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Three Essays on Land Ownership, Gender, and Agricultural Productivity in The Case of Developing Countries

Krishna H. Koirala

Louisiana State University and Agricultural and Mechanical College

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THREE ESSAYS ON LAND OWNERSHIP, GENDER, AND AGRICULTURAL
PRODUCTIVITY IN THE CASE OF DEVELOPING COUNTRIES

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Agricultural Economics and Agribusiness

by

Krishna H. Koirala

M.S., University of Arkansas at Monticello, 2012

M.S., Louisiana State University, 2015

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This dissertation is dedicated to my parents, Late Mr. Kul Chandra Koirala and Mrs. Tara Devi Koirala.

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ABSTRACT

The first essay investigates the impact of land ownership on the productivity and technical efficiency of rice farmers in the Philippines. We use a 2007-2012 Loop Survey from the International Rice Research Institute (IRRI) and analyzed it by using a stochastic frontier function method. Results show that land ownership has a significant impact on technical efficiency. In particular, counter to the theory, the Comprehensive Agrarian Reform Policy (CARP) may have reduced the technical efficiency of leasehold farmers compared with owner operators. Additionally, results show that land area, fuel cost, fertilizer cost, irrigation cost, and labor cost are significant factors that affect rice production. We found a mean technical efficiency score of 0.79—still leaving room for improvement.

The second essay investigates the impact of gender on rice production using the average treatment effect and farm level data from the Philippines. Results indicate that female-headed farm households, despite having limited access to land, have a higher value of rice production than their male counterparts. However, there is no significant difference between net farm incomes earned by male- and female-headed farm households. Female-headed households have higher fixed costs, consequently earning less total household income. Findings from this study indicate that women are less efficient in farming, but are more likely to adopt improved seed varieties. In addition, female-headed farm households are better at controlling farming costs.

The third essay examine how gender affects technical efficiency using a case of maize production in Malawi. Maize is a staple food crop in sub-Saharan Africa. Using the third Integrated Household Survey data from Malawi and stochastic production frontier, we estimate maize productivity and technical efficiency in Malawi for male-headed and female-headed farm households, separately. Results show that, contrary to expectations, technical efficiency is 5% higher for female-headed farm households than for male-headed farm households.

CHAPTER 1: INTRODUCTION

Demand for agricultural products is expected to increase faster than their production in the developing countries. A high rate of population growth and income growth is a major factors for rapid increase in demand in such countries.¹ Rice, wheat, and maize are the three major food crops in the world, sharing 42% of all calories consumed by the entire human population. According to Childs (2014), global rice production for 2014/15 is projected to be about 475 million tons (milled basis), while global rice consumption in the same period is projected at a record level of about 483 million tons—leading to a deficit of about 8 million tons. Among these three major food crops, rice is the most important field crop. Rice farming is the single most important source of income and employment for the rural population in most developing countries (GRiSP, 2013). Rice is mainly cultivated in South Asia, including Philippines. African countries like Malawi and Senegal are also producers and consumers of rice.

The Philippines, a developing country, has a land area of 30 million hectares and only a third of it is devoted to agriculture. Coconut is the most widely planted crop followed by rice, corn, banana, pineapple, and others. Rice leads both in planted area and production and is a staple food for most Filipinos. Incidentally, the Philippines is the world's eighth-largest rice producer.² More than 70 percent of the population is dependent on agriculture. With an area of 4.2 million hectares of rice lands³, Philippines produce about 11 million metric tons (MT) of milled rice, sufficient for about 90% of its population.

¹ USDA, Economic Research Service; Developing countries dominate world demand for agricultural products. <http://www.ers.usda.gov/amber-waves/2013-august/developing-countries-dominate-world-demand-for-agricultural-products.aspx#.VGonIvmwJBYY>

² Philippines produced 18.44 million Metric Tons of rice in 2013, which was 2.5% higher than 2012. Source: <http://countrystat.bas.gov.ph/?cont=10&pageid=1&ma=A10PNVCP>

³ 3.01 million hectares are irrigated and 1.2 million hectares are non-irrigated land.

The Philippines, being the top rice importer country in the world, purchases 1 to 2 million metric tons (10% of total rice consumption) each year from Thailand and Vietnam (GRiSP, 2013). USDA/ERS (2014) reports that the Philippines 2015 import forecast would rise to about 2 million tons. Bordey (2010) stated that the Green Revolution's seed-fertilizer technology and access to irrigation facilities resulted in an increase in rice production by three fold from 1970 to 2008. According to Mariano et al., (2012), the establishment of two rice research and development institutions, namely the Philippine Rice Research Institute (PhilRice) and the International Rice Research Institute (IRRI), paved the way for the extensive development of modern rice technologies in the Philippines.⁴

Findings from previous research studies (GRiSP, 2013; Vargas, 2003) indicated that climate change, growing population, declining land area, high cost of inputs, poor drainage, inadequate irrigation, and improper land reform policies are the major constraints to rice production in the Philippines. Additionally, agricultural land area has been decreasing due to the conversion to the resettlement areas and industrialization (Reynaldo, 2000). Among several constraints to rice production, land reforms and underdeveloped land rental markets are the major constraints in the Philippines.⁵

Land reform in the Philippines was designed with the objective of redistribution and correction of inequalities in the distribution of land ownership. The Comprehensive Agrarian Reform Policy of 1988 (CARP⁶) was designed to restrict ownership ceilings to 7 hectares. The land reform policy prohibits the transfer of awarded land except by hereditary succession

⁴ International Rice Research Institute was established in 1960 while Philippine Rice Research Institute was established in November, 1985; both are working to make Philippines self-sufficient country in terms of rice.

⁵ Philippines have one of worse land tenure systems in the world. See more details Vargas (2003).

⁶ Under CARP, by end of 2012, 4.49 million hectares land are acquired and distributed, which is 84% of the 5.37 million hectares targeted for distribution. See more details Fabella (2014).

(Ballesteros and Cruz, 2006; Ballesteros and Bresciani, 2008; Vargas, 2003 Otsuka, 1991; Otsuka et al., 1992). Land reform policies are said to be successful in the land redistribution when small-scale farmers are able to engage in agriculture, compete in the market, and increase their capital. Land ownership and land titling would increase on-farm productivity and technical efficiency. Additionally, land reform activities provide land access to rural farm households. Land access to rural poor farmers for agriculture is essential for increasing food production thus enhancing food security and economic development of a country. Land ownership can increase investment in land and thus improve farmers' access to credit (Gerstter, 2011). There is lower productivity of reform land relative to owned land and rental land. Additionally, sales restrictions of modern reform land makes land sales prices lower compared to owned land (Deininger et al., 2008). Therefore, the first objective of this study is to analyze impact of the land ownership to the agricultural productivity and technical efficiency of rice farmers in Philippines.

Lack of land ownership and control of property is the single most important contributor to the gender gap in women's economic well-being, social status, and empowerment (Arun, 1999; FAO, 2011). Women face a surprisingly consistent gender gap in access to productive assets, inputs, and services. Findings from previous studies (Swaminathan et al., 2012; Arun, 1999; FAO, 2011) concluded that asset ownership⁷ by women has a positive impact on their status and bargaining power, and thereby enhances individual and household well-being. Additionally, land ownership can increase investment in land and enables female farmers to access credit markets. Finally, asset ownership may also reduce domestic violence for women and have positive effects on children's nutrition, education, and health.

⁷ Asset ownership is defined as land ownership and access to input resources.

Gender difference, socially adopted norms, is a crosscutting issue that attracts the attention of development professionals, policy-makers, and researchers. This is mainly due to the fact that involvement of women has become compulsory in any development intervention. In the developing countries where agriculture is the backbone of the economy, participation of women in the field is very high. Agriculture is the most important source of employment for women in these countries. Women are farmers, workers, and entrepreneurs. Therefore, agriculture and women have a dual relationship. Women are important to agriculture and agriculture is important to women (Doss, 2010).

A rapid rise in the number of rural families with women as head of household is mainly due to migration of male heads of households to urban centers and other countries; there are many other related events such as single parenting, widows, and divorces. In spite of increased numbers of women-headed households, women have unequal access to rural land and credit. Women are more likely to hold low-wage, part-time, and seasonal employment compared to men. They tend to be paid less even when their qualifications are equal to or higher than men's. Additionally, in the context of labor availability to farming, female-headed households face more labor constraints than male-headed households mainly due to fewer members and more dependents. With respect to educational attainment, FAO (2011) notes that in most developing countries gender differences in education are significant as female heads have less education than their male counterparts. Similarly, there exists a gender gap in the access to new technologies including machines and tools, improved plant varieties and animal breeds, fertilizers, pest control measures, and management techniques. Moreover, adoption of improved technologies is positively correlated with education.

In the Philippines, access to resources, both in society and in the family, has traditionally been skewed toward men. Land ownership is passed to sons through generations in each family. Credit markets may treat women and men differently in a discriminatory fashion for example, in Philippines, male entrepreneurs generally have better access to credit and lending from informal channels whereas micro-lending institutions give more preference to female entrepreneurs. However, no special credit program has been created by the government for women entrepreneurs. The issue of gender differentials in relation to farm productivity and technical efficiency has been of special interest from the standpoint of public policy in developing countries. Closing the gender gap is a top priority for agriculture, food security, and society. Gender difference in agricultural productivity is mostly explained by lower access to inputs. Gender gaps can be observed in the following areas: (1) access to land; (2) rural labor markets; (3) financial services; (4) social capital, and (5) technology. However, in developing countries, there have been number of land reform policies to reduce the gender gap in the context of access to land. Therefore, the objective of the second essay is to analyze the role of gender on net farm income, total farm output, farming efficiency, production costs, and total household income.

Finally, there is growing literature concerning gender based farm productivity and technical efficiency issues across Africa. Most of the previous research estimates of male-female agricultural productivity differences show that male and female farmers are equally efficient in controlling inputs levels and human capital (Peterman et al., 2001; Gilbert et al., 2002; Thapa, 2008; Horrell and Krishnan, 2007; Doss, 2010; FAO, 2011), while some studies have concluded that female-headed farm households are more technically efficient than male-headed farm households (Dadzie and Dasmani, 2010; Oladeebo and Fajuyigbe, 2007). Additionally, FAO (2011) estimated that female managed plots would increase their yields by 20-30 percent if they

had the same access to productive resources as men. On the other hand, some other studies concluded that male-headed farm households are more efficient than female-headed farm households (Udry, 1996; Quisumbing et al., 2001; Holden et al., 2001; Ogunniyi and Ajao, 2010).

The gender gap in agriculture is substantial and closing the gap is not an easy task. However, carefully designed policies, strategies, and projects can work within existing cultural norms through the public and private sectors. The dominance of female labor (ranges from 30-80 percent) and a substantial gender gap in agricultural productivity (ranges from 4 to 40 percent) are the prominent features of African agriculture (Palacios-Lopez and Lopex, 2014). Additionally, women have less authority for higher average return crop commodities. It is not surprising to see the presence of gender differences in the rural sector of Malawi. The prime motivation of this study is the disparity of women in agriculture and the significant gender gap in agricultural productivity in Malawi. Therefore, the objective of this third essay is to analyze gender differences on farm productivity and technical efficiency of rural Malawian households.

1.1. Objectives of the Study

The objectives of this study are to determine:

1. The impact of land ownership on productivity and efficiency of rice farmers of Philippines.
2. The role of gender on agricultural productivity in the Philippines: an average treatment effect model.
3. The farm productivity and technical efficiency of rural Malawian households: does gender make a difference?

CHAPTER 2: IMPACT OF LAND OWNERSHIP ON PRODUCTIVITY AND EFFICIENCY OF RICE FARMERS: THE CASE OF THE PHILIPPINES

2.1. Introduction

Agriculture is the main source of income in many developing countries and increased agricultural productivity has the potential to increase farming income and alleviate poverty in rural areas. Rice is the single most important agricultural crop in the Philippines, and is therefore a major source of income for millions of Filipino farmers (Bordey, 2010; Koide et al., 2013).⁸ Interestingly, rice production in the Philippines increased from 5.32 million metric tons in 1970 to 16.82 million metric tons in 2008. However, because of natural disasters (such as strong typhoons⁹), production declined to 15.77 million metric tons in 2010. In 2011, rice production in the Philippines showed a remarkable improvement and production rose to 16.68 million metric tons. This increase could be attributed to an increase in total area allocated to rice farming, which increased by 3.4% during 2011-2012. On the other hand, rice yield increased significantly from 3.71 metric tons per hectare in 2011 to 3.84 metric tons per hectare in 2012. This increase can be mainly attributed to improved seed-fertilizer technology and increased access to irrigation facilities.

The literature (Diagne et al., 2013; Rola, 1990; Timmer, 2012) points to several factors, such as the world food crisis in 2008, high prices of agricultural inputs, limitations on land ownership, and rising population, that set the Philippines back in its rice-self-sufficiency efforts—resulting in higher rice imports. The Philippines' high dependence on rice imports exposes the country to international market shocks and may have a serious risk for food security

⁸ The Filipino government still imports rice (about a million tons of rice per year). On average, 20% of the Filipino household's food expenditure is allocated to rice. Hence, a slight increase in the price of rice will greatly affect the standard of living for most Filipinos.

⁹ Philippines Rice Industry. <http://pinoyrkb.com/main/resources/facts-and-figures>.

(Dawe et al., 2006; Timmer, 2012). Self-sufficiency in rice is a primary goal of agricultural policy in the Philippines; achieving rice security is directly related to the nation's struggle in eliminating extreme hunger and poverty. The access of rural poor people to land for agriculture is essential for food security and economic development in the Philippines. Finally, the Philippine government in 2010 implemented a program to support rice self-sufficiency, which mandated a reduction in imports by 70% from 2.3 million tons in 2010 to 707 thousand tons in 2012.¹⁰

Agricultural farms in the Philippines are heterogeneous. On the one hand, you have small groups of farmers who operate large farms; on the other hand, many farmers operate small subsistence farms—a large majority of which are still practicing traditional agricultural systems. The land resource in the Philippines is the major limiting factor in rice production and the cause of increased imports. Recent data show that the Philippines harvested only 4.69 million hectares of rice in 2012 compared to major rice-producing countries in Asia. For example, during the same time period, India, China, Indonesia, and Thailand harvested 44, 29, 12, and 10 million hectares of rice, respectively. According to the International Rice Research Institute (IRRI, 2014), the main factors that make the Philippines a rice-importing country are (1) limited land area, (2) population growth, (3) diet, (4) weather, (5) old infrastructure, and (6) lack of land ownership.

Economic theory predicts that the lack of land ownership may restrict farmers' access to land and also access to credit that are required for improved land practices. Since the land is central to agricultural development, it has attracted the attention of both researchers and policymakers in the developing countries (Abdulai et al., 2011; Ballesteros and Bresciani, 2008;

¹⁰ IRRI. <http://irri.org/our-work/locations/philippines>.

Arun, 1999; Ding, 2013). Land income is the major contributor to farm income. The land rental market is an important institution in Filipino agriculture. The Filipino government has enacted several land reform policies to improve accessibility to land. The Philippine land reform law applies only to tenant areas growing rice and corn. The most recent policy, the Comprehensive Agrarian Reform Program (CARP), was enacted in 1988 (but is still not fully implemented¹¹), to redistribute agricultural land to landless farmers and tenants. These land reforms have stipulated that no more than 7 hectares of all cropland could be owned (Vargas, 2003). The CARP could have an adverse effect on the efficiency of the land rental market. It may constrain rental activity because of the possibility that leasing of lands awarded under the CARP could lead to rental disputes and/or the cancellation of awarded rights to land—perhaps resulting in higher land rental rates.¹²

With the self-sufficiency goal in mind, higher rental rates for land could result in a loss of rice productivity and technical efficiency. Therefore, the objective of the study is to assess the impact of land ownership on rice production and technical efficiency (TE) of rice producers in the Philippines. Specifically, using recent farm-level pooled data (2007-2012), we investigate whether land ownership has an impact on technical efficiency.

2.2. Land Ownership in the Philippines

The Philippines is an archipelago of about 7,100 islands off the coast of Southeast Asia. It covers an area of 300,000 square kilometers, of which 298,170 square kilometers are land. The geography of the Philippines has implications for land use and tenure relations. Land of the Philippines is categorized in two basic categories, namely Alienable and Disposable (A&D)

¹¹ Though the law was passed in 1988, the implementation of the law has been slow and has been extended until the end of 2014.

¹² Note that renting land is across farm sizes and forms, with share tenancy as the most common arrangement on farms (Ballesteros and Bresciani, 2008; Estudillo et al., 2000).

(14.2 million hectares) and protected areas (15.88 million hectares). The A&D type of land is mostly privately owned (65%) or state-owned but eligible for transfer to private hands.

According to Vargas (2003), the Philippines has one of the worst land tenure problems in the developing world. The size of landholdings is a major determinant of household income in an agrarian community such as the Philippines, where the people depend on farm production (Estudillo et al., 2000). In spite of having a lot of land in the Philippines, much of it is mountainous or made up of small islands, and those areas are unsuitable for rice production. Therefore, land area for growing rice is limited in the Philippines.

The first major land reform law (Presidential Decree, 1972) was passed in 1972—also known as Operation Land Transfer (OLT), which outlawed tenancy, in particular sharecropping. The OLT program, which transferred land to others, was applied in the case of excess land more than 7 hectares. Sharecropping was the preferred contract. Thus, the main objective of the land reform program was to convert a leasehold land (land shared by farmers with a landlord) situation to a share tenant (land leased with money for some years) situation. A Certificate of Land Transfer (CLT), a program that transferred land to eligible tenants, provided rights to purchase land by paying amortization fees. A CLT holder was required to pay amortization fees to the Land Bank within 15 years in the Philippines. In spite of having a retention limit, certain landlords register excess holdings in the names of sons, daughters, and close relatives (Otsuka, 1991; Otsuka et al., 1992).

Operation leasehold (LHO), a parallel program, absorbed tenants and landlords not covered by OLT. Since small landlords (7 hectares or less) were exempted from OLT, their tenants were not eligible to receive CLTs. Tenants were not evicted but were presumed to have shifted from share tenancy to a leasehold arrangement (under either an oral or written contract).

In 1986, Corazon Aquino's presidential campaign put forth a land reform first priority—"Land-to-the-Tiller"—slogan. The land reform commission was formed in July 1987, Aquino proclaimed the Comprehensive Agrarian Reform Program (CARP) and Congress passed the CARP in 1988. The major purpose of the land reform program was to transfer land to actual cultivators (Estudillo et al., 2000). The CARP was enacted to redistribute public and private agricultural lands to farmers and farmworkers who were landless. The CARP's vision was to have equitable land ownership. It prohibited any form of transfer of land for 10 years and mandated landlords to retain 7 hectares of land. Additionally, under the CARP, any form of transfer of land awarded under the CARP was prohibited; land exceeding 7 hectares were bought by the government and sold to landless farmers. Gordoncillo (2012) reported that the CARP was a major intervention to affect rural development in the Philippines. However, because of current problems with land titling and registration, the CARP has not been fully implemented.

Nonetheless, land reform activities can improve farming efficiency and productivity. Land reform activities provide access to land to those with high agricultural ability to farm but who own little or no land. Findings from previous studies (Ballesteros and Bresciani, 2008; Tenaw et al., 2009; Kyomugisha, 2008) conclude that small farms tend to be more productive than large farms from land reform activities. Tenaw et al. (2009) stated two reasons why there was a positive link between access to land and agricultural productivity. Land ownership eliminates the anxiety and uncertainty of expropriation, which encourages farmers to make long-term investment decisions on land and to adopt best cropping systems. Similarly, it makes it easy for farmers to use the land as collateral for credit. Therefore, access to land enables farmers to make a durable investment and helps to intensify production systems in inputs, thus boosting agricultural productivity. In another study, Kyomugisha (2008) stated that land tenure was an

important institutional factor that promotes investment in agricultural technology and enhances the productivity of the land. Today, land tenure systems in the Philippines can be classified into three categories: fully owned land, share tenant land, and leasehold land. Fully owned land refers to land operated with a title of ownership in the name of the holder and, consequently, the right to determine the nature and extent of the use of the land. Fully owned land is also land categorized under the CLT and OLT program. Share tenant land refers to rented lands wherein the rental arrangement is in the form of a share of the produce or harvest. Finally, leasehold land refers to land that is cultivated by a lessee, which belongs to or is legally possessed by another, the lessor. This category also includes land cultivated under borrow, pawned-in, mortgaged-in, and rented-in. The rental payment is in the form of a fixed amount of either money or produce, or both.

2.3. Literature Review

Several studies have investigated rice productivity and technical inefficiency of rice production in developing countries (e.g., see Dawson and Lingard, 1989; Battese and Coelli, 1992; Tiongco and Dawe, 2002; Abedullah and Mushtaq, 2007; Rahman and Rahman, 2009; Manjunatha et al., 2013). The frontier production function, developed by Farrell (1957), has been used to measure technical efficiency of farms. For example, in the early 1990s, Battese and Coelli (1992), using panel data of 1975-1985 with time-varying firm effects, studied the production function of paddy farmers in India, and found that the share of irrigated land, farm area, and labor costs had a positively significant effect on rice production. Similarly, Abedullah and Mushtaq (2007) investigated production function and technical efficiency of rice producers in Pakistan using a stochastic production frontier and cross-sectional data. Their findings indicated that planted area, irrigation hours, and labor hours were positive and significant, while

plowing hours and amount of fertilizer were negatively significant factors affecting rice production. Additionally, they found that age of the farmer and farm size had a significantly positive effect on technical inefficiency, whereas education and farm mechanization (owning a tractor) played a significant role in improving farmers' technical efficiency.

In a recent study, Diagne et al. (2013) investigated rice productivity in the Senegal River Valley using panel data from 2002-2006 and a fixed effects simplified translog production function. They found that land, seed, fertilizer, and services had a significantly positive effect on rice production, while labor costs had a negative effect on rice production. They also obtained technical efficiency scores ranging between 55% and 60%. Further, the authors found that fertilizer, herbicides, bird-chasing efforts, date of sowing, and the use of post-harvest technologies such as a thresher-cleaner significantly improved the technical efficiency of rice producers. Khai and Yabe (2011) investigated the technical efficiency of rice producers in Vietnam using a household living standard survey, 2005-2006, and Cobb-Douglas production function. The authors found that irrigation, education, and labor force had a positively significant effect on technical efficiency—with 82% technical efficiency.

Using a stochastic frontier model and using data from a Loop Survey, but different years (1970, 1974, 1979, and 1982), Dawson and Lingard (1989) studied farming efficiency in the Philippines. Note that initially the Loop Survey was conducted every four years. The authors estimated four, for each year, different production functions. They concluded that technical inefficiency is a major reason for deviation from the frontier production function. They calculated technical efficiencies for each farm in each year and found the highest technical efficiency score (70%) in 1982. Tiongco and Dawe (2002) studied long-term rice productivity in the Philippines. They found that long-term productivity was stagnant in important rice-growing

areas of the Philippines. The authors concluded that emphasis should be given to crop genetic yield potential to improve productivity and alleviate poverty in farming households.¹³

Using Malmquist productivity indices from 1971 to 1990, Umetsu et al. (2003) investigated regional differences in total factor productivity, efficiency, and technological change in the Philippine rice sector. They found that cyclical productivity growth was negative during the early 1970s, positive in the late to early 1980s, and negative in the late 1980s, whereas some regions, such as Central Luzon, Western Visayas, and Southern and Northern Mindanao, had higher rates of technological change. They argue that positive growth is mainly due to the introduction of new rice varieties, while negative growth can be attributed to the intensification of rice production in lowland farming systems. Using pooled Loop Survey data from 1990 to 1997,¹⁴ Villano and Fleming (2004) investigated technical efficiency and production risk in rice farming in the Philippines. The authors chose rice producers in the rainfed lowland environment and found a 79% average technical efficiency score during this time period (1990-1997). The authors found that age of the operator, ratio of adults in the farm household, and off-farm income had a statistically significant and negative effect, while education had a positive effect on technical efficiency of rice farmers in the rainfed lowland environment.

In the early part of the 21st century, Yao and Shively (2007) studied technical change and productive efficiency on irrigated rice farms of the Philippines using panel data, a Loop Survey, from 1995 to 2002. They concluded that development in irrigation facilities led to a positive gain in technical efficiency. However, the level of technical efficiency decreased because of both distance to the irrigation canals and problems related to siltation of irrigation canals. Mariano et

¹³ Recall that the use of high-yielding varieties during the late 1960s increased rice production from 3.9 million metric tons in 1961 to 9.6 million metric tons in 1990 (IRRI, 2014).

¹⁴ Pooling data during these years led to a dataset of 500 rice producers in the rainfed lowland environment.

al. (2011) studied the technical efficiency of rice farms in different agro-climatic zones¹⁵ and pooled farm-level data (1996/97, 2001/2002, and 2006/2007 crop years) from the Philippines. The dataset used in this study was from the Rice-Based Farm Household Survey (RBFHS) conducted by the Philippine Rice Research Institute. Using a stochastic metafrontier production function, the authors found that farm size, amount of seeds, fertilizer, pesticides, labor cost, irrigation access, and machine cost increased rice productivity. On the other hand, age and education of the farm operator and non-rice income negatively affected technical efficiency, while experience and training, and land and machine ownership, had a significantly positive effect on the technical efficiency of rice producers in all four climatic zones.

As reported above, rice production has been the focus of attention for a number of studies in the developing countries—especially in South Asia. In the Philippines, several studies have analyzed the factors that affect rice production and the technical efficiency of rice producers. However, a potential drawback of these studies is the lack of focus on land ownership. Specifically, none of the previous studies have analyzed the impact of land ownership on the technical efficiency of rice producers. Recall that, since the implementation of the CARP (1988), though it has yet to be fully implemented, land ownership is an issue that is discussed not only by policymakers but also by farmers and peasants who have a significant stake in land policy reforms. As mentioned above, land reform and land rental markets are important in the Philippines. This study focuses on the impact of land ownership on the technical efficiency of rice farmers in Central Luzon, also known as the “rice bowl” of the Philippines. We use the most recent pooled farm-level data (2007-2012), collected by the International Rice Research Institute.

¹⁵ The authors use four climatic zones—these vary in intensity of sunlight, temperature, and rainfall—in this study (see Mariano et al., 2011 for details).

This time period coincides with the final phase of CARP implementation.¹⁶ Finally, we use both a half-normal and exponential distribution model to investigate which model explains the data better.

2.4. Data

This study uses pooled farm-level data from the Central Luzon Loop Survey conducted by the Social Sciences Division of IRRI. Central Luzon is a major rice-producing area of the Philippines, also known as the “rice bowl of the Philippines” (Koide et al., 2013). This survey contains detailed information on rice yields, input cost, labor use, land tenure systems, farm mechanization, culture, and labor practices that is related to rice production. The Loop Survey began in 1966 and is conducted about once every four years. The main objective of the Loop Survey is to monitor the changes in rice farming in the Philippines. The Loop Survey collects data from two domains of rice farming households. One domain is along a loop of the main highway north of Metro Manila through the provinces of Central Luzon, namely, *Bulacan*, *Nueva Ecija*, *Pampanga*, *Tarlac*, *Pangasinan*, and *La Union*. The other domain is along a loop through the towns of Laguna. Most parts of these regions are heavily irrigated. In both domains, double cropping is normal and the production systems in these two areas are similar. Rice is established by transplanting and pesticide application has been lower since the mid-1980s.

Table 1 presents descriptive statistics of inputs and farm-specific variables to estimate a stochastic frontier production model using half-normal and exponential methods. There are 324 total number of households for pooled data. Each year on an average number of households ranges from 75-84. The average Filipino rice farmers in the sample operated, on average, 1.24 hectares, ranging from 0.1 to 4.8 hectares, suggesting a significant variability in farm size. The

¹⁶ The author(s) realize that, though the intention of the original bill was to fully implement the CARP by 2013, it was extended to 2014.

total value of farming retained by farmers after harvest was PHP 80,828 (per year). With the expectation of higher returns from rice farming, Filipino farmers spend a significant amount of money on fertilizer, PHP 11,077 (per year). Farm-specific variables included in our model are planting season, sex and age of the farm operator and educational attainment of the operator and spouse, and household size. The average age of the operator was about 59 years, higher than that of spouses (55 years). The average educational attainment of the operator was higher than that of females. Finally, average household size was about 5 members.

Table 1. Summary statistics of the variables

Variable	Description	Mean	St. Dev	Min.	Max.
Land	Land in hectares	1.241	0.737	0.1	4.8
Output value	Output of rice production*	80827.94	64272.45	5400	537600
Seed	Total seed cost*	3440.78	2967.26	0	18000
Fuel	Total fuel cost*	2248.08	3607.58	0	26840
Fertilizer	Total fertilizer cost*	11076.88	7815.14	0	45800
Labor cost	Total labor cost*	21660.05	18798.69	1532.4	160790.6
Capital	Land rental value*	3701.21	6587.60	0	44800
Irrigation	Total irrigation costs	902.99	1499.804	0	10000
Male age	Male age in years	58.59	12.71	24	91
Male edu	Male education in years	8.57	3.263	0	15
Female age	Age of female household in years	54.64	12.18	21	87
Female edu	Female education in years	7.96	3.28	0	14
H_size	Household size	5.34	2.22	2	13

Note: * unit of cost is pesos (1 PHP=US\$0.023)

Finally, the Loop Survey collects information on land tenure status. Using that information, we categorized tenure into three categories: leaseholders, owner operators, and share tenants. The leasehold tenure system includes land under a borrower, rented land, and land purchased under some collateral bonds, while land under an overseer is categorized under the

share tenant tenure system. In our data, 47% of the rice farmers were owner operators, 33% were leasehold farmers, and the remaining 11% were classified as share tenants. Data show that, during 2007-2012, in the Loop Survey region, the share of leasehold and share tenant farmers is increasing, while at the same time the share of owner operators is decreasing. For example, owner operators were 52%, 50%, 51%, and 46% in 2007, 2008, 2011, and 2012, respectively. Likewise, leasehold operators were 30%, 31%, 27%, and 30% in 2007, 2008, 2011, and 2012, respectively. The data reveal a steady rise in the share tenant farmer category—18%, 19%, 22%, and 24% in 2007, 2008, 2011, and 2012, respectively. Perhaps this trend can be attributed to the CARP and other land reform programs in the Philippines.¹⁷ It is evident that the land policy reforms have had a small and perhaps insignificant impact on decreasing the number of share tenants.

2.5. Econometric Model

Technical efficiency is an important topic studied in agricultural production because of policy decisions and firms' ability to use input mixes in the most efficient manner to produce maximum output. Two approaches have been proposed to determine the technical efficiency of a firm: parametric and non-parametric. The parametric approach assumes the production functional form a priori estimation of the data. However, the non-parametric approach uses the data to determine the functional form. The major limitation of the non-parametric approach is that it assumes no sampling error and attributes all derivation from the production frontier to inefficiency (Diagne et al., 2013). In this study, we use the parametric approach to estimate technical inefficiency.

¹⁷ Recall that the CARP and other land reforms in the Philippines have stipulated that no more than 7 hectares of all cropland could be owned.

2.5.1. Stochastic Production Frontier (SPF) Models

The stochastic frontier model is used in studies of production, cost, revenue, profit, and other models of goal attainment. The stochastic production function is a parametric analysis that has been commonly used to estimate technical inefficiency. The stochastic production frontier shows the most efficient use of inputs to produce the maximum output. The stochastic frontier regression model is a linear regression model having non-normal asymmetric disturbance. It was originally developed by Aigner et al. (1997) and Meesuen and van den Broeck (1997). It has the general form:

$$Y_{it} = f(X_{it}, \beta) \exp(\varepsilon_{it}) \quad (1)$$

$$Y_{it} = f(X_{it}; \beta) + V_{it} - U_{it} \quad (2)$$

where Y_{it} is the output of farm i ($i = 1, 2, \dots, N$) in t ($t = 1, 2, \dots, T$) year; X_{it} is the vector of inputs; β is the vector of parameters to be estimated; and ε_{it} is the error term, which is composed of two independent elements, V_{it} and U_{it} , such that $\varepsilon_{it} \equiv V_{it} - U_{it}$. Here, V_{it} is assumed to be symmetric identically and independently distributed errors that represent random variation in output due to factors outside the control of farmers. It is assumed to be normally distributed with mean zero and variance σ_v^2 . It is also called pure random error, which is linked to productivity. U_{it} express non-negative random variables that represent the stochastic shortfall of outputs from the most efficient production. It is also called one-sided error and is linked to efficiency.

A random variable U_{it} is of particular interest because it measures the percentage by which a particular observation fails to achieve the frontier, ideal production rate (Greene, 2003). The firm-specific technical efficiency parameter, U_{it} , takes the value of zero for a technically efficient firm and one for a technically inefficient firm (Kalirajan and Shand, 1989). There are four distributional frameworks for the inefficiency component: normal-half-

normal($u \sim N[0, \sigma_u^2]$), normal-exponential ($u \sim \text{exponential}$ with parameter θ), truncated normal, and normal-gamma ($u \sim \text{gamma}$ with parameters θ and P). We use the half-normal and exponential model in this study to compare which model performs better in explaining the data. In the exponential method, u_i are independently exponentially distributed with variance σ_u^2 . In the half-normal, u_i are independently half-normally $N^+(\mu, \sigma_u^2)$ distributed. A frontier command maximizes the log-likelihood function of a stochastic frontier model by using the Newton-Raphson method, and the estimated variance-covariance matrix is calculated as the inverse of the negative Hessian matrix (Belotti et al., 2012).

2.5.2. One-step SPF

Basically, the two-stage estimation approach is used in the estimation of the stochastic production frontier. Specifically, the first stage involves the specification and estimation of a stochastic frontier and prediction of the technical efficiency scores. The second stage estimates the impact of the explanatory factors on the technical efficiency scores obtained in the first stage. Some previous studies such as Wang and Schmidt (2002), Kumbhakar (1993), Kumbhakar et al. (1991), Huang and Liu (1994), Reifcheneider and Stevenson (1991), and Battese and Coelli (1995) stated that the two-stage estimation method is inconsistent and noted that one should use a single equation model. The second stage contradicts the assumption of independently, identically, and normally distributed (i.i.d.) inefficiency effects in the stochastic frontier function (Battese and Coelli, 1995). Wang and Schmidt (2002) stated that the first step of the two-step procedure is biased if x and z are correlated. Further, the first-step regression that ignores z suffers from omitted variable problems. Additionally, second-step regression (the effect of z on inefficiency) is likely to be biased downward, which is true regardless of whether x and z are correlated. The estimate of β will be biased by the omission of z if z affects y and if z and x are

correlated. The direction of the bias depends on the direction of the effect of z on u and the sign between them. In this study, all the parameters of the stochastic frontier function as well as those of the inefficiency function were estimated together with a single maximum likelihood estimation (MLE) procedure.

We can extend equation (2) by introducing heterogeneity in the one-sided inefficiency (u) as:

$$\begin{aligned} y &= f(x; \beta) + v - u \\ y &= f(x; \beta) + v - u(z, \delta') , \quad u(z, \delta') \geq 0, \\ \sigma_u^2 &= \exp(\delta' z) \end{aligned} \quad (3)$$

where σ_u^2 is the variance in the inefficiency term. This variation is modeled as a function of variation in z variables. Here, z variables include land tenure, socioeconomic, and demographic variables. Variance in equation (3) is known as variance in inefficiency. In the above equation, v is independent of x , z , and u . The technical inefficiency effect U_{it} in equation (2) could be specified in equation (4):

$$U_{it} = z_{it}\partial + W_{it} \quad (4)$$

where W_{it} is a random variable and defined by truncation of normal distribution with zero mean and variance σ^2 . The technical efficiency score of farms is estimated by the following equation:

$$TE_i = \exp(-\hat{u}_i) \quad (5)$$

$$0 < TE_i < 1 \quad (6)$$

Here, TE_i is greater than zero and less than one.

2.5.3. Functional Forms and Variables

The stochastic frontier production function estimated in our study is defined as:

$$\ln Y_{it} = \alpha_0 + \sum_k \beta_k \ln X_{kit} + v_{it} - u_i \quad (7)$$

$$\ln Y_{it} = \alpha_0 + \sum_k \beta_k \ln X_{kit} + v_{it} - u_i(z_{it}, \delta')$$

where the subscripts i , t , and k represent, respectively, farm, year, and inputs. The dependent variable, $\ln Y_{it}$, is the log-transformed value of rice production (in pesos). Here, α_0 and β_k are parameters to be estimated. The independent variable, $\ln X_{kit}$, is the log-transformed factors of production (cost of fertilizer, seed, fuel, and labor, and farm size); v_{it} represents random statistical noise; and $u_i \geq 0$ represents technical efficiency. Here, z_{it} includes the land tenure dummy variables (owner operator, leasehold operator, and share tenant) and age and education of the male and female members of the household—the farmer and spouse.

2.6. Results and Discussion

We applied a one-stage stochastic production frontier function as discussed by Wang and Schmidt (2002). A Cobb-Douglas production function was estimated using half-normal and exponential stochastic production methods. Parameter estimates of both models are presented in Table 2. The estimated signs of the parameters are as expected. When comparing between the half-normal and exponential model using a likelihood ratio test, we fail to reject the null hypothesis (i.e., the half-normal model is the more suitable model).

Consistent with theory, Table 2 indicates that an increase in the quantity of input increases the quantity of output produced (rice). We found that land area, fuel cost, fertilizer cost, labor cost, capital, and irrigation cost are significant and have positive and significant effect on the value of rice. Since all input variables and dependent variables (value of rice output) are log-transformed, the coefficient represents elasticity. The coefficient of farm size (land area) is significant and positive at the 5% level of significance. The result implies that a 1% increase in land size increases the value of rice output by about 0.40% in both models. Another significant variable is fuel cost. It is significant at the 10% level of significance. Though the coefficient of

fuel cost is very low, it indicates that a 1% increase in fuel cost increases the value of rice output by 0.004%.

Table 2. Estimation of rice production and technical efficiency in the Philippines

Variable	Half-normal	Exponential
Land area	0.41**(6.71)	0.40**(6.55)
Seed cost	0.003(0.51)	0.003(0.52)
Fuel cost	0.004*(1.87)	0.004*(1.82)
Fertilizer cost	0.029**(3.69)	0.029**(3.79)
Labor cost	0.518**(11.55)	0.519**(11.48)
Capital	0.004*(1.93)	0.004*(1.93)
Irrigation cost	0.004*(1.79)	0.004*(1.74)
Constant	5.940**(13.33)	5.857**(13.16)
$\text{Ln}\sigma_v^2$	0.007(0.34)	-2.53**(-13.83)
<i>Inefficiency components</i>		
Male age	0.007(0.34)	0.01(0.35)
Male education	-0.015(-0.27)	-0.024(-0.28)
Female age	0.005(0.22)	0.007(0.23)
Female education	0.123*(1.68)	0.236*(1.72)
Leasehold ownership	1.002**(2.04)	1.378**(2.12)
Share tenant ownership	0.804(0.98)	1.153(1.08)
Constant	-4.244**(-3.15)	-6.213**(-3.60)
Log pseudolikelihood	-94.56	-94.24
Wald test	1541.72(0.0000)	1531.77(0.0000)

Notes: * and ** indicate significance at the 10 and 5 percent level of significance, respectively. Parentheses have *t*-statistics.

Likewise, fertilizer is another important variable that can affect rice production. We found that fertilizer (both organic and inorganic) cost is significant at the 10% level of significance. The findings indicate that a 1% increase in fertilizer cost increases the value of rice output by 0.03%, a much higher effect than that of fuel cost. Similarly, the coefficient of labor

cost has a positive and significant impact on output, indicating that a 1% increase in the cost of labor increases the value of rice output by 0.52% in both the half-normal and exponential model. In this analysis, labor cost does not include unpaid labor such as family labor. Similarly, capital (the cost of renting land) is positive and significant at the 10% level of significance, indicating that a 1% increase in the rental cost of land increases the value of rice output by 0.004%, about the same effect as fuel cost. The result shows that the cost of irrigation has a positive and statistically significant effect on the value of rice production.

We turn our attention to the bottom part of Table 2, which provides the estimates for the factors that affect technical inefficiency. In particular, we are interested in the impact of land ownership on technical inefficiency (or efficiency, with opposite signs). The results show that, compared with that of owner operators, the coefficient on leasehold operators is positive and statistically significant at the 5% level of significance, implying that being a leaseholder operator (called leaseholders) increases technical inefficiency by 1% compared with owner operators. This finding may provide some insight into the counterproductive land reform policies that have been established in the Philippines over the past decades. Recall that, under the CARP, landowners can legally own only 7 hectares of land and the rest of the land is redistributed to landless farmers, tenants, and leaseholders. In most cases under such reforms, ownership was converted from share tenancy to fixed-rent leaseholds, and this yielded technical inefficiency in rice production—presumably because of the agency problem.¹⁸ Another possible explanation is that farmers who lease land (leaseholders) for farming are less likely to invest in land improvement activities, resulting in lower output (Abdulai et al., 2011). Additionally, for rice production, especially with new hybrid rice varieties, investment in land and input improvement

¹⁸ Eswaran and Kotwal (1985) point out that, compared with share tenancy, fixed-rent leasehold would provide no incentive for landowners to provide managerial skills.

is highly needed in order to ensure higher yields. Finally, because of the lack of security and absence of sufficient incentives for returns on investment, farms operated by leaseholders may not perform efficiently (Otsuka and Hayami, 1988).

Another source of technical inefficiency is the spouse's education. The coefficient on female educational attainment is positive and statistically significant at the 10% level of significance. A plausible explanation is that farm operators are usually males and make day-to-day farming decisions while spouses tend to work off-farm for additional income. Additionally, supervision intensity decreases with off-farm wages—off-farm wages increase the opportunity cost of females' time. The findings here are consistent with the results obtained by Villano and Fleming (2004), who found that off-farm income had a negative effect on the technical efficiency of rice farmers in the rainfed lowland environment. Finally, based on the estimated production function, we calculated the technical efficiency score of rice farmers in the Philippines. The technical efficiency (TE) of a given firm is a ratio of its mean production to the corresponding mean production if the firm used inputs most efficiently. This can be calculated by subtracting: $TE = 1 - T$ (technical inefficiency). Table 3 shows the summary statistics for technical efficiency. We found a mean technical efficiency score of about 0.80 with standard deviation of 0.09. The TE score for rice farmers in the sample ranged from 0.39 to 0.94 across all farms. The mean TE score for our sample was 0.79 (79%), indicating that rice farmers in the Philippines can increase rice production by 21% with existing technologies. Our findings are consistent with the results obtained by Villano and Fleming (2004)—79% TE in Central Luzon, Philippines (for 1990-1997). Our findings are comparable with the results obtained by Khai and Yabe (2011), who found a TE score of 82% among Vietnamese rice producers. However, it should be noted that Khai and Yabe (2011) used cross-sectional data.

Table 3. Summary of technical efficiency

Summary statistics	Technical efficiency
Mean	0.79
Standard deviation	0.09
Min.	0.39
Max.	0.93

Table 4. Distribution of the TE of Filipino rice farmers

Range of TE	Frequency	% of farms in TE interval
0.30<TE<=0.40	1	0.31
0.40<TE<=0.50	3	0.92
0.50<TE<=0.60	14	4.29
0.60<TE<=0.70	20	6.13
0.70<TE<=0.80	82	25.15
0.80<TE<=0.90	191	58.59
0.90<TE<=1.00	15	4.60
Total	326	100.00
Technical efficiency		0.79 (0.09) ¹

Note: ¹ standard deviations for technical efficiency in parentheses

Table 4 shows the distribution of technical efficiency of rice farmers in the Philippines. A higher percentage of farmers (59%), which is 191 farmers out of 326 total farmers, have a TE score in the range of 80-90%. The table shows that approximately 88% of the rice farmers (in the sample) achieved technical efficiency of 70% or higher.

2.7. Summary and Conclusions

Agriculture is the main source of income in developing countries and increased agricultural productivity has the potential to alleviate farmers' poverty. Improvement in agricultural productivity is a topic of high importance in these countries. Agricultural farms in

developing countries are heterogeneous: although some farms are commercialized, many still practice traditional agricultural systems. Fifty years after the Green Revolution, the Philippines continues to struggle to produce sufficient rice to feed its population. Food security is a major problem in the Philippines and it is largely affected by farmers' production decisions, inappropriate land reform programs, and technical inefficiency of rice production. High production costs, low government support, and a significant decrease in farm productivity are some of the constraints that have led to a crisis in Philippine agriculture.

Additionally, the Filipino government has enacted several land reform policies to redistribute agricultural land to landless farmers and tenants. The CARP could have an adverse effect on the efficiency of the land rental market. It may constrain rental activity because of the possibility that leasing of lands awarded under the CARP could lead to rental disputes and/or cancellation of awarded rights to land—perhaps resulting in higher land rental rates. This study attempted to estimate the rice production function using pooled farm-level (2007-2012) longitudinal data from the Philippines. Particular attention was given to the role of land ownership in technical inefficiency.

The findings here suggest that land reforms in the Philippines may have been counterproductive. Our results indicate that leaseholder operator farms are likely to have lower technical efficiency. Our analysis shows that the TE level of Filipino rice production is about 79%—still leaving room for improvement under current production methods and technology. An interesting finding here is that the technical efficiency scores have remained the same over the 2007-2012 time period, compared with 1990-1997. Rice production is affected by farm size, fuel, fertilizer, labor, and irrigation channels. Technical inefficiency scores tend to increase with the spouse's education.

2.8. References

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CHAPTER 3: THE ROLE OF GENDER IN AGRICULTURAL PRODUCTIVITY: THE CASE OF THE PHILIPPINES

3.1. Introduction

Agriculture is a significant part of the national economy in many Asian countries.¹⁹ For example, agriculture plays a significant role in the Philippine economy, in which nearly 20 percent of the gross domestic product (GDP) comprises agriculture and agriculture-related enterprises. Additionally, nearly half of the labor force is employed in the agricultural sector; two-thirds of the population depends on agriculture for its livelihood. Approximately half of all rural women are classified as economically active; women play important roles in the production of cash and subsistence crops, and in small livestock rearing. Interestingly, Quisumbing et al. (2014) note that women comprise about 43% of the agricultural labor force in developing countries, ranging from 20% in Latin America to 50% in sub-Saharan Africa and East Asia. In agriculture, the largest number of women workers are involved in the production of rice, coconut, and banana crops. In addition, women have a principal role in agribusiness, food processing, marketing, consumer-related activity, and value-added food processing (Lu, 2010).

In most developing countries, women's actual contribution to food production and the rural economy remains undervalued, because of which women have less access to productive resources or assets. For example, Quisumbing et al. (2014) noted that agriculture is underperforming because half of its farmers—women—do not have equal access to resources and opportunities. The authors noted that an empowered woman who can make decisions about planting materials and inputs is more productive in agriculture. Swaminathan et al. (2012)

¹⁹ Nearly 50 percent of the economically active women in Asia are in agriculture and they contribute 65 percent of household food production in Asia.

identified inter- and intra-household differences as key drivers of the dynamics affecting the resource status of most female-headed farm households.²⁰

In the international arena, female-headed farm households are commonly regarded as the “poorest of the poor” throughout the world mainly because of their low income (Chant, 1997). Pandey et al. (2010) studied the role of gender in rice farming in the Philippines and found that gender roles and gender relations within households are strongly influenced by social, cultural, and economic circumstances, family structure, and the degree of labor participation in the marketplace. They found that 32% of the agricultural labor force in the Philippines was female and there was a high incidence of migration of women from rural to urban areas and overseas. The International Rice Research Institute (IRRI) acknowledges the role of women in the global rice sector as both paid and unpaid family labor. Women contribute at least half of the total labor inputs in rice production in Asia and sub-Saharan Africa.²¹ Some 39-49% of the farming households in the Philippines hire women workers in both planting and harvesting activities in rice fields. Women’s participation is also significant in planting and/or transplanting, manual weeding, care of crops, and harvesting in the rice sector. Male workers are generally engaged in land preparation, seedbed preparation, leveling, and care of irrigation canals.

Finally, rural women are mostly responsible for meeting the capital needs of the farm and thus are most likely to engage in off-farm activities to help augment their household income. Generally, the female labor force participation rate is 50 percent in the Philippines whereas the male participation rate is 80 percent. An Asian Development Bank (ADB) project in the Philippines helps to increase women’s influence in the farm decision-making process.²²

²⁰ Female-headed farm—female principal operator, the individual, responsible for day-to-day management of the farm.

²¹ IRRI: <http://irri.org/our-impact/engagine-women>.

²² ADB: www.adb.org/sites/default/files/adb-annual-report-2013.pdf.

Recently, female-headed farm households have been increasing in the Philippines not only as a result of widowhood but also of social changes such as the migration of males, awareness of gender equity in society, and the rise in female labor force participation rates (Miralao, 1992).

A few studies discussed the role of gender using average treatment effect (Zanutto, 2006; Holland, 1986). For example, Zanutto (2006) studied the effect of gender on salary from information technology using the average treatment effect method. We may not consider the effect of gender on outcomes to be a treatment effect in the causal sense because we cannot manipulate gender. The main motivation of the use of gender in this study is to make descriptive comparisons of the outcomes of similar female-headed farm households and male-headed farm households. The role of gender in agriculture gained considerable attention among policymakers, donors, and researchers in 2012. Consequently, policymakers need more knowledge and stronger empirical evidence on the role of gender in agriculture and agricultural productivity in particular. Gender equality can also lead to productivity gains, women's increased control of household resources can improve outcomes for the next generation, and empowering women as economic, social, and political actors can result in more representative decision making. Therefore, the objective of this study is to assess the impact of gender in rice farming in the Philippines. Specifically, we investigate how gender affects net farm income, total farm output, farming efficiency, production costs, and total household income.

3.2. Literature Review

3.2.1. Gender Status in the Philippines

In the developing countries, including the Philippines, gender gaps remain substantial in terms of economic opportunities, decision making, and access to resources (Illo, 2010).

According to the Global Gender Gap (GGG) Index, introduced by the World Economic Forum

(2013),²³ the Philippines ranks fifth (GGG Index=0.78) in the world, suggesting a smaller gender gap between men and women. On the other hand, looking at educational attainment in the Philippines (GGG Index=1.00), the country ranked first among 136 countries, implying that there is no gender gap in the schooling of men and women. Similarly, based on economic participation and opportunity, the Philippines ranked 16th globally (GGG Index=0.78), indicating a smaller gender gap. Similarly, the report notes that women's access to land ownership was at the 0.5 level⁶, women's access to credit at 0.5, and women's access to property other than land at the 0.00 level. These numbers suggest that a significant gender gap exists for the access to land ownership, access to credit, and access to property for females.

Filipino women's actual contribution to food production and the rural economy remains undervalued if not invisible. As a result, Filipino women have less access to productive resources than men do. Women farmers toil with their male counterparts in most farm tasks, except for food preparation, which is usually undertaken by the women, and for ploughing with tractors, which is usually done by men. Rice production in the Philippines—from selecting the seeds to uprooting and transplanting the seedlings, and storing the grains—has long been the domain of women. Filipino women are also mostly responsible for accessing capital needed for farm production. In addition, many of these women engage in off-farm activities that can help augment household income (PPI, 2002).

3.2.2. Previous Findings

In the context of rural livelihood, women make essential contributions not only to agriculture but also to households' social welfare. Handa (1996) studied expenditure behavior and children's welfare for female-headed households in Jamaica and concluded that children from female-

²³ World Economic Forum: www3.weforum.org/docs/WEF_GenderGap_Report_2013.pdf.

headed households were less likely to suffer from poor health conditions and low educational outcomes than those from male-headed households. This could be due to the fact that female-headed farm households are more educated, caring for offspring, and efficient in the use of household income. Gender differences in developing countries are mainly observed in access to and use of agricultural inputs, tenure security and related investments in land and improved technologies, market and credit access, human and physical capital, and informal and institutional constraints. These factors explain the difference in agricultural productivity between male-managed plots and female-managed plots (Palacios-Lopez and Lopez, 2014; Peterman et al., 2011).

Udry et al. (1995) studied gender differentials and farm productivity in African households and found that plots controlled by women for all crops have significantly lower yields than plots controlled by men. This is because women have less access to productive resources and opportunities than men. Quisumbing et al. (2014) argued that, if women had the same access to productive resources as men, they could increase farm yields by 20-30%. However, they have less access than men to productive resources and opportunities, especially in land assets, inputs, financial services, extension, technology, and training in agriculture. Hwang et al. (2011) studied women's role in intra-household decision making in Korea and the Philippines and found that, in spite of playing major roles in agricultural households, women have less power in the decision-making process. Indeed, in the case of the Philippines, although women are actively involved in most agricultural work, elder men still own the land, control women's labor, and make agricultural decisions.

According to Layton and MacPhail (2013), in a report published by the Asian Development Bank, women own less land than men. Women are disadvantaged through

inheritance laws, land-titling systems, and their ability to purchase land. Women are responsible for subsistence crops and have less access to cash crops and the resulting income. Layton and MacPhail (2013) also report that women receive less agricultural extension training and credit in the Philippines. This is true not only in the Philippines but also in South America. For example, a study by Fletschner (2008) in Paraguay found that women-headed farm households were unable to meet their credit needs, and thus unable to produce as much as they possibly could.

Similarly, Hoppe and Korb (2013) studied the characteristics of women farm operators using census data from 1978 to 2007 in the United States. They found that the share of U.S. farms operated by women tripled over the past decades, from 5 percent in 1978 to 14 percent by 2007. Their findings note that most women-operated farms are very small, women farm operators are older and highly educated, their farms are mostly related to livestock, and they often rely on off-farm work and income. However, Chant (1997) studied women-headed farm households in the Philippines, Mexico, and Costa Rica and concluded that female household headship may sometimes be a positive strategy for survival. The reason behind this is that female household headships are good in the use of resources and are likely to obtain a loan from micro-lending institutions.

When it comes to tasks performed by women in rural areas, women in the Philippines are traditionally in charge of budgeting. The cultural setting in the Philippine household is that men are expected to turn their earnings over to their wives for budgeting and allocation of resources; however, women complain that their husbands do not turn over all of their income (Ashraf, 2009). In the Philippines, women can own, inherit, acquire, and dispose of property in their own right but income from the wife's pre-marriage property is considered conjugal income whose use is subject to the husband's consent. In rice-producing villages of the Philippines, daughters

typically receive less land and non-land assets than sons (Quisumbing, 1994a). Lu (2010) studied women in Philippine agriculture and their occupational issues and stated that women's engagement in agricultural work is more intense than that of the males. However, they are marginalized with respect to economic and social empowerment.

3.3. Econometric Model

Treatment effects are designed by matching individuals with the same covariates instead of through a linear model for the effect of covariates. Treatment effect techniques use observational data to create groups of treated and control units that have similar covariates values so that comparisons, made within these matched groups, are not confounded by differences in covariate distributions. It was initially used in medical research concerned with the causal effects of binary variables, such as an experimental drug or a new surgical procedure. We applied the average treatment effect (ATE) to analyze the impact of gender on income and rice production in the Philippines. ATE basically measures the difference in mean outcomes between units assigned to the treatment and units assigned to the control (Uematsu and Mishra, 2012; Tauer, 2009). Two assumptions are that the treatments groups must have overlapping characteristics and firm characteristics must be unconfounded to reduce selection bias are two assumption necessary for effective use of the method of matching samples (Gillespie and Nehring, 2014).

We are interested in estimating the average effect of a binary treatment (gender) on the proxy of rice productivity status: cost of production, farming efficiency, net farm income, total household income, and value of rice produced. For individual i , $i=1, \dots, N$; let $\{Y_{i0}, Y_{i1}\}$ denote the two potential outcomes: Y_{i0} as the outcome when the household head is male and Y_{i1} as the outcome when the household head is female. In ATE, we have two values: Y_{i0} is the value of the outcome variable for untreated individual i and Y_{i1} is the value of the outcome for treated

individual i —in our case, the treatment variable being the female-headed household. The treatment effect for an individual is expressed as $ATE = Y_{i1} - Y_{i0}$. The average treatment effect for the entire population, population average treatment effect, is given by $E[Y_{i1} - Y_{i0}]$. ATE for a sample is denoted as $\frac{1}{N} \sum_{i=1}^N (Y_{i1} - Y_{i0})$, where N is size of the sample. In this method, each farm is compared with a matching farm. In this method, each farm is compared with a matching farm. In this paper, we choose average treatment effect for treated because a relatively small percentage of farms in our Loop survey.

A practical problem with a cross-sectional dataset is that these two groups are mutually exclusive, which means that we can observe either Y_{i1} or Y_{i0} . In treatment effects, impact can be measured in terms of two estimates. We can estimate what would be the cost of production for male-headed farm households had they are female-headed farm households. Alternatively, we can estimate such impact on female-headed farm households had they are male-headed farm households. In this study we estimated average treatment for the treated (ATT) which is represented as (Khanal et al., 2015)

$$ATT = E[Y_{i1} - Y_{i0} | T = 1] \quad (1)$$

where $T=1$ indicates assignments to the treatment (female-headed farm households); 0 otherwise.

The biggest challenge in treatment effect in observational studies is the fact that assignment to treatment is not random. In our context, we do not randomly assign farmers to become female-headed farm households or male-headed farm households. Unlike the experimental studies where we can set up randomness in treatment and control, individuals often self-select into the treatment in most of observational research. Thus, observational treatment effect are not free from self-selection biases. An estimation of ATEs without accounting for self-selection leads to biased estimation. There are a number of ways developed and suggested to

correct for this bias. One of the ways is to use of matching estimators which involves matching observations between treatment and control groups on the basis of some key observable factors.

There is always an overlap of the characteristics between treated and non-treated groups after sorting and that can limit for any self-selection bias. Propensity score matching is one of the matching estimators used in ATE analysis. In propensity score matching, the predicted probability score of being in the treatment is estimated using either a logit or a probit model (Becker and Ichino, 2002). In propensity score matching, a female-headed household will be matched to a male-headed household with some similar characteristics, thereby ensuring that dissimilar households and outliers will have no/little influence on the treatment impact. The propensity score, defined by Rosenbaum and Rubin (1983), is expressed as

$$p(X) \equiv \Pr\{D = 1|X\} = E\{D|X\} \quad (2)$$

where $D = \{0,1\}$ is the indicator of exposure to treatment and X is the multidimensional vector of pre-treatment characteristics.

In this study, we use the nearest neighbors-matching estimator developed by Abadie and Imbens (2011). Each unit is used as a match more than once because matching is done with replacement. Matching with replacement reduces biases in our analysis. The nearest neighbor-matching estimator summarizes information from a multiple covariate into a single index using the vector norm $\|x\|_V = (X'VX)^{1/2}$, where V is a positive definite matrix. The nearest neighbor-matching sets define the minimum distance between two observations and this is represented as $\|z - x\|_V$, where z and x are the vectors of observable characteristics for two observations. The estimator for ATT is defined as

$$ATT = \frac{1}{N_1} \sum_{i:T_1=1}^{N_1} [Y_{i1} - \hat{Y}_{i0}] \quad (3)$$

where N_1 is the number of observations in the treatment and the subscript i represents individual observations, whereas Y_{i1} is the observed outcome and Y_{i0} is an unobserved variable for the i th individual. An unobserved variable is expressed as

$$Y_{i0} = \begin{cases} Y_i & \text{if } T_i = 0 \\ \frac{1}{M} \sum_{m \in M_i} Y_m & \text{if } T_i = 1 \end{cases} \quad (4)$$

where M is the number of matched observations and M_i is the set of observations in the control group matched to the i th observation in the treatment. Similarly, the term $\frac{1}{M} \sum_{m \in M_i} Y_m$ is simply a weighted average of the outcome variables for all matched observations in the control group. The nearest neighbor-matching estimator allows us to specify the number of matches, m for each treated observation. We need to be very careful in choosing the values of m . If $m = 1$, each treated observation is matched with an observation in the control group with the closest distance. A large number of m can reduce the quality of the match because of the use of more observations in the matching process.

To consistently estimate the treatment effect of interest, we assume that assignment to a treatment is independent of the outcomes and the probability of assignment is bounded away from zero and one. Generally, more than one covariate is specified in ATT. When more than one covariate is used, the matching depends on the weighting matrix. The output of ATT reflects our choice of the inverse variance-weighting matrix (Abadie et al., 2004). We do not need to assume specific functional form of the dependent variable and do not need to impose any distributional assumption,²⁴ due to which matching estimators are considered as non-parametric types of estimators. Although the matching estimator attempts to eliminate selection bias, there is always

²⁴ In a standard regression, we assume some specific functional form of the dependent variables and we impose distributional assumption of the dependent variables. See more details: Uematsu and Mishra, 2012.

an effect of unobservable factors explaining the treatment. Therefore, a matching estimator is used to reduce selection bias rather than to completely eliminate selection bias (Becker and Ichino, 2002; Sitienei et al., 2014; Khanal et al., 2015). A treatment effect limits the impact of outliers and provides a data reduction method. These benefits justify its use here with small sample size and since female farms are likely to cluster around small acreage.

3.4. Data

This study uses farm-level cross-sectional data from the Central Luzon Loop Survey, commonly known as the “Loop Survey,” conducted by the Social Sciences Division of the International Rice Research Institute (IRRI). Central Luzon is the major rice-producing area of the Philippines, also known as the “rice bowl of the Philippines.” This region grows rice three times a year. This survey contains detailed information on rice yields, prices, fertilizer use, pesticide inputs, labor use, land tenure systems, mechanization, and cultural and labor practices related to rice production. The Loop Survey began in 1966, and is conducted about once every four years.

We used the most recent (2012) Loop Survey for this study. The Loop Survey collects data from rice-farming households along a loop of the main highway north of Metro Manila through the provinces of Bulacan, Nueva Ecija, Pampanga, Tarlac, Pangasinan, and La Union. Figure 1 shows the area under study, Central Luzon and its provinces. Variables of interest include the costs of production (variable costs and fixed costs), the value of farm production, indicators of income, rice yield per hectare, and farming efficiency. Fixed costs include the cost of land rental and capital rental. Variable costs include the cost of seeds, fertilizer, fuel, irrigation, and labor. Total household income and net farm income indicate the performance of the farm. The farming efficiency variable is mostly related to managerial characteristics, and it is

defined as the ratio of gross value of production to total variable costs. A number of exogenous variables, such as age, education, household size, land area, dummy variable for marital status, and occupation, were used to match the farms.

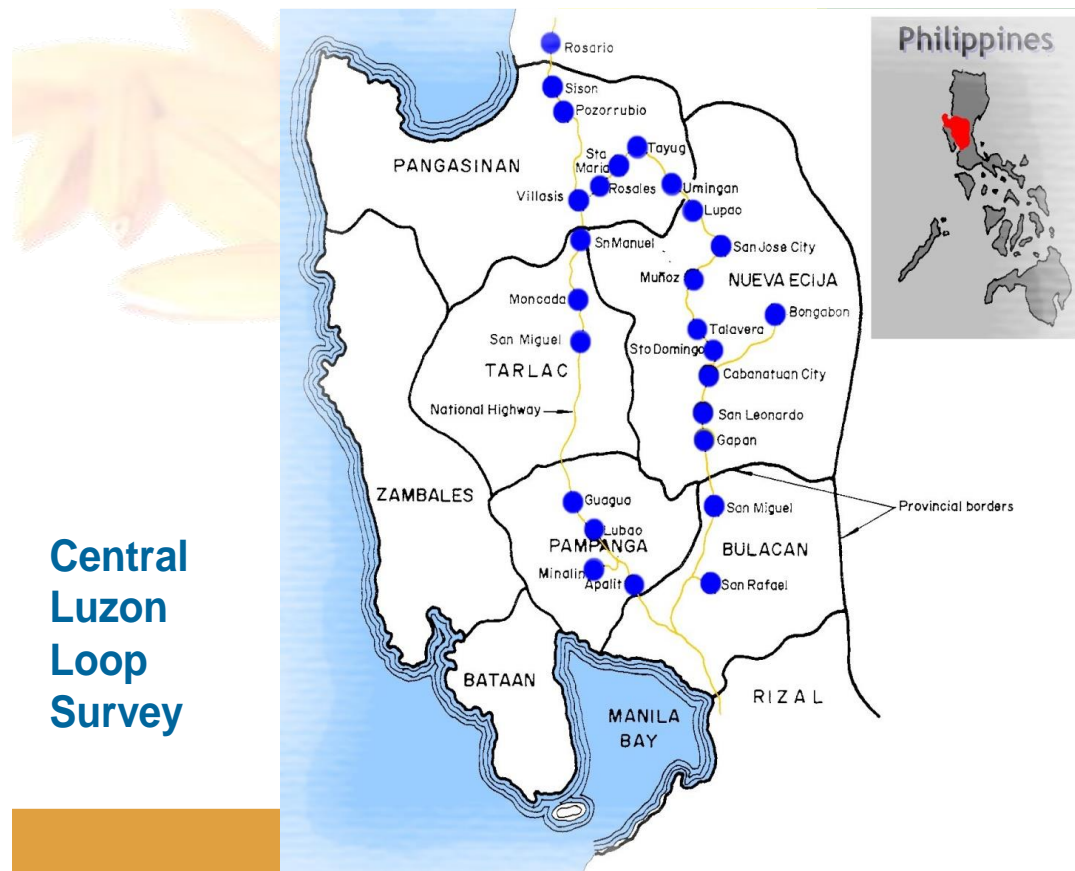


Figure 1. Research study area, Central Luzon, Philippines
Source: Political map of Central Luzon, Wikipedia

Table 5 provides the definition and summary statistics of the variables used in our analysis for the entire sample, female-headed farm households and male-headed farm households. Of 76 household observations, only 18 (or 23.6% of the entire sample) were female-headed farm households. The last column of Table 1 shows *t-statistics* or *z-statistics*, which compare the means of the treated (female-headed farm households) and control (male-headed farm households) observations. These test statistics simply compare the means of each variable

of interest without controlling for any underlying factors. Under such circumstances, a matching estimator would help to overcome this issue and estimate the effect of the treatment variable on the outcome variable (Uematsu and Mishra, 2012).

On average, female-headed farm households' total household income was PHP 26,272 while male-headed farm households earned PHP 34,127 per year. The average female-headed farm household annual net farm income was PHP 27,166, which was slightly below that of the average male-headed farm household (PHP 27,933). Similarly, the value of rice produced by female-headed farm households (PHP 117,453) was lower than that of male-headed farm households (PHP 119,188). Compared with male-headed households, female-headed households, on average, tended to have higher fixed costs, higher seed and fuel costs, and higher remittance. Interestingly, female-headed households had lower fertilizer and irrigation costs, lower household income, and lower net farm income. However, there was no statistically significant difference between the treated and control group in terms of age, education, fuel cost, remittance, and land preparation cost.

3.5. Results and Discussion

The average treatment effect (ATT) was estimated using matching estimator m_i where $i = 1 \dots 5$. Table 6 presents the results of ATT of gender on costs of production, value of production, income indicators, yield per hectare, and farming efficiency. The choice of m does not influence the statistical significance. The results indicate that the ATT on the households' net farm income is negative for all $m = 1 \dots 5$ and significant. The findings suggest that the average effect of having a female-headed farm household is associated with lower net farm income. The point estimates of ATT indicate that female-headed farm households, on average, earned range of PHP 11,575 to PHP 14,575 less in net farm income than male-headed farm households.

Table 5. Variable definition and summary statistics

Variable definition	Mean			t/z score ^a
	Entire sample	Female HH	Male HH	
Age (in years)	60	60	60	-0.69
Education (in years)	8	9	8	1.23
Household size	4.8	4	5	1.92*
Marital status (=1 if married; 0 otherwise)	0.76	0.36	0.81	6.87**
Occupational status (=1 if farming; 0 otherwise)	0.77	0.72	0.78	0.38
Land area (hectares)	1.39	1.38	1.40	1.95*
Land preparation cost (PHP)	2,350	3,142	2,192	1.56
Post-harvest cost (PHP)	15,167	14,890	15,222	1.77*
<i>Costs of production</i>				
	<i>Fixed costs (PHP)</i>			
Land rent	4,374	6,738	3,900	-1.73*
Capital rent	7,157	10,444	6,499	-1.85*
	<i>Variable costs (PHP)</i>			
Seed cost	4,478	4,746	4,424	-2.01**
Fertilizer cost	12,174	11,968	12,215	-1.98**
Fuel cost	2,728	3,158	2,642	-1.46
Irrigation cost	1,663	1,176	1,760	1.68*
Variable labor cost	31,518	33,400	31,225	1.83*
Permanent labor cost	8,929	9,949	8,726	-2.03**
Value of rice produced	1,18,899	1,17,453	1,19,188	2.07**
<i>Income indicators</i>				
Household income (PHP)	32,818	26,273	34,127	1.98**
Net farm income (PHP)	27,805	27,166	27,933	2.54**
Remittance (PHP)	19,212	19,291	19,196	-1.45

Table 5 continued

Variable definition	Mean			t/z score ^a
	Entire sample	Female HH	Male HH	
<i>Production</i>				
Yield per hectare (kg)	5762.49	5362.97	5842.40	3.08**
<i>Efficiency</i>	<i>(Gross value of production/total variable costs)</i>			
Farming efficiency	5.66	4.76	5.84	1.72*

** and * indicate statistical significance at 5% and 10%, respectively.

^aThe differences in means are obtained by subtracting means for farm households with female-headed households from those of households with male-headed. For continuous variable, *t* test is used and *t* statistics is reported; test on the equality of proportions is used to compare the differences for binary variables and *z* score is reported

Similarly, the total household income for m_1 , m_2 , and m_3 of female-headed farm households is negative and significant, suggesting that female-headed farm households, on average, earned range of PHP 11,658 to PHP 62,114 less total household income than male-headed households. Interestingly, female-headed farm households receive more in cash remittance, range of PHP 1900 to PHP 11,472 more than male-headed households, though this variable is insignificant for all m_i in ATT. Estudillo et al. (2001) reported that 60% of the females in Central Luzon participated in non-farm employment compared with only 42% of the males. Generally, female participants earned more in non-farm employment because they were more educated, with about 2 years of additional schooling. It should be pointed out that women's farm wages are 48 percent lower than men's during the wet season of rice production in the Philippines (Quisumbing, 1994a).

The ATT estimates of fixed costs such as land rent and capital rent show that female-headed farm households have higher fixed costs than male-headed farm households. The matching estimators m_1 and m_2 are significant for land rent at the 10 percent level of significance. Results in Table 6 show that a female-headed farm household, on average, pays

PHP 4,081 to PHP 4,290 more in land rent than a male-headed farm household. The entire matching estimators are positive and significant at the 10 percent level of significance for capital rent. The ATT on capital rent ranged between PHP 3,918 and PHP 4,484. Because of legal, social, and institutional disparities between males and females, female-headed farm households usually have higher levels of physical and human capital than male-headed households (Quisumbing, 1994a).

We estimate the ATT on variable costs, which include seed cost, fertilizer cost, fuel cost, irrigation cost, permanent labor cost, and variable labor cost. Among them, fertilizer cost and fuel cost are not significant. This implies that there is no statistically significant difference in fertilizer cost and fuel cost between female-headed farm households and male-headed farm households. However, seed cost is positive and significant. A female-headed farm household spends more (range of PHP 1,183 to PHP 1,554) on seeds than a male-headed farm household, although it should be noted that female farmers are more likely to use improved seed varieties and use agrochemicals (Quisumbing, 1994a). On the other hand, female-headed farm households spend less (range of PHP 970 to PHP 1,516) on irrigation cost than male-headed farm households. The total permanent labor cost is significant for m_1 , m_2 , and m_3 and it has a positive value. Similarly, variable labor cost is significant for m_1 and has a positive value. The findings suggest that a female-headed farm household pays range of PHP 5,691 to PHP 8,230 more in permanent labor cost than a male-headed farm household.

Similarly, a female-headed farm household pays more (on average PHP 10,699) on variable labor cost than a male-headed farm household. In the Philippines, women generally tend to have lower marginal products of labor because of cultural constraints in farm work. Female-headed farm households have less access to land and own fewer tools, and are less likely to adopt

farm machinery and a tractor because of the higher capital requirements. Therefore, female-headed farm households invest large amounts in hiring labor compared with male-headed households (Quisumbing, 1994a; Arun, 1999).

Although female-headed farm households lag behind their counterpart, the most important result obtained from our analysis is that female-headed farm households have a higher value of rice production than male-headed farm households. The results in Table 6 show that, in spite of having less area of production and higher fixed costs and variable costs, female-headed farm households have higher output as well as a higher value of rice production than male-headed farm households. The value of rice production is significant for m_1 and m_2 and has a positive sign. Table 6 indicates that a female-headed farm household earns (range of PHP 19,969 to PHP 23,802) more from sales of rice than a male-headed farm household. There is one questionnaire asking about who buys more improved seed. From response of survey it was found that female buys more improved and high quality rice varieties while males were more interested to use previous year seed. Thus, a female-headed farm households spends more money to buy improved varieties of seeds compared to a male-headed farm households. Since women are more likely to adopt improved seed varieties, they will obtain more income from the sale of quality rice.

The ATT estimate on rice yield (kg/hectare) indicates that female-headed farm households have lower yield (on an average 1,320 kg/ha) than male-headed farm households. It should be pointed out that, in the Philippines, Estudillo et al. (2001) and Quisumbing (1994b) studied the gender differences in land inheritance and stated that sons receive 0.15 additional hectare of land compared with daughters. However, Estudillo et al. (2001) and Quisumbing (1994b) note that daughters were treated more favorably for schooling, receiving 2 more years of

schooling than sons, and were more likely to obtain off-farm jobs. This may explain why female-headed farm households have small farms and lower total rice production than male-headed farm households (Hoppe and Korb, 2013). Additionally, Saito et al. (1994) found that female-headed farm households generally managed fewer quality plots than male-headed farm households.

It is plausible that female-headed farm households in the Philippines manage poor-quality land and this may explain the lower yield per hectare than male-headed farm households. Finally, we estimated farming efficiency for female-headed and male-headed farm households. Farming efficiency is a ratio defined as the total value of rice production divided by the total variable cost of rice production. The ATE estimates on farming efficiency are negative and significant at the 5 percent level of significance. A female-headed farm household is less efficient (a range of 1.10 to 1.33) than a male-headed farm household. This is not a surprise because female-headed farm households spend more money than male-headed farm households on variable costs, which eventually leads to lower farming efficiency. The findings here are consistent with those of Fletschner (2008), who found that credit constraints for women can cause an additional 11% drop in household/farm efficiency in Paraguay. Female farmers have less access to formal credit because they are less mobile than men and they lack adequate collateral, particularly ownership of land. Women are also less likely to have access to extension and other services, which may lead to less efficiency in the use of inputs in rice (Saito et al., 1994; Lastarria-Cornhiel, 2008).

Table 6. Estimates of the average treatment effect (ATE) for the treated (ATT)

Variable	Number of matches (<i>m</i>)	ATT	S.E.	p-values
Net farm income (<i>PHP/year</i>)	1	-14,425.26	6,750.19	0.033**
	2	-11,862.00	6,771.342	0.047**
	3	-14,040.11	6,580.052	0.026**
	4	-11,574.82	5,633.507	0.031**
	5	-14,242.80	6,120.775	0.022**
Total household income ¹ (<i>PHP/year</i>)	1	-11,6518.2	61,114.86	0.050**
	2	-62,113.64	29,287.22	0.034**
	3	-42,893.94	24,888.90	0.031**
	4	-29,093.18	21,478.19	0.176
	5	-23,025.09	18,201.00	0.206
Cash remittance ² (<i>PHP/year</i>)	1	11,472.73	11,419.70	0.315
	2	9,909.09	12,057.27	0.411
	3	7,181.81	10,642.12	0.500
	4	-1,900.00	9,776.52	0.846
	5	-4,025.45	11,238.04	0.720
Land rent (<i>PHP/year</i>)	1	4,081.22	2,067.009	0.048**
	2	4,289.40	2,290.774	0.061*
	3	2,916.71	2,686.924	0.278
	4	2,636.45	3,107.607	0.396
	5	2,899.97	3,215.504	0.367
Capital rent (<i>PHP</i>)	1	4,483.85	2,637.765	0.049*
	2	3,917.95	2,350.988	0.050**
	3	4,063.64	2,230.784	0.044**
	4	4,315.25	2,497.216	0.059*
	5	4,413.57	2,448.035	0.042**
Seed cost (<i>PHP</i>)	1	1,553.41	853.936	0.069*
	2	1,283.52	612.405	0.036**
	3	1,182.57	675.000	0.080*
	4	1,243.75	708.032	0.079*
	5	1,282.27	650.705	0.049*
Fertilizer cost (<i>PHP</i>)	1	347.50	1,817.091	0.848
	2	1,827.56	1,402.346	0.193
	3	826.481	903.059	0.360
	4	1,449.31	1,103.188	0.189
	5	1,599.81	1,373.679	0.244

Table 6. continued				
Variable	Number of matches (<i>m</i>)	ATT	S.E.	p-values
Fuel cost (<i>PHP</i>)	1	1,599.45	1,546.848	0.301
	2	825.40	1,689.823	0.625
	3	1,030.03	1,807.261	0.569
	4	1,245.06	1,752.459	0.477
	5	1,141.76	1,715.816	0.506
Irrigation cost (<i>PHP</i>)	1	-1,515.90	651.671	0.020**
	2	-969.31	554.648	0.081*
	3	-622.27	614.235	0.311
	4	-405.22	493.800	0.412
	5	-426.81	527.558	0.418
Permanent labor cost (<i>PHP</i>)	1	8,229.79	3,677.301	0.025**
	2	6,444.45	3,629.718	0.076*
	3	5,691.00	3,201.107	0.075*
	4	4,837.23	3,220.189	0.133
	5	3,900.91	2,936.442	0.184
Variable labor cost (<i>PHP</i>)	1	10,699.07	5,613.910	0.050**
	2	7,472.53	4,778.788	0.118
	3	6,847.96	4,643.541	0.140
	4	6,036.96	5,346.909	0.259
	5	5,127.82	5,218.842	0.326
Value of rice production (<i>PHP</i>)	1	23,801.91	12,206.57	0.051*
	2	21,940.69	11,129.39	0.049**
	3	19,968.00	12,166.58	0.057*
	4	15,819.75	11,352.04	0.163
	5	18,181.15	12,630.72	0.150
Yield per hectare (<i>kg/ha</i>)	1	-1,320.87	692.824	0.050**
	2	-587.26	452.638	0.194
	3	-510.54	434.700	0.240
	4	-573.38	468.956	0.221
	5	-505.00	458.870	0.271
Farming efficiency (<i>value of production/total variable cost</i>)	1	-1.3310	0.6454	0.039**
	2	-1.1029	0.5865	0.060*
	3	-1.1913	0.4971	0.017**
	4	-1.1152	0.4614	0.016**
	5	-1.1240	0.4797	0.019**

** and * indicate statistical significance at 5% and 10% level, respectively.

¹ Includes income available to the household of the principal operator. It includes farm business income, income from other farming activities, and off-farm income.

² Cash obtained from migrated family member of a family.

3.6. Summary and Conclusions

About 60 percent of the employed women in South Asia and in sub-Saharan Africa work in agriculture. Women's participation in the agricultural labor force and as owners and operators is increasing in Africa and Asia. In Asia, women's participation is much greater in rice-based cropping systems, especially in transplanting, harvesting, weeding, and post-harvest activities, than in other farming. In the developing countries, there is still a valid perception that "women are not farmers," which has resulted in the exclusion of women in agricultural research and extension for development programs.

This study examined the role of female-headed farm households in rice farming. In particular, we investigated the impact of female-headed farming operations on farm output, income, costs (fixed and variable costs), and farming efficiency. To do this, we used a non-parametric approach and the nearest neighbor matching method along with farm-level data from rice-producing areas of the Philippines. We found that there was no statistical difference between female-headed and male-headed farm households in terms of age, education, fuel cost, fertilizer cost, and land preparation cost. An interesting finding from this study was that female-headed farm households have a higher value of production than male-headed households. However, female-headed farm households are less efficient (farming efficiency and yield per hectare) when it comes to farming. Rental cost of land and farm capital and variable costs such as hired labor and seeds were higher for female-headed households. However, irrigation costs were lower for female-headed farm households than for male-headed farm households.

Female-headed farm households are a growing phenomenon in the Philippines, where farms operated by women have more than doubled in the past 30 years. In spite of improvements, women still face constraints on productive resources such as land, credit, and

reliable hired labor. Women have weaker rights to land than their counterparts because land allocation patterns are generally skewed toward men. Additionally, women do not have the same access to agricultural extension services. An understanding of women's role in farming and the constraints faced by women farmers is a prerequisite in preparing a gender policy in agriculture not only in the Philippines but in any country. Therefore, legal provisions such as equal access to land and other resources should be the starting point of a gender-sensitive agricultural policy. Finally, gender differences appear in the type of technology and information disseminated to farmers. Several knowledge-intensive technologies require knowledge and skills. Thus, steps could be taken to strengthen extension services to educate, train, and provide guidance to women farmers in farming activities as well as value chain enhancements in production agriculture and the food industry.

3.7. References

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CHAPTER 4: FARM INPUT SUBSIDY PROGRAM AND TECHNICAL EFFICIENCY OF RURAL MALAWIAN HOUSEHOLDS: DOES GENDER MAKE A DIFFERENCE?

4.1. Introduction

Agriculture in Malawi accounts for 30% of Gross Domestic Product (GDP), 80% of the labor force, and over 80% of foreign exchange earnings. Agriculture provides 64% of the total rural household income, 65% of raw materials for the manufacturing sector, and 87% of total employment.²⁵ The agricultural sector is comprised of two sub-sectors—the smallholder sub-sector (70% GDP) and the estate sub-sector (30% GDP). The smallholder sub-sector is further divided into three distinct categories: net food buyers, intermediate farmers, and net food sellers. Farmers with less than 0.7 hectares of land are categorized as net food buyers; these farmers are unable to produce sufficient food for their needs, hence, depending mostly on off-farm activities to increase income and food security. Farmers with 0.7 to 1.5 hectares of land are categorized as intermediate farmers. Net food sellers are farmers who can produce more than enough food for their needs and have more than 1.5 hectares of land (Chirwa, 2007; Chirwa et al., 2008; FAO, 2012).

A famous Malawian saying, “Maize is life,” articulates the importance of maize in Malawi (Derlagen, 2012). Smallholder agricultural households, which account for 90% of total maize production to meet subsistence requirements, are less likely to grow hybrid maize and maize yields are consistently lower than those of estate households, which comprise less than 10% of the agricultural sector (Chirwa et al., 2008). Aside from maize, other important food crops includes cassava, sweet potatoes, rice, sorghum, groundnuts, and pulses. However, the

²⁵ Report published by World Bank, Basic agricultural public expenditure diagnostic review (2000-2013) www.worldbank.org/afr/agperprogram

priority of the Malawian government is to reorient the agricultural sector from focusing on subsistence farming to commercial crops (Jayne et al., 2008; Malawi Government, 2011; Chirwa, 2007).

Policymakers also argue over the issue of food security (mainly defining it in terms of access to maize, the main staple) in Malawi, high productivity and efficiency in maize production, therefore, is critical to food security in the country. Already, over 80% of cultivated land is dedicated to maize. However, several factors play into diminished productivity. Low input use, inadequate access to agricultural credit, poor output and input markets, unfavorable weather, small land holdings, and lack of proper technology are the main reasons for lower agricultural productivity in Malawi (Malawi Government, 2011; Denning et al., 2009; Njuki et al., 2011; Phiri et al., 2004). In addition, the combined effects of the HIV/AIDS pandemic and constant migration of rural labor to urban areas contribute to a shortage of labor availability for farming operations²⁶ (Ngwira et al., 2012). Consequently, agricultural productivity in Malawi has fallen below its potential, given the available technology (Tchele, 2009).

During the 1960s and 1970s in Malawi, adoption of improved seed varieties, mainly hybrids and application of fertilizers, increased productivity. Fertilizer use in Africa is strikingly low (8 kg/ha) compared to East and Southeast Asia (96 kg/ha) and South Asia (101 kg/ha). In 2005, the government of Malawi enacted the Farm Input Subsidy Program (FISP) in an effort to boost maize production by providing subsidies on improved seed varieties and fertilizer. This program had three primary goals: (I) to increase income of resource poor households; (II) to encourage cash crop production; and (III) to help farmers achieve food self-sufficiency. As a result, FISP has significantly influenced the agriculture and food security issues in Malawi since

²⁶ Food insecurity encourages unsafe sexual practices leading to incidence of HIV/AIDS. See more details in Denning et al., 2009.

its implementation.²⁷ Proponents of FISP claim that FISP was so successful in 2006 and 2007 that it led to major surpluses (Denning et al., 2009). The program is of special interest to the authors of this paper because the Malawian government initially enacted FISP to ensure benefits to female-headed farm operator households; however, most beneficiaries were ultimately male-headed farm operator households (Dorward and Chirwa, 2011; Chirwa, 2007).

The example of FISP points to how socially constructed relationships and gender differences can affect the distribution of resources and responsibilities between men and women. A gender difference is shaped by ideological, religious, ethnic, economic, and cultural determinants (Quisumbing, 1996). For example, a female usually acts as the head of a household in one of two scenarios: widowhood or abandonment. A female-headed farm operator household is defined as those households where the women make the majority of decisions about agricultural production and marketing (Njuki et al., 2011). A report presented to the World Bank and UNDP (Ngwira et al., 2003) acknowledges that one-third of Malawi's rural households, mostly farmers, are female-headed. Overall, women comprise 51% of the total population. Of these, about 97% of rural women are engaged in subsistence farming. Therefore, we can safely say that women in both joint-headed and female-headed operator households are poor.

Throughout the agricultural sector in sub-Saharan Africa, two key features related to productivity are the dominance of female labor and the prevalence of a gender gap. The gender differential in agricultural productivity is based on the economic condition of the country, the representativeness of the data, the type of crop, and other related factors. Previous research has found that gender differentials in agricultural productivity range from 4 to 40% (Palacios-Lopez and Lopez, 2014). Less access to productive inputs coupled with liquidity constraints may

²⁷ IFPRI newsletter <http://www.ifpri.org/sites/default/files/publications/massppn18.pdf>

decrease the productivity of female-headed households as compared to male-headed households (Saito and Weidemann, 1991; Njuki et al., 2011; Fletschner, 2008). Despite this, females may continue to engage in agricultural labor instead of turning to off-farm activities due to discrimination. Several factors may contribute to the differences in agricultural productivity between farms operated by men and women in African rural households. Firstly, each group is occupied with additional, gender-specific activities both on and off the farm. Second, differential access and adoption of technologies, endowments of land rights, and factors of production which impact efficiency of production (Oladeebo and Fajuyigbe, 2007).

In developing countries female-headed households are more likely to be poorer than male-headed households, however, in Malawi female-headed households are becoming richer than male-headed households (Handa, 1995). Malawi has a heavier concentration of matrifocal ethnic groups, higher female participation in shifting agricultural systems (Handa, 1995) as well as a matriarchal system which involves women in decision-making processes (Njuki et al., 2011). Findings from previous studies point to other possible factors in the gender differential agriculture in Malawi. These include: (1) the quantity of inputs applied; (2) the quality of inputs (such as land, soil quality); (3) crop choice; and (4) shadow prices of inputs and access to credit by male-headed and female-headed farm households, respectively.

Therefore, the objective of this study is to estimate the determinants of productivity and identify the factors that explain variations in technical efficiency. Particular attention is given to FISP and access to credit, as previous studies have failed to estimate the gender differential impact of FISP on maize productivity and technical efficiency. Our study specifically analyzes the average differences in agricultural productivity between plots belonging to male-headed farm operators and those belonging to female-headed farm operators, separately.

4.2. Literature Review

4.2.1. Agricultural Sector of Malawi

Malawi is a landlocked tropical country and its economy is heavily dependent on agriculture (Denning et al., 2009). Malawi has always been vulnerable to food insecurity due to its limited resources, high population density, rainfed agriculture, and frequent droughts and floods. Eighty-four percent of Malawians live in rural areas and about 11 million Malawians are engaged in smallholder subsistence farming. However, due to mountains, forests, and rough pastures, only one-third of the land is suitable for agriculture. Maize, a major staple food, is grown by 97% of farming households and accounts for 60% of total calorie consumption in Malawi (Denning et al., 2009). They compared the average yield of maize of Malawi (1.3 metric tons per hectare) with the average yield of rainfed maize in Iowa (10 metric tons per hectare) for 1997-2007 periods and concluded that the absence of significant use of fertilizer in Malawi was the major cause behind such inferior production.

Nonetheless, Derlagen (2012), in a technical note published by FAO, states that maize yields increased from 0.99 to 2.3 tons per hectare between 1990 and 2010 time periods. The total harvested area for maize increased from 1.14 million hectares to 1.65 million hectares between 1980 and 2010 while production more than tripled from 1.2 million to 3.8 million tons in these periods. Total maize production was 3.64 million tons in 2013 and was expected to be 3.9 million tons (8% more than 2013) in 2014.²⁸ This strong increase in production and yields has been observed each year since 2006.²⁹ Reasons for this include continuation of the Farm Input Subsidy Program, a small expansion in planted area, and timely rainfall.

²⁸ FAO, Malawi <http://www.fao.org/giews/countrybrief/country.jsp?code=MWI>

²⁹ A Farm Input Subsidy Program has been effective since the 2005/2006 harvest season and is a major cause of increase in maize production.

The 2004/2005 maize cropping season was worse than usual in Malawi. Severe drought conditions during the crucial tasseling and ear development stages resulted in very low national average maize production (0.76 tons per hectares). Total maize production was 24% less in 2005 compared to previous year production, which leads to the rise of maize price in local markets and significant food deficits. Therefore, to increase maize production, the government of Malawi decided to provide subsidies for rural farmers. The objective of FISP is to increase access to improved agricultural inputs for resource poor smallholder farmers, with the subsequent aim of food sufficiency, intensified maize production, and increased incomes in the long term.³⁰ The FISP support measures are primarily for maize production. They were first implemented during the 2005/06 cropping season and are still in existence (Denning et al., 2009; Derlagen, 2012; Chibwana et al., 2010). It is targeted to 1.5 million rural smallholders (about half of total farmers) and provides each farmer with two coupons³¹ (1 coupon=50 kilogram bags of fertilizer).

A farmer receiving FISP should pay a small redemption fee, equating to a subsidy of two-thirds or more of the commercial fertilizer price. A smallholder farmer is eligible for this program if he or she cannot afford fertilizer at commercial price but has sufficient land and human resources to make effective use of subsidized inputs (Arndt et al., 2013). In addition to this, FISP also focuses on vulnerable groups such as child or female-headed farm households; however, female-headed farm households and asset-poor households are less likely to receive any type of coupons (Chibwana et al., 2010). FISP mandates a minimum distribution of 150,000-170,000 metric tons of fertilizer per year; actual distribution peaked at 216,000 metric tons in

³⁰ Basic agricultural public expenditure diagnostic review (2000-2013), a report published from World Bank. See more details in http://www-wds.worldbank.org/external/default/WDSPContentServer/WDSP/IB/2014/07/17/000333037_20140717142122/Rendored/PDF/895110WP0P119400Box385284B00PUBLIC0.pdf

³¹ Two coupons were provided: One for a 50 kg bag of NPK (base fertilizer) and one for a 50 kg of urea (top dressing).

2007/08. Additionally, FISP provides improved seeds³² to farmers, starting at 2-3 kilograms per farmer in 2005/06 and 5-10 kilograms in 2009/10. Thus, a full package FISP program includes 5-10 kg of seeds and 100 kg of fertilizer (Pauw and Thurlow, 2014).

When FISP was introduced after the drought years of 2004/2005, yield dramatically improved in Malawi. Maize yields increased to 1.59 tons per hectare (2.58 million tons national production) in 2005/06, doubling the yield (0.76 t/ha) and production (1.23 million tons) of 2004/05. This increase was due to subsidies on fertilizer and seeds coupled with favorable weather (rainfall) during 2005/06. In the subsequent cropping season 2006/07, national maize production (3.44 million tons) and yield (2.04 t/ha) further improved (Denning et al., 2009). According to Arndt et al. (2013), FISP generates modest direct returns in the form of higher maize productivity and production. Additionally, FISP also generates indirect benefits which are represented by an economy-wide benefit-cost ratio on the national level. These findings from previous studies (Chibwana et al., 2010; Arndt et al., 2013; Derlagen, 2012) lead us to conclude that FISP programs are successful in achieving food self-sufficiency.

Several other factors contribute to diminished agricultural productivity in Malawi. One significant problem Malawian farmers continue to face is limited availability of irrigation. Agricultural production is mostly rainfed. Unfortunately, over the past two decades, Malawi has experienced significant drought, including severe droughts in 1991/92, 1993/94, 1994/95, and 2000/01 (Edriss et al., 2004; Derlagen, 2012) which have led to fluctuating maize production. Two additional binding constraints for agricultural productivity are land and poverty. Malawi's smallholder farmers are too poor to be able to benefit from any kind of government assisted

³² FISP provides both composites and hybrid seeds to farmers. A farmer can choose between composite and hybrid seed varieties. Options are either 2 kg hybrid seeds or 4 kg open pollinated seed varieties. In 2009/10, FISP provided 90% of hybrid seeds.

credit program. Moreover, land constraints are so severe that even if they had access to adequate credit and inputs, any increase in productivity would still fall below food demand (Diagne and Zeller, 2001; FAO, 2011b). Edriss et al., (2004) noted that both the quantity and quality of land input were major constraints for agricultural production in Malawi. However, the authors stated that the largest contributing factor in the decline of maize productivity was a decrease in farm labor input share.

4.2.2. Previous Findings

There is a growing literature concerning gender-based farm productivity and efficiency issues across Africa. Peterman et al. (2011) studied gender differences in agricultural productivity in Nigeria and Uganda using the 2004-2010 *Fadama II* data collected by IFPRI. Using Cobb-Douglas production function in the first stage and multivariate Tobit models in the second stage, the authors addressed gender differences. They found that female-owned plots and female-headed household tend to have lower productivity than plots and households owned by men in Nigeria and Uganda; women, it seems, farm on resource-poor farm land. Combaz (2013) studied unequal decision-making power between male and female-headed farm households in Uganda and concluded that men make about 70% of the decisions regarding marketing and men and women jointly make 15% of the decisions, demonstrating that women have little authority over marketing, sales, income, and spending.

Previous research on gender differences in agricultural productivity and technical efficiency reach mixed conclusions. A number of studies in the late 1980s and early 1990s, as well as some recent studies found no significant differences in the technical efficiency of male and female-headed farms when differences in inputs are controlled (Peterman et al., 2001; Gilbert et al., 2002; Thapa, 2008; Horrell and Krishnan, 2007). In fact, some studies found that

female-managed farms are more efficient than male-managed farms (Dadzie and Dasmani, 2010; Oladeebo and Fajuyigbe, 2007). For example, Oladeebo and Fajuyigbe (2007) studied technical efficiency of upland rice farmers in the Osun State of Nigeria using separate stochastic dominance production function for female-headed and male-headed households. They found that women farmers are more technically efficient than men farmers.

On the other hand, several studies have concluded that female-headed households or female-managed plots have lower agricultural productivity and are technically less efficient than male-managed plots (Udry, 1996; Quisumbing et al., 2001; Holden et al., 2001; Ogunniyi and Ajao, 2010). Udry (1996) studied gender, agricultural production and the theory of the household using four-year panel data (1981-1985) on Burkina Faso farm households from the International Crops Research Institute for the Semi-arid Tropics (ICRIST). The author studied why female-managed farms are less efficient and conclude that factor allocation (inputs) is not Pareto efficient across plots. Plots controlled by women are farmed much less intensively than similar plots controlled by men within the household with 6% of output lost due to inefficient factor allocation within the household. Ogunniyi and Ajao (2010) studied gender and cost efficiency in maize production in the Oyo State of Nigeria using two separate stochastic production function and concluded that females are more cost inefficient than their male counterparts. Female farmers, they found, have less access to seeds and tend to use the seed from the previous harvest.

Among various reasons of lower efficiency and productivity of female-managed farms, access to credit is one of major barriers. For example, Fletschner (2008), in a study of 210 couples in Eastern Paraguay, studied women's access to credit and its effect on household efficiency³³ using non-parametric data envelope analysis method. Findings showed that the

³³ Household efficiency includes economic efficiency, technical efficiency, and allocative efficiency. For more details, see Fletschner (2008).

women were unable to meet their needs for capital and their households experienced an additional 11% loss in household efficiency. Diaz and Sanches (2011) studied gender wage gap in Europe using stochastic frontier approach and data from European Community Household Panel Data (1995-2001) and concluded that wage discrimination in women might be a reason for lower productivity and efficiency of female-managed plots.

In spite of women appearing to have less productivity in farming, the general consensus is that they are no less efficient than men in their use of resources. However, they generally face greater barriers in procuring as many resources as their male counterparts. Similarly, access to extension services is another barrier for female farmers. Gilbert et al. (2002) studied gender analysis of a nationwide cropping system in Malawi using cross-sectional data of the 1998-99 cropping season. He found that agricultural extension services were biased toward male farmers; i.e., extension agents chose 81% male farmers for a complex agronomic trial.

Studies have also shown that in Malawi, female-headed households have smaller landholdings than male-headed households. According to a report published by FAO (2011) females own less land and consequently use about 10% less total labor per hectare than their male counterparts. This may occur for several reasons. Firstly, in general, family size is smaller in female-headed households than male-headed households, due to the absence of the male (Quisumbing, 1994a). But this is an additional hardship for the household since in some farming operations, such as plowing and spraying, male labor is necessary. Consequently, female-headed households need more cash to hire male labor to perform those farming activities.

Many studies explain and highlight the important factors that can affect efficiency of farmers, information which is useful in helping determine technical efficiency of maize producers in Malawi. For example, Chirwa (2007) analyzed technical efficiency of 156 maize

farms in Southern Malawi using 2006 cross-sectional data from a smallholder farmer questionnaire. He found that smallholder maize farmers were 46.23% technically efficient and stated that smallholder maize farmers in Malawi are inefficient, while hybrid seeds and club membership could increase the efficiency of maize farmers. Farmers using hybrid maize seeds are more efficient than farmers using local maize seeds. Tchale (2009) studied the efficiency of smallholder agriculture in Malawi using stochastic production frontier model. The author found a 53% average technical efficiency score with determinants of efficiency being access to markets, extension services, fertilizer, and improved seed varieties.

Similarly, Tchale and Sauer (2007) studied efficiency of maize farming household and plot level data using 2003 survey data from the Agricultural Development Divisions in Malawi. Using bootstrapped translog frontier, the authors concluded that integrated soil fertility, access to agricultural input and output markets, credit provision, and extension services strongly influence smallholders' technical efficiency. Edriss et al. (2004) studied the impact of labor market liberalization on maize production and productivity using a frontier production function and Divisia Index. They found that between 1985-2000 time periods, total factor productivity declined at a rate of 1.2% per annum. Two factors contributed most: decrease in farm labor input share and labor market liberalization. The labor market liberalization including labor market reform had directly or indirectly shifted allocation of labor from own farm to the other farms or non-farm activities, resulting in a lower productivity and efficiency in maize production in Malawi.

Taking this a step further to the topic of gender and its relationship with markets in Malawi, Njuki et al. (2011) studied linkage between gender and intra-household dynamics. The authors concluded that women only have the authority to control those commodities that

generate lower average revenues, while men are able to control commodities that have high revenue. Thus, women are significantly excluded from markets and opportunities to move them from subsistence agriculture to commercial agriculture in Malawi. Lack of arable and productive land ownership, lack of access to resources, unequal domestic decision-making power, and a gendered division of labor and time are hindering factors leading to lower productivity of female-headed households' plots than male-headed households' plots.

4.3. Data

We use the third Integrated Household Survey (IHS3) data conducted by the Government of Malawi through the National Statistical Office (NSO) in the period of March 2010 to March 2011. The NSO conducts the survey every 5 years to monitor and evaluate the changing conditions of Malawian households. The IHS3 consists of four distinct questionnaire instruments: the household questionnaire, the agriculture questionnaire, the fishery questionnaire, and the community questionnaire. The household questionnaire covers a wide range of topics including economics activities, demographics, welfare, and other sectorial information of households. The agriculture questionnaire is carefully designed to provide consistency with the National Census of Agriculture and Livestock and other surveys in sub-Saharan Africa. In this study, we take data from both the household and agriculture questionnaires.

The IHS3 survey includes all three major regions of Malawi—North, Central, and South - and 31 districts of Malawi. It does not include the island district of Likoma, which only represents about 0.1% of the total Malawian population. For the collection of cross-sectional data, households were visited only once. The survey data include output of maize and other food crops produced and inputs used in the production process (such as land, labor, capital, fertilizer,

pesticides and seed) as well as demographic and socio-economic characteristics of the households.

The IHS3 collected a total of 12,271 households' observations. Among these, cross-sectional data comprised 9,024 households and panel data comprised the remaining 3,247 households. In this study, we use only cross-sectional household observations. Table 7 shows the summary statistics of the variables used in this analysis. Data reveals that in Malawi, about 80% of rural households are headed by males who farm 1.15 hectares of maize compared to about 0.97 hectares of maize for female-headed households. A plot managed by a male has higher land rent and land value compared to female-headed farm households. This implies that female-headed farm households grows maize in less valuable land compared to male-headed farm households. A female-headed farm household uses more fertilizer (418 kg) both organic and inorganic, than male-headed farm households (353 kg). Pesticide use is minimal for both types of household. A female-headed farm household participates less (3.9 months/year) in ganyu labor compared to male-headed farm households (4.1 months/year). Ganyu is the word used to describe informal off-farm labor opportunities, which is the common survival strategy for the rural poor in Malawi (Sitienei et al., 2014; Takane, 2008).

Total quantity of maize sold and total value of sales are higher for male-headed farm households than female-headed households. However, the data reveals that the average quantity of maize output is higher for female-headed farm households (414 kg per year) compared to male-headed farm households (335 kg per year). Similarly, net income for female-headed households (2220 MK)³⁴ is higher than for male-headed households (2045 MK).

³⁴ MK denote Malawian Kwacha, measurement unit of money in Malawi. (1 US Dollar= 454.50 MK on data 2/20/15)

The family size of an average Malawi household is about four persons, but for female-headed households the average family size was about five. Mean farming experience, educational level, total livestock sales, and household size are higher in female-headed farm households than male-headed farm households. On the other hand, mean amount of seed use and total hired labors are higher for male-headed farm households. Similarly, male-headed farm households are likely to receive greater subsidies, participate in more off-farm activities, and be more food secure than female-headed farm households.

Table 7. Summary statistics of the variables

Variables	Female-headed households		Male-headed households	
	Mean	S.D.	Mean	S.D.
Land area (hectares)	0.97	0.79	1.15	9.59
Total value of sales	19048.4	40035.1	20835.56	49966.79
Sold quantity	49.16	150.48	56.54	244.29
Income	2219.59	63160.86	2045.01	15130.51
Farming experience (years)	21.26	18.10	14.40	13.31
Household size (number)	4.70	2.47	3.86	1.86
Capital	4705.89	25405.44	3569.01	20716.57
Total fertilizer (kg)	417.51	996.05	352.22	724.52
Months for ganyu (off-farm)	3.95	3.08	4.05	3.08
Education level (years of school)	2	1.27	1.40	0.96
Seed (kg)	14.14	50.27	20.19	78.98
Total hired labor (days)	1.41	7.09	1.53	6.61
Age of household head (years)	48	18.79	43	11.28
Output (kg)	414.39	1369.95	335.18	673.70
Marital status (=1 if married, 0=others)	0.78	0.33	0.67	0.29
Farm Input subsidies (=1 if yes, 0=otherwise)	0.28	0.45	0.30	0.46
Ext. service ¹ (=1 if yes, 0=otherwise)	0.82	0.36	0.83	0.37
Access to credit ² (=1 if yes, 0=access)	0.91	0.27	0.92	0.26
Food security ³ (=1 if yes, 0=otherwise)	0.51	0.49	0.74	0.44

Note: Mk denote Malawian Kwacha, measurement unit of money in Malawi.

Note: ¹ if the farmers receives extension services from agricultural agents.

² if applied for credit and received credit for farming activities.

³ If the farm household was food secure from the output of the farm.

4.4. Econometric Methods

Production functions have been widely used in the literature to estimate gender differences in productivity and technical efficiency. The two-stage approach for estimating technical efficiency has been criticized for inconsistency between the independency assumptions of u_{it} (inefficiency term) in the first step and the dependency assumption in the second step. Another criticism is that a firm's knowledge of its level of technical inefficiency influences its input choice, so subsequent inefficiency may be dependent on the explanatory variables (Wang and Schmidt, 2002). Therefore, we use one-stage simultaneous estimation approach in which the inefficiency effects are expressed as an explicit function of a vector of firm-specific variables (Chirwa, 2007; Wang and Schmidt, 2002). The mean of u_{it} is assumed to depend on exogenous variables. In African societies, men and women manage separate plots, so it is feasible to estimate the technical efficiency difference on those plots (Quisumbing, 1996). We use a separate stochastic production frontier approach for male-headed households and female-headed households and then compare the parameters of production function and coefficient of technical efficiency across gender. A two-stage stochastic production frontier as proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) is defined as

$$y_i = x_i\beta + v_i - u_i \quad , i = 1, \dots, N, \quad (1)$$

where y_i is the production (or the logarithm of the production) of the firm i ; x_i is a vector of inputs used by farm manager i ; β is an vector of unknown parameters; v_i is random error which is assumed to be identical and independently distributed; and u_i is non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be identical and independently distributed. This production function assumes both that land quality is the same for male-headed households and female-headed households. They both

produce the same output. The reason behind use of separate production function is to estimate managerial ability in the utilization of resources between male and female-headed farm households. A separate equation of stochastic production function as represented in Equation 1 is applied for female-headed farm households and male-headed farm households, which is defined as

$$Y_{it} = f(X_{it}; \beta) \exp(v_{it} - u_{it}) \quad (2)$$

where Y_{it} is a vector of maize output for i farm and t households $\{t = (f, m)\}$ managed by females Y_f and males Y_m ; X_{it} is the set of inputs (land, labor, capital, fertilizers, seeds) used in female and male-headed farm households; β is vector of parameters to be estimated, v_{it} is a vector of two-sided error term assumed to be identically and independently distributed; u_{it} is a vector of non-negative technical inefficiency component of the error terms.

Now, we are applying a single step stochastic production frontier using Cobb-Douglas functional form to Equation 2, which is expressed as

$$\ln Y_{if} = \alpha_0 + \sum_k \beta_k \ln X_{ifk} + v_i - u_i(z_{if}, \delta'); \quad u_i(z_{if}, \delta') \geq 1 \quad (3)$$

$$\ln Y_{im} = \alpha_0 + \sum_k \beta_k \ln X_{imk} + v_i - u_i(z_{im}, \delta'); \quad u_i(z_{im}, \delta') \geq 1 \quad (4)$$

$$\sigma_{u_f}^2 = \exp(\delta' z_{if}) \quad (5)$$

$$\sigma_{u_m}^2 = \exp(\delta' z_{im}) \quad (6)$$

where the subscripts i, f, m , and k represent farm, female, male, and inputs. The dependent variable in Equations 3 and 4 are the log-transformed output of maize in female-headed farm households and male-headed farm households, respectively. Inputs are seed, days of hired labor, maize cultivated area, capital used in farming, and amounts of fertilizer used in farming activities. The variance of the inefficiency for female-headed and male-headed farm households in Equation 5 and 6 are represented as $\sigma_{u_f}^2, \sigma_{u_m}^2$, respectively. The factors that can affect

technical inefficiency, represented by z_{it} where $t = (f, m)$, are subsidies coupons, months of ganyu labor (informal labor, worked for cash income, off the farm), marital status, extension services, access to credit, food security status of a family, age of household head, and education of household head. A technical efficiency (TE) of the farm is estimated as

$$TE_i = \exp(-\hat{u}_i), \quad 0 < TE_i < 1 \quad (7)$$

4.5. Results and Discussion

We performed a mean comparison test. Table 8 shows the results of mean comparison test for all variables. In the mean comparison test, land area, fertilizer, months of ganyu, farming experience, household size, capital, educational level, seed, total hired labor, age, maize output, and total livestock sales, as well as dummies for irrigation system, off-farm income, subsidies, extension services, and access to credit are significant at 5% level of significance between female-headed households and male-headed households, while pesticide use is found to be significant at 10%. Variables such as quantity of maize sold, total value of sales, medical costs, seed costs, number of farm visits by extension agent, net income, transportation costs for sales, and marital status are not significant.

The female-headed households in Malawi do more livestock transaction than male-headed households. The argument here could be that males value livestock ownership for cultural reasons such as payment of dowry, signs of wealth, etc., unlike females who strictly keep livestock for transactional purposes. Njuki et al., (2011) confirmed that women do manage and control the ownership and marketing of livestock. Results from this test show that use of resources between female-headed households and male-headed households is statistically significant.

Table 8. Mean comparison test results

Variables	Mean			T/Z score ^a
	Entire sample	Female HH	Male HH	
Land area	1.13	0.97	1.15	-2.72**
Total fertilizer	359.53	417.52	352.22	2.81**
Pesticide	0.14	0.08	0.15	-1.79**
Months of ganyu	4.04	3.95	4.05	-2.53**
Sold quantity	55.46	49.16	56.54	-1.14
Total value of sales	20572.01	19048.4	20835.56	-1.32
Farming experience	15.72	21.26	14.40	37.91**
Household size	4	5	4	57.61**
Capital	3735.28	4705.89	3569.02	7.18**
Medical cost	4815.27	4104.96	4988.51	-1.19
Educational level	1.45	1.82	1.40	50.80**
Seed	19.37	14.14	20.19	-4.69**
Seed cost	1134.12	1113.74	1137.33	-0.44
No. of farm visit by ext. age	1.42	1.68	1.38	1.24
Total hired labor	1.51	1.41	1.53	-2.46**
Income	2070.55	2219.59	2045.01	0.84
Age	43.21	47.7	42.5	57.54**
Output	346.07	414.39	335.18	6.14**
Transportation cost for sales	1072.41	1163.26	1056.69	0.77
Total sales of livestock	20962.73	243551.5	3186.54	4.40**
Irrigation	0.004	0.005	0.003	2.84**
Wetland	0.83	0.83	0.83	0.43
Marital status	0.69	0.78	0.67	0.56
Off-farm	0.96	0.95	0.96	-10.41**
Subsidies	0.30	0.28	0.30	-7.40**
Extension service	0.83	0.83	0.83	2.5**
Access to credit	0.92	0.91	0.92	-2.62**
Food security	0.71	0.51	0.74	-6.78**

Notes: * and ** indicate significance at the 10 and 5% level of significance, respectively.

^a The differences in means are obtained by subtracting means for farm households with female-headed from those of households with male-headed.

We applied separate single-stage stochastic production frontier function for female-headed farm households and male-headed farm households, respectively. A Cobb-Douglas production function was estimated using a half-normal distribution model. The estimated coefficient represents elasticity. Parameter estimates of both female-headed and male-headed farm households are presented in Table 9.

Table 9. Estimation of maize production and technical efficiency in the Malawi

Variables	Female-headed farm households	Male headed farm households
Seed (kg)	0.85**(8.92)	0.56*(1.92)
Land area (acres)	0.18**(3.10)	0.22** (3.56)
Labor (in days)	-0.08 (-0.76)	0.35** (3.76)
Capital	-0.52**(-3.22)	-0.42** (-2.22)
Fertilizer (kg)	0.16**(2.16)	0.07(1.06)
Constant	3.75**(6.28)	4.30**(4.80)
$\text{Ln}\sigma_v^2$	-0.92**(-5.46)	-1.87**(-4.21)
<i>Inefficiency components</i>		
Subsidies coupon	-4.17**(-2.83)	-3.29** (-2.33)
Months of ganyu	0.78**(2.19)	0.81**(2.91)
Marital status	-1.74**(-3.48)	-0.54** (-2.48)
Extension dummy	0.17(0.73)	0.16 (0.63)
Access to credit	-1.95**(-3.58)	-1.27** (-2.30)
Food security	0.89**(2.87)	0.40** (3.41)
Age	0.32**(3.09)	0.42**(3.19)
Education	-0.28(-0.08)	-0.18 (-0.07)
Constant	-2.77 (-1.35)	-3.19 (-1.45)

Notes: * and ** indicate significance at the 10 and 5% level of significance, respectively. Parentheses have *t*-statistics.

The estimated signs of the parameters are as expected. Results indicate that output of maize for female-headed farm households is affected by amount of seed, amount of fertilizer, land area, and capitals. All of these variables are significant at 5% level of significance. Total use of hired labor (days) is not significant. The coefficient of seed use is positive and significant which implies that with a 1% increase in seed amount, maize productivity would increase by 0.85%. Similarly, area of maize cultivated and amount of fertilizer use is also positive and

significant at 5% level of significance. The coefficient of capital is negative which implies that a 1% increase in capital used decreases the maize output by 0.52%.

In the case of male-headed farm households, output of maize is affected by land area, capital, seed, and labor days. The coefficient of maize cultivated area, capital, and labor is significant at 5% level of significance while seed variable is significant at 10%. Amount of fertilizer use is insignificant in the case of male-headed farm households. The only difference between female-headed and male-headed farm households is that fertilizer use is not significant in male-headed farm households and labor is not significant in female-headed farm households. Previous research notes that females comprise a major portion of agricultural labor in Malawi. A female head-of-household with her children spends more days on farm work than the members of male-headed households. This is mainly due to the lower income of female heads of households who have more household members, which forces them to rely more on agricultural wage income than their male counterparts (Takane, 2008). Since female-headed farm households cultivate maize in low fertilizer land and low value land, they use more fertilizer compared to male-headed farm households. Thus, in spite of having less land area available for cultivation, female-headed rural households have higher income and total output, indicating that female-headed households are more productive than male-headed rural households.

Table 9 provides the estimates for the factors that affect technical inefficiency of maize farmers. We find similar results and signs for both female-headed farm households and male-headed farm households. Technical inefficiency is affected by subsidies coupons, months of ganyu, marital status, credit constraints, food security, age, and education. For instance, households that were food insecure were technically inefficient. Older farm operators and those who participated in ganyu labor were also technically inefficient. On the other hand, negative

coefficients were obtained for subsidies, marital status, credit constraints, and educational level of farm operators indicating a negative correlation between technical inefficiency and these variables. A dummy variable for subsidy coupons is defined as those people who are getting subsidies from government. About 46% of male-headed farm households and about 42% of female-headed farm households received coupon subsidies. Our results show that female heads are less likely to receive any type of coupons, which is also concluded by Chibwana et al. (2010). As per our expectation, higher subsidies have significant and negative effects on technical inefficiency. In other words, a subsidy leads to increased technical efficiency of maize farmers. This is mainly due to the increased access to farm inputs which provide for poor Malawian maize farmers. This result is consistent with the findings of Darko and Ricker-Gilbert (2013).

Another variable, months of ganyu labor, is also significant and has a positive impact on technical inefficiency. This implies that if farmers participate in ganyu, they work away from their own farm and spend less time on their own fields which leads to increased technical inefficiency. This result is consistent with the findings of Edriss et al. (2004). On the other hand, if a head of household, either male-headed or female-headed, is married, technical inefficiency of farming is decreased. This may be due to married households investing more time on farming while an unmarried head-of-household focuses more on off-farm activities.

A dummy variable for access to credit, if farmers have applied for and received credit, is significant and is negatively related to technical inefficiency of farmers. This implies that increase of access to credit increases the technical efficiency of Malawian farmers. However, while about 38% of male-headed households receive credit, only 31% of female-headed farm households receive credit. A dummy variable for food security, whether a household is food secure, is positive and significant at 5% level. This implies that if a household is food secure by

any means, they are less efficient in farming. Age of a household head is also positive and significant at 5% level, meaning that as the household head age, technical inefficiency also increases.

Table 10 shows the summary statistics for technical efficiency for female-headed and male-headed farm households. We found a mean technical efficiency score of about 0.64 with standard deviation of 0.22 for female-headed farm households, while for men, the mean technical efficiency score was 0.58 with standard deviation of 0.16. Findings here suggest that, both female-headed and male-headed farming operations, still have room to improve technical efficiency given the existing inputs and technology. This demonstrates that technical efficiency was higher for female-headed farm households than male-headed farm households. A plausible reason could be related to the higher educational levels of female-headed farm households and their easy access to credit from local micro-finance and cooperatives, relative to male-headed farm households. Table 11 shows the distribution of technical efficiency for female-headed and male-headed farm households. About 60% of farms headed by females are operating at higher than 60% technical efficiency, while only 55% of male-headed farm households are operating at higher than 60% technical efficiency.

Table 10. Summary of technical efficiency

Summary statistics	Female-headed farm households	Male-headed farm households
Mean	0.64	0.58
Standard deviation	0.22	0.16
Min.	0.04	0.12
Max.	0.91	0.89

Table 11. Distribution of the TE of Malawi maize farmers

Range of TE	Female-headed farm households		Male-headed farm households	
	Frequency	% of farms in TE interval	Frequency	% of farms in TE interval
0.00<TE≤ 0.10	86	4.74	212	2.9
0.10<TE≤0.20	112	6.17	345	4.7
0.20<TE≤0.30	109	6.00	424	5.88
0.30<TE≤ 0.40	189	10.41	797	11.05
0.40<TE≤ 0.50	245	13.50	1,390	19.27
0.50<TE≤ 0.60	436	24.03	2,056	28.76
0.60<TE≤ 0.70	425	23.42	1,480	20.52
0.70<TE≤ 0.80	112	6.17	260	3.1
0.80<TE≤ 0.90	85	4.76	150	2.08
0.90<TE≤ 1.00	15	0.08	96	1.33
Total	1,814	100	7,210	100
TE	0.64		0.58	

In the light of these research results, it seems that substantial gains in outputs could be attained by using the existing technology on maize farms in Malawi, for both female-headed and male-headed farming operations. Under these circumstances, the policy implications are clear, regardless of the gender of the operator. Policy makers should focus on (i) enhancing farm inputs subsidies program, (ii) reducing dependence on cash income from off-farm labor supply, (iii) raising the educational level of operators, and (iv) providing farmers with greater access to credit in order to reduce technical inefficiency.

4.6. Summary and Conclusions

The majority of smallholders in Malawi are characterized by average landholdings of less than 1 hectare, which does not grow enough food to feed their families. Maize is the major food crop and tobacco is the major cash and export crop in Malawi. This paper explores the relative efficiency of maize producing farms in Malawi particularly focusing on the difference between male-headed households and female-headed households.

Findings from this study show that the level of technical efficiency among female-headed farm households is about 5% higher than male-headed farm households under similar conditions. Maize production is affected mainly by amount of seed, land area, capital, and labor. Technical efficiency increases with input subsidies coupons, which implies that input subsidies have a positive impact on technical efficiency of maize farmers—for both female-headed and male-headed farming operations. This implies that the FISP is playing an important role in improving technical efficiency of Malawian maize farming households. However, its success depends on socioeconomic conditions, climatic conditions, and the agricultural policy. Another positive factor for technical efficiency is access to credit. Although male-headed farm households receive more subsidies than their counterparts, female-headed farm households are technically more efficient. Additionally, the inefficiency effect model showed that factors such as access to credit, and marital status negatively influenced technical inefficiency, while age, food secure farming households, and off-farm income (ganyu) showed a positive relationship with inefficiency.

4.7. References

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CHAPTER 5: CONCLUSION

This dissertation provides new knowledge on the land ownership, gender role, and agriculture productivity in developing countries. The third and fourth chapters provide insights on the role of gender in agricultural productivity and efficiency of rural farmers in Philippines and Malawi. The second chapter provides evidence of land tenure status and the impact of land ownership on the productivity and technical efficiency of Filipino farmers. Land is a key factor in production agriculture and the land rental market is an important institution in agriculture. Rental activity of both sharecropped and fixed rent arrangements represent about 25% of cultivated land in the Philippines. The Comprehensive Agrarian Reform Program (CARP) of 1988, which essentially redistributes land to landless farmers, has implications for land ownership and farm productivity. This study uses a 2007-2012 Loop Survey from the International Rice Research Institute (IRRI). Findings of this study show that land ownership has a significant impact on technical efficiency. A mean technical efficiency score of 79 percent indicated that there is still room for improvement.

The third chapter provides knowledge on role of gender in agricultural productivity in Philippines. Rural women are involved in a variety of production and farm management activities. There is a significant increase in female-headed farm households in Philippines mainly due to social changes such as the migration of males, awareness of gender equity in society, rise in female labor force participation rates, and widowhood. The objectives of this chapter is to make compare similar female-headed farm households and male-headed farm households in terms of productivity parameters such as production cost (variable and fixed costs), farming efficiency, net farming income, total household income, and yield per hectare. A non-parametric approach and the nearest neighbor matching method was used. An interesting finding of this

study was that female-headed farm households have a higher value of production than male-headed farm households; however, they are less efficient in farming.

In the fourth chapter, we analyzed gender difference in farm productivity and technical efficiency of Malawian maize farmers. Our main purpose of this study is to examine the role of gender on farm productivity and technical efficiency in an African country. For this study, we use the third Integrated Household Survey data from Malawi. There is a growing interest in investigating gender-based farm productivity and efficiency issues across Africa. The pressure of population growth as well as greater off-farm employment opportunities for men have led to an increasing proportion of African households headed by women. This might have led to diminished technical efficiency in rural farms. We estimated maize productivity and technical efficiency in Malawi for male-headed and female-headed farm households, separately. Findings of this study reveal that female-headed farm households are 5 percent technically more efficient compared to male-headed farm households under similar farming conditions. Additionally, subsidies have a positive impact on technical efficiency of maize farmers. The Farm Input Subsidy Program plays a driving role in the increase in production by improving technical efficiency of rural Malawian households.

VITA

Koirala is from Chitwan, Nepal. He graduated BS from Institute of Agriculture and Animal Science, Tribhuvan University in 2006 majoring in Agriculture Economics. He then got opportunity to participate one year on the job training program conducted by Arava International Center for Agriculture Training (AICAT), Central Arava, Israel. After completion of training program, he joined in Local Initiatives for Biodiversity, Research, and Development (LI-BIRD) as enumerator for short period and in Sustainable Enterprise and Environmental Development Society (SEEDS) as project officer for a year. Afterward, he enrolled at University of Arkansas at Monticello to pursue a MS in forest economics. He graduate in 2012 and enrolled at Louisiana State University to pursue doctorate degree in agricultural economics. He got second MS in agriculture economics from Louisiana State University in May, 2015. He will be awarded doctoral degree in August, 2015.