two poor regions.

I will now consider only male household heads using the same variables I used for females to determine the effects on their productivity:

Table 9: Regressions for male household heads' plot productivity

Variables	**Model 3**		**Model 4**	
head_age (ln years)	0.0159	(0.173)	-0.218	(0.168)
school_head1 (=1)	0.108	(0.118)	0.0741	(0.109)
school_head2 (=1)	0.432**	(0.147)	0.278	(0.147)
school_head3(=1)	0.602**	(0.185)	0.454*	(0.183)
head_tongue (=1)	0.224*	(0.0881)	0.458***	(0.115)

head_migr(=1)	-0.0120	(0.141)	0.00498	(0.131)
labour (ln number of individuals)	-0.0412	(0.103)	-0.0103	(0.0980)
plot_oparea (ln hectares)	-0.444***	(0.0292)	-0.429***	(0.0302)
head_credit (=1)	0.514***	(0.136)	0.408***	(0.122)
head_techassi (=1)	0.234	(0.243)	0.0710	(0.200)
exp_seed (ln nuevos soles)	0.0794***	(0.0199)	0.0453*	(0.0206)
exp_fert(ln nuevos soles)	0.199***	(0.0227)	0.143***	(0.0222)
exp_insect (ln nuevos soles)	0.142***	(0.0283)	0.111***	(0.0257)
reg1 (northern coast)			0.612***	(0.177)
reg2 (southern and central coast)			0.602**	(0.231)
reg3 (northern highlands)			-0.844***	(0.159)
reg4 (central highlands)			-0.144	(0.112)
Constant	4.816***	(0.733)	6.102***	(0.738)
Observations	**3281**		**3281**	
Adj. R-sq.	**0.309**		**0.363**	

Notes: Standard errors in parentheses are clustered at household level.* p<0.05 indicates significance at the 5 % level, ** p<0.01 indicates significance at the 1 % level, *** p<0.001 indicates significance at the 10 % level.

The results of the estimation in Table 9 show a higher value of R^2 compared with females' 0.309 for Model 3, i.e., without controlling for regional variations and 0.363 for Model 4 i.e., by controlling for regions, both of which are significant, as indicated by the significance of the F values 50.75 and 51.98 respectively. This means that the variables in Model 3 explain 30.9 % of the variation of the gross value of production per hectare. The variables in Model 4 explain 36.2 % of the variation of output per hectare. Based on the specified variables, the coefficients for operational plot area, access to credit expenses in fertilizers and insecticides and the northern highland are also statistically significant for men. Compared to female heads, other variables appear to be statistically significant for men such as primary and secondary school level, mother tongue, expenses on seeds and the regional dummies for coastal region. Introduction of the regional variables makes the variable of secondary education insignificant.

The coefficient of operational plot area is significant and takes a negative sign with a slightly higher value compared with female heads. It would be expected that the increase in the size of the operational plot area also increases productivity but the negative sign indicates that men could experience a similar situation as women, so that they also face low access to inputs and high costs. According with these results both female and male heads productivity are negative influenced by plot operational size, even when descriptive statistics show that female heads hold smaller plots than male heads. This is not exactly a gender issue, but rather about land size and productivity. One way to explain the negative relationship between productivity and farm size is by saying that "farmers who sell off land in distress (thus becoming small holders) sell off the relatively less fertile part of their holdings" (Ray, 1998, p. 453). Another way to think about this phenomenon is that larger plots may be cultivated by seasonal laborer that have less incentive to put a high effort in the cultivation activity as compared to family labor. This argument is backed by empirical work discussed in Ray (1998).

Speaking Spanish as a mother tongue led to an increase in yield. This is shown by the positive and significant coefficients with high size while controlling for regional variations. This is consistent with the access to credit and land property as they probably need the language to access to those inputs. To be bilingual may open the possibility to get access to institutional services and inputs in general. Other reason may be explained by the sample size as the female heads subsample is smaller to capture significant results in comparison with the male head sample. The male heads sample is around three times bigger than the female heads subsample which is a considerable difference.

Increases in access to credit lead to an increase in the gross value of production per hectare. The coefficients in both models are positive and statistically significant with less size in comparison to the coefficients presented in the regression for female heads. This is shown by the positive signs of both fertilizers and insecticides but also of seeds. This means that an increase in fertilizers, seeds and insecticides leads to an increase in gross value of production per hectare for male heads.

My first question seeks to find features that affect female household head's productivity. To answer this question I have considered subsamples of both female and male household heads independently from each other as it is not possible to answer this question without studying male household heads as well. In this first simple analysis, female household heads' productivity is statistically significant affected by the size of the operational area of the plot, access to credit, and expenses on fertilizers and insecticides. Introducing the regional variables indicates that the northern and central highland regions have statistically significant effects on female household heads' productivity. Examining the subsample for male household heads reveals that the size of the operational area of the plot, access to credit, and expenses on fertilizers and insecticides have statistically significant effects on productivity, just as for the female subsample. Individual attributes such as postgraduate education and Spanish mother tongue also have statistically significant effects on the productivity; as well as expenses on seeds. Introducing the regional variables indicates that the northern, central and southern coastal as well as the northern highland regions have statistically significant effects on male household heads' productivity. My findings show that none of the individual attributes have statistically significant effects on female household heads' productivity while education and mother tongue are individual attributes that have statistically significant effects on male household heads' productivity. One reason could be that males on average get more schooling than women. There are not only a higher percentage of men to get schooling but also do they attend schools longer. This would also explain why the dummy variables for the coastal regions have a significant impact on productivity for males but not for females. In those regions you have agro industries, meaning that there is a better educational infrastructure, leading to higher average incomes of the households. From the descriptive statistics it can be seen that the coastal regions have the smallest portions of female headed households. All this taken together might explain why schooling, Spanish as a mother tongue and the coastal regional dummies do have significant effects on productivity for male but not for female headed households.

5.2.2 Analysis of Household Gender Composition and Land Productivity

Next the gender composition of the household shall be analyzed with regard to its influence on plot productivity. This is a second way of looking at how gender affects productivity, next to the household head perspective. To answer this second research question it is worthwhile to mention that although inheritance tends to favor men in rural Latin America, it is also the principal mean by which rural women acquire land as Deere (2003) argued. It may be expected that the number of males compared to females in the household will influence the way the households choose to produce on their land. A pooled regression was done that included the female household head dummy as well as variables capturing household composition disaggregated by sex and age.

The models are constructed as follows: Models 5 and 6 present pooled regressions that were estimated for the entire sample and include the female household head dummy variable. This approach is often used to estimate differences in technical efficiency between male and female household heads. Quisumbing (1996) claims that this method is recommended if all farms produce similar crops. By using a sex dummy variable, the analysis allows for differences regarding sex. Interaction between the sex dummy with other variables show its effect on input utilization. Access to resources and individual attributes allow for gender differences.

Both models include a set of variables disaggregated by sex and age in three groups: adults, teenagers and children. Only Model 6 introduces the set of regional variables in order to control for regional differences. Note that the southern highland region *(reg5)* variable is dropped in Model 6 to avoid multicollinearity. Each model represents a separate regression from left to right. All of the models are regressed under the assumption that the production function presents constant returns to scale. Sample sizes and pseudo R-squared values are reported at the bottom of each column. Table 10 presents the results.

Table 10 Regressions log gross value of agricultural production per hectare by plot (ln nuevos soles per hectare) results for the full sample, Peru.

Variables	**Model 5**		**Model 6**	
fem_head (=1)	-0.0916	(0.0954)	-0.127	(0.0899)
fem_adu (ln members)	-0.142	(0.0824)	-0.153	(0.0784)
male_adu(ln members)	0.108	(0.0848)	0.100	(0.0782)
fem_teen (ln members)	-0.0681	(0.169)	-0.165	(0.150)
male_teen (ln members)	0.257	(0.168)	0.316*	(0.157)
fem_chil (ln members)	-0.0674	(0.152)	-0.0155	(0.146)
male_chil (ln members)	-0.0767	(0.141)	-0.0266	(0.136)
head_age (ln years)	0.0249	(0.161)	-0.230	(0.154)
school_head1 (=1)	0.000556	(0.0996)	-0.0484	(0.0931)
school_head2 (=1)	0.296*	(0.129)	0.107	(0.130)
school_head3 (=1)	0.367	(0.188)	0.177	(0.187)
head_tongue (=1)	0.113	(0.0790)	0.350***	(0.101)
head_migr(=1)	-0.0341	(0.121)	0.0634	(0.110)
plot_oparea (ln hectares)	-0.426***	(0.0265)	-0.417***	(0.0268)

head_credit (=1)	0.595***	(0.128)	0.453***	(0.116)
head_techassi (=1)	0.0686	(0.265)	-0.0776	(0.225)
exp_seed (ln nuevos soles)	0.0809***	(0.0184)	0.0404*	(0.189)
exp_fert(ln nuevos soles)	0.198***	(0.0206)	0.146***	(0.0204)
exp_insect (ln nuevos soles)	0.147***	(0.0254)	0.121***	(0.0232)
reg1 (northern coast)			0.606***	(0.170)
reg2 (southern and central coast)			0.532**	(0.198)
reg3(northern highlands)			-0.894***	(0.143)
reg4(central highlands)			-0.222*	(0.0992)
Constant	4.910***	(0.677)	6.371***	(0.666)
Observations	**4125**		**4125**	
Adj. R-sq.	**0.299**		**0.355**	

Notes: Standard errors in parentheses are clustered at household level.* p<0.05 indicates significance at the 5 % level, ** p<0.01 indicates significance at the 1 % level, *** p<0.001 indicates significance at the 10 % level.

The coefficient of the female dummy is negative but not statistically significant. A positive and statistically significant female dummy would indicate that female household heads are more productive than male heads. A negative and statistically significant female dummy would indicate that female household heads are less productive than male heads. Finding that the female dummy is not significant shows no evidence of difference in productivity between female and male heads. This result supports the phenomenon found in econometric evidence reported by different studies in Kenya, reviewed by Quisumbing (1995). It could, however, also be the case that the gender effect was taken up by some other variables, such as the regional dummies, since the t-test shown in Table 6 revealed a significant productivity difference for male and female household heads.

The introduction of regional dummies makes the male teenagers' variable statistically significant. The number of female adults in the household is negatively associated with the gross value of production per hectare, indicating that one more female over 19 years of age in the household leads to a decrease in productivity. The number of male teenagers in the household is positively associated with the dependent variable, indicating that one more male between 11 and 18 years old leads to increased productivity. However, there is no clear evidence for concluding that there is a male impact on productivity.

The explanatory variables such as the size of the operational area of the plot, head access to credit, expenses in seeds, fertilizers and insecticides are statistically significantly associated with the gross value of production per hectare, as was found in Section 5.2.1. All of these variables have the same sign and slightly similar coefficients. Access to credit is shown with a considerably positive and stronger effect on productivity. These results confirm the finding that there is a significant effect of the inputs on productivity, rather than gender effects.

The introduction of the regional dummies makes the number of male teenagers in the households statistically significant and the influence of the secondary school insignificant. The coastal regions are also statistically significant to explain productivity only for male heads. The negative signs in the coefficient of the coastal regions imply that a plot located in highlands is a fact to have significantly negative effects on productivity. Note that the negative effect is even higher in *reg3;* i.e. the northern highlands. The *reg2* variable (i.e., the southern and central coast) is positive and significant on productivity, indicating that the plots located in this region are more productive. These results may be of no surprise if we examine the differences between the highlands and coast once again. The coastal region may have technological advantages over the poor highlands which may explain these results. To speak Spanish as mother language leads to increase in productivity by introducing the regional variations. This is consistent with the analysis conducted in section 5.2.1.

Additionally, two regressions including interactions between the female head dummy and the gender composition variables were performed. I excluded the interaction term constructed by multiplying the female head and the natural logarithm of female adults since their correlation was high (0.63). Only the variable of female children was significant and highly positively associated with a coefficient of 67.9 % and the p-value equals 0.045 while controlling for regional differences. Overall, no evidence for a significant impact of gender household composition was found, which is why results are not listed here.

To sum up, table 10 shows that household gender composition has a rather insignificant effect on productivity. Only the variable for male teenagers appeared to be positively significant on a 10 % level, but only after introducing the regional dummies. This may indicate that males are more concerned to inherit fertile land to their male heirs, as was discussed in the beginning of this section and in Chapter 2. Furthermore, it was found that being a female household head has a negative influence on productivity, though this effect appears to be insignificant. Reasons for this could be that either the effect was taken up by other variables, or that there is simply no difference of productivity between male and female household heads.

5.2.3 Exploring Omitted Variables Bias, Selection Sample Bias and Endogeneity of the Input Choice

My basic models are designed to include the variables commonly used in female and male agricultural productivity studies that are generated from the data collected in standard economic surveys, and to estimate the yield impact of inputs used by farmers such as land size, labor, fertilizer, as well as individual attributes such as gender and education. For the methods of estimation used above, it could be argued that the reported results reflect selection bias and there also is a risk that I have not controlled for all relevant variables, and that the results thus suffer from an omitted variable bias. For instance different studies have included variables not available in the data at hand such as irrigation, livestock, pest control (Peterman et al., 2010, Quisumbing, 1996). In this section, I am going to discuss the possibility of endogeneity bias as I consider this relevant for presenting my results.

Bias can result from unobservable data, such as unobserved household level factor, inputs or other plot characteristics. The first set of plots that were omitted as they did not have any kind of information about harvesting I assume they were not planted and were not surveyed for crop production, (they do not even present crop names) so that these plots may be headed by peasants that lived there and did activities other than agriculture. Taken this to be the case, this reduction of the sample should not affect my results.

The second set of plots that were omitted due to the impossibility of providing market values for their production, accounts for about one third of the total sample. I finally ended up using 4.126 plots. Looking at the characteristics of the deleted plots I found that 50.9 % of the plots cultivated a flower plant called Alfalfa, and 24.08 % a natural grass. Both Alfalfa and natural grass are important for livestock in Peru (MINAG, 2011). The rest of the deleted sample (25.02 %) was cultivated with 56 different crops, the most representative of which are fruits and corn. Within the total deleted subsample 82.98 % of the plots were located in the highlands, where the majority is in the southern highlands, and only 17.02 % are located in the coastal region where the majority is at the northern coast. Around 81.63 % of the total crop output belongs to plots that are headed by males, while 18.37 % are headed by females. By using t-test and chi2, I draw descriptive statistics for this subsample with the same variables used in Section 5.1 to test for differences in socioeconomic factors as well as for characteristics of the plots headed by males and females. The results follow the same pattern, with a slightly different size of coefficient as compare to the results in Section 5.1.

According to the characteristics described above, it seems that I could have removed data from plots belonging to households that might be very poor, the majority of which are headed by males. Although values of production in my dependent variable were omitted, it makes sense to argue regarding this data that removing these observations should not affect my results. This argument is also built on the fact that plots located in the highlands that are headed by males are not underrepresented relative to the females' population. Plots with these characteristics, in which harvested crops may be not part of the agroindustry, are headed by males in the majority of the full sample.

Endogeneity is related to the omitted variable bias. Omitted variable bias is the most common illustration of what economists refer to as endogeneity. Endogenous variables are variables that are determined within the model while exogenous variables are determined outside the model so that they serve as external shocks to the model. The other most important source of endogeneity is reverse causality, a term that refers to a situation in which some of the explanatory variables are affected by the dependent variable. The results shown in sections 5.2.1 and 5.2.2 may describe these phenomena. If we study the effects of access to credit by household heads on productivity but the access to credit depends on productivity, itself so that access to credit, is profitable only for the productive heads or only productive households can get access to credit the result is biased. The effects of inputs such as seeds, fertilizers and insecticides may suggest endogeneity, too. If only household heads with credit can afford these inputs and their use depends on productivity itself so that seeds, fertilizers and insecticides are profitable only for the productive heads, the result is biased.

The next step in the analysis (which is beyond the scope of this work) would be a methodological address. Different methods can be employed to control for these biases. According to Stock and Watson (2007), how best to minimize omitted variable bias depends on whether or not data is available for the potential omitted variable and whether the omitted variable is observed or not. When using panel data, instrumental variables regression and randomized controlled experiments are methods for omitted variable bias when the omitted variable is not observed. In this modest attempt to evaluate gender differences in agricultural productivity, I believe I probably do not have the data required to aim proper corrections but I have the insight that valid instruments could be a method at hand.

6 Conclusion

This study aimed at finding features that affect female household head agricultural productivity using cross-sectional data collected in Peru. The analysis reveals that the size of the operational area of the plot, access to credit, and expenses on fertilizers and insecticides have statistically significant effects on productivity for both female and male household heads. My findings show that none of the individual attributes have statistically significant effects on female household heads' productivity while education and mother tongue are individual attributes that have statistical significance on male household heads' productivity, specifically, postgraduate schooling and mastering the Spanish language. My data suggest that males get on average more schooling than women. There are not only more men to get schooling but also do they attend schools longer. This would also explain why the dummy variables for the coastal regions have a significant impact on productivity for males but not for females. In those regions you have agro industries, meaning that there is a better educational infrastructure, leading to higher average incomes of the households. The coastal regions have the smallest portions of female headed households. Thus, we can conclude that schooling, Spanish as a mother tongue and the coastal regional dummies do have significant effects on productivity for male but not for female headed households.

A second way of looking at how gender affects productivity was considered, next to the household head perspective. This household head composition analysis shows no evidence to conclude that the number of individuals, both male and female in the household, has a significant effect on plot productivity. Male teenagers appeared to be the number of individuals that positively affect plot productivity on 10 % significance level, but only after introducing the regional dummies. This may give the insight that males are more concerned to inherit fertile land to their male heirs, as was discussed in the beginning of this section and in Chapter 2. Furthermore, it was found that being a female household head has a negative influence on productivity, though this effect appears to be insignificant. Reasons for this could be that either the effect was taken up by other variables, or that there is simply no difference of productivity between male and female household heads, which is rather unlikely.

Finally, an additional discussion was conducted to address whether the fact that I removed certain observations affects my results. The general insight is that the sample was so large initially that, even after removal of some of its cases, it provided enough data for accurate analysis, and that there is thus no evidence for my results being affected by severe bias. Exploring methodological approaches to address potential bias in my work might still be worthwhile to consider for further analysis.

My results indicate there are no real effects of sex of the household head itself as well as no effects of sex of the household individuals on plot yield hectare. Furthermore, productivity differences are shown to be attributable to the several inputs male and female household heads use for their agricultural production. The inputs they use appear to be influenced by the different characteristics of the regions where the plots are located. Education and Spanish as one's mother tongue were shown to be of high importance for agriculture in the Peruvian context. This suggests Spanish language skills and education to be a policy priority for female household heads to increase female household heads' productivity in comparison to males', since the lack of these characteristics may describe a disadvantage of females to be more productive. Better education may help in various ways to improved productivity of female-headed plots. Most importantly does it enable women to earn an income from other income activities as well as to apply agricultural techniques more correctly leading to higher outputs, which in turn may enable females to invest more into fertilizers and insecticides. Also the access to loans is of high importance in this context and should be a policy priority. Women with access to loans may not be forced to take part in distress sales, leading to less and less cultivable land available to them, and thereby limiting their possibilities to catch up with males' productivity.

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