HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

Doctoral School of Economic and Regional Sciences

ARMINGTON SUBSTITUTION ELASTICITIES AND TECHNICAL EFFICIENCY FOR VEGETABLE PRODUCTION IN MONGOLIA

PhD Dissertation

DOI: 10.54598/000650

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Gödöllő, Hungary

2021

Hungarian University of Agriculture and Life Sciences

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ACRONYMS

GDP- Gross Domestic Product

NSO- National Statistics Office of Mongolia

MOH – Ministry Health of Mongolia

WHO- World Health Organization

MOFA- Ministry of Food, Agriculture and Light Industry, Mongolia

SDC- Swiss Agency for Development and Cooperation

FAO- Food and Agriculture Organization of the United Nations

SFA-Stochastic Frontier Analysis

CES- Constant Elasticity of Substitution

MNT – Mongolian National currency, tugrik

$ – United States currency, dollar

WEIGHTS AND MEASURES

ha – Hectare

tn – ton

thous - thousand

km - kilometer

I. INTRODUCTION

Vegetables are one of the main varieties of vitamin food sources for humans and the main part of the staple diet. In Mongolia, vegetables are one of the main products of crop production after wheat and potato. After the crop production sector was established in 1957, Mongolian people started to mostly used potatoes and vegetables in the intake. Nowadays, Mongolian vegetable consumption has been 6 times lower than the recommended intake by the World Health Organization (WHO). Also, it has been 3 times lower than the Ministry Health of Mongolia (MOH). For example, monthly vegetable consumption per capita (by equivalent adults) was 2.1 kg in 2019 (National Statistics Office of Mongolia, 2019). In recent years, half of the population live in the urban area, who is commonly used to potato, cabbage, carrot, turnips, onion, garlic, cucumber, tomato, beets, and pepper. On the other hand, population food structure has been improving who has been using many types of vegetables in daily diet.

In Mongolia, there are planting a few varieties of vegetables due to the climatic extreme condition such as potato, cabbage, carrots, turnips, onions, garlic, cucumber, tomatoes, watermelon, and a small number of peppers, beet, etc. Potato is one of the main vegetables in Mongolia. In 2019, total vegetable production was 291.7 thousand tons, the potato production constituted 65.9% of its and while the remaining 34.1% accounted for vegetables. The Central and Western regions constituted 84.5% of its and while the remaining 15.5% accounted for East, Khangai, and Ulaanbaatar regions. Therefore, Selenge, Darkhan-Uul, Tuv (Central region), and Khovd (Western region) are the four main growing areas of vegetable production (including potato) composition with a share of 22.8%, 7.0%, 41.2%, and 7.6%, respectively (National Statistics Office of Mongolia, 2019). Also, the households' production dominates in vegetable production (approximately 77% of total vegetable production).

After a political and economic transition time, the crop sector has dropped, which was causing increasing vegetables import to supply excess demand of the population. After a massive collapse, the Mongolian government paid attention to this recession, the crop sector was substantially revived through a national campaign that was titled the "Atar-3 Land Rehabilitation" and implemented between 2008 and 2010. As a result of this program, we became fully self-sufficient in wheat and potato production. But until now, the vegetable market is a high reliance on vegetable imports such as a self-sufficient rate was approximately 60 percent (National Statistics Office of Mongolia, 2019). Also, there were implemented many projects to increase vegetable domestic production and possibly to supply domestic consumption. For example, "Mongol potato" (2004) and "Inclusive and sustainable vegetable production and marketing" (2016) projects by SDC

(Swiss Agency for Development and Cooperation, 2015), “Vegetable value chain program in Mongolia” project by (USAID, 2014), “Current situation analysis of vegetable value chain in Mongolia” (2016) Support to Employment Creation in Mongolia (SECiM) project by FAO and European Union (SECiM, 2016), “Community vegetable farming for livelihood improvement” (2017) project by Japan Fund (Japan Fund for Poverty Reduction, 2017), and Asian Development Bank (ADB) project for improving vegetable value chain to increasing income-generating and employment opportunities in rural areas (Asian Development Bank, 2020), etc. All the projects focused on how to improve the vegetable market situation especially, vegetable value chain mapping (sales, transportation), how to increase household revenue and to determine faced challenges to household vegetable production. Such as, according to the SDC report, the vegetable sector has a lot of challenges, for instance, there is a lot of old sorts of vegetable, lack of machinery, equipment and warehouse, profession and technical advice is not enough, households’ cooperative is low, lack of market information and lack of correspondence between household and public sector (Swiss Agency for Development and Cooperation, 2015). Therefore, as a result of the SDC project, there has improved seed production of vegetables, brought about a more convenient market for vegetables, and increased household production. However, agricultural productivity and efficiency studies (exception Bayarsaihan and Coelli, 2003) still seem to be rare but, there is no complex analysis for vegetable production.

This dissertation focused on the vegetable market analysis (especially substitution elasticity between import and domestic vegetable), and vegetable production technical efficiency (especially household level by using the Stochastic Frontier Analysis). Substitution elasticity called the Armington model is based on the assumption of products distinguished by place of production. In other words, it depends on the degree of substitutability between domestic products and import products (Armington, 1969). A greater elasticity indicates that consumers did not differentiate between domestic and imported products and consumers considered them similar. Therefore, this dissertation provides to define the home bias value using substitution elasticities. Finally, vegetables’ production efficiency has estimated by SFA (Aigner et al., 1976) method. Consequently, reliable our research results on the efficiency of vegetable production can help to contribute to policies that increase vegetable production, improving domestic food supplies for policymakers.

1.1 Problem statement

According to Maslow (1943) hierarchy of needs, foods are one of the physiological needs. Thus, peoples always face the challenges of using quality, nutrition, and safe food every day. Nowadays, food security, food safety, and sufficiency are considered to be very important concepts in every country. These concepts are defined as being able to access adequate food, available sufficient quantities of food on a consistent basis and obtain appropriate foods for a nutritious diet, and not being at risk of losing. According to the definition of the World Food Summit (1996), food security

> " *exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*".

In Mongolia, according to the "Law of Food", food security has defined as *"All people consume to sufficient, quality, safe and nutritious food that is does not matter economic, social and geographic conditions"* (Mongolian Government, 2012). Therefore, a standard population's optimal consumption was identified by Nutrition Research Center and by the statement of the Ministry of Health and Social Protection (former name) in 1997 which was defined 13 commodity groups (namely, meat and meat products, milk, dairy products, flour and flour products, all types of rice, sugars and sweeteners, potato, vegetables, fruits and berries, pulses, egg, and edible oil) by the National Statistical Organization, Ministry of Agriculture and Food, Nutrition Research Center associated with Mongolian Government announced "Food security year" of 2008.

Vegetables are more important components of a healthy diet. The main crops of Mongolia comprise the staple food of Mongolians are wheat, potato, and vegetables (Park et al., 2016). Currently, wheat and potato consumption has supplied 100 percent of domestic production but vegetable supply is still has been imported. However, vegetable production increased to meet approximately 60 percent of the supply level of domestic production in 2019 (National Statistics Office of Mongolia, 2019). Such as approximately 57.3 percent of cabbage, 64.1 percent of onion and garlic, 51.9 percent of melons, 20.7 percent of tomato, 9.3 percent of cucumber, and 5.2 percent of carrot and turnips consumptions provided by import vegetables in 2019. Therefore, most of the vegetables were imported from the People's Republic of China. For example, 80 % of the onion, garlic import, 99% of the cabbage, 60% of the carrot, turnips were imported from the People's Republic of China last year.

Based on the 2019 data from the National Statistical Office (NSO) of Mongolia, the monthly per capita consumption rates were about 2.6 kg/month for potatoes and 1.8 kg/month for vegetables, which is less than the 3.6 kg/month of potatoes and 7.2 kg/month of vegetables recommended by the Ministry of Health. While current potato production almost meets the per capita recommendation, vegetable production needs to be increased by around 75%. Also, vegetable consumption is 6 times lower than the recommended intake by WHO. Therefore, Mongolia has one of the highest incidences of cardiovascular disease (rank was #14 in the world), which is also the country's leading cause of death. One of the main reasons is lower fruit and vegetable consumption to increase the risk of noncommunicable diseases. It is evidenced that Mongolian people do not use to not too many vegetables every daily diet.

Thus, the Mongolian government attention to this situation, there were implemented many projects to increase vegetable domestic production and possible to supply domestic consumption. Mongolia has made strides to become self-sufficiency potato production, but until now, vegetable farming has received undeveloped and inefficient. However, agricultural productivity and efficiency studies (including Bayarsaihan and Coelli, 2003) still seem to be rare but, there is no efficiency analysis of household-level vegetable production. Many policymakers need to focused on improving productivity and efficiency as an important source of potential growth in vegetable production. Because vegetable production development causes vegetable household production regarding dominant vegetable production.

Nowadays, food safety and food sufficiency are considered very important, and as well as consumer consumption has been increasing. Indeed, we need to pay attention to the increase of food production (especially vegetable production) that meets the food hygiene standard, its consumption increase, and the full supply of domestic production.

1.2 Significance of the study

The vegetable is a primary healthy food staple. It shares a little part of the Mongolian's daily diet. But last a few years it has been changing due to urbanization and concentration. Such as, half of the population of Mongolian (approximately 1.5 million people) live in the urban area. For this reason, policymakers have become particularly concerned with vegetable domestic production. Thus, our research focuses on a substitute to possible domestic vegetable for import vegetable and focus on the efficiency of vegetable production. Also, our study characteristics are never being applied to a comprehensive study of vegetable production in Mongolia. Therefore, our study's significances are as follows:

First, it is determined a complex analysis of the vegetable market. Especially, it is characterized that estimated of substitution elasticity between import and domestic vegetable production using the Armington model. Also, we determined home bias value for vegetable consumption which indicates consumers' preference.

Second, the Armington model is characterized by product level. Most of the previous studies were focused on the industry level.

Finally, our study was characterized by applied technical efficiency analysis using household-level data.

1.3 Objectives of the study

In correspondence to the previously mentioned problems, the overall objective of this study is to analyze the current situation of the vegetable market, and determine technical efficiency level and investigate a recommendation for vegetable production for policymakers in Mongolia. The objective of this study will serve four main purposes:

First, it will describe an analysis of the vegetable market situation and main production location in Mongolia.

Second, it will present an estimation elasticity of substitution for import vegetables using the Armington model and home bias value in Mongolia.

Third, it will investigate the technical efficiency of vegetable household production and determine impact factors to technical efficiency in Mongolia.

Four, it will define recommendations for policymakers to make a consistent policy for increasing vegetable production, improving food supplies, and increasing household income in Mongolia.

1.4 Research questions and hypotheses

Based on the estimation of substitution elasticity using the Armington model objectives and the literature review the following hypotheses were formulated:

> *Hypotheses 1:* Long-run substitution elasticity higher than short-run substitution elasticity of vegetables
>
> *Hypotheses 2:* Home bias value in long-run is higher than short-run home bias value in vegetables
>
> *Hypotheses 3:* Vegetable import price elasticities are higher than domestic price elasticities.

Based on the technical efficiency of the household vegetable production objectives the below research questions:

1. Are vegetables household producers in Mongolia technically efficient?

2. What are the main influencing factors to vegetable household production? Does vegetable household's (smallholder) output value significantly and positively increase with the increase in inputs?
3. Is there any relationship between a vegetable household size (smallholder size is depending on land size) and technical efficiency?
4. What are the main factors that influence the technical efficiency of vegetable household production levels?

II. LITERATURE REVIEW

The literature review can be divided into 2 parts due to 2 studies in the thesis. The first part presents the Armington model. The first study aims to carry out research on the estimation of substitution elasticity between import and domestic vegetable production using the Armington model. Additionally, there is an estimated home bias value using substitution elasticities. Thus, first part of the literature review provides the theory of demand for differentiated by production place (called Armington model) and reviews selected studies relevant to the methodology involved in estimating with the Armington model.

The second part of the literature review provides efficiency. Because my study aims to determine technical efficiency level using the Stochastic Frontier Analysis (SFA) in the household vegetable production in Mongolia. Also, I can be provided influencing main factors to technical inefficiency and determine the inputs elasticity of production. Thus, the second part introduces the efficiency including technical, allocative, and economic efficiency, and reviews selected studies with respect to efficiency analysis.

2.1 A theory of demand for products differentiated by production place

In an open economy, each product can be differentiated by source of production. In other words, there are two types of products, domestically produced and import. Since 1970, a theory of demand for differentiation by production place has been used in international trade theory. In traditional theory of demand for tradable products is founded that products of a supplied in one country is a perfect substitute for same products of supplied by other countries. In other words, traditional trade theory is based on the assumption of perfect substitution. However, domestic products and imports are considered different. Thus, this theory presents products that are distinguished by their production place.

2.1.1 Armington model

Since the seminal work conducted by Armington (1969), called Armington elasticities have been widely used in international trade theory and trade policy. He formulated the theory of substitution elasticity related to consumer preference. This theory based on that consumer distinguish different varieties of goods by country of origin and obtain variables satisfaction depending on the country from which is imported. In other words, the Armington elasticities provide the degree of substitution demand between homogenous products of import and domestically produced. He explained that the procedure to analyze trade elasticities in products using two kinds of products such as machinery and chemicals produced in two different countries. Armington made two major assumptions. First, the buyer or importing country's substitution elasticity is constant without considering the share of a product. Second, a single substitution elasticity for each product pair within a market. Also, he supposed a two-stage procedure, assuming that at the first stage, the buyer or importing country decides on the total quantity to buy to maximize utility and then allocates a portion of the total quantity to individual suppliers in order to minimize the costs.

An early application of the Armington model in agriculture trade analysis Babula, (1987) stated that the Armington model has four advantages. First, the often observed two-stage buyer or importing country optimization procedure is endogenized in a manner consistent with the one-stage process and in a way, that does not violate Hicksian consumer theory. Second, reduced multicollinearity may arise from the model's weak separability. Third, further multicollinearity reductions may arise through indexing of collinear prices in both stages of the two-stages buyer or importing country optimization. Finally, it permits the price elasticities to be estimated indirectly.

After that, many researchers (Lundmark and Shahrammehr, 2011; Kawashima and Puspito, 2010; Welsch, 2008; Gallaway et al., 2003; Lopez and Pagoulatos, 2002; Blonigen and Wilson, 1999; Reinert and Roland-Holst, 1992) have studied to use the Armington model in comprehensive manufacturing industries. Besides, it has been used in computable general equilibrium (CGE) model such as, (Olekseyuk and Schürenberg-Frosch, 2016; Németh et al., 2011; Ha Son Jung et al., 2009; Kerkelä, 2008; Zhang and Verikios, 2006). Therefore, sub-industry level estimates of the Armington elasticities have appeared in agriculture and forest sector. For example, (Wunderlich and Kohler, 2018; Baraouki et al., 2011; Lundmark and Shahrammehr, 2011; Song, 2005; Lopez and Pagoulatos, 2002; Kapuscinski and Warr, 1999).

One of the systematic review papers has written by McDaniel and Balistreri, (2002) have pointed out some findings with respect to Armington elasticities based on previous studies. They found that three robust findings from the econometric literature. In addition, Olekseyuk and Schürenberg-Frosch (2016) mentioned that adding one more finding - micro elasticity find higher than macro elasticity. Table 1 shows the main findings based on Armington's previous studies results.

Armington elasticity presents a degree of substitution between products imports and produced domestically. If elasticity is higher, it indicates that domestic products are easier to substitute with import products. In other words, these two products are fairly homogenous products for consumers. Conversely, a low value of substitution elasticity means that the two products are dissimilar and weak substitutes. The traditional trade theory is indicated on the assumption of perfect substitution between import and domestically produced products. But Armington model is based on imperfect substitution products that are differentiated not only by their kind but also by their production place. Most of the previous studies' results showed that long-run elasticities are higher than short-run elasticities which means that there is no discrimination between domestically produced and imported goods in the long-run compared to the short-run.

Table 1. Main some findings have appeared by McDaniel and Balistreri (2002) based on the previous studies.

Robust findings	Meaning of elasticities	References
Long-term elasticities are larger than short-term elasticities	Long-term elasticities are larger than short-term elasticities. It means that substitution between domestically produced and imported goods are easily made in the long-term compared to in the short-term.	Baraouki et al., 2011; Gallaway et al., 2003; Whalley and Xin, 2009; Gan, 2006; Gibson, 2003; Welsch, 2006; Lundmark and Shahrammehr, 2011; Aspalter, 2016; Kapuscinski and Warr, 1999; Blonigen and Wilson, 1999; Lopez and Pagoulatos, 2002.
Micro-elasticities are higher than macro elasticities	The "micro"-elasticity which defines the ease of substitution between foreign goods of different origins is much higher than the "macro"-elasticity between domestic and foreign goods. This point, too, is quite intuitive especially in the context of a large gap in technology between the respective country and its trading partners.	Németh et al., 2011; Aspalter, 2016; Feenstra et al., 2016, Hanrahan et al, 2001.
More disaggregate analyses find higher elasticities	The estimated elasticities increase with the degree of disaggregation in the data. As more disaggregated data contains sectors that are more homogeneous in the produced goods and, higher in their international substitutability.	Aspalter, 2016; Gallaway et al., 2003; Welsch, 2006; Reinert and Roland-Holst, 1992; Tourinho et al., 2003; Huchet and Pishbahar, 2008; Welsch, 2008.
Time-series studies are smaller than cross-sectional data studies	Time-series studies find rather small elasticities compared to cross-sectional studies.	Gan, 2006; Gibson, 2003; Welsch, 2006; Kapuscinski and Warr, 1999, Shiells and Reinert (1993).

Source: Own description based on Olekseyuk and Schürenberg-Frosch, (2016).

Armington macro elasticity of substitution indicates that between import and domestic products, while micro elasticity of substitution shows that between different import sources Aspalter, (2016). Macro elasticities are lower than micro elasticities such as, Németh et al., (2011) have been to estimate the European countries industrial sectoral elasticities of the two nesting models (substitution between domestically produced products and imported products-macro elasticity; substitution between imported goods according to the country of origin-micro elasticity). They found that macro elasticities are lower than micro elasticities in European countries. The work of the Feenstra et al., (2016) has identified micro and macro elasticities in the U.S disaggregate data between 1992 and 2007. Also, they indicated macro elasticities are lower than micro elasticities. Indeed, Olekseyuk and Schürenberg-Frosch, (2016) mentioned that micro elasticity is higher than macro elasticity is related to countries' technology characteristics and trading partners.

McDaniel and Balistreri, (2002) have found that elasticities of substitution analysis are higher elasticities using more disaggregation data. Also, Olekseyuk and Schürenberg-Frosch have stated that aggregation data used for the CGE model. These findings confirmed by (Németh et al., 2011; Ha Son Jung et al., 2009; Welsch, 2008). Some of the Armington elasticities estimates have appeared using disaggregated data confirmed by (Gallaway et al., 2003; Gibson, 2003; Tourinho et al., 2003; Welsch, 2006; Feenstra et al., 2016). Armington estimates are using single country and time-series data and there is a few number studies of cross-section data or panel data analysis (Olekseyuk and Schürenberg-Frosch, 2016; Welsch, 2008) etc.

Armington elasticities estimation studies provide very different results depending on the country, estimation method, data types (time-series, cross-section or panel data) and industry level (aggregation or disaggregation level). I tried to classify Armington elasticities studies based on an industry level. Table 2 describes the review results of the some studies. There are including proxy studies of U.S data case, Philippines data case, South African data case, Brazilian data case, and European countries cases. Interestingly, the Armington estimates for agriculture, forestry and fishery, food, beverages, tobacco, textile, wearing apparel, clothing, coke, steel, petroleum, transport vehicles, and equipment’s elasticities found to import elastic (approximately average elasticity coefficient $\sigma \geq 1$), while rubber and plastic products, wood and paper products, metal and chemical products, machinery including electronical equipment’s elasticities were considered moderately import sensitive (Table 2, approximately average elasticity coefficient $0.5 \leq \sigma < 1$).

Table 2. Armington elasticities range based on empirical studies

Industries name	Reinert and Roland -Holst, (1992)	Kapuscinski and Warr, (1999)	Gallaway et al., (2003)	Gibson, (2003)	Tourinho et al., (2003)	Welsch, (2008)	Olekseyuk and Schürenberg-Frosch, (2016)
Agriculture, forestry and fishery products	0.35-1.99	0.2-3.8	-0.07-1.69	1.27	2.68-3.18	0.08-1.41	-
Manufacturing sectors (Food, beverages, tobacco)	0.02-3.49	0.03-1.07	-0.27-3.13	0.94-1.57	0.95-2.47	0.05-0.85	1.3-1.9
Manufacturing sectors (textile, clothing and leather products)	0.45-2.53	0.03-0.1	0.08-1.61	1.16-2.04	0.15-2.34	0.16-1.49	1.2-1.4
Mining, coke, petroleum, gas and fuel	0.16-1.22	3.06	0.15-1.18	0.73-2.77	0.38-0.6	0.39-0.92	0.6-0.8
Wood and paper products	0.05-1.68	0.03-0.7	0.39-1.54	0.08-1.21	0.51-1.58	0.21-0.42	0.02-2.95
Rubber and plastic products	0.01-1.71	-	0.34-1.22	0.27-1.14	1.08-1.22	0.05-3.16	0.56-0.89
Metal and fabricated metal products	0.22-3.08	0.16-0.42	0.35-1.21	0.59-0.74	0.47-0.51	0.004-0.91	0.57-1.25
Chemical products	0.4-0.67	-	0.71-1.18	0.67-0.79	0.58-1.51	0.12-1.88	0.87-0.88
Machinery and equipment	0.2-1.06	-	0.18-1.21	0.49-0.74	1.84	0.22-2.43	0.92
Electronic, computer, optical and electrical equipment	0.02-2.69	1.56-2.05	0.2-1.38	0.44-1.43	0.18-0.2	0.41-1.49	0.2-0.59
Transport vehicles and equipment	0.3-1.73	1.04-2.04	0.46-1.66	0.86	0.19-5.28	1.54-1.85	1.13-1.41

Source: Own description based on previous studies

Wunderlich and Kohler (2018) mentioned that Armington's elasticity for agriculture sectors is lower than other sectors especially, investment and high-added value sectors. Therefore, they discussed that this fact might be due to home bias. Because most of the countries implement many programs to buy home-produced products such as to protect for home-produced production. In other words, there is might be an increased differentiation between import and home-produced products.

A number of studies have identified explaining variables for the different elasticities across the industries. For instance, Blonigen and Wilson (1999) attempted to explain differences in Armington elasticities across industries in the United States. The authors choose the explanatory variables using three specifications: First, variables reveal discrimination of current products second, variables that show multinational companies role in U.S market and finally, variables as a proxy for political and economic variables. They defined nine explanatory variables are ratio of industry imports from developing countries, ratio of industry shipments for final consumption, the ratio of industry owned by a foreign parent, the ratio of downstream industrial consumers owned by a foreign parent, downstream importers, median firm size, dummy variables for the industry to protections and ratio of union workers in the industry. Empirical results have found that one of the strong variables affecting to substitution elasticity between domestic and import products is the presence of foreign-owned industries. Lopez and Pagoulatos, (2002) studied substitution elasticities of the United States food industry. The authors described three variables which are advertising cost for each industry, foreign direct investment, and the percentage of total output sold to final consumers. They found that foreign firms more efforts to affecting greater substitutability between foreign and domestic goods. Therefore, consumers willing to buy domestic products due to domestic firms are more spending cost on advertising.

The last 50 years have yielded a large body of research on Armington elasticities studies closely related issues: Armington's trade models and import demand, Armington elasticities for trade policy, home bias, and border effect in Armington model, Armington elasticities, and computable general equilibrium model (CGE), etc. We divided 4 categories with respect to estimating Armington elasticities.

The first, Armington elasticities of substitution studies, which was leading degree of substitutability between domestic goods and import goods and comparative studies between Armington demand elasticities and other import demand theory such as, AIDS (almost ideal demand system) model, affecting factors to Armington elasticities. For example, many of studies namely, (Alaouze et al., 1977; Marquez, 1988; Babula, 1987; Shiells et al., 1988; Alston et al., 1990; Ito et al., 1990; Yang and Koo, 1993; Davis and Kruse, 1993; Song, 2005) have pointed out that the simple Armington model assumes a number of restrictive assumptions on consumer utility maximization behavior. For example, Firstly, the Armington model assumes that utility over the domestic and foreign good in each industry is weakly separable from the total utility. This means the marginal rate of substitution between home and foreign good is independent of the consumption of goods in other industries. Secondly, the constant elasticity of substitution (CES) functional form further assumes weak separability between the domestic and the foreign good within the sub-utility group. Lastly, demands are assumed homothetic, which is seen in the fact that relative market shares are independent of total expenditures on the import and domestic goods.

Alston et al., (1990) the study test to restriction of Armington assumptions. The Armington model assumes that import demands are homothetic[1] and separable among import sources. Accordingly, within a market, trade designs change just with relative price changes, and the elasticities of substitution between all sets of products (e.g., between the United States and Canadian wheat) are indistinguishable and consistent. These assumptions are strong limitations on demand. in this way, they examined these limitations by three import demand approach. First, nonparametric methods. This methodology provides a complete test of the hypothesis in question with no extra assumptions concerning functional form. Second, the Armington model is evaluated and tried as a nested model characterized by a set of parametric limitations on a double-log import demand model joining the complete set of relative prices. Finally, the almost ideal demand system (AIDS) of Deaton and Muellbauer (1980) is utilized to evaluate the parameters of the import demand equations, and Armington limitations are tried parametrically. The Armington limitations are rejected by the data but, rather, regardless of the resulting elasticity estimates are significantly one-sided.

A second concern is the application of the standard Armington model. There are a number of studies, including, (Wunderlich and Kohler, 2018; Olekseyuk and Schürenberg-Frosch, 2016; Aspalter, 2016; Feenstra et al., 2016; Schürenberg-frosch, 2015; Lundmark and Shahrammehr, 2011; Welsch, 2008; Gallaway et al., 2003; Gibson, 2003; Lopez and Pagoulatos, 2002; Plassmann, 2005; Zahoor and Muhammad, 2005; Gan, 2006) are used to standard model. These studies have pointed out the long-run and short-run estimation of Armington elasticities at the comprehensive manufacturing industry level. Most of the studies concerning using the United States' data. Kapuscinski and Warr, (1999) focused on Philippines data in the Asian country. This study estimates the elasticities of substitution in demand between the imported and domestically produced over 30 tradable products. Some of the studies are based on European countries and some of the studies in South Africa and Australia. Hence, the Armington elasticity of industrial level assumes a key role in applied modeling that is regularly used to evaluate ex-ante economy-wide effects of policy changes, such as tariffs and taxes. Indeed, applied partial equilibrium and general equilibrium models used to examine trade policy are all around sensitive to trade elasticities. While the Armington assumption impressively rearranges the task of parameterizing a

[1] -We called homothetic consumer's preference If utility function represented by homogeneous of degree

multi-region trade model, the trade-substitution elasticity is a key behavioral parameter that drives the quantitative, and sometimes qualitative, outcomes utilized by policymakers. Concept of these elasticities is important for computable general equilibrium (CGE) policy modeling, because the degree to which a policy change will influence a country's trade balance, level of income, and employment rely on the size of the elasticity utilized in the model.

Aspalter, (2016) estimated Armington elasticities for a panel of 15 European Monetary Union (EMU) the Member States utilizing highly disaggregated data. Empirical results indicate a significant difference between micro and macro elasticities for up to one-half of the consistent product groups considered, suggesting preferences over EMU countries are not perfectly lined up with non-discriminatory tariffs. Median ordinary least square estimates for the micro elasticity range between 0.928 and 1.076, for the macro elasticity between 0.661 and 0.896.

Gibson, (2003) attempted to estimate substitution elasticities at the industry level in South Africa. The study determined elasticities of the forty-five-industry sector in the short-run and long run. Also, it analyzed policy effects in South Africa. The results show that short-run elasticities estimated in coal mining - 2.771, footwear - 2.04, beverages - 1.57, leather and leather products - 1.474 and tobacco - 1.35, catering and accommodation services - 0.42, basic chemicals - 0.677 and coke and refined petroleum products - 0.73 as well as result relevant to long-run elasticity estimates are obtained only three sectors which were civil engineering and other construction - 2.688, building construction - 2.1, and tobacco - 0.676.

Gallaway et al., (2003) have pointed out estimation of Armington elasticity of 309 industry level - four-digit U.S. Standard Industrial Classification (SIC) in long-run and short-run in the United States. The study focused on trade policy analysis generally interpreted as the long-run effects of policy changes. The results show that the long-run estimates are twice as large as the short-run estimates, and overall up to five times larger than the long-run estimates. Specifically, 277 industry-level short-run estimates were statistically significant and of the correct sign, and of the 118 long-run estimates, 83 were statistically significant and of the right sign.

The third is including studies of home bias and border effect in the Armington model. number of researchers (Trefler, 1995; Mccallum, 1995; Hillberry et al., 2005; Brulhart and Trionfetti, 2009; Whalley and Xin, 2009) have analyzed with respect to estimating elasticities of substitution for home bias and border effect. For example, Mccallum, (1995) has focused on the size of the trade-substitution elasticity is significant in the discussion regarding the "border effect". International borders are reducing trade flows among countries but the extent relies upon the degree of substitutability between domestic and imported goods. Also, Trefler, (1995) used an Armington assumption to represent home bias. He found that the Armington assumption suspicion clarifies why trade over nations is such a great amount lower than that predicted by conventional trade theory. That the Armington assumption suspicion clarifies what Trefler calls “the case of missing trade” opens various inquiries concerning the determinants of consumer preferences that lead to bringing lower trade volumes.

Whalley and Xin, (2009) argue that numerous biases can operate in Armington trade models with different domestic regions and two or more countries and related trade impacts can occur either across or within borders. These biases can be isolated out one from another (such as a traditional home bias or a regional bias) in generating any trade (or border) impact the model yields as an answer. All Armington models unavoidably imply bias (or distinction) in behavior in respect to a equivalent homogeneous products model since changes in world prices (or a tariff) are not completely transmitted to domestic prices and trade impacts are smaller than in the case of homogeneous goods.

Blonigen and Wilson (1999) have estimated Armington elasticities between United States domestic and foreign goods across almost 150 industrial sectors at 3 digit-industrial Standard Industrial Classification (SIC) level from 1980-1988 and examined the role of product, industry, political, and “home bias” factors as determinants. The results showed that the average Armington elasticities were 0.81. For the second stage, they examined the influencing factors for explaining the differentiation in Armington elasticities. They choose the nine explaining variables which were the ratio of industry imports from developing countries, the ratio of industry shipments for final consumption, the ratio of the industry by a foreign parent, the ratio of downstream inputs that imported, the ratio of domestic downstream industrial users owned by foreign parents, downstream importers and downstream foreign-owned, firm size, a dummy variable for whether industry subject to protection or protectionist threat and ratio of union workers in the industry. One of the main strong influencing factors was the presence of multinational organizations such as, foreign-owned companies which affected Armington's elasticities in important ways, and some support that entry barriers and union current situation have an effect it. Also, they tried to home bias solely in terms of preferences in the home country and provide a measure of home bias that links the elasticity of substitution and the estimated intercept from Armington elasticity regressions. They claim home bias in their sense is removed by setting equal share parameters on domestic and foreign goods. They found that 124 of the 151 sectors (82 percent) home bias’s coefficient was higher than 0.5, suggesting a higher relative weight on the home good. They suggested 3 assumptions for determinants of home bias. First, as hypothesized, home bias is larger in sectors with a greater share of imports from developing countries. This means that from actual or perceived quality differences. Second, home bias is lower for goods that are more likely destined for final consumption than as intermediate inputs. Lastly, some evidence that the current situation of the foreign-owned company in the sector reduces home bias. Therefore, their study results approved the last assumption.

Fourth, a number of recent studies have estimated Armington elasticities at an industrial level and computable general equilibrium (CGE) related to trade terms effect. CGE models are broadly used for policy evaluation and impact analysis. In other words, CGE models are a class of economic models that use actual economic data to evaluate how an economy may respond to changes in policy, technology, or other external factors. These models have been utilized to study the economic impacts of trade policies, such as tariffs and non-tariff barriers (NTBs), also the impact of trade liberalization on an economy, in an assortment of settings (Blonigen and Wilson, 1999). CGE models are valuable to model the economies of countries for which time series data are rare or not significant, which might be because of disturbances such as regime changes. Substitution elasticities in policy-oriented computable general equilibrium (CGE) models are key parameters for model outcomes since they define to conduct in these models. These elasticities are well known for their critical role in defining model outcomes. Some of authors (Zang, 2008; Welsch, 2008; Lloyd and Zhang, 2006; Zhang, 2006; Schürenberg-Frosch, 2015) have pointed out elasticities of substitution with respect to CGE model.

Olekseyuk and Schürenberg-Frosch, (2016) were studied Armington elasticities in European countries. Also, they illustrated CGE application in these countries. In other words, how impact trade policy to welfare of country. Huchet and Pishbahar, (2008) attempted to respond to the following questions: First: Does the inclusion of import tariffs in the specification lead to different estimated Armington elasticities in rice import of EU? Second: When a discriminating tariff is introduced, what happens to the market access of large rice exporters to the EU, especially the less-developing countries). Also, they used the homothetic and non-homothetic CES function to estimated Armington elasticity with and without tariff. Their empirical findings were the assumption of homotheticity was valid only for specific cases and ignoring the import tariff when estimating Armington elasticities may cause them to be underestimated. Therefore, it was worthwhile considering non-homothetic preferences and ignoring tariffs and subsistence-level requirements when estimating the model may also lead to biased results.

2.1.2 Armington elasticities in the agricultural sector

The agricultural sector is the most important sector and the main core of food safety in every country. Armington elasticities are one of the main instruments in foreign trade policy.

Specifically, Armington elasticity is often used to assess to effects of trade policy and policy changes such as tariffs and taxes. Indeed, we provide the analysis of Armington elasticities in the agricultural sector. The substitution elasticity (Armington elasticity) has become increasingly popular in agricultural trade analysis (Wunderlich and Kohler, 2018; Zeraatkish et al., 2018; Song, 2005; Lopez and Pagoulatos, 2002; Ito et al., 1990; Lundmark and Shahrammehr, 2011).

Wunderlich and Kohler, (2018) have found that agricultural some products' substitution elasticities lower than previous studies (for example elasticities ≤0.5) for Swiss consumers. In other words, Swiss people indicate more preference for domestic products than importing products in agricultural production. Also, this study defined that price elasticities for some agricultural products. For example, estimated elasticity for dairy products was -0.6, oil and fats elasticities were -0.09, fruits and vegetables elasticities were -0.6, etc. Estimated price elasticities for agricultural products, which were confirmed that agricultural products are necessities of daily life goods with inelastic and lower elasticities.

Zeraatkish et al., (2018) studied substitution elasticity of Armington and transmission elasticity in fishery products in Iran. The study results showed that Armington elasticity in the long-term was greater than that in the short-term and the prices of these products have been influenced by global prices and the swings in global prices can be transported all the more effectively to the internal market for these products in the long-term than in the short-term. For the fishery products, whose import demands are elastic to import prices, it is expected that the decline of import prices by tariff reduction results in the expansion in import demands, and afterward the loss of domestic production of these products. In this way, the policies for these sectors should be the ones that help to rebuild these sectors instead of the ones bringing about the abundance supply.

Ogundeji, (2007) was to estimate Armington elasticities for selected agricultural products in South Africa. The products considered in the study, as specified under the harmonized system, were the meat of bovine animals (fresh or chilled), the meat of bovine animals (frozen), the meat of swine (fresh, chilled, or frozen), maize or corn, wheat, soybeans (broken or not broken), and sunflower seeds (broken or not broken). The result indicates short-run elasticities range from 0.60 to 3.31 and long-run elasticities range from 0.73 to 3.21. Considering the long-run elasticity results, the meat of bovine animals (frozen) is the most import-sensitive product followed by maize, the meat of bovine animals (fresh or chilled), and sunflower seed, while wheat and the meat of swine (fresh, chilled, or frozen) are the least import- sensitive products. Regarding short-run elasticities, soybeans are the most import-sensitive product followed by the meat of bovine animals (fresh or chilled), while the meat of swine (fresh, chilled, or frozen) is the least import-sensitive product. The study also considered the seasonality of agricultural products by including dummy variables in the estimated equations. Dummy variables for livestock products were found to be statistically insignificant, except for quarter four for the meat of swine (fresh, chilled, or frozen).

Song, (2005) studied econometric estimates of import-demand elasticities for the agricultural sectors in Korea using the data classified following HS (Harmonized System) from five aggregated agricultural sectors (grains, livestock products, dairy products, fruits, and vegetables) to 27 disaggregated agricultural sectors using Armington specification. This specification is regarded as an adequate approximation of the functional form of an import-demand equation. Based on the Armington approach, it is assumed that consumers distinguish goods by their source, which means consumers differentiated between domestic goods and their imported goods. The study used two estimation methods. One was the ordinary least squares (OLS) with first-order autoregressive correction (AR1) and the second method was the two-stage least squares (2SLS) with first-order autoregressive correction (AR1). The study result showed that both domestic and import prices rarely affect import-demands in the aggregated level except in the sectors of vegetables and livestock products. At the disaggregated level, import demands of the products that are classified as livestock products tend to be highly elastic to import prices. A special feature of these products such as vegetable’s domestic price elasticity smaller than import price elasticity. But disaggregate level, for garlic, import demand was highly elastic to domestic price. Thus, the difference between the import price and domestic price of garlic is very significant in determining the import demand for garlic. This implies that the relative price of garlic affects the import demand it. Therefore, cabbage and onion’s import price elasticity was greater than domestic price elasticity, carrot, corm’s import price elasticity was smaller than domestic price elasticity.

Lopez and Pagoulatos, (2002) estimated that Armington elasticities for 40 4-digit Standard Industrial Classification (S.I.C) food manufacturing industries in the U.S and explained variables affecting to difference elasticities across industries. Using time-series data between 1977 and 1992, they obtained seven food manufacturing industries. Elasticities were estimated between 0.09 for wines, brandy, and spirits and 5.93 for soybean oil mills. In other words, the elasticities result showed that quite large. Therefore, they determined explanatory variables in differentiation elasticities across industries following Blonigen and Wilson's (1999) approach. The authors concluded foreign firm's efforts for downstream producers and foreign direct investments are affecting greater substitutability between foreign and domestic goods.

Yang and Koo, (1993), this paper builds up a generalized Armington model, which relaxes the single CES and homotheticity limitations, and includes the Armington model as a special case. The Armington and generalized Armington trade models are connected to the Japanese meat import demand to show their performance. The empirical study applied to the Japanese import demand for red meat showed that the single CES and homotheticity assumptions are not maintained. The Armington model gives one-sided estimates because the data do not support those assumptions. The price elasticities tend to be underestimated with the Armington model when applied to Japanese meat import demand. The expenditure elasticities from the generalized Armington model differ significantly for all products, and the United States has the largest expenditure elasticity. (Ito et al., 1990), this study examines the assumptions commonly made when using the Armington procedure and suggests modifications for agricultural trade analyses. But they used to estimate with two types of Armington model which was the original model (single CES and homothetic) and modified model (multi - CES and non-homothetic). Study results indicate that the assumption of the single - CES is not reliable with the data for world rice markets. Moreover, homotheticity is not an appropriate assumption for this market. Based on changed second-stage equations, some interesting empirical results were acquired. Specifically, it gives the idea that importers are quite sensitive to relative prices. This result is steady with the way that the world market for rice is quite small relative to total rice production.

2.2 Efficiency concept and efficiency measurement

Efficiency is one of the most important concepts in production. Efficiency analysis has significance in determining the possibility to increase the productivity of the firm, improving uses of inputs, and ability to increase their competitiveness. Therefore, efficiency analysis help policymakers process optimal policy for producers. This part has been written for the efficiency concept.

2.2.1 Technical, allocative, and economic efficiency concept

According to the neoclassical paradigm, those producers are successful optimizers in that firm (farm, producers) produce maximum outputs and profits given the technology in place and the resources that are available (Kumbhakar et al., 2015). Also, producers as efficient operators, maximizing their output (revenue) and profit, minimizing their cost, and pursuing other behaviors/objectives.

The efficiency analysis focus on the efficiency of some production process transforming inputs to outputs. For example, we face to below questions according to efficiency.

- How much more can we produce with a given level of inputs?
- How much input reduction is possible to produce a given level of observed output?
- How much more revenue can be generated with a given level of inputs? Similarly, how much reduction in input costs of achieved?

The concept of efficiency measurement started by Farrell (1957), which gave that the efficiency of a firm comprises of two parts. One of the parts is technical efficiency, another one is allocative efficiency. Technical efficiency can create produce a maximum output from a given set of inputs, or where output levels are fixed with minimum inputs. In other words, technical efficiency is expressed as the side of production and defined as the level of production that ratio between the observed output to the potential output. Allocative efficiency can create produce a possible joining output at least expense, or use inputs in optimal proportions for given input prices and technology. If the firm has both technical and allocative efficiency, a firm is said to be economically efficient (Coelli et al., 2005).

Figure 1 illustrates technical and allocative efficiency. According to Farrell's illustration, a glance at figure 1 shows that technical efficiency and allocative efficiency. The firm use two inputs (z_1 and z_2) to produce a single output (A). CC′ curve is the isoquant curve and QQ′ line is the iso-cost line. There are serve to the assumption of constant return to scale. A firm is said to be fully efficient if it is represented by CC′ in Figure 1. OP line indicates production frontier using the two inputs in the same ratio.

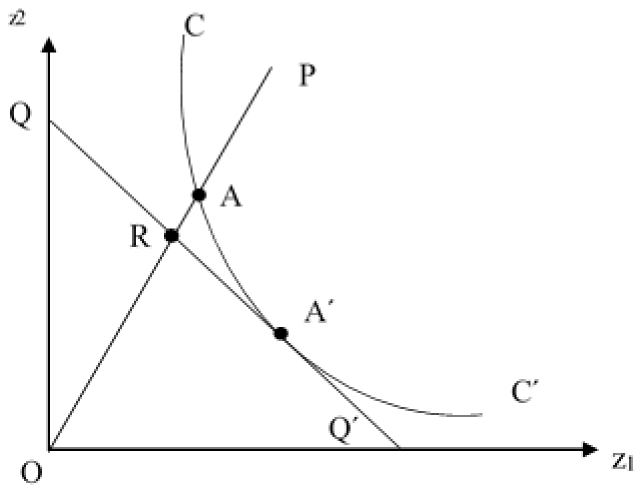

Figure 1. Technical and allocative efficiency

Source: Kumbhakar et al., (2015)

Isoquant demonstrates that fully efficient circumstance. In any cases, there are not known practically speaking. If a given firm uses quantities of inputs, determined by the point P, to produce a unit of output, the technical inefficiency of that firm could be represented by the distance AP, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is normally expressed in percentage terms by the ratio AP/OP, which represents the percentage by which all inputs need to be decreased to achieve technically efficient production. The technical efficiency (TE) of a firm is most generally estimated by the ratio

$$TE = \frac{OA}{OP} \quad (2.1)$$

which is equal to one minus AP/OP. It takes a value between zero and one, and, hence, provides an indicator of the degree of technical efficiency of the firm. A value of one implies that the firm is fully technically efficient. For example, point A is technically efficient because it lies on the efficient isoquant (Coelli et al., 2005). Technical efficiency is a measure of how well the individual transforms inputs into a set of outputs based on a given set of technology and economic factors. Following Farrell, the concept of allocative efficiency (also called "price efficiency") is related to the ability of the firm to choose its inputs in a cost-minimizing way. It reflects whether a technically efficient firm produces at the lowest possible cost.

Allocative efficiency (AE) is represented at point A′ because it is the touchpoint of isoquant and the budget line QQ′. At this point the proportion of inputs is optimal and the same amount of output is produced at minimum cost. Allocative efficiency is measured by the ratio

$$AE = \frac{OR}{OA} \quad (2.2)$$

Economic efficiency would be the production technical efficiency and allocative efficiency. The economic efficiency point is A′ (Figure 1). Economic efficiency related to the structure of agriculture, the survival of the family farm, the impacts of agriculture policy on smaller farmers have stayed controversial. It has been motivated in large part by an attempt to distinguish the factors affecting the efficiency of resource allocation in agriculture (Chavas and Aliber, 1993).

There are two measurements of efficiency which are input-oriented (IO) and output-oriented (OO). In other words, technical efficiency is measured as the ratio between the observed outputs to the maximum outputs level that can be produced for given inputs (called output-oriented “OO”), or as the ratio between the minimum inputs to the observed inputs under the assumption of fixed outputs, called input-oriented “IO” (Coelli et al., 2005). In Figure 2, point A is the observed input combination. If the production is technically efficient, the input combination at point A should produce output level y_1. In this occurrence, the isoquant passing through point A is on the shape of the production corn, and thus, it represents the frontier production level (i.e., A lies on the frontier on a plane above y_0 at $y = y_1$). However, with technical inefficiency, inputs at point A only produce observed output level y_0, where y_0/y_1 (i.e., A lies inside the frontier on a plane below y_1 at $y = y_0$) (Kumbhakar et al., 2015).

The IO technical inefficiency can be measured by moving radially downward from point A to point B. The isoquant at point B has an output level equal to y_0. This move demonstrates that the observed output (y_0) could be produced using less of both inputs.

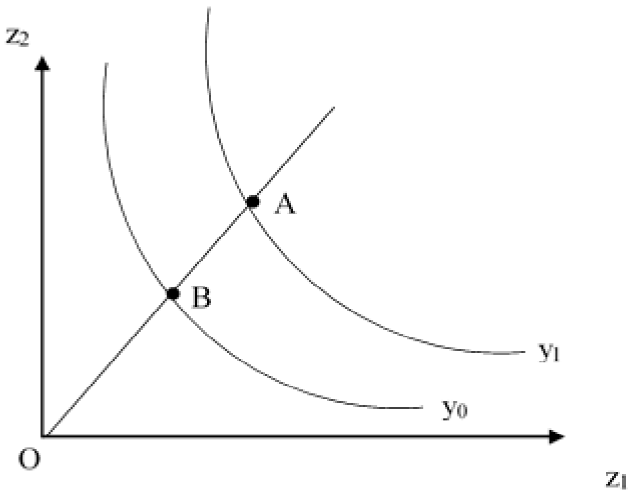

Figure 2. Input-oriented (IO) and output-oriented (OO) technical inefficiency in a two-input, one-output case

Source: Kumbhakar et al., (2015)

More precisely, input quantities can be reduced by the proportion $\overline{AB}/\overline{OA}$ which is the measure of IO technical inefficiency. On the other hand, IO technical efficiency (which measures the inputs in efficiency units) is $1 - \frac{\overline{AB}}{\overline{OA}} = \frac{\overline{OB}}{\overline{OA}}$ Mathematically, a production plan with IO technical inefficiency is written as:

$$y = f(x \cdot \exp(-\vartheta)), \qquad \vartheta \geq 0 \qquad (2.3)$$

Where u measures IO technical inefficiency (TI) and $\exp(-\vartheta)$ measures IO technical efficiency (TE). For small ϑ, $\exp(-\vartheta)$ can be approximated by $1 - \vartheta$. Thus, we get the following familiar relationship, TE= 1-TI, which is clear from Figure 2. ($\frac{\overline{OB}}{\overline{OA}} = 1 - \frac{\overline{AB}}{\overline{OA}}$).

We can also measure efficiency using OO measure. The input quantities (given by point A) that are related to output level y_0 can be used to produce a higher level of output as appeared by the isoquant labeled y_1. Seen along these lines, the inputs are not changed, but a higher level of output is produced. In this way, one can measure inefficiency in terms of the output differential. This is the thing that we call OO technical inefficiency (TI) and is measured by $(y_1 - y_0)/y_1$, and TE is y_0/y_1. A mathematical formulation of OO technical inefficiency is

$$y = f(x) \cdot \exp(-u), \qquad u \geq 0 \qquad (2.4)$$

where u measures OO technical inefficiency. Once more, for small u, we can approximate $\exp(-u)$ by $1-u$, which gives us the familiar result, TE=$\exp(-u)$= $1-u=1-TI$.

Scale efficiency concept is with related to extending the firm. In other words, if the main production technology is a constant returns-to-scale (CRS) technology then the firm is automatically scaling efficiently. Returns to scale can be illustrated from the production technology. The efficiency of the firm concerning the production technology frontier and at a given level of input and output prices, and it is possible that firm is both technically and allocative efficient but the scale of operation of the firm may not be optimal. Assume the firm is utilizing a variable returns-to-scale (VRS) technology. At that point, the firm included might be too small in its scale of activity, which may fall within the expanding returns to scale part of the production function. Similarly, a firm might be too large and it may operate within the diminishing returns to scale part of the production function. In both of these cases, the efficiency of the firms may be improved by changing their scale of activities (Coelli et al., 2005). Some empirical results show the presence of substantial economies of scale for very small farms. Also, it gives some proof of diseconomies of scale for larger farms. Such diseconomies of scale appear to be fairly small (Chavas and Aliber, 1993). Scale efficiency is depended on the types of farms. For example, livestock farms more scale-efficient than crop farms (Latruffe et al., 2005).

In recent years, efficiency is being studied in the relationship between competitiveness and productivity. For example, (Fatah, 2017; Toth-Mihaly, 2017; Holtkamp, 2015; Kumbhakar and Lien, 2010; Nivievskyi, 2009; Msuya, 2008; Masterson, 2007) etc. The competitiveness measured by social cost-benefit ratio indicator using a distance function approach. There are two decompositions, first one is static decomposition shows a positive relationship between the levels of technical efficiency and competitiveness. The second is dynamic decomposition shows a positive relationship between total factors productivity and competitiveness growth. The sources of competitiveness growth include factor costs effect, terms of trade effect, scale effect, technical change, technical efficiency changes, and allocative effects (Nivievskyi, 2009). There are inversely proportion between productivity and efficiency. In other word, there is an inverse relationship between total output divided by net cropped area and farm size, and that using gross cropped area reduces the strength of this relationship. The scan for an opposite relationship for physical yield of individual harvests yielded weak evidence, but a strong opposite relationship between cropping intensity and farm size was found. Opposite relationships were found between labor intensity and farm size, between family labor and farm size, between capital input intensity and farm size, however not between the middle inputs and farm size. And an opposite relationship between percentage of land irrigated and farm size was discovered. Farm size and productivity are inversely proportional in some empirical evidence. For example, small farms have both higher land productivity and equal or better technical efficiency in Paraguayan (Masterson, 2007).

2.2.2 Efficiency measurement methods

Frontiers have been estimated widely using two principal methods that have been used are data envelopment analysis (DEA) and stochastic frontier analysis (SFA), which involve mathematical programming (non-parametric analysis) and econometric methods (parametric analysis), respectively (Coelli et al., 2005). In the agricultural economics literature, the stochastic frontier approach has generally been preferred. This is most likely connected with various components. The assumption that all deviations from the frontier are associated with inefficiency, as expected in DEA, is difficult to accept, given the natural variability of agricultural production, due to weather, fires, pesticides, diseases, etc. Besides, because many farms are small family-owned activities, the keeping of precise records is not generally a need. In this way, much accessible data on production are probably to be subject to measurement errors (Battese and Coelli 1996). DEA methods provides a simple way to estimate technical efficiency by conducting a benchmarking assessment of the most efficient farms in the frontier. However, the major drawback of DEA is that all deviations from the production frontier are attributed to technical inefficiencies, and any consideration of random events is ignored (Coelli et al., 2005).

Summaries of the literature can be found for instance in (Bravo-Ureta et al., 2007). Following (Bravo-Ureta et al., 2007) some findings emerge from the literature.

1. The econometric results suggest that stochastic frontier models generate lower mean technical efficiency (MTE) estimates than non-parametric deterministic models.
2. Parametric deterministic frontier models yield lower estimates than the stochastic approach.
3. Frontier models based on cross-sectional data produce lower estimates than those based on panel data.
4. Technical efficiency for animal production is higher than crop farming.

The SFA indicates that parametric stochastic models consistently yield lower than non-parametric deterministic DEAs. In other words, DEA models generate higher estimates than SFA, while parametric deterministic frontier models yield lower estimates. There are two important advantages that DEA has over regression-based methodologies. First, the methodology is nonparametric in the sense that a priori specification of the production function is not required. Rather, the methodology estimates the frontier using the minimum extrapolation rule under the maintained axioms of monotonicity and convexity of the production possibility set. Second, and maybe increasingly significant, DEA easily handles multiple inputs and multiple outputs and permits direct comparisons of production possibilities without requiring additional input price data (Collier and Johnson, 2011). DEA approach can easily handle disaggregated inputs and multiple-output technologies. Economies of scope is related to the benefits of the integrated multi-products firm because most farms produce more than one output. The parametric approach's weakness was required imposing parametric restrictions on the technology and the distribution of the inefficiency terms. For the non-parametric approach, it has the advantage of imposing no prior parametric restrictions on the underlying technology. The empirical results found that, while most farms exhibit substantial economies of scope, economies scale care to decline sharply with the size of the enterprises. Also, they found empirical evidence suggesting that the existence of important economies scale on very small farms and show some diseconomies of scale on the larger farms (Chavas and Aliber, 1993).

SFA is widely used in policy - relevant empirical studies. In other words, SFA have proved analyzing the structure of producer performance, and in investigating the determinants of producers' performance (Lovell, 1995). Some of researchers suggested that frontier analysis is more suitable to investigate the existence of inefficiency (Reifchneider, 1991). Therefore, my study focus on SFA to the estimation of technical efficiency in vegetable production in Mongolia. In my country case, vegetable production dominates household production. Thus, we focus on previous studies related to small farms or household's technical efficiency analysis using SFA. The SFA model is motivated by the theoretical idea that no economic agent can exceed the ideal "frontier", and deviations from this extreme represent individual inefficiencies (Bellotti and Daidone, 2013). SFA, as a parametric approach, requires the specification of a functional form for the production frontier, which implies that the actual shape of the frontier is known. Also, parametric measures of efficiency make assumptions about the distribution of efficiency. This is the main shortcoming of the SFA method to estimate efficiency. However, these assumptions permit statistical hypothesis testing of the most likely shape of the frontier and the distribution of inefficiency. Hypothesis tests for the significance of inefficiency in the model are also possible (Henderson and Kingwell, 2001). Some empirical results show SFA estimates would be expected to be higher than from the deterministic DEA which is estimated using linear programming. It should be argued, however, that if bad luck and other factors beyond the control of firms are actually attributed to inefficiency in deterministic models, it is also possible that favorable factors facing firms are attributed to efficiency. Therefore, whether stochastic or deterministic frontiers yield higher or lower estimates cannot be determined a priori (Alene et al., 2006). Most of the empirical estimation results using DEA and SFA are similar inefficiency. For example, (Kovács and Pandey, 2017; Porcelli, 2009; Henderson and Kingwell, 2001), etc.

2.2.3 Estimation methods

The parametric model estimation procedure is the following steps: (1) Estimating the parameters of the frontier function, (2) Estimating inefficiency (Kumbhakar et al., 2015). There are two using estimation methods for efficiency analysis. The first one is distribution-free approaches (DFA), another one is maximum likelihood estimation (MLE) methods.

The distribution-free approach (DFA)'s main characteristic is there is no need required specific distribution assumptions on error components while MLE's main characteristic is required specific distribution assumptions on error components. We explain the difference between DFA and MLE methods (Table 3). DFA method has three approaches which are corrected ordinary least square (COLS), corrected mean absolute deviation (CMAD), and thick frontier approach (TFA). These methods are not required specific assumptions on the error component. In other words, there does not allow random variable v_i. Some of researchers (Coelli, 1995) found that MLE is significantly better than the COLS estimator when the distribution of technical efficiency error term is large.

The maximum likelihood estimation method is widely used in SFA for technical efficiency. The MLE was first pioneered by (Aigner et al., 1976). Most of the efficiency studies using with MLE method. The estimation model of SFA which has both random variables v_i and u_i in the model. The two random variables are identified through imposing parametric distribution functions on v_i and u_i. Once the distribution assumptions are made, the log-likelihood function of the model is derived and numerical maximization procedures may be used to obtain the maximum likelihood estimates of the model parameters. The choice of distributional assumptions is at the center of the ML approach. The choice is often not an issue for the random error variable v_i, and a zero-mean normal distribution is widely accepted in this context. The choice for the random variable u_i of inefficiency is more the issue at stake. The distribution must be in the nonnegative domain, and its joint distribution with v_i would ideally have a closed form (this is necessary to derive the likelihood function of the model) (Kumbhakar and Wang, 2015). For example, (Kiprop et al., 2015; Mwajombe and Mlozi, 2015) using the maximum likelihood estimation technique, asymptotic parameter evaluates were estimated to describe efficiency determinants. Study results uncovered that a mean technical efficiency index was accomplished inferring that output from urban agriculture production could be increased by using available technologies. Regardless of urban farmers having entrepreneurial insight, they faced a few challenges in resource allocation. Land size, total variable costs, and extension service charges negatively impacted on technical efficiency index. (Collier and Johnson, 2011) the study recommends that the government using urban agriculture and livestock extension agents should investigate beneficial levels for promoting urban area enterprises to learn profitable technical efficiency index levels and urban area units.

There are two types of approaches to analyze the existence of technical efficiency. The first approach is the likelihood ratio test; another approach is the gamma parameter. The likelihood ratio (LR) test can be constructed based on the log-likelihood values of the restricted model and unrestricted model. LR test statistic is

$$-2[L(H_0) - L(H_1)] \tag{2.5}$$

Where $L(H_0)$ is log-likelihood values of the restricted model (OLS). $L(H_1)$ is the log-likelihood value of the unrestricted model (SF). If the LR test for the unrestricted model is higher than a restricted model, which means reject the null hypothesis of no technical inefficiency. In other words, there is exist technical inefficiency. The second approach is the gamma parameter. Gamma parameter is defined as the following equation.

$$\gamma = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} \tag{2.6}$$

Gamma value takes between 0 and 1. If $\gamma \sim 0$ is indicated that there is no technical inefficiency. If $\gamma \sim 1$ there is exist technical inefficiency.

The MLE method has also four distribution assumption approaches 1) Half-normal distribution approach, 2) Truncated-normal distribution approach, 3) Truncated-normal distribution approach with scaling properties, and 4) Exponential distribution approach (Table 3).

Table 3. Estimation methods for production frontier model

Estimation methods	Methods	Description	Production frontier model
Distribution free approaches	Corrected ordinary least squares (COLS)	COLS model indicates deterministic frontier model which means that there is no stochastic error. Corrected OLS (COLS) seminal work conducted by Winsten, (1957). Compared to SFA, the model does not allow any random error v_i and the SFA is therefore non-stochastic. The functional form of u_i does not require any assumptions, it estimates the technology parameters by OLS and corrects the downward bias in the estimated OLS intercept by shifting it up until all corrected residuals are non-positive and at least one is zero (Porcelli, 2009). The constant term can be consistently estimated simply by shifting the least-squares line upward sufficiently that the largest residual is zero. The resulting efficiency measures are $-\widehat{u_i} = \widehat{e_i} - max\widehat{e_i}$. Thus, absolute estimators of the efficiency measures in this model are directly computable using nothing more elaborate than OLS (Greene, 2007). The technical efficiency of each observation can then be calculated as TE=$\widehat{TE_i} = \exp(-\widehat{u_i})$.	$lny_i = lny_i^* - u_i$ $u_i \geq 0$ $lny_i^* = f(x_i, \beta)$
	Corrected mean absolute deviation (CMAD)	CMAD method is based on the mean of absolute deviation of regression. CMAD procedure is the same as COLS procedure. The main difference between COLS and CMAD is the median (or mean) of data.	
	Thick frontier approach (TFA)	TFA is more convenient in the estimation of cost frontier analysis. This approach divides into four quartiles (or N quantiles). According to the production function estimation, the first quartile is hypothesized lower than average production efficiency. The other quartile is higher than average production efficiency. In other words, the production function is evaluated between the efficient and the inefficient group sample quartile. One of the main characteristics is TFA allows the existence of random errors within the quartiles.	
Maximum Likelihood		Half-normal distribution has a single parameter distribution. This approach assumes that v_i has a normal distribution, u_i	$lny_i = lny_i^* - u_i$ $u_i \geq 0$

Estimator (MLE)	Half-normal distribution	has a half-normal distribution. A half-normal distribution can be derived in two different ways. First is a non-negative truncation of a zero-mean normal distribution. The second is folded zero-mean normal distribution.	$lny_i^* = f(x_i,\beta) + v_i$ $u_i \sim i.i.d.N^+(0,\sigma_u^2)$ $v_i \sim i.i.d.N(0,\sigma_v^2)$
	Truncated-normal distribution approach	A truncated-normal distribution approach indicates the inefficiency distribution to have a non-zero mode. In other words, u_i 's normal distribution is different from zero ($\mu \neq 0$). If $\mu = 0$, it appears that half-normal distribution.	$lny_i = lny_i^* - u_i$ $u_i \geq 0$ $lny_i^* = f(x_i,\beta) + v_i$ $u_i \sim N^+(\mu,\sigma_u^2)$ $v_i \sim N(0,\sigma_v^2)$
	Truncated-normal distribution approach with scaling properties	This approach's main characteristic is a random variable u_i depend on the basic distribution u^*. In other words, $u_i \sim h(z_i,\delta)u^*$. Where u^* does not depend on z_i. $h(z_i,\delta)$ is indicated scaling function.	$lny_i = lny_i^* - u_i$ $u_i \geq 0$ $lny_i^* = f(x_i,\beta) + v_i$ $u_i \sim h(z_i,\delta) \cdot N^+(\tau,\sigma_u^2)$ $= \exp(z_i'\delta)$ $\cdot N^+(\tau, \exp(c_u))$ $v_i \sim N(0,\sigma_v^2)$ Where $h(z_i,\delta)$ is an observation- specific non-stochastic of the exogenous variables,
	Exponential distribution approach	Exponential distribution has a one-parameter function as half-normal distribution. Random variable u_i the form is defined by the following equation. $f(u_i) = \frac{1}{ή} \cdot \exp(-\frac{u_i}{ή})$ $u_i \geq 0$	

Source: Kumbhakar et al., (2015)

2.2.4 Factors affecting efficiency

There exists also vast empirical literature worldwide discussing efficiency in agriculture. Many factors affecting to technical efficiency in agricultural production. Agricultural production is a very important sector in every country, but that is the reliance on climatic conditions in some countries. There are many studies related to technical efficiency, especially used to second-step methods to the estimation of technical efficiency. The affecting factors have small differences which depend on the characteristic of production and climatic condition of the country. Factors can be divided into 2 categories:

- input factors (direct inputs) to produce, which is mean such as, fertilizer, labor, capital, etc., and;

- exogenous factors (socio-economic variables and institutional variables), which is mean such as, education of farm head, access to infrastructure, access to credit.

Now, I reviewed based on previous studies that how to influence these inputs and variables in technical efficiency? For example, efficiency analysis of developing countries, the exogenous variables, especially socio-economic variables that have been used most frequently in these models are farmer education and experience, contacts with extension, access to credit, and farm size, with the exception of farm size, the results reveal that these variables tend to have a positive and statistically significant impact on technical efficiency. Also, the results of the efficiency literature based on frontier methodology are generally consistent with the notion that human capital plays an important role in farm productivity in developing countries, Consequently, public investments designed to enhance human capital can be expected to generate additional output even in the absence of new technologies. The fact that significant increases in output could be obtained by making better use of available inputs and technology does not mean that research designed to generate new technology should be overlooked, Rather, those in the business of increasing the supply of agricultural products should keep in mind that there is much that can be done while the scientists are hard at work in developing the new know-how (Bravo-Ureta and Pinheiro, 1993).

Size of farms affects negatively the efficiency, meaning that smaller farms are more efficient; this may be due to the better use and higher care for the use of inputs by smaller farms because they are also poorer. Fertilizer use also affects negatively efficiency. This may be due to the fact that larger amounts of fertilizers need higher management and technical skills and more knowledge to scale them up during the production process and effectively combine them with other inputs such as water, insecticides, manure, etc. This reveals an important problem, the need for better and systematic technical assistance to farmers for the use of inputs, fertilizers included, and production techniques that would possibly lead to higher technical efficiency (Osmani and Andoni, 2017).

Land, fertilizer, and pesticide input had positive coefficients, indicates a positive contribution of these inputs to household rice output. These results designated enlarging harvested land, the increasing quantity used of fertilizer and pesticide could cause the increase of household rice output. Furthermore, the annual area of rice harvested was the main input factor driving extra output for household rice production compared to fertilizer and pesticide, which means farmers who cultivate additional lands have the ability to maintain reasonable levels of the necessary inputs. labor input has a negative coefficient but not significant at any statistical level, reveals that there was no significant relationship between labor and household rice production. The impact of the education level of the household's head is negatively significant on the efficiency of the household's rice production, implying less educated rice farmers are more efficient than better-educated farmers. Family size, irrigated area, number of the plot area, and sex of household head also have a positive influence on technical efficiency (Kea et al., 2016).

Seok et al., (2018) was examined the effect of aging and income subsidies on farm efficiency in Korea. They used the panel data between 2008 and 2015 to determine the technical efficiency and used the Cobb-Douglas production function and translog production function. The study was found translog function was more appropriate than the Cobb-Douglas function and revealed that there was a negative relationship between technical efficiency and age. In other words, they revealed an inverted – U relationship between age and efficiency. Also, their result confirmed that education, the share of farm labor, the share of own land, debt rate, share of non-farm income, the share of subsidies was a positive effect on technical inefficiency in Korea. Only family size found a negative relationship with technical inefficiency.

Kea et al., (2016) studied technical efficiency of the Cambodian household rice production using the SFA model. Cambodian rice production technical efficiency was low or 34 %. The study was used panel data of 5 years. They found that household head’s age, education, family size, female labor, distance to the district, and disaster were positively affected to technical inefficiency in Cambodian rice household producer. Alternatively, household head’s sex, irrigated area, distance to water sources, number of the plot area, and number of cultivation per year variables were negative relationship with technical inefficiency. They mentioned three main conclusions. First was increasing in harvested land and water management practices were the main reason to improve technical efficiency. Second, land elasticity was higher. Thus, fertilizer and pesticide were the most important inputs. Finally, improvement of other positive effecting variables such as irrigated area was lead to increasing technical efficiency of rice household production in Cambodia.

Anang et al., (2016) estimated propensity score matching to study the technical efficiency of rice-growing farms with and without credit in Ghana and found that the mean efficiency did not differ between credit users and non-users. Also, the major determinants of inefficiency included the respondents' age, sex, educational status, distance to the nearest market, herd ownership, access to irrigation, and specialization in rice production. The study indicates that women farmers are more likely to take part in microcredit in Ghana. Land scarcity is observed in all three production estimations, as the plot size manifests as the biggest coefficient in the production. In addition, labor and chemicals such as fertilizer and herbicides are significantly relevant for each production. Institutional variables such as the ownership of land certificates and especially sharecropping arrangements between farmers, enhance the efficiency of rubber production. Furthermore, the distance to the trader influences the efficiency not only in rubber but also in autochthonous oil palm systems. Farmers selling to traders outside their village or farther away increase their efficiency, while selling to local traders has the opposite effect. Subsequently, in the case of both oil palm groups, contractual arrangements with a trader affects the efficiency level positively (Holtkamp, 2016).

Rajendran et al., (2015) studied technical efficiency of African traditional vegetable production in Tanzanian case. Because, traditional vegetable production is significant contribution to food and nutrition security and enhancing smallholder's income. They found that larger land size smallholders are more efficient than small sized land smallholder. Also, large-scale smallholders are using machinery which lead to increase productivity. Finally, farm labor engage is necessary to have better incentive of farming activities.

Kiprop et al., (2015) focused on land fragmentation and farm-specific influencing in technical efficiency in Kisii county of Kenya. The land fragmentation index is negative, indicates that land in Kisii county is highly subdivided and overused. A decrease in land fragmentation level by increasing cause by inducing in agricultural output. Sabasi and Shumway, (2014) argue that efficiency change is driven by education, extension, the ratio of family-to-total labor, farm size, as well as weather variables, and agro-climatic condition in US Agriculture. Also, they studied the relationship between efficiency and total productivity. The results from this study contribute to the policy debate about how to surmount the recent downturn in agricultural productivity. Technical change is the primary component driving total factor productivity growth. Public policy can impact its growth rate most through investment in public research and facilitating additional education and health care access in rural areas.

Addai and Owusu, (2014) studied effects of farmer-based organization on the technical efficiency of maize farmers across various agroecological zones of Ghana. The results reveal that extension, mono-cropping, gender, age, land ownership and access to credit positively influence technical efficiency. High input price, inadequate capital, and irregularity of rainfall are the most persuading problems facing maize producers in the forest, transitional, and savannah zones respectively. The study, therefore, recommends that policies that would improve extension service, education and development of crop varieties suitable to the different agro-ecological zones should be pursued. Amos, (2014) this study seeks to identify which factors drive differences in technical efficiency in the Ghanaian mango farming sector (i.e. the socioeconomic characteristics in the production environment and farm husbandry or management practices that influence mango production) and this study provides a multi-output production efficiency analysis of banana farms using a stochastic distance function approach.

Abate et al., (2014) studied the effect of cooperation on farmers' efficiency and argue that agricultural cooperatives are more effective in providing support services and this contributes to member’s technical efficiency. In other words, these results are found to be increased participation in agricultural cooperatives should further enhance efficiency gains among smallholder farmers. Khan and Saeed, (2011) a study on Pakistan found that public education and again extension services are determinants of the efficiency, of tomatoes growers. Economic efficiency indices also varied significantly showing that there was a great potential for increasing the gross output and profit with the existing level of the resource base. Regarding the sources of productive efficiencies, the study concluded that farmer education, extension visits, age, and access to credit contributed significantly and positively to these efficiencies. The study recommends that the government of Pakistan should implement two policies for tomato farmers, one is to invest more in education in farmers, education would reduce productive inefficiencies. Another policy is that extension services, which help to increase farm output and profit.

Tan et al., (2010) studied the impact of land fragmentation on rice producer’s technical efficiency in South-East China. The empirical result showed that the land fragmentation index was found that more important determinant of technical efficiency in early-rice and one-season rice production. Therefore, the land fragmentation index was a positive relationship with technical efficiency. On other hand, an increase in the number of the plot was found to increase technical efficiency. Onumah et al., (2009) examined the productivity of hired and family labor and determining of technical inefficiency of fish farms in Ghana. They found that family labor and hired labor used in fish farm in Ghana are productive. Msuya, et al., (2008) used SFA to analyze efficiency for a particular crop, small farmers growing maize in Tanzania, based on a sample of farmers. They confirm the role of extension services, but also high input prices, low education, land fragmentation, limited capital having a negative effect on farmer’s technical efficiency.

Nyemeck et al., (2008) provided technical efficiency of groundnut and maize-based systems farmers in the slash and burn agriculture zone of Cameroon, and to identify farm-specific characteristics that explain variation in the efficiency of individual farmers. An understanding of these relationships could provide the policymakers with information to design programs that can contribute to measures needed to expand the food production potential of the nation. Also, they representing socio-economic characteristics of the farm to explain inefficiency, including education (number of completed years of schooling for the farmer), age (number of years of the farmer), distance of the plot from the main access road (kilometers), soil fertility index, club (a dummy variable to measure if the farmer is a member to a peasant club or association), extension contact (dummy variable to measure the influence of agricultural extension on efficiency) and access to cash credit (dummy variable to measure the influence of credit access on efficiency). The study results show that the distance of the plot from the main access road, the soil fertility index, the credit access, and the variable club have a significant impact on the technical inefficiency of farmers among farming systems in the slash and burn agriculture zone, while the educational level has only a significant impact on the technical inefficiency of the farmers practicing the maize mono-cropping system.

Bozoglu and Ceyhan, (2007) studied the technical efficiency of vegetable farms in Samsun province of Turkey using SFA. They found that mean of technical efficiency was 0.82, Samsun's vegetable farms are substantially efficient. Variables of schooling, experience, credit use, participation by women, and information score were negatively affected to the technical inefficiency. And age, family size, off-farm income, and farm size were found to a positive relationship with technical inefficiency. This study recommended that providing better extension services and farmer training programs, raising the education level of farmers, and providing farmers with greater access to credit were important issues to enhance technical efficiency in Samsun province.

Dinar et al., (2007) used a non-neutral SFA to analyze the effects of both public and private extension on farm performance in the Cretan case. They focused on especially extension service effect to farms' production. Study result has found that combining both types of extension service is more efficient as compared to no extension or only one type (public or private) extension service. Also, they calculated that marginal effect of efficiency effects model variables. Abdulai and Eberlin, (2001)- this study examines the significance of some major factors that are believed to influence levels of farm production and efficiency, including education, liquidity constraint, and experience. Although the importance of these factors has often been raised in policy debates on Nicaraguan agriculture. The study results reveal that larger families appear to be more efficient than smaller families, level of education, access to formal credit, family size, and tractor use each has a positive impact on efficiency. Participation in non-farm work, however, appears to have a negative effect on efficiency. The negative sign for the education variable indicates that higher levels of education increase efficiency. The negative and significant relationship between access to credit and inefficiency suggests that farmers who face credit constraints on purchased inputs experience higher technical inefficiency.

Bravo-Ureta, (1997) pursued first by estimating a stochastic production frontier which provides the basis for measuring farm-level technical (TE), economic (EE), and allocative (AE) efficiency and performed where separate two-limit Tobit equations for TE, EE, and AE are estimated as a function of various attributes of the farms. Socio-economic factors are farmers producing any crop under contract with an agribusiness firm or not, farm size, education of farms' head, age of farmers, and family member. An interesting implication emerging from the second step analysis is that improvements in allocative efficiency offer a higher potential, compared to technical efficiency, for enhancing economic efficiency. From a policy perspective, contract production, farm size, and agrarian reform status are the variables found to be most promising for improvements in economic efficiency, primarily through gains in allocative efficiency.

Battese and Coelli, (1996: 1995), studied inefficiency factors for Indian farms and found that age, education, and farm size were important factors for the technical efficiency of Indian farms. They used two-stage SFA with panel data, that is they put in one model the production inputs and inefficiency determinants or factors. Results of their studies, land, labor, coefficient of the proportion of irrigated land are positive, reflecting the higher productivity of irrigated land. The coefficient of the ratio of hired labor to total labor, was negative, indicating that hired labor is less productive than family labor. Also, the age of farmers, education level, and coefficient of the year was a negative sign. For example, the older farmer tends to have smaller inefficiencies than younger farmers. For education, farmers with greater years of formal education tend to be more efficient in agricultural production. In other words, if greater these factors tend to be more efficient in agricultural production.

Bravo and Pinheiro (1993) paid attention to the relationship between technical efficiency and socio-economic variables, such as the age of the head of farms, level of education of farmer, farm size, access to credit, and utilization of extension services. The factors information provided to significant use to policymakers attempting to raise the average level of farmer efficiency. Chavas and Aliber, (1993) focused on various aspects of production efficiency based on non-parametric analysis for multiple outputs- crop production and livestock production. They used to main factors (namely, labor family, labor hired, miscellaneous inputs (repairs, rent, custom hire, supplies, insurance, gas, oil, and utilities), animal inputs (purchased feed, breeding, and veterinary services), crop inputs (seeds, fertilizers, and chemicals), intermediate and long-run assets and exogenous factors (namely, farm size, the financial structure of the farm, etc.). Efficiency indexes suggest that the financial structure of farms can have some significant influence on their ability to attain economic efficiency.

Last a few years, the technical efficiency evaluation concept has been the main important concept in production. For example, Xu Yin et al, (2018) focused on developing a technical efficiency evaluation system based on the SFA model in China vegetable production. The development of the technical efficiency evaluating system not only promoted the advancement of vegetable industry informatization but also provided decisions for the practice of precision agriculture.

Therefore, they discussed the system functions, including data management, data query, statistical analysis, technical efficiency measurement, and influence factor analysis. The system provided a useful system for end-users, including vegetable producers, government agencies, enterprises, and other relevant stakeholders, to evaluate the technical efficiency of the vegetable production process, understand the key influential factors, thus improving the producers' income. Also, the evaluation results showed that the technical efficiency evaluation system for the vegetable production process can improve automation, efficiency, and convenience of evaluating technical efficiency. Therefore, they mentioned that how to modify its systems to optimize performance. They appeared two possible solutions for improving performance: one solution is to further details about the business process, but it would take more time and effort than initially expected and budgeted for; the other solution is to not only improve the system operating speed and data processing ability from the point of view of users and system management.

Some main affecting factors to the technical efficiency and production are described in Figure 3 based on previous literature. There are two main affecting factors to the household production level: Input factors and exogenous factors.

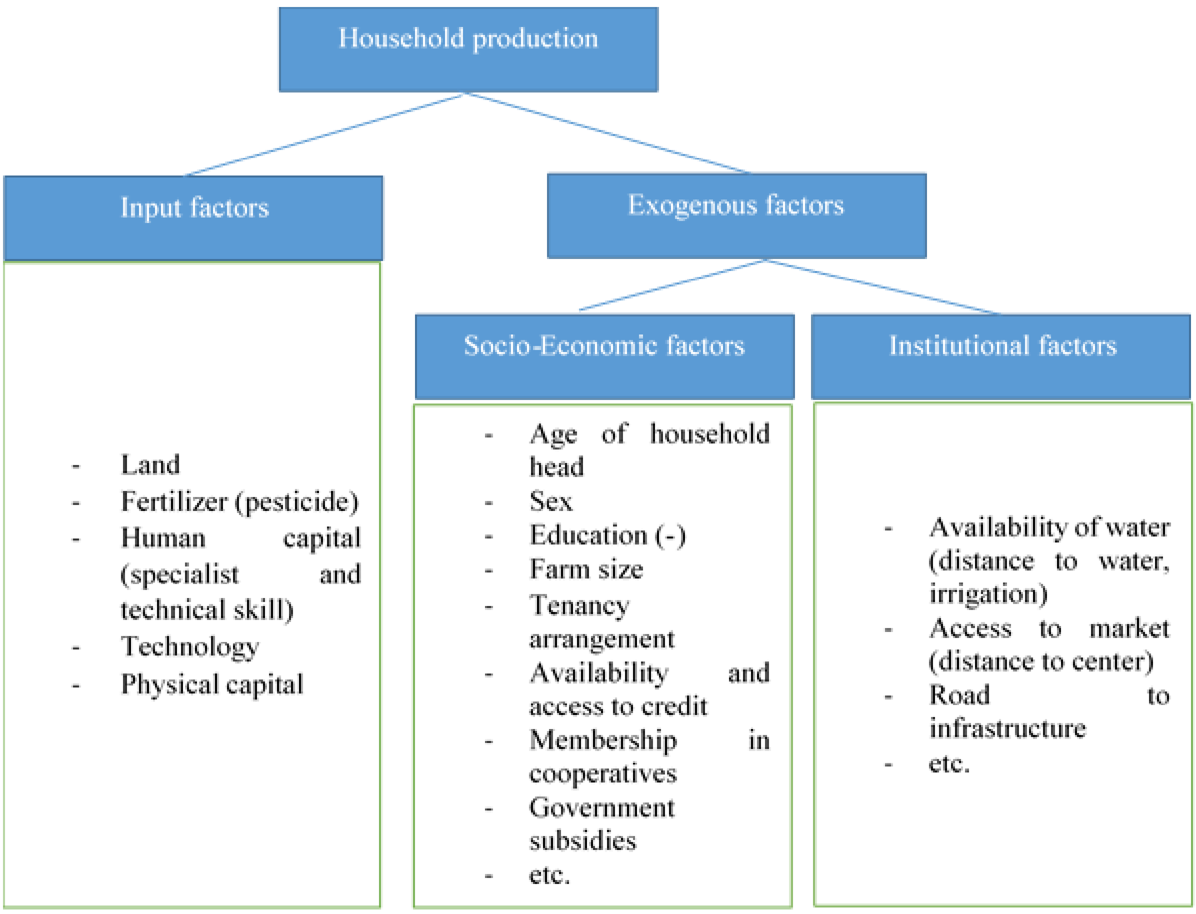

Figure 3. Main affecting factors in household production
Source: Own description based on literature review

Inputs factors are including the following inputs namely, land, fertilizer (most important inputs for agricultural production), labor (human capital), and technological innovation. Exogenous factors are determined by socioeconomic factors and institutional factors. Socio-economic factors indicate some general factors such as age, education sex, membership in cooperatives, availability of credit, etc. Institutional factors are including infrastructure problems, access to the market, availability of water sources, etc.

Affecting factors to technical efficiency (inefficiency) expected sign is described in Table 4. The expected sign has been defined based on previous literature. Some of the determining affecting factors are impacting to technical efficiency (inefficiency) directly positive and negative while, some of variables are ambiguous.

Table 4. Some variables meaning

Inputs	To be estimated sign	Meaning	Some related references
Affecting factors to production level			
Land	+	The increasing quantity used of total irrigated area and non-irrigated area could cause the increase of farms' production.	Battese and Coelli, (1996)
Fertilizer, pesticide et.al	+	The increasing quantity used of fertilizer, the pesticide could cause an increase in farms' production.	Kea et al., (2016), Hasnain et al, (2015)
Labor	+	The total quantity of labor for family members and hired labor	Battese and Coelli, (1996)
Affecting factors to the technical efficiency (inefficiency)			
Age	+/-	The effect of this variable is ambiguous on efficiency. Some of the researchers reveal that the older farmers who are likely to be more experienced in farming utilize resources more efficiently in production. If the household head is older, there is the likelihood that the family labor may increase as the children become older. A number of authors such as (Seok et al., 2018) state a negative relationship between age and efficiency in Korea. In other words, farm efficiency is continuously decreasing in age. Because older farmers are less adaptable to new technological developments.	Anang et al., (2016), Mwajombe and Mlozi, (2015), Pitt and Lee, (1981) etc.
Education	+	Education is expected to improve the technical efficiency of farmers. The lower efficiency level of educated farmers in the current study may be due to the fact that	Addai and Owusu, (2014), Seok et al., (2018),

		educated farmers are more likely to find jobs outside the farm sector, which may interfere with the time they allocate to farming activities.	Abdulai and Eberlin, (2001), Amaza and Olayemi, (2010), Sharif and Dar (1996).
Gender (sex)	+/-	Male farmers are more efficient. Many researchers have recognized the important role of women as agricultural producers. However, gender inequality in access to production technology in many developing countries means that women farmers are often disadvantaged which can adversely affect their level of efficiency. Women also face other challenges that have a negative impact on their technical efficiency.	Msuya, et al., (2008), Khai and Yabe, (2011)
Experience	+	More experienced farmers are expected to a positive effect on technical efficiency.	Tegar et al., (2016), Abdulai and Eberlin, (2001), Khai and Yabe, (2011)
Farm size	+/-	This variable expected sign is smaller farms are more efficient; this may be due to the better use and higher care for the use of inputs by smaller farms because they are also poorer.	Osmani and Andoni, (2017), Bravo-Ureta and Pinheiro, (1993), Anang et al., (2016), Abdulai and Eberlin, (2001) etc.
Family size	+/-	The relationship between family size and technical efficiency is complex and ambiguous. Some empirical studies result show larger families appear to be more efficient than smaller families (Kumbhakar et al., 1991). Some authors reveal fewer family members imply more efficiency than larger family members (Kea et al., 2016).	Kumbhakar et al., (1991), Kea et al., (2016) etc.
Availability and access to credit	+	The credit helps producers to hire in labor and buy other production inputs that may enhance their technical efficiency.	Bozoglu and Ceyhan, (2007), Laha, (2006), Mwajombe and Mlozi, (2015), Brummer and Loy, (2000), Liu, (2000)
Membership in cooperatives	+	Increasing participation in agricultural cooperatives enhance efficiency in smallholder farmers.	Abate et al., (2014)
Government subsidies	+	Subsidies affect a positive influence on technical efficiency.	Kumbhakar and Lien, (2010), Henningsen et al., (2009)
Availability of water (distance to water, irrigation)	+	Irrigation users also had higher efficiency of production than non-irrigators. Access to irrigation enables farmers to maximize the use of other inputs such as fertilizer due to the availability of water throughout the farming season.	Battese and Coelli, (1996), Kea et al., (2016)

Road to infrastructure	+	The effect of near to market on efficiency is positive. Conversely, farmers, who living further away from the local market are more efficient in production. The longer distance to markets is likely to affect the timely acquisition of farm inputs to carry out farm operations which can affect technical efficiency.	Fuwa et al., (2007), Fatah, (2017), Nyemeck et al., (2008), Shanmugam and Venkataramani, (2006).
Non-farm income	+/-	The effect of non-farm income on efficiency is ambiguous. Because increasing participation in the non-farm labor market may be increasing inefficiency. Even though increasing non-farm income reduces financial constraints, it might cause poor attention to own production.	Abdulai snd Eberlin, (2001), Bozoglu and Ceyhan, (2007), Xu and Jeffrey, (1998)
Land fragmentation index	+/-	Some of the researchers found that increase in the number of the plot in the land to increase in technical efficiency.	Tan et al., (2010)

Source: Own description based on literature review

2.3 An overview of agricultural sector in Mongolia

Mongolia is located in Central Asia and has a total area of 1564.2 thous.km square. It is divided into five sized economic regions, namely Western, Khangai, Central, Eastern, and Ulaanbaatar area. The country consists of 21 aimags (provinces) and the capital city (Ulaanbaatar). Aimags are divided into 330 soums (sub-provinces). The Mongolian population is nearly 3.3 million, while the population density was 2 persons per kilometer, but 311 persons per kilometer in Ulaanbaatar GDP (National Statistics Office of Mongolia 2019). Mongolia has an extreme climatic condition. The country is dryland and has a low level of precipitation, and absolutely temperature is from -30°to -54° Celsius in winter and from +30°to +45° Celsius in the summer.

The four main key drivers to the Mongolian economy are the agriculture sector, mining sector, manufacturing sector and, whole and retail trade sector. In 2019, the mining sector contributed nearly 23.7% to the Gross Domestic Product (GDP), followed by the whole and retail trade sector 16.5%, manufacturing sector 11%, and the agriculture sector 10.7%. The agriculture sector is a traditional sector of Mongolia and the most important contributor to the Mongolian economy. However, it showed a declining trend from 38% in 1995 to 10.7% in 2019 (Figure 4).

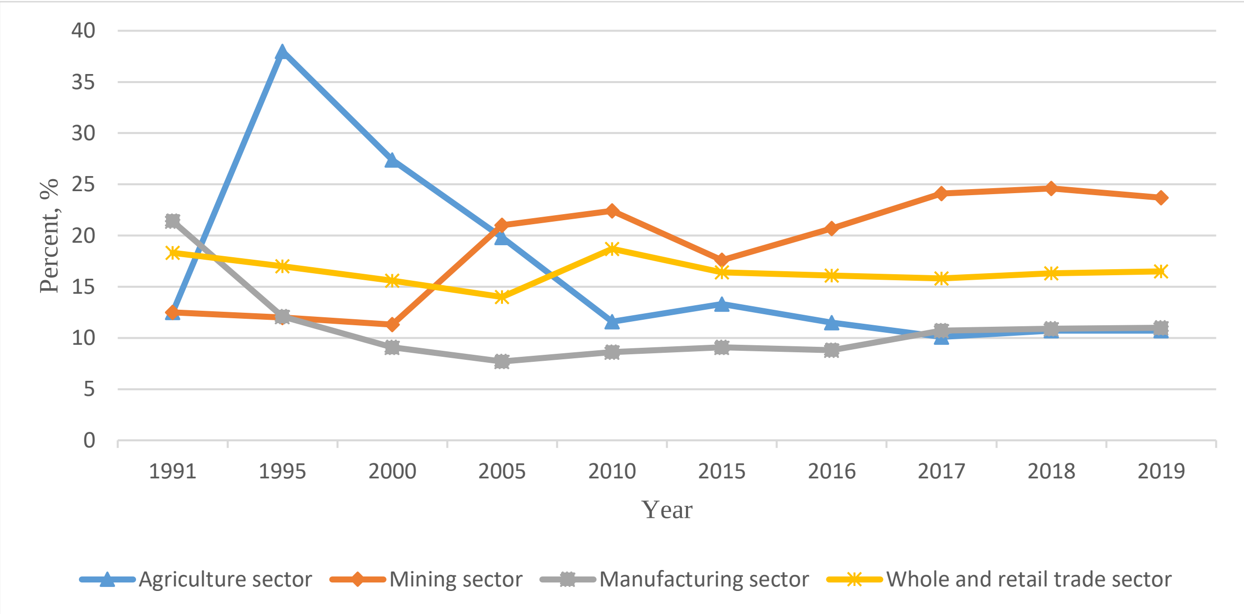

Figure 4. Main sectors component of the GDP
Source: Mongolian statistical yearbook, 2019

The Mongolian agricultural sector can be divided into 2 sub-sectors: livestock sector and crop production. The livestock sector accounts for 88 percent of agricultural production, while the remaining 12 percent is sourced from crop production (National Statistics Office of Mongolia, 2019). The Mongolian livestock sector relies on the production of five types of livestock, including goats, sheep, cattle, horses, and camels. In 2019, Mongolia had 70.9 million livestock (National

Statistics Office of Mongolia, 2019). The main agriculture export products are cashmere, hides, and hair of livestock. The country's climate is more suitable for extensive grazing, which covers 80 percent of the land area.

Mongolia's economy had basically been based on livestock sector until 1959. However, since 1960, crop production has been supplying relatively part of crop's domestic consumption of the population. The crop production sector was established after implemented the "Atar-1 Land Rehabilitation" campaign by the Mongolian Government on bringing virgin lands under cultivation in 1959. The crop production needs to solve many factors such as meeting the growing demand of the population, increasing the production of wheat, potatoes, and vegetables are grown on motherland soil, and improving the risk-bearing capacity of the pasture livestock sector (Coslet et al. 2017).

Wheat is the main crop produced, followed by potatoes, vegetables, and others including, fodder crops and, industrial crops. The total sown area in Mongolia was 526.1 thousand hectares in 2019 that is decreased by 33.2 percent compared to the 1990 year (Table 5). In terms of land, the sown area shares 1% of the total land area of Mongolia (Santiago, 2003). The sown area was approximately 70 percent cereals production, 2.8 percent in potato, 1.6 percent in vegetables, 25.3 percent in fodder crops, industrial crops, and others (National Statistics Office of Mongolia, 2019). At the peak of crop production in 1989, approximately 1.38 million hectares of land were classified as arable or planted in permanent crops, and about 700.0 thousand ha (approximately 50%) of this was actively harvested (Santiago, 2003).

Table 5. Total sown area, by types of crops, thousand hectares

Types	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Cereals	654.1	356.5	194.7	159.1	259.2	390.7	377.8	390.9	366.8	369.4
Potatoes	12.2	6.2	7.9	9.8	13.8	12.8	15.0	15.1	12.9	14.9
Vegetables	3.6	3.2	5.4	5.9	7.0	7.7	9.1	8.3	8.8	8.4
Others	117.8	6.7	1.3	14.7	35.8	113.8	103.4	109.9	119.3	133.4
Total sown area	787.8	372.6	209.3	189.5	315.3	525.0	505.3	524.3	511.8	526.1

Source: Mongolian statistical yearbook, 2019

Since the political and economic transition, the total sown area had been dropped to 189.5 thousand hectares until 2005. Mongolian Government started to pay attention to this situation and implemented the "Atar-3 Land Rehabilitation" campaign national program between 2008 and 2010. As a result, the total sown area increased step by step to 526.1 thousand hectares in 2019.

Before 1990, crop production was developed more than the free market system. The dramatic decline in crop production is mainly the result of the transition from a centrally planned economy to a market-based economy in the early 1990s and has been accompanied by a lack of the use of irrigation infrastructure, machinery, and other agricultural inputs, such as fertilizers (Coslet et al. 2017). For example, in 2005, crop production sharply declined to cereals harvest was 75.5 thousand ton, the potato was 82.8 thousand ton, vegetables were 64.2 thousand ton and others were 9.5 thousand ton (Table 6). Compared to 1990, cereals harvest decreased by almost 9.5 times, potato's harvest decreased by 1.5 times, vegetables increased by 1.5 times.

Table 6. Total harvest, by types of crops, thousand ton

Type	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
Cereals	718.3	261.4	142.1	75.5	355.1	216.3	483.5	238.1	453.8	433.3
Potatoes	131.1	52.0	58.9	82.8	168.0	163.8	165.3	121.8	168.9	192.3
Vegetables	41.7	27.3	44.0	64.2	82.3	72.3	94.4	82.1	100.7	99.5
Others	527.1	18.7	4.4	9.5	45.9	72.3	76.5	61.8	147.7	155.1
Total harvest	1418.2	359.4	249.4	232.0	651.2	524.7	819.7	503.8	871.1	880.2

Source: Mongolian statistical yearbook, 2019

After a massive collapse, the crop sector was substantially revived through an "Atar-3 Land Rehabilitation" national program. This program focused on especially wheat production, the program facilitated a fully self-sufficient level.

The agricultural sector provided 25.3% of total employment in 2019 (National Statistics Office of Mongolia 2019). However, the agricultural sectors' workforce indicated a declining trend from 354.6 thousand workers in 1995 to 290.2 thousand in 2019. In other words, percent of the total employment has been decreasing 46.1% in 1995 to 25.3% in 2019.

Table 7. Agricultural productivity per worker, at the current price

	Employment, thousand workers	Percent of total employment	Productivity per worker, thousand MNT
1995	354.2	46.1	5214.5
2000	393.5	48.6	3384.7
2005	386.2	39.9	4427.9
2010	346.6	33.5	5126.9
2015	327.6	28.4	9438.3
2017	356.4	28.8	7460.9
2018	334.1	26.7	8979.6
2019	290.2	25.3	11315.8

Source: Mongolian statistical yearbook, 2019, at constant 2015 price

In Mongolia, the agricultural sector's employees' total productivity was approximately 6.3 million MNT in 2017 and annual changes of average productivity of agricultural sectors have been decreasing year to year. For example, it was down from minus 15.5 percent in 2000 to 0 percent in 2017 (National Statistics Office of Mongolia, 2019). In the agricultural sectors labor force was 356.4 thousand employees in 2017. The workforce in the agricultural sector, however, showed a declining trend from 393.5 thousand employed persons in 2000 to 327.6 thousand in 2010. After that, it has been increasing to 356.4 thousand until 2017. The annual productivity per worker, increased from 5214.5 thousand MNT in 1995 to 11315.8 thousand MNT in 2019 (Table 7), thus positively affecting the GDP growth in this sector. Technological innovation and changes increase agricultural productivity and reduce labor requirements.

2.3.1 Vegetable production and import in Mongolia

Potato and vegetable sown area

Vegetables are one of the most important agricultural products in crop production after wheat and potatoes. In Mongolia, there are planting a few varieties of vegetables due to the climatic extreme condition such as potato, cabbage, carrots, turnips, onions, garlic, cucumber, tomatoes, watermelon, a small number of peppers, and beet. Vegetable's sown area constituted only 3 percent of the total crop's sown area (National Statistics Office of Mongolia 2019). Potato is the main vegetable in Mongolia which constitutes approximately 70% (average between 1960 and 2019) of the total vegetable's sown area (Figure 5). In 1960, Mongolia began to planting potato and vegetable sown area was 3.0 thousand hectares. Since then, the sown area has increased every year associated with the "Atar -1 (1959) and Atar -2 (1979) Land Rehabilitation" campaign. Before transition time, at the peak vegetable sown area was planted in 16.8 thousand hectares. The crop sector had been booming until 1990, which collapsed due to political and economic transition, potato and vegetable sown area then plunged to a minimum level of just 9.4 thousand hectares in 1995. Mongolian government paid to attention this recession while started to implement the "Green revolution" program between 1996 and 2012, and the "Atar-3 Land Rehabilitation" program between 2008 and 2010. Consequently, the "Atar-3 Land Rehabilitation" program, the potato and vegetable sown area has increased to 23.9 thousand hectares in 2012 which was the peak sown area in vegetable production. In 2019, the potato and vegetable sown area were 23.3 thousand hectares, potato's sown area composed 63.9% of the total vegetables' sown area.

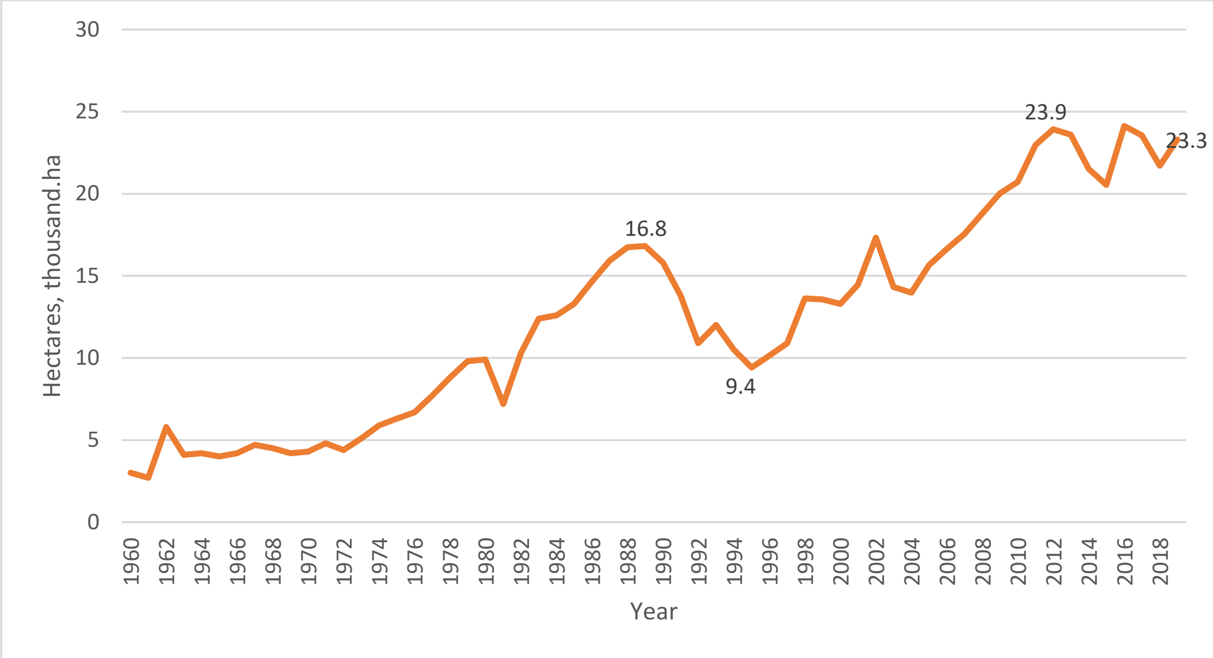

Figure 5. Vegetable’s total sown area, by thousand hectares, between 1960 and 2019

Source: www.fao.org/faostat/en/

Only four types of vegetables with the exception of potato constituted approximately 80% of the total vegetable sown area in the period 2010 and 2019. In other words, the vegetable sown area was 13.9% for cabbage, 24.4% for turnips, 30.7% for carrots, 10.4% for onion and, 20.6% for others (including garlic, cucumber, tomato, watermelon, etc.) (Table 8).

Table 8. Components of the vegetable's sown area, by percent

№	Years	1976-1980	1981-1990	2005-2010	2011-2019
1	Cabbage	35.8	65.5	25.5	13.9
2	Turnip	18.3	11.1	21.1	24.1
3	Carrot	10.0	6.1	20.5	30.7
4	Onion	28.9	9.7	5.3	10.6
5	Garlic	7.0	7.6	27.6	1.1
6	Cucumber				4.4
7	Tomato				2.4
8	Watermelon and melons				6.4
9	Others				6.5
Total, %		100.0	100.0	100.0	100.0

Source: Densmaa and Chuluunbaatar, (2016),
https://www.1212.mn/tables.aspx?TBL_ID=DT_NSO_1001_038V2

In the period of 1976 and 1980, cabbage contributed 35.8% to the total vegetable sown area, followed by onion (28.9%), turnip (18.3%), carrot (10%), and others (7%). At peak production of cabbages’ sown area was 65.5 percent in between 1981 and 1990. In recent years, cabbage is characterized by decreasing about 5 times compared to period 1981-1990 years. The main influencing factors to the decreasing cabbage sown area was the necessary growing condition, vegetable household avoid to the planting cabbage to the related to irrigation system and sprouts (Densmaa and Chuluunbaatar 2016). Other vegetables such as garlic, cucumber, tomato, watermelon, and melons' sown area relatively increased 27.6 % in period 2005-2010 and 20.6% in period 2010-2019.

The Central region is the main potato and vegetable growing area in Mongolia, followed by the Western region. In 2019, the Central and Western regions constituted 84.3% of potato and 81% of the vegetable sown area while the remaining accounted for Eastern, Khangai, and Ulaanbaatar regions. Therefore, Selenge, Darkhan-Uul, Tuv (Central region), and Khovd (Western region) are the four main growing areas of vegetable sown area composition with a share of 29.7%, 16.2%, 13.6%, and 11.4%, respectively.

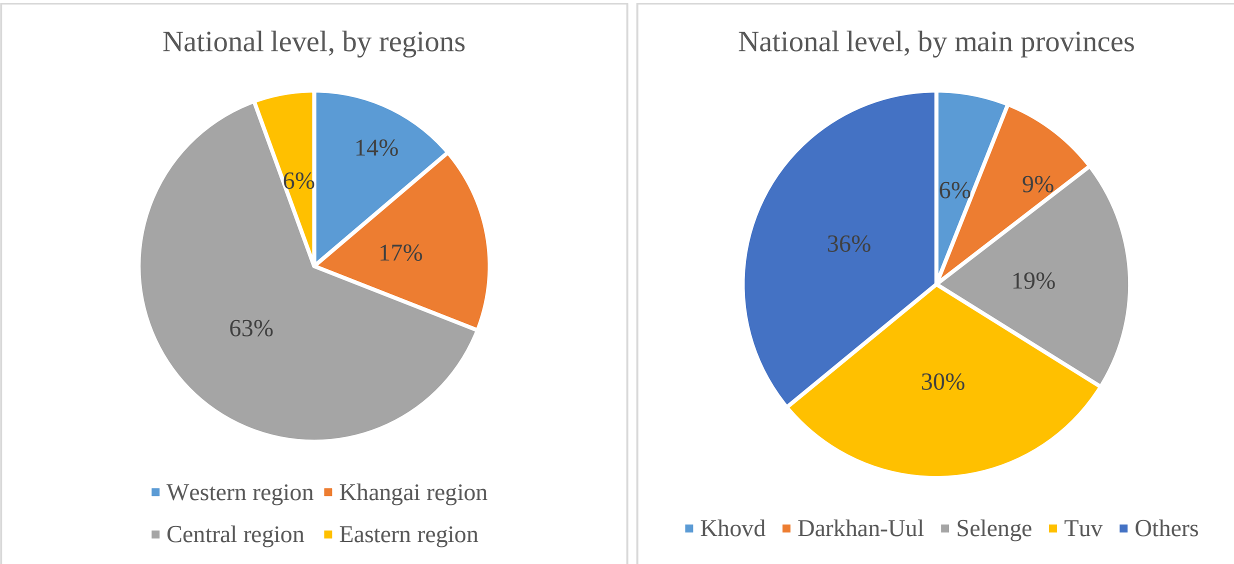

Figure 6. Vegetables' sown area, by location, between 1960 and 2019, on an average
Source: https://www.1212.mn/tables.aspx?TBL_ID=DT_NSO_1002_003V1

The potato sown area contributed to the 4.5% (Khovd), 3.9% (Darkhan-Uul), 16.6% (Selenge), and 52.8% (Tuv) provinces (National Statistics Office of Mongolia 2019). Figure 6 provides potato and vegetable average sown area on average over the last 60 years. The potato and vegetables' sown area contributed to 63% (Central region), 17% (Western region), 14% (Khangai region), and 6% (Eastern region). Selenge, Darkhan-Uul, Tuv, and Khovd provinces composed nearly 64% of the total potato and vegetables' sown area at the national level (Figure 6).

After transition time, the privatization of crop production has partly failed and is still incomplete. Private vegetable household production is a relatively new industry in Mongolia. Currently, approximately 14728 households and 1401 companies are engaged in crop production. About the household covered by a region, it locates 63.2 percent in Western and Central regions, 18.4 percent in the Khangai region, 9.3 percent in the Eastern region, and 9.2 percent in the Ulaanbaatar region. For the company, which is located 13 percent of the company in the Western region, 20.7 percent in the Khangai region, 53.5 percent in the Central region, 8.9 percent in the Eastern region, and 4 percent in the Ulaanbaatar region (National Statistics Office of Mongolia 2019). Most of the potato (about 77.9 percent of potato) and vegetables (about 79.8 percent of vegetable) have been planted by household (Table 9).

Table 9. Sown area component by type of producer, by main crops, 2019

Types	Company		Household		Total, thousand hectares
	Thousand ha	Share, %	Thousand ha	Share, %	
Potato	3.3	22.8	11.6	77.9	14.9
Vegetables	1.7	20.2	6.7	79.8	8.4

Source: Agriculture statistic report, 2019

The households' production dominates in potato and vegetable production (approximately 80% of total potato and vegetable production)

Potato and vegetable production

Potato is the main vegetable in Mongolia, composing 65 % of all vegetables on average. The potato and vegetable harvests were 25.4 thousand tons in 1960, as measured by official statistics. Before transition time, crop's peak production in Mongolia in 1989, during this period was classified as the planted area was approximately 50% (700000 ha) of total arable land (www.fao.org/faostat/en/) which were harvested 155.6-thousand-ton potato and 59.4-thousand-ton vegetable in this period. Due to transition time in potato production decreased from 155.5 thousand ton in 1989 to 46.0 thousand ton in 1996, while vegetable production from 59.4 thousand ton in 1989 to 16.3 thousand ton in 1992. This collapse was caused directly from shortages of fuels, fertilizers, seed, and agriculture equipment and indirectly from increasing production cost, inadequate extension services and training for household production, limited credit availability, and limited technical innovation (Santiago, 2003).

Total vegetable production volumes of common vegetables harvested in Mongolia between 1960 and 2019 are shown in figure 7. In the beginning of 1990, vegetable production has been continuously decreasing till 1996. Since then, potato and vegetable production increased to 344.8-thousand-ton harvest in 2012 which was at the peak production of vegetables. In this period, the potato was approximately 245.9-thousand-ton, while the vegetable harvest was 98.9 thousand tons.

In 2019, the total potato harvest was 192.2 thousand tons, while the vegetable production was 99.5 thousand tons, a total of 291.7 thousand tons.

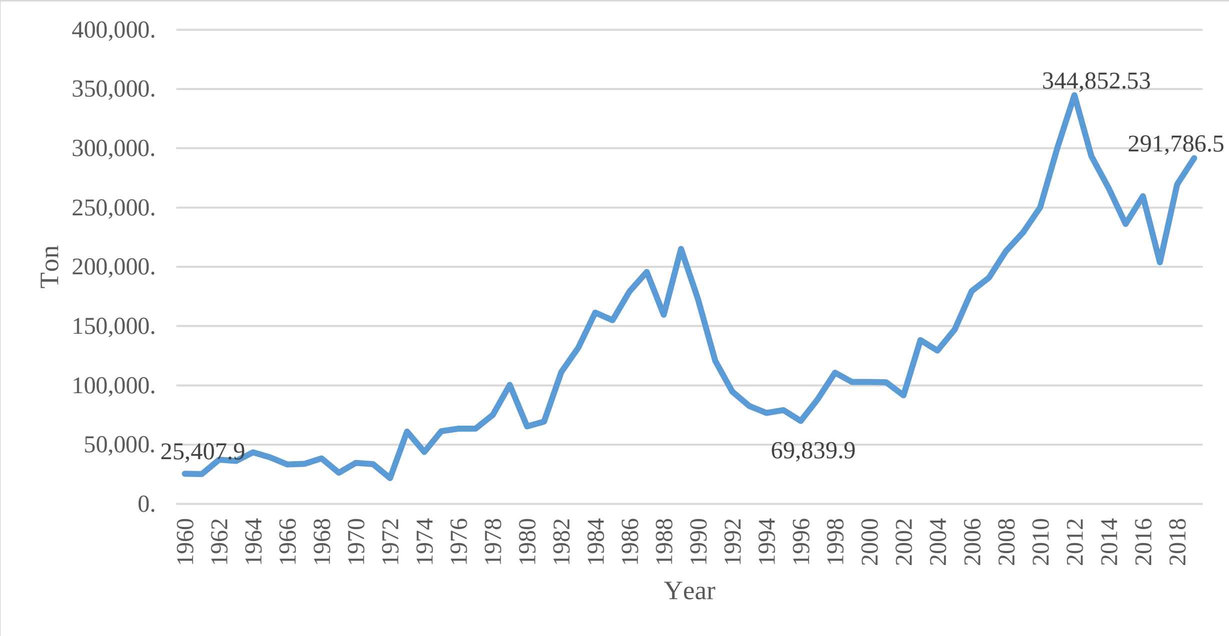

Figure 7. Potato and vegetable's total harvest, by the ton, between 1960 and 2019

Source: www.fao.org/faostat/en/

Due to the lack of official statistics, common vegetable production harvested in Mongolia between 1995 and 2019 is shown in Table 10.

Table 10. Main component vegetables' harvest, by thousand ton

Types	1995	2000	2005	2010	2015	2016	2017	2018	2019
Potato	51.9	58.9	82.8	167.9	163.7	165.3	121.8	168.8	192.2
Cabbage	9.2	15.8	14.9	17.9	15.4	16.7	15.2	18.8	21.9
Carrot	3.7	5.9	20.9	24.4	18.5	31.0	21.7	26.3	28.9
Turnips	10.2	13.9	14.7	22.0	13.9	17.4	12.5	18.5	16.0
Onion	1.6	1.1	2.8	5.4	6.7	10.0	12.1	14.1	9.5
Garlic	-	-	-	0.4	0.7	0.7	0.4	0.5	0.8
Cucumber	0.8	2.6	2.4	3.4	3.8	3.7	3.9	3.8	4.7
Tomato	0.5	2.1	1.8	1.6	1.9	2.2	2.0	1.9	1.9
Watermelon and melons	-	1.4	4.7	3.9	6.5	7.2	8.8	9.6	9.1
Total vegetables, specified	77.9	101.7	145.0	246.9	231.1	254.2	198.4	262.3	285
% of specified in all	98.4	98.8	98.6	98.7	97.9	97.8	97.3	97.3	97.7
Total	79.2	102.9	147.0	250.2	236.1	259.8	203.9	269.6	291.7

Source: https://www.1212.mn/tables.aspx?TBL_ID=DT_NSO_1001_038V3

Total production for potato and other vegetables are shown, along with specified data for cabbage, carrot, turnips, onion, garlic, cucumber, tomato, watermelon, and melons' production, the sum of which is shown as the percentage of the total production. These common vegetables dominated (constitute approximately 98%) in all vegetables produced in Mongolia between 1995 and 2019. Also, only potato production constitute 56%-65.8% of total vegetable production during this period. In 2019, all vegetables' production increased during the analyzed years with the exception of turnips and onion. The three main regions to the potato and vegetable productions are the Central region, Khangai region, and Western region.

In 2019, the Central region produced 76.7% to the potato and 62.4% to the vegetables followed by the Khangai region with 10.2% of potato, 11.1% of the vegetable, Western region 9.5% to the potato and 18.9% to the vegetable production. The Central region was the largest producer in Mongolia, with a total of 147.4-thousand-ton potato and 62.1-thousand-ton vegetable. The second-largest producer in vegetable production was the Western region, with a total of 18.9 thousand tons (Table 11).

Table 11. Vegetable production, by region

Region name	Name	1995		2005		2015		2019	
		Yield, thous. tn	*%, Total production*	*Yield, thous. tn*	*%, Total production*	*Yield, thous. tn*	*%, Total production*	*Yield, thous. tn*	*%, Total production*
Western region	Potato	5.3	10.3	16.0	19.3	18.0	11.0	18.2	9.5
	Vegetable	1.7	6.4	14.3	22.3	14.1	19.4	18.8	18.9
Khangai region	Potato	8.1	15.6	16.6	20.0	20.3	12.4	19.6	10.2
	Vegetable	2.1	7.7	6.4	9.9	12.7	17.5	11.0	11.1
Central region	Potato	27.8	53.5	42.7	51.6	115.7	70.7	147.4	76.7
	Vegetable	17.1	62.8	38.9	60.7	37.9	52.4	62.1	62.4
Eastern region	Potato	2.4	4.6	3.2	3.9	6.6	4.0	5.6	2.9
	Vegetable	1.1	4.0	1.7	2.7	4.0	5.5	3.0	3.0
Ulaanbaatar area	Potato	8.3	15.9	4.3	5.2	3.1	1.9	1.5	0.8
	Vegetable	5.2	19.1	2.8	4.3	3.8	5.2	4.5	4.6
Total	Potato	52.0	100.0	82.8	100.0	163.8	100.0	192.2	100.0
	Vegetable	27.3	100.0	64.2	100.0	72.4	100.0	99.5	100.0

Source: Mongolian statistical yearbook, 2019

In 2019, only four provinces (Khovd (Western region), Tuv, Selenge, Darkhan-Uul (Central region)) constituted 81.1% of potato production and 73.7% of vegetable production. Especially, Tuv province had the highest production (54%) in potato and the Selenge produced the largest portion of vegetables (33%) (Figure 8).

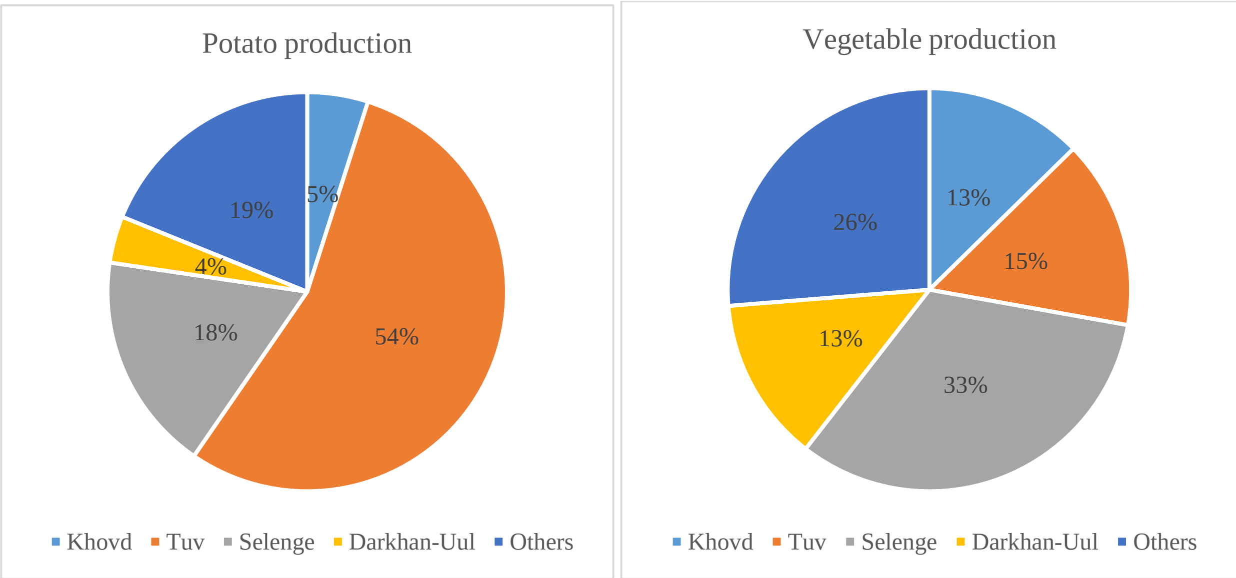

Figure 8. Potato and vegetable's production, by province, 2019
Source: Mongolian statistical yearbook, 2019

Yields per hectare harvest are the main parameter in the productivity and efficiency of crop production. Potato's yields per hectare data officially have announced by NSO and we calculated vegetable's yields per hectare that ratio between total vegetable harvest and total sown area (Figure 9).

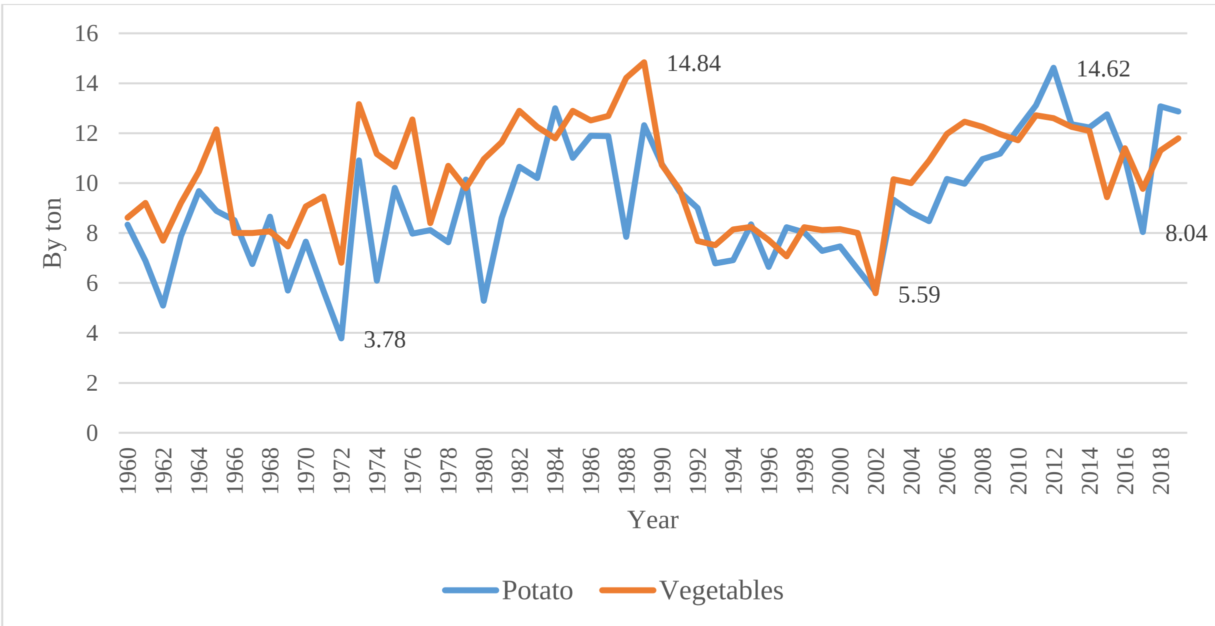

Figure 9. Potato and vegetable's yields per hectare, by the ton
Source: https://www.1212.mn/Stat.aspx?LIST_ID=976_L10_2&type=tables

In 1960, potato and vegetable production's yield per hectare was 8.3 ton and 8.6 ton, respectively. Even though yield per hectare was increasing trend until 1990, after the transition time, in 2002 yield per hectare had been decreasing minimum level 5.6 ton in potato and 5.6 in vegetables.

Therefore, there were main negative factors such as financial concentration instruments, weak policy due to the privatization of crop production. As a result, large-scale engineering irrigation systems have been cut off from use, and the size of vegetable growing areas, especially the most sizable cabbage cultivation, has decreased in seeds and varieties, abolition, old structure and structure, integrated production, management, and sales systems, etc. (Densmaa and Chuluunbaatar 2016).

Potato and vegetable import

Since 1995, Mongolia has started to provide potato and vegetable consumption by import. During the transition period, crop production has fallen related with that privatization, shortages of fertilizers, seeds, and parts for agricultural equipment are the proximate reasons for this collapse, although more indirect causes can be attributed to the liberalization of the economy and increased costs of production, restricted credit availability, lacking extension services and training for farmers, and limited technical innovation and research (Santiago, 2003). A glance at figure 10 presents that some striking similarities between vegetables (including potato) import between 1995 and 2019. Potato import quantity was higher than other vegetables import quantity. Such as potato import quantity comprised 50-70% of all vegetable import until 2005. After that, the potato import quantity started to decrease to date. Cabbage import is comprising 20-30% of all vegetables after potato. Since 2008, all vegetable import has been steadily increasing with exception potato, carrot and turnips' import (Figure 10).

Also, vegetable import has been sharply increasing until 2012. After that, the import was slightly fallen, for example, in 2019 vegetables imported 0.3-thousand-ton potato, 29.4 thousand ton of cabbage, 18.4 thousand ton of onion and garlic, 8.3-thousand-ton carrot and turnips, 9.8 thousand ton of melons, 0.5 thousand ton of tomato, and 0.48-thousand-ton cucumber. In terms of import quantity, about 90% of vegetables are carrot, cabbage, turnips, garlic, and onion. Customs data demonstrate that vegetables were imported into Mongolia from various countries but most of the vegetables were imported from only one country- The people's Republic of China. For example, 80 % of the onion, garlic import, 99% of the cabbage, 60% of the carrot, turnips were imported from the People's Republic of China in 2019.

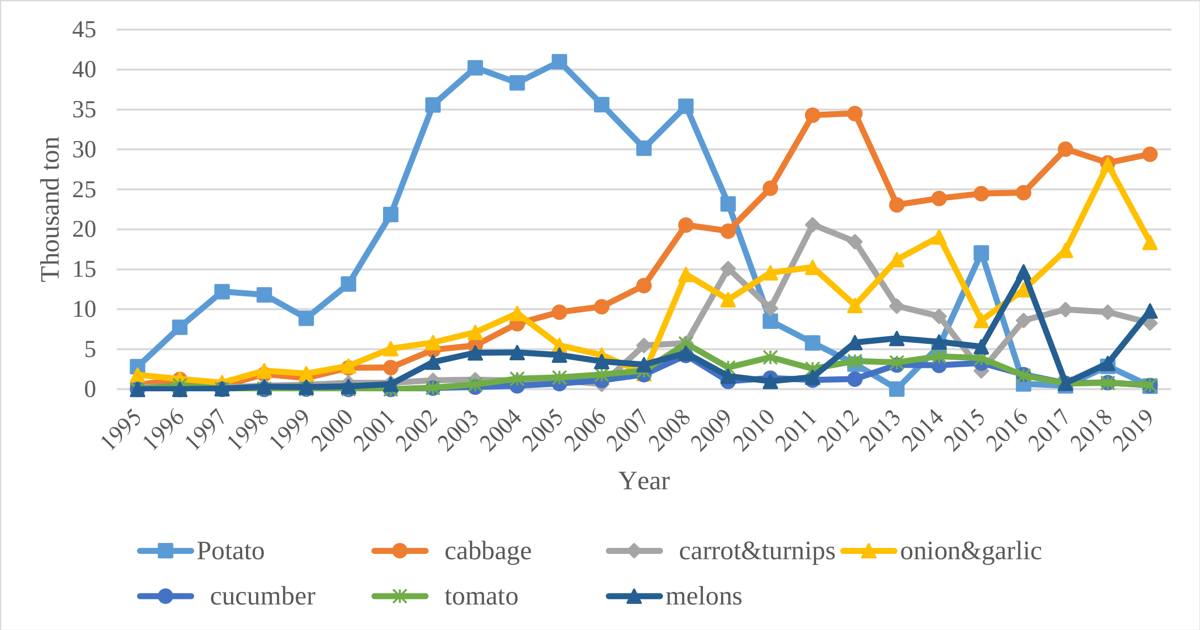

Figure 10. Vegetable import, by types, thousand ton, between 1995 and 2019

Source: https://customs.gov.mn/statistics/index.php?module=users&cmd=info_st

2.3.2 Potato and vegetable consumption and self-sufficiency rate

Potato and vegetable consumption and demand

Since 1997, Mongolia was started to pay attention to food security and food nutrition. A standard population's optimal consumption was identified by the Nutrition research center and by the statement of the Ministry of Health and Social protection (former name). Also, a standard population's food supply 13 commodity groups identified by National Statistics Office of Mongolia (former name National Statistical organization), Ministry of Agriculture and Food and Nutrition center associated with Mongolian government announced "Food security year" of 2008. A standard population's optimal consumption for per year is identified by the Nutrition research center and Ministry of Health (current name) meat and meat products are 69.4 kg, milk is 58.4 kg, dairy products are 65.7 kg, flour is 36.5 kg, flour products are 65.7 kg, all types of grains 18.3 kg, sugars, and sweeteners are 12 kg, potato is 43.8 kg, vegetables are 94.9 kg, fruits and berries are 73 kg, pulses is 14.6 kg, the egg is 7.3 kg, vegetable oil is 8.4 kg and butter 3.7 kg (National Statistics Office of Mongolia, 2019). In other words, Ministry of Health of Mongolia recommended daily intake 460 grams' vegetable and fruits for standard population in Mongolia while international experts (such as WHO) have recommended a daily intake of least 400 grams of fruit and vegetables (Agudo, 2017).

I calculated domestic potato and vegetable consumption between 1995 and 2019 based on a standard population annual food consumption. Last 26 years, potato and vegetable consumption increased by approximately 1.1 percent per annum. Therefore, on average of last 26 years, 127.3 percent of the potato consumption, 45.1 percent of vegetable consumption provided by total demand respectively. Demand is defined ability to purchase goods and services. In other words, demand is equal to the sum of the total resources of the market. However, we determined using statistical data that total demand is defined as that sum of potato and vegetables' domestic production plus imports minus exports. Table 12 shows the potato and vegetable consumption, production, and supply level.

Table 12. Potato and vegetable consumption and supply level, between 1995-2019

	Consumption, thousand ton		Demand (domestic production +import-export), thous.tn		Supply level	
	Potato	Vegetables	Potato	Vegetable	Potato	Vegetable
1995	88.4	191.6	54.8	29.9	62.0	15.6
1996	89.7	194.4	53.8	27.2	60.0	14.0
1997	91.0	197.1	66.4	35.6	73.0	18.0
1998	92.2	199.9	77.0	50.6	83.4	25.3
1999	93.6	202.7	72.6	43.2	77.6	21.3
2000	94.7	205.2	72.1	50.8	76.1	24.7
2001	95.9	207.8	79.9	53.8	83.4	25.9
2002	97.2	210.6	87.5	55.3	90.0	26.2
2003	98.4	213.1	118.9	78.8	120.9	37.0
2004	99.4	215.4	118.6	74.2	119.3	34.5
2005	100.6	217.9	123.8	86.9	123.1	39.9
2006	101.8	220.6	144.7	92.2	142.1	41.8
2007	103.3	223.8	144.7	104.1	140.0	46.5
2008	105.1	227.7	170.2	133.7	162.0	58.7
2009	107.1	232.0	174.4	129.4	162.9	55.8
2010	108.8	235.8	176.5	138.5	162.1	58.8
2011	110.8	240.1	207.4	174.3	187.1	72.6
2012	113.0	244.9	249.1	173.0	220.3	70.6
2013	115.5	250.3	191.7	164.3	165.9	65.7
2014	118.1	255.9	166.9	169.9	141.3	66.4
2015	120.5	261.2	180.8	120.2	150.0	46.0
2016	110.5	239.5	166.0	158.3	150.2	66.1
2017	112.5	243.8	122.2	141.7	108.6	58.1
2018	112.9	244.6	171.8	171.7	152.2	70.2
2019	113.2	245.2	192.6	166.4	170.2	67.9
Average	103.8	224.8	135.4	105.0	127.3	45.1

Source: Indicators for food security statistics, 2019

One of the important ways to reduce reliance on imported vegetable produce is to increase the self-sufficiency rate of domestic production. The self-sufficiency rate indicates a country producing a proportion of its domestic food consumption. The last 26 years on average self-sufficiency rate was 97.6 percent of potato, 40.3 percent of cabbage, 87.6 percent of carrot and turnips, 37.3 percent of onion and garlic, 72.2 percent of cucumber, 50.5 percent of tomato, 61.5 percent of melons (Table 13). The self-sufficiency rates of cabbage, onion, and garlic were lower than other vegetables. And domestic production of potatoes provided total demand with a 100 percent self-sufficiency rate due to some implemented projects such as the "Mongol potato" national program by SDC.

Table 13. Vegetable production self-sufficiency rate, between 1995-2019

	Potato	Cabbage	Carrot and turnips	Onion and garlic	Cucumber	Tomato	Melons
1995	94.8	94.4	98.3	47.1	-	-	-
2000	81.7	85.5	96.2	27.5	-	98.2	79.4
2005	66.9	60.7	97.0	33.7	77.5	55.3	52.4
2010	95.2	41.5	82.1	28.6	70.6	28.1	79.7
2011	97.2	37.9	72.4	28.5	79.5	47.8	83.1
2012	98.7	37.0	75.4	37.2	74.1	37.4	52.4
2013	100.0	47.2	84.5	38.8	58.8	42.6	45.8
2014	96.8	43.9	91.8	35.4	61.3	36.7	51.7
2015	90.6	38.7	104.2	46.0	53.9	32.5	54.8
2016	99.6	40.4	91.6	46.1	66.9	56.4	33.0
2017	99.6	33.6	86.8	42.0	84.3	73.7	92.1
2018	98.3	39.9	92.7	34.2	82.0	70.4	74.7
2019	99.8	42.7	94.8	35.9	90.7	79.3	48.1
Average	97.6	40.3	87.6	37.3	72.2	50.5	61.5

Source: Own calculation using data from the National Statistics Office of Mongolia.

2.3.3 Government policy for crop production

Mongolian people consumed meat more than vegetables due to traditional nomadic culture. Nowadays, the Mongolian diet has been changing who consume more vegetables with associated urbanization. The majority of people (half of the population) living in urban areas, mostly in the capital city Ulaanbaatar in 2019. Thus, the Mongolian government has been intervening especially in crop production. Such as, "Green revolution" national program, "Atar-3 campaign" national program, "Mongolian vegetable" national program, etc. Also, there are many projects implemented by international organizations. The "Green Revolution" National Program, which has been implemented in two stages from 1996 to 2012. The national program's main purpose was to increase vegetable's domestic production and restore some cultivation area (Densmaa and Chuluunbaatar, 2016). As a result of the program, vegetable producers connected to a commercial bank for the loan to buy some tractors, small and medium-sized irrigation equipment, fertilizer, and so on. Also, the agro-park has been established in the province and soum. Table 14 shows brief information on medium and long-term policies for crop production.

Table 14. Medium and long term policies for crop production

	Term	Main target
1	In the long- term	- To provide domestic demand for potato, vegetable, and oil products, and develop export-oriented. - To develop winter and summer greenhouses and cellars for vegetable growing and to provide sustainable urban and rural populations with fresh produce of the year.
2	In the medium-term	- To improve the utilization of circulating areas, establish areas for cultivation and intensive livestock husbandry. - To supply the demand for cereals, potatoes, and vegetables and 50 percent supply to fodder crops. - To increase the variety and diversity of fruits. - To develop winter and summer greenhouses and complex farms and, - To supply fresh vegetable crops demand for urban area residents.

Source: https://mofa.gov.mn/exp/blog/8/245

Ultimately, the vegetable production has been stabilized, an average annual harvest increased by 3.5 times and yield per hectare by 38 percent compared to the previous decades. In 2012, 756 cooperatives and business entities benefiting from the "Green Revolution" program, 41.2 thousand households cultivated potatoes, vegetables, and berry crops, planted 23.4 thousand hectares, harvesting 341.3 thousand tons. And 90.0 kg potatoes and 36.2 kg vegetables per person are the real results of this program.

One of the important implemented project was “Mongol” potato program funded by the SDC. As a result of “Mongol” potato program, country enabled to be fully self-sufficient in potato production. Since 2016, SDC has been started to implementing project to support for vegetable production based on the success of the “Mongol” potato program (Swiss Agency for Development and Cooperation, 2017).

After the transition period, many projects and programs have been starting to implement support by international donor organizations in Mongolia. Table 15 shows the implementation of some programs and the project’s purpose.

Table 15. Implementing projects and supporting organizations related to crop development in Mongolia

	Implementing program	Period	Donor or implementing organization	Main target
1	"Mongolian vegetable" National program	2016-2022	Swiss Development Cooperation	The project aims to increase the living standards of rural farmers and urban vulnerable groups through the promotion of gender equality and sustainable vegetable production. 1. To sharing knowledge of technology for household vegetable's producer 2. To increase household vegetable producer's income 3. To develop vegetable production of the household for the supply of demand 4. To innovate policies for vegetable production's law, rule, and system
2	"Atar-3 Land Rehabilitation" campaign national program	2008-2020	Ministry of food and agriculture	The overall goal is this campaign: "To intensify the development of the arable land of Mongolia, by creating legally and economically favorable conditions for engaging in farming and steadily supplying the population with safe products (thus eliminating dependence on imports)."
3	"Food security" national program	2008-2016	Ministry of food and agriculture	The overall goal of the program is to ensure the sustainable supply of nutritious, secure, and accessible food, which enables healthy livelihood and high labor productivity of the population, involving the participation of the citizens, government, public and private sectors (National program for food security, 2009).
4	"Green revolution" national program	1996-2012	Ministry of food and agriculture	The program's main purpose was to increase vegetable's domestic production and restore some cultivation area.
5	"Price stability of main food products" subprogram	Since 2012	Mongol bank	The program's main objective is to keep in price stability of main food products with related to exchange rate.
6	Development of dairy agriculture and food security	2004-2006	Japan government, UNDP	To increase herder's income by developing dairy production and supplying food security
7	Modern dairy farm, vegetable production, and improved veterinary services	1996-2009	JSC Joint Community Services	To increase household income associated with improving the modern dairy farm, increasing vegetable production, and improving livestock veterinary services for herders.

8	"To establish winter complex greenhouse for vegetables" project	2016-2020	Ministry of food and agriculture	The project's main purpose is to establish in winter greenhouse for vegetable production during the winter season in a specific area (namely, Ulaanbaatar, Central, and West region)

Source: https://mofa.gov.mn/exp/blog/8/245 and (Santiago, 2003)

Since 2016, the Mongolian Government started implementing the "Mongol vegetable" national program (MOFA, 2017). Currently, this subprogram is one of the main programs in the crop sector. Aims of the program are focused on diversification and production of vegetables and support a sustainable annual supply of domestically produced vegetables by smallholder farmers and cooperatives (especially household production). The "Mongolian vegetable" National Program on vegetables has the following major components:

1. To sharing knowledge of technology for household vegetable producers – to introduce state of technology to intensify vegetable household production and irrigation systems, to invest increase storage capacity, and develop and support a direct marketplace for vegetables.
2. To decrease reliance on imported vegetables – to increase the efficiency of vegetable production and to supply consumer's consumption with fresh vegetables during the year.
3. To support seed production and to supply quality and high-yielding seed with adaptable in Mongolian extreme climate.
4. To enhance the knowledge and skill of vegetable household farmers.

III. MATERIALS AND METHODS

3.1 Determinants of the Armington substitution elasticities

Since the seminal work conducted by Armington (1969), the Armington model has been widely used to evaluate international trade policy in applied international economics.

3.1.1 Armington model

In a country that has an open economy and free liberalization trade, it is influencing to expanding the consumer choice of country and consumer's basket constitutes from home goods and foreign goods. Thus, consumer utility is based on consuming between domestic goods and foreign goods. In other words, consumer distributes their spending between domestic and various import goods and they may reconsider their choice whenever relative international prices change. Armington formulated the demand theory for tradable goods in 1969. After that, so-called Armington elasticities are based on the differentiation of products with respect to their origin and the imperfect substitution in demand between domestic products and import supply. Using a two-stage budgeting method, he supposed in the first stage that a buyer (or importing country) determines the total quantity to buy to maximize the utility, and in the second-stage, allocates shares of the total quantity to individual suppliers (or exporting countries) in order to minimize the costs. In the first-stage equation, he specifies the total demand for both foreign and domestic products as the dependent variable (Huchet and Pishbahar, 2008). For the second-stage equation, Armington (1969) made two main assumptions:

1. The elasticity of substitution for each market are constant
2. The elasticity of substitution between any two products competing in a market is the same as that between any other pair of products competing in the same market.

These two assumptions, which are together regarded as the 'single CES assumption, allow us to reduce the number of coefficients to be estimated and make the estimation process easier. Armington elasticity is an indication of the degree of substitution between domestic products and imported products. Higher elasticity indicates greater substitution between domestically produced products and imported products which means these products are identical. On the other hand, lower elasticity means that these products are dissimilar and weak substitutes. Product differentiation does not turn on physical differences between goods alone. Physical identical goods may be differentiated by availability in time, the convenience of purchase, after-sales service, or even consumers' perceptions of inherent. But, consumer' perception of inherent quality has been shown to be strong in some cases, even when they are shown that they cannot distinguish between the two products when using them. However, Blonigen and Wilson (1999) have studied influencing factors to the difference of Armington elasticity across industrial sectors. They found that strong support variable foreign-owned industries affect substitution between domestic and import goods. Based on the Armington approach, the structure of Armington demand has succinctly been described by following Figure 11. In other words, consumer demand constitutes domestic products and import products. In the Armington model, consumers have a two-stage budgeting process. In the first stage, consumers (or importing country) decide between domestically produced and imported products (macro elasticity), and in the second-stage, imported products are differentiated by country of origin (micro elasticity).

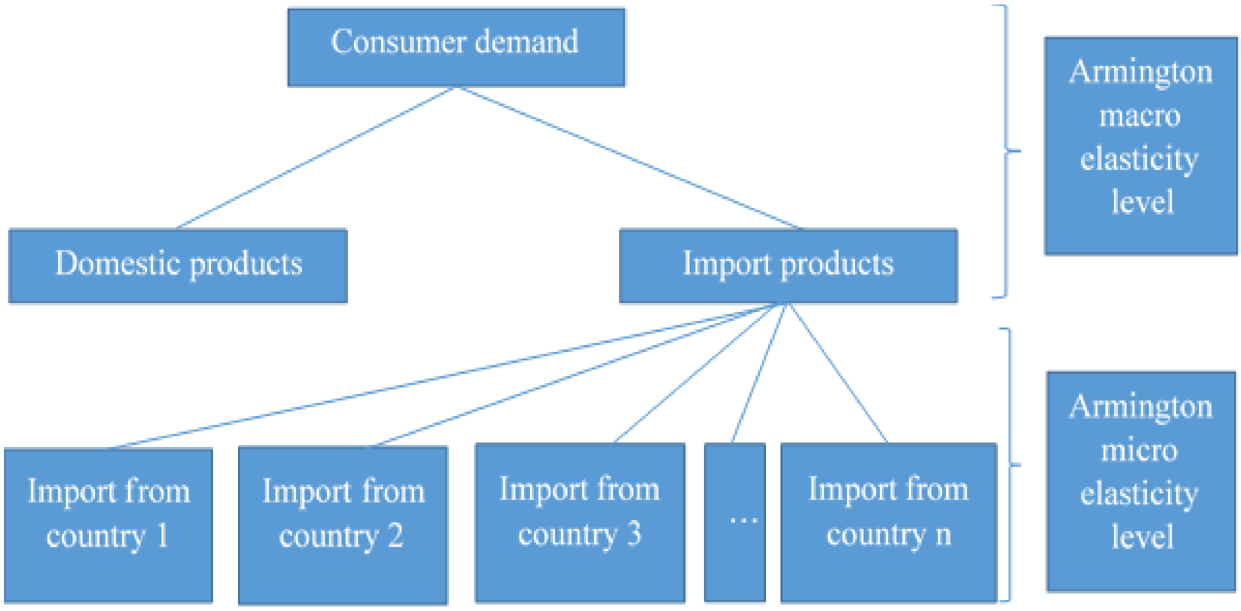

Figure 11. Structure of Armington demand

Source: Wunderlich and Kohler, (2018)

According to Armington theory, much of the occurring literature in assuming that consumer utility is given in the form of a constant elasticity of substitution (CES) sub-utility function in order to model the demand for domestic and imported product. If consumers are to be satisfied, demand functions state relationships that must exist among specific variables. Consumer's satisfaction depending on getting the most for their money, given the available selection of products and their prices. Demand functions may along these lines be seen as statements of conditions under which an index of consumer's satisfaction is high as restricted incomes and given prices permit (Armington, 1969).

CES function general form

In my attempt to explain the elasticity we will first explain the constant elasticity of substitution (CES) function. In 1961, Arrow, Chenery, Minhas, and Solow have developed production functions with constant elasticity of substitution (CES) as an extension of the Cobb-Douglas function. It is possible to determine the optimal ratio of domestic production and imported goods. The CES function is shown below by the equation.

$$y = \gamma(\beta x_1^{-\rho} + (1-\beta)x_2^{-\rho})^{-\frac{\nu}{\rho}} \qquad (3.1)$$

Where $y -$ output, $x_1, x_2 -$ inputs, γ – parameter of productivity, β – share parameter, ρ – elasticity of substitution, $\sigma = 1/(1+\rho)$, $\nu -$ elasticity of production dimension. Leontief, Cobb-Douglas functions are special cases of the CES function. That is,

ρ =0 and σ= 1 is Cobb-Douglas function

ρ = -1 and $\sigma = \infty$ is linear function

$\rho = \infty$ and σ=0 is Leontief function

The special cases of CES function, for example, that is ν=1, γ =1 we get the CES function is shown below equation (3.2). Also, we need to remember the relationship between σ and ρ. In other words, it shows the $\sigma = 1/(1+\rho)$.

$$y = (\beta x_1^{-\rho} + (1-\beta)x_2^{-\rho})^{-\frac{1}{\rho}} \qquad (3.2)$$

3.1.2 Empirical specification

The elasticity of substitution between home goods and import goods can be derived from the two-stage budgeting process. In the first stage, the consumer determines the total quantity to buy to maximize the utility. In the second stage, the consumer allocates a share of the total quantity to the individual supplier in order to minimize the costs. Armington models typically specify a constant elasticity of substitution (CES) function. Previous studies related to the Armington model have been using base CES sub-utility function in order to model such as (Wunderlich and Kohler, 2018; Olekseyuk and Schürenberg-Frosch, 2016; Welsch, 2008; Reinert and Roland-Holst, 1992) et al. Therefore, we assume that consumer maximizes sub-utility U, who use domestic products and foreign products at the same time and same products. Our CES (Constant elasticity of substitution) sub-utility function is based on Blonigen and Wilson (1999) approach (also used in Wunderlich and Kohler, 2018) follow as:

$$U = (\beta M^{\frac{\sigma-1}{\sigma}} + (1-\beta)D^{\frac{\sigma-1}{\sigma}})^{\frac{\sigma}{\sigma-1}} \quad (3.3)$$

$$\text{s.t} \qquad I = P_M M + P_D D$$

Where U is consumer sub-utility, M is *the* quantity of import goods, D is *the* quantity of domestic goods, β is a parameter that weights the import good relative to domestic good, σ is the elasticity of substitution between imports and domestic goods, I is the consumers' total income, P_M is the import price, and P_D is the domestic price. Additionally, we assumed that the CES sub utility function is homothetic that is means the share of income spent on domestic and imported goods does not change with income. In order to maximize utility, prices are made equal to the marginal utility derived from purchasing the associated products so that $\frac{\partial U}{\partial M} = P_M$ and $\frac{\partial U}{\partial D} = P_D$. Utility maximization of equation (3.3) yields the following first-order condition is given by:

$$\frac{\partial U}{\partial M} = \frac{\sigma}{\sigma-1}\left[\beta M^{\frac{\sigma-1}{\sigma}} + (1-\beta)D^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}-1} \cdot \frac{\sigma-1}{\sigma}\beta M^{\frac{\sigma-1}{\sigma}-1} = P_M$$

$$\frac{\partial U}{\partial D} = \frac{\sigma}{\sigma-1}\left[\beta M^{\frac{\sigma-1}{\sigma}} + (1-\beta)D^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}-1} \cdot \frac{\sigma-1}{\sigma}(1-\beta)D^{\frac{\sigma-1}{\sigma}-1} = P_D \quad (3.4)$$

Then, can be rewritten as: $\frac{P_M}{P_D} = \frac{\beta}{1-\beta}\left(\frac{M}{D}\right)^{\frac{-1}{\sigma}}$ (3.5)

Therefore, to see the implication from equation (3.5), we obtain the ratio of domestic goods and import goods

$$\frac{M}{D} = \left[\frac{\beta}{1-\beta} \cdot \frac{P_D}{P_M}\right]^{\sigma} \quad (3.6)$$

Where P_D is the price of domestic goods, P_M is the price of import goods. Taking natural logarithm yields:

$$\ln(\frac{M}{D}) = \sigma \ln\left(\frac{\beta}{1-\beta}\right) + \sigma \ln(\frac{P_D}{P_M}) \quad \text{or} \quad \ln(\frac{M}{D}) = a_0 + a_1 \ln(\frac{P_D}{P_M}) + \varepsilon \quad (3.7)$$

Equation (3.7) is our general econometric estimation model, where $a_0 = \sigma \ln\left(\frac{\beta}{1-\beta}\right)$, a_1 is short-run substitution elasticity. The short-run Armington elasticity can be derived directly from the estimated coefficient of the price relation between domestically produced and imported products. However, long-run elasticity can be derived from three different ways (McDaniel and Balistreri, 2002; Wunderlich and Kohler, 2018).

First, our data (time series of quantity and price series) are stationary log-level data I (0), we estimate using the parsimonious geometric lag model (eq. 3.8) which is easy to extract short-run and long-run estimates. In other words, if $0<a_2<1$ is long-run elasticity can be estimated $\sigma^* = \frac{a_1}{1-a_2}$.

$$\ln\left(\frac{M}{D}\right)_t = a_0 + a_1 \ln\left(\frac{P_D}{P_M}\right)_t + a_2 \ln\left(\frac{M}{D}\right)_{t-1} + \varepsilon \qquad (3.8)$$

Second, if data are both stationary I(1) and cointegrated, we use a single-equation error correction model that determines the long-run elasticity (equation 3.9 is unrestricted error correction model). Long run elasticity estimate is $-a_3/a_2$.

$$\Delta\ln\left(\frac{M}{D}\right)_t = a_0 + a_1\Delta\ln\left(\frac{P_D}{P_M}\right)_t + a_2 \ln\left(\frac{M}{D}\right)_{t-1} + a_3 \ln\left(\frac{P_D}{P_M}\right)_{t-1} + \varepsilon \qquad (3.9)$$

Finally, our data are stationary I(1), but not cointegrated or one series is stationary, we able to determine only short-run Armington elasticity. However, we determine short-run elasticity using the following equation.

$$\Delta\ln\left(\frac{M}{D}\right)_t = a_0 + a_1\Delta\ln\left(\frac{P_D}{P_M}\right)_t + \varepsilon \qquad (3.10)$$

Many authors augment this model with dummy variables. Such as seasonal dummy and time trend etc.

Home bias value

The home bias concept is consumer preferences in favor of home-produced over foreign-produced goods (Whalley and Xin, 2009). The literature contains a variety of characterizations of home bias. For example, some of researchers have studied home-bias related to geographic (Hillberry and Hummels, 2002). Blonigen and Wilson (1999) discussed home bias exclusively in terms of preferences in the home country and provide a measure of home bias that links the elasticity of substitution. In other words, it has estimated intercept from Armington elasticity regression. We can calculate a home bias using substitution elasticity following as

$$1-\beta = \frac{1}{1+\exp\left(\frac{a_0}{a_1}\right)} \qquad (3.11)$$

β is indicated import weight on consumer total demand. In other words, β coefficient is defined by equation 3.11(a).

$$\beta = \frac{\exp\left(\frac{a_0}{a_1}\right)}{1+\exp\left(\frac{a_0}{a_1}\right)} \qquad (3.11a)$$

Estimating of the price elasticities of import demand and domestic demand

The price elasticities of demand measure the response of consumers to changes in prices. Such elasticities give the percentage change in demand for a product in the case of a 1% change in the price for the particular good. Typically, price elasticities of demand for consumer goods and services are estimated between 0 and more than −1. A price elasticity larger than −1 is elastic. If the demand for a good is inelastic (price elasticity is close to zero), the changes are small in the case of increasing prices. Specifically, the necessities of daily life and goods with fewer substitutes are inelastic and have lower elasticities. I try to define elasticities for the price of import demand and domestic demand in the short-run and long run. In this part, we have calculated the price elasticities for import demand and domestic demand. We can use the shared parameter (based on consumption) in this calculation. Prevoius price elasticties studies indicated that using aggregate level for import and export price elasticities (Imbs and Mejean, 2010).

The import and domestic production causes from the price of import and demand, which is is shown below in equations (3.12) and (3.13).

$$lnM = \frac{1}{1-\rho} ln\beta - \frac{1}{1-\rho} lnP_M + lnD - \ln\left(\beta^{\frac{1}{1-\rho}} P_M^{-\frac{1}{1-\rho}} + (1-\beta)^{\frac{1}{1-\rho}} P_D^{-\frac{\rho}{1-\rho}}\right) \tag{3.12}$$

$$lnD = \frac{1}{1-\rho} \ln(1-\beta) - \frac{1}{1-\rho} lnP_D + lnM - \ln\left(\beta^{\frac{1}{1-\rho}} P_M^{-\frac{1}{1-\rho}} + (1-\beta)^{\frac{1}{1-\rho}} P_D^{-\frac{\rho}{1-\rho}}\right) \tag{3.13}$$

The solution to the price elasticities of import and domestic demand, whose derivatives by the price of import and domestic from equation (3.12) and (3.13).

$$E_{P_M}^{M} = -\frac{1}{1-\rho} + \left(\frac{\rho}{1-\rho}\right) \frac{\beta^{\frac{1}{1-\rho}} P_M^{\frac{\rho}{1-\rho}}}{\left(\beta^{\frac{1}{1-\rho}} P_M^{-\frac{1}{1-\rho}} + (1-\beta)^{\frac{1}{1-\rho}} P_D^{-\frac{\rho}{1-\rho}}\right)} \tag{3.14}$$

$$E_{P_D}^{D} = -\frac{1}{1-\rho} + \frac{(1-\beta)^{\frac{1}{1-\rho}} P_D^{-\frac{\rho}{1-\rho}}}{\left(\beta^{\frac{1}{1-\rho}} P_M^{-\frac{1}{1-\rho}} + (1-\beta)^{\frac{1}{1-\rho}} P_D^{-\frac{\rho}{1-\rho}}\right)} \tag{3.15}$$

The σ and ρ are relative below the equation.

$$\frac{1}{1-\rho} = \frac{\sigma}{2\sigma-1}, \quad \frac{\rho}{1-\rho} = \frac{1-\sigma}{2\sigma-1}$$

Where

ρ, σ- elasticities of substitution

$E_{P_M}^{M}$- elasticity of import price

$E_{P_D}^{D}$- elasticity of domestic price

P_M- average price of import

P_D −average price of domestic

β- optimal allocation parameter

3.1.3 Data collection

This study estimates the substitution macro elasticity (see Figure 11) and uses time-series data series. There are need to require four data series which are vegetables import and domestic production and the prices of those products. I choose the following vegetables due to a lack of information. These vegetables are potato, tomato, garlic and onion, cabbage, carrot and turnips, and cucumber. This study uses the yearly data of the National statistical yearbook, Customs yearbook (https://customs.gov.mn/statistics/, Harmonized System (HS) code was 07 categories products), and Mongol Bank (Central bank of Mongolia) yearbook data from 1995 to 2019 (Table 16).

All quantities are given in a thousand tons and prices in real (base period was chosen 2015 values) MNT (Mongolian currency tugrik) per ton. Vegetables domestic production quantity was collected from Statistical yearbook for Agriculture sector, Mongolian Statistical yearbook and www.1212.mn official statistical website for each product.

Table 16. Database from NSO and Customs yearbook

Harmonized System code	Vegetable name	Domestic production quantity	Import quantity	Domestic unit price	Import unit price
0701	Potato	available	available	available	calculate
0702	Tomato	available	available	available	calculate
0703	Garlic and onion	available	available	available	calculate
0704	Cabbage	available	available	available	calculate
0706	Carrot and turnips	available	available	available	calculate
0707	Cucumber	available	available	available	calculate

Source: Own description based on data information

Wunderlich and Kohler, (2018) have estimated Armington elasticities using a retail price measured in stores barcode scanner. Thus, I am able to use retail prices for domestic vegetables which are published by National Statistics Office of Mongolia (NSO). Furthermore, vegetable import quantity gathered from Customs yearbook for each product. The import unit price was calculated as the ratio between the customs value of these vegetables and quantity multiplied by the exchange rate. In other words, the import price for each vegetable constructed from:

$$P_M = \frac{\sum Customs\ value\ of\ each\ prodct}{import\ quantity\ of\ each\ product} \cdot exchange\ rate$$

The annual exchange rate data is used for converting US $ to MNT. The final step is all prices converted to real prices using the Laspeyres index.

3.2 Determinants of technical efficiency

Efficiency concept is pioneered by Farrell, (1957), there are two widely used methods of measuring the efficiency of a decision-making unit: The Data Envelopment Analysis (DEA) - non-parametric approach and the Stochastic Frontier Analysis (hereafter SFA)- parametric approach. My research determines the technical efficiency of vegetable smallholder production in Mongolia using the SFA. Thus, this part describes the SFA.

3.2.1 Stochastic frontier analysis (SFA)

The stochastic frontier analysis approach was independently proposed by (Aigner et al., 1976; Meeusen and Broeck, 1977). After that, the SFA model has been widely used to estimate the technical efficiency in applied economic research. The stochastic frontier production function has two error components: One is to account for the existence of technical inefficiency of production and the other one is express random error. Early stochastic frontier analysis applications were based on a two-step estimation method. For example, Bravo-Ureta and Pinheiro, (1993), Kalirajan, (1981) have utilized a two-step estimation method. The first step is to estimate a standard stochastic frontier model. The second step is to estimate the relationship between estimated inefficiency and influencing factors of a firm's characteristics. But this two-step estimation approach contradicts the assumption on the independence of inefficiency effects in the stochastic frontier model. A number of researchers solved this problem in their studies using a single-step estimation approach. For example, Seok et al., (2018), Kumbhakar and Lien, (2010), Nyemeck et al., (2008), Wang and Schmidt (2002), Bozoglu and Ceyhan, (2007), Battese, (1995), etc. The single-step estimation approach with output-oriented technical efficiency function is defined by the following equation.

$$y_i = \exp\left(f(x_i, \beta) + v_i - u_i\right) \tag{3.16}$$

$$\varepsilon_i = v_i - u_i \tag{3.17}$$

Where y_i represents output, x_i denotes a set of inputs and β is parameters to be estimated, *i* is the *i*th firms or individuals, ε_i is error term which is indicated a composed error, difference between stochastic error and technical inefficiency, v_i is the random error (stochastic), and u_i is the non-negative random variable of the technical inefficiency part. The error component u_i needs to satisfy the assumption $u_i \geq 0$. The technical inefficiency part is defined by the following equation:

$$u_i = \alpha z_i + w_i \tag{3.18}$$

Where u_i is represented the mean of αz_i with truncated normal distribution at zero and σ^2 variance, α is estimated parameters, z_i is the technical inefficiency explanatory variables, and w_i is determined by the truncated normal distribution with non-zero mean and variance, σ^2. The technical efficiency of the firm *i* is indicated in the following equation:

$$TE_i = \exp(-u_i) \tag{3.19}$$

The value of the technical efficiency takes between 0 and 1. If the firm is fully efficient that TE_i is equal to 1.

My study has used truncated-normal distribution to estimate technical efficiency. The truncated-normal distribution approach proposed by Stevenson (1980) which allows the inefficiency distribution has a nonzero (μ) mean and variance σ^2. In other words, u_i can be defined as $N^+(\mu_i, \sigma_u^2)$. If $\mu = 0$, it collapses to a half-normal distribution model. Truncated -normal distribution density function of z_i specified as

$$f(z_i) = \frac{\frac{1}{\sigma}\varphi(z_i)}{1-\varphi(\frac{-\mu}{\sigma})} = \frac{1}{\sqrt{2\pi\sigma}\varphi(\frac{\mu}{\sigma})} \exp\{-\frac{(z_i-\mu)^2}{2\sigma^2}\}, \qquad z_i \geq 0 \tag{3.20}$$

Estimation of the variance parameter, likelihood function for unconstrained numerical maximization can be defined by $\sigma_u^2 = \exp(w_u)$, $\sigma_v^2 = \exp(w_v)$. Where $w_u$and w_v are unrestricted constant parameters.

The function of exogenous variables for technical efficiency is defined by following general function form.

$$\mu_i = \alpha z_i' \tag{3.21}$$

Where, z_i' is the vector of exogenous variables, α is the estimating parameter. The single-step estimation approach is more preferably used in efficiency analysis.

3.2.2 Empirical specification

The Cobb-Douglas production function mostly dominates in stochastic frontier analysis using cross-section and panel data. My stochastic production frontier model in equation 3.22 is estimated using the form of the Cobb- Douglas production function. The Cobb-Douglas production function is described by the following function. The SFA model can be written as:

$$lny_i = \beta_0 + \sum_{j=1}^{5} \beta_j \, lnx_{ij} + v_i - u_i \quad (3.22)$$

Where, ln- is expressed natural logarithm, y_i- is the total income from vegetable production of i^{th} household (smallholder), x_{ij}- is denotes of j^{th} inputs of the i^{th} household j is the number of inputs variables, j= 1, 2, 3 …. 5, namely, sown area (ha), seed cost (million MNT, MNT is the abbreviation of Mongolian currency tugrik, hereafter MNT), labor (man/days), used manure (ton), capital (million MNT) is aggregated value of total machinery cost plus total expenditure on machinery rent cost for cultivation, harvesting, manure, pesticide and diesel cost on cultivation, harvesting and transportation cost to market. β_0, β_j are to be estimated coefficients. v_i is the random error that was assumed to be independently and identically distributed with $N(0, \sigma_v^2)$, u_i is a non-negative random variable, which is assumed distribution of truncated distribution with $N^+(\mu_i, \sigma_u^2)$. The elasticity of input x_j is given by

$$E_j = \frac{\partial lny_i}{\partial lnx_j} = \beta_j \quad (3.23)$$

The Cobb-Douglas production functions' returns to scale coefficient is equal to the sum of the β values on the individual inputs with related to the corresponding inputs are constant (Debertin, 2012). Therefore, my study's vegetable household production's return to scale (RTS) is defined by

$$RTS = \sum_{j}^{5} \beta_j \quad (3.24)$$

The technical inefficiency function is defined as:

$$u_i = \alpha_0 + \alpha_1 size + \alpha_2 age + \alpha_3 sex + \alpha_4 edu + \alpha_5 exp + \alpha_6 nfi + \alpha_7 cre + \alpha_8 lfi + w_i \quad (3.25)$$

Where, α is estimated parameters, *size* is the number of family members, *age* is the age of household heads, *sex* is household head's sex, which is dummy variable value is one if has female, 0 is male, *edu* is the household head's education level i.e. value of one if household head is illiterate, two if has a primary school, three if has a secondary school, four if has associated and five is a bachelor (graduate university), *exp* is the experience of household heads in vegetable production, *nfi* is the non-farm income dummy variable (non-vegetable income=1, otherwise 0), *cre* is the credit also dummy variable (if the household has a credit =1, otherwise 0) and *lfi* is the land fragmentation index. Maximum-likelihood estimates of the parameters for the stochastic frontier production function were obtained using the Stata.14 computer program. An important test to using likelihood ratio (LR) test (equation 2.5) in order to check the existence of technical inefficiency. is one-sided error specification.

3.2.3 Study population

The research population for this study was vegetable households producers in Mongolia. Private vegetable household production is a relatively new industry in Mongolia. Currently, vegetable household production consists of approximately 80 percent of total vegetable production in Mongolia (Table 17). Vegetable household is mainly growing potato, carrot, turnips, cabbage, onion, garlic, cucumber, tomato, watermelon, and melons. In 2019, there are approximately 14728 households and 1401 companies are engaged in crop production. About the household covered by a region, it locates 63.2 percent in Western and Central regions, 18.4 percent in the Khangai region, 9.3 percent in the Eastern region, and 9.2 percent in the Ulaanbaatar region. For the company, which is located 13 percent of the company in the Western region, 20.7 percent in the Khangai region, 53.5 percent in the Central region, 8.9 percent in the Eastern region, and 4 percent in the Ulaanbaatar region (National Statistics Office of Mongolia 2019).

Table 17. Vegetable production, by producers, national level, 2019

Types	Company		Household		Total, thousand ton
	Thousand ton	Share, %	Thousand ton	Share, %	
Potato	44.8	23.3	147.5	76.7	192.2
Vegetables	22.9	23.0	76.6	77.0	99.5

Source: Agriculture statistic report, 2019

Central, Eastern, and Ulaanbaatar areas were potato and vegetable company producing levels higher than a national company producing level, but Western and Khangai regions' potato and vegetables' company producing level lower than the national level (Table 18). Western and Khangai regions' household production level higher than national household production level in 2019. The central region is potato and vegetables' main growing area in Mongolia, there is household produced potato and vegetable portion were 75.2% and 71.1%, respectively. The population for this study consists of 300 vegetable households.

Table 18. Vegetable production, by producers, by regions, 2019

Regions	Types	Company		Household		Total, thousand ton
		Thousand ton	Share, %	Thousand ton	Share, %	
Western	Potato	1468.6	8.1	16725.4	91.9	18194.0
	Vegetable	841.2	4.5	17964.9	95.5	18806.1
Khangai	Potato	3230.9	16.5	16392.5	83.5	19623.4
	Vegetable	1061.8	9.6	9970.5	90.4	11032.3
Central	Potato	36517.3	24.8	110866.0	75.2	147383.3
	Vegetable	17942.7	28.9	44205.8	71.1	62148.5
Eastern	Potato	2621.2	47.1	2941.8	52.9	5563.0
	Vegetable	1172.8	38.9	1838.5	61.1	3011.3
Ulaanbaatar	Potato	941.0	63.7	535.2	36.3	1476.2
	Vegetable	1914.3	42.1	2634.1	57.9	4548.3

Source: Mongolian statistical yearbook, 2019

3.2.4 Sample size

According to the Agriculture statistics report (2019), there was 14728 vegetable household producers. My study could not be studied in entirely the population. Therefore, in this research, the total random sample was 300 vegetable households from the Khovd and the Selenge provinces in the Western and the Central regions. These regions are the main vegetable-producing regions in Mongolia. In 2019, the Central region produced 76.7% of the potato and 62.4% of the vegetables followed by the Western region 9.5% of the potato and 18.9% of the vegetable production. The Central region was the largest producer in Mongolia, with a total of 147.4-thousand-ton potato and 62.1-thousand-ton vegetable. The second-largest producer in vegetable production was the Western region, with a total of 18.9 thousand tons (National Statistics Office of Mongolia 2019). Thus, my study data collection's sample distribution showed in Table 19. I used a multi-stage stratified random sampling technique to select the respondents following principles. First, I choose the dominant regions (namely, Central and Western regions) in vegetable production using secondary data. Second, I determined 2 provinces based on vegetable output. Third, I identified soums in provinces. Lastly, I selected randomly 300 households in these soums and selected the equal number of households from each soum. The Khovd and Selenge provinces consist approximately 30 percent of total vegetable production in Mongolia.

Table 19. Sample distribution

Regions	Provinces	No. of households (vegetable farmers)	Sample households
Western	Khovd	860	150
Central	Selenge	3386	150
Total		4246	300

Source: Field survey conduct in Mongolia

https://www.1212.mn/BookLibraryDownload.ashx?url=Khovd_2019.pdf&ln=Mn
https://www.1212.mn/BookLibraryDownload.ashx?url=Selenge_2019.pdf&ln=Mn

The study collected data from all the 300 households from 9 soums (Buyant, Myangad, Jargalant, Khovd, Zuunburen, Mandal, Sant, Khushaat, Sukhbaatar) in two provinces.

3.2.5 Data collection

My data used in the study was collected from household growing vegetables in the Khovd and Selenge provinces. To examine the technical efficiency of vegetable household production, primary data was collected through a semi-structured questionnaire using a random sample technique. The semi-structured questionnaire is including respondents related to vegetable production quantity, vegetable price, inputs (seed quantity and price, used manure, pesticide, herbicide’s quantity and price, diesel cost, maintenance cost, etc. Also, the household’s main characteristics indicators age, sex, education, non-farm income, distance to water, distance to market, etc.

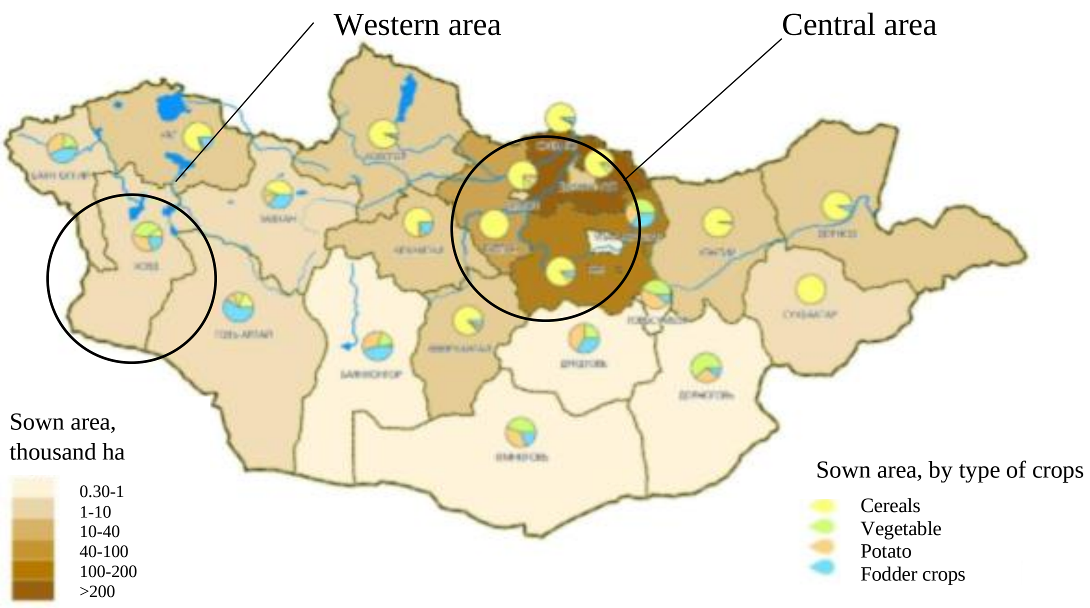

Figure 12. Study area
Source: Agriculture statistics report, 2019

My research field survey was carried out in two stages. In the first stage, my questionnaire was pre-tested 100 randomly selected vegetable households in Khovd province between July and August in 2019. This pre-tested survey helped to improve and ascertain my questionnaire. After that, second stage, my research was carried out between November 2019 and January 2020 including 300 vegetable households in Khovd and Selenge provinces in Mongolia. Specialists of the Agriculture Administration Office (AAO) of Province helped me to collect my data during this period. The response rate was 86.7%.

3.2.6 Descriptive statistics and variable meaning

For the household production function, my study used one output (sales income of the household) and five inputs including sown area, seed cost, manure cost, labor, and capital. Table 20 shows the summary statistics of our variables. The sampled vegetable households are growing comparative many vegetables including potato, carrot, cabbage, onion, garlic, tomato, cucumber, watermelon, and melons. The household's land fragmentation was average (estimated average value was 0.54). Every vegetable household was planting approximately five to six types of vegetables. For example, approximately 28.8-85.8 percent of the total sampled household planted potato, turnips, carrot, cabbage, watermelon, and onion. Therefore, output quantity and used input's fluctuation were very high.

The dependent variable for the production function to estimate technical efficiency is sales income of household (output value) in currency (MNT). The monetary value as a dependent variable has been addressed in some empirical studies (Seok et al., 2018; Kovács and Pandey, 2017). Sales income is calculated by household vegetable sales income. The output price and sales quantities were gathered from the household. All vegetable sales of the household were aggregated into one output value (Mongolian tugrik, hereafter MNT). Therefore, I divided into 2 sections to collect price information in my questionnaire. Because the wholesale vegetable price and retailed prices are different. In other words, the wholesale price is lower than the retail price. Because the harvesting period is very short (between May to September) in Mongolia and some of the household keep vegetables to sell higher price in winter and spring time. Sample vegetable household revenue averaged approximately 12.02 million MNT.

The land is the one of important main inputs in vegetable production. Thus, my study collected sown area (used land size) of the vegetable household production. The average sown area for the sample household was 2.04 ha, the minimum sown area was 0.09 ha and the maximum sown area was 10 ha. Some of the households could not able to use the whole of the land. Because they face too many challenges to use total land for vegetable production. For example, lack of money, lack of labor, lack of machinery and tractor, seed price is higher, etc. land input expected to have a positive effect on household vegetable production.

Table 20. Descriptive statistics of households' vegetable production in 2019

Variables	Mean	Standard deviation	Minimum	Maximum
Sales income, million MNT	12.02	11.26	1.40	74.20
Sown area, ha	2.04	1.62	0.088	10.00
Seed cost, million MNT	2.05	1.87	0.037	12.72
Labor man/days	179.57	140.27	25.00	873.62
Used manure, ton	24.14	28.30	2.00	160.00
Capital, million MNT	11.87	8.00	1.08	50.07
Family size	4.33	1.69	1	10
Household head's age	46.73	11.10	24	74
Household head's sex	1.95	0.21	1	2
Education	3.60	0.94	1	5
Owner's experience	15.34	9.61	2	42
Non-farm income	0.37	0.48	0	1
Credit use	0.73	0.44	0	1
Land fragmentation index	0.54	0.29	0.11	1.25

Source: Randomly selected 260 vegetable households' observations

Labor input variable measured man/days. Total labor indicated as total annual working days, including family member's working days and hiring workers working days on the cropland. Most of the households responded that hiring workers during the cultivating and harvesting period otherwise, family members work on the cropland. Average labor was 179.6 man/days. Some of the researchers mentioned that labor negative effect on agricultural production. Because, in developing countries, most of the labors in agricultural production such as rice production, vegetable production, palm production et.al are unskilled, low productivity, and not well educated (Kea et al., 2016). Conversely, most of the researchers revealed that labor positive effect to production. In other words, labor is input to participating in the production process. Therefore, labor was expected to have a positive effect on household vegetable production.

Seed cost input was the total amount of expenses for vegetable seed in MNT. Most of the household was sowing by average 4 to 6 kinds of vegetables. Thus, this input could not indicate quantity. Therefore, I asked that bought see quantity and price. After that, I calculated the total seed cost for every household. Most of the households responded that to buy seed on sowing period. Because they do not have enough warehouse but some household has a warehouse. Fifty-two percent of the sampled household responded that had a warehouse. The maximum seed cost was 12.7 million MNT; the minimum seed cost was 0.03 million MNT. Seed cost was expected to have a negative and positive effect on vegetable production. Because, if seed cost is higher which causes a reduction of the vegetable output. Manure is one of the main inputs in vegetable production in Mongolia. Most of the households used organic manure during the sowing period. Used manure quantity is measured as a ton. The maximum used manure quantity was 160 tons;

the minimum used manure quantity was 2 tons. Averaged quantity is 24.1 tons. Manure is expected to have a positive effect on vegetable output.

The capital was calculated the aggregate value of machinery and technical equipment and total expenses for diesel cost, maintenance cost for machineries, rented machines cost, seed cost, manure cost, pesticide, and herbicide cost, labor safety cost within a year. In other words, machinery and technical equipment are including agricultural machineries (tractors, trucks for transportation, car, pumping machines, pesticide prayers, and motorcycles) owned by the household. I calculated the net value for total machinery with total expenses for purchasing and annual depreciation. The average capital value was 11.87 million MNT, minimum capital value and maximum value were 1.08; 50.07 million MNT, respectively. Capital investment was expected to have a positive effect on vegetable production. In other words, the more capital household has a generate higher opportunities than a few capital households.

In the technical inefficiency model, there were eight factors of household vegetable production. Exogenous variables that we hypothesize will affect technical inefficiency based on previous studies. Household characteristics are including family size (number of a family member), household's head age, sex, education and experience, non-farm income, credit use, and land fragmentation.

Sample vegetable households averaged 4.33 family members and 95% of the total household head was male. My study hypothesis between family size and technical efficiency is that the larger families are more efficient with fewer families. Because most of the household members work in the field of vegetables. Some empirical studies result show larger families appear to be more efficient than smaller families. This finding is consistent with the work of (Bravo-Ureta and Pinheiro, 1993; Abdulai and Eberlin, 2001). When they could not able enough family members, they hire a worker for the harvesting and cultivating period. Therefore, family size is expected to have a positive effect on technical efficiency. The household head's sex is male which means that males decision more than females in the household. This hypothesis is confirmed by (Kumbhakar et al., 1991).

For the education variable, if have education level has higher, it enhances farm technical efficiency (Fuwa et al., 2007; Seok et al., 2018). It shows that the education of the household head and, i.e. education value of one if household head is illiterate, two if has a primary school, three if has a secondary school, four if has associate and five if a bachelor (graduate university).

Household head's averaged 46.7 years old and their experience in vegetable production was 15.3 years. Age and experience variables are indicated the possibility of farmers adopting innovations and more technical skills. But some of the authors such as, Bozoglu and Ceyhan, (2007) mentioned that younger farmers are more quickly adapted to innovations. Thus, these variables positively affected technical efficiency confirmed by (Seok et al., 2018; Anang et al., 2016; Mwajombe and Mlozi, 2015), etc. My study hypothesis is household heads older and more experience are more technically efficient. In other words, these variables are expected to a positive impact on technically efficient.

We gathered data on non-farm income, it represents the relationship between technical efficiency and the existence of non-farm income. Because some of the households have another source of income. For example, in the exception of vegetable production, there has livestock and some of the family members work public sector and retire. The non-farm income variable was a dummy if the household has a non-farm income is equal to 1, otherwise 0. The previous empirical studies showed the relationship between non-farm and technical efficiency. These results are ambiguous that non-farm income how to affects production efficiency. For example, some of the researchers' non-farm income revealed a negative effect on production efficiency. Contrary to other researchers, non-farm income positive effect on production efficiency.

Also, we estimate the relationship between technical inefficiency and credit use. Credit can help to increase technical efficiency because the household decides to overcome financial constraints for the purchase of inputs (Abdulai and Eberlin, 2001). For example, seed, rent a tractor during the cultivating period. Credit use indicates dummy variable if the household used credit to 1, otherwise 0. Anang et al., (2016) studied especially the relationship between agriculture microcredit and technical efficiency in Northern Ghana. The result showed that there is no difference between credit users and non-users.

The household land fragmentation average index was 0.54. I calculated the land fragmentation index in vegetable household production in Mongolia using the following equation.

$$lfi = \frac{\sum_{i=1}^{n} a^2}{A^2} \qquad (3.26)$$

lfi - is the land fragmentation index, which takes between 0 and 1. If $lfi \sim 1$, which means that fragmentation is low, $lfi \sim 0$, it means that fragmentation is high.

n - is the number of parcels that belong to the land. In my case n shows a number of parcels of the vegetable household.

a – is the size of the parcel. It measures by a hectare of the parcel in the vegetable household.

A – is the size of total land, which indicate the total land size of vegetable household.

Most of the sampled household was planted potato, turnips, carrot, cabbage, watermelon, and onion. The relationship between land fragmentation and technical efficiency is ambiguous. For example, some of the authors Tan et al., (2010) mentioned that an increase in the number of plots causes an increase in technical efficiency. Rahman and Rahman, (2009), Kiprop et al., (2015) argue that increasing land fragmentation goes down technical efficiency. But if the household could manage that, land fragmentation positively affected technical efficiency.

Table 21 shows that summary of the hypotheses expected sign of the technical inefficiency analysis of the household vegetable production in Mongolia.

Table 21. Summary of the hypotheses expected sign of variables

Variables	Expected sign
Sown area, ha	+
Seed cost, million MNT	+
Labor man/days	+
Used manure, ton	+
Capital, million MNT	+
Family size	+
Household head's age	-
Household head’s sex	+/-
Education	+
Owner's experience	+
Non-farm income	+
Credit use	+
Land fragmentation index	-

Source: Own description based on previous studies

IV. RESULTS AND DISCUSSION

4.1 Estimation of the Armington substitution elasticities of vegetable products in Mongolia

This part discusses estimating substitution elasticity between domestic vegetables and importing vegetables using the Armington model. A greater Armington model shows that consumers did not discriminate between domestic and imported vegetables. In other words, consumers considered these vegetables are same. Also, this part indicates home bias value and vegetables price elasticities (depend on import and domestic price). Home bias value is higher it means that consumers more used domestic produced products compared to importing products. And price elasticity indicates the measure of the change in the quantity of a purchased product in relation to a change in its price.

4.1.1 Substitution elasticities in short-run and long-run

According to the general econometric model equation (3.7), we estimated Armington elasticities for vegetables in Mongolia. I choose six types of vegetables namely potato, tomato, garlic and onion, cabbage, carrot and turnips, and cucumber with related to the lack of data. But these vegetables were commonly used in the household diet. To estimate elasticities was to check whether our time series data are stationary and integrated. Indeed, if our data are stationary or the same integrated of order log level I(0) or one I(1), it is possible to determine the relationship between these two variables in the long-run. Additionally, the cointegration relationship is defined by the Engle-Granger test. The Engle-Granger test is only valid that all variables are I(1). In other words, two variables are integrated into the same order but non-stationary (please see empirical specification).

Prior to estimation, we tested data stationery or integrated using Augmented Dickey-Fuller (ADF) test. Non-stationary variables imply the risk of spurious regression unless they are cointegrated. An ADF test for identifying the order of integration for the price and quantity ratio is conducted to determine the order of integration. Most of the series are non-stationary, but integrated of order one, excluding garlic and onion (Table 22). For the cucumber series, two variables are not cointegrated, only one variable is stationary. Indeed, there is no long-run relationship between these two variables. Also, we tested the Engle-Granger test for integrated variables, we found a cointegrating relationship in other vegetables. Therefore, we estimate elasticities for the short-run and long-run using the approach of (McDaniel and Balistreri, 2002).

Table 22. ADF test result

HS code	Name of vegetables	M/D	Pd/Pm
0701	Potato	I (1)	I (1)
0702	Tomato	I (1)	I (1)
0703	Garlic and onion	I (0)	I (0)
0704	Cabbage	I (1)	I (1)
0706	Carrot and turnips	I (1)	I (1)
0707	Cucumber	I (0)	I (1)

Source: 'Stata' software result

Table 23 reports the estimation result of short-run and long-run substitution elasticities derived from the models (equation 3.8, 3.9, 3.10) described in the previous section (see 3.1.2). Of the six types of vegetables short-run elasticities, five vegetable elasticities had positive and significant at 1 %, 5 %, and 10 %. Cabbage's short-run elasticity was not significant. The mean value of the estimated average short-run elasticity of substitution is 1.32, with a significant range between 0.86 and 2.57. The average long-run elasticity is 2.21, with a range between 1.34 and 3.26. Our estimation results are vegetable's long-run average substitution elasticities approximately 2 times higher than short-run average elasticities. This finding is similar to one of the emerged findings from (McDaniel and Balistreri, 2002). Also, this result confirmed from other authors' results such as Lopez and Pagoulatos, (2002) obtained a coefficient between 0.09 and 5.93 for food manufacturing industries, Ogundeji, (2007) estimates range between 0.6 and 3.31 for agriculture some products, Kapuscinski and Warr, (1999) indicated average elasticity of 1.5 for vegetables.

Table 23. Armington elasticities estimation result in the short and long run

Vegetable name	Short-run elasticity	Long run elasticity	Ad. R2	DW
Potato	2.571**	1.343**	0.45	1.54
Tomato	1.929**	3.26**	0.45	1.52
Garlic and onion	0.858**	1.808**	0.32	2.01
Cabbage	0.112	2.149	0.24	2.73
Carrot and turnips	1.171***	2.471***	0.18	1.93
Cucumber	-0.412*	-	0.12	1.97

Source: 'Stata' software result

***, **, * -1%, 5%, 10% significance. DW- Darwin Watson

In reviewing the short-run elasticities, garlic, onion, and cabbage's elasticities were ≤ 1, it appears to be a quite difference between domestic and import goods. This means that substitution is becoming harder between these products in Mongolia. This result was reported by Wunderlich and Kohler, (2018) who obtained from fruits and vegetables especially, tomato's elasticities of substitution estimates are quite lower for Switzerland's some agriculture products. In other words, they concluded Swiss people exhibit a strong tendency to buy domestically produced products. Potato, tomato, garlic and onion, carrot, and turnips long-run substitution elasticities were estimated excluding cucumber. For the long-run elasticity, vegetables are tomato, garlic, and onion, cabbage, carrot, and turnips, long-run elasticities are higher than short-run elasticities. The higher elasticity of substitution in the long-run leads to more substitutability between domestic vegetables and imported vegetables. In other words, a greater elasticity indicates that consumers did not discriminate between domestic and imported vegetables and the consumers considered them the same. In this case, these vegetable imports will rise in the long-run in Mongolia. The only potato, import potato will decrease because short-run elasticity is higher than long-run elasticity. In other words, consumers more prefer domestic growing potatoes to import potatoes.

4.1.2 Calculation of home bias value

Table 24 shows the home bias value for vegetables in the short-run and long-run. According to the approach of Blonigen and Wilson, (1999), calculated to home bias value using the Armington elasticities in the short-run and long-run. We found that all the vegetable home bias value was higher ($1\text{-}\beta \geq 0.58$), which suggested a higher relative weight on the home good in the short-run and long-run. The short-run home bias value was estimated higher than the import value in the short-run. In other words, consumers express a stronger preference for domestic vegetables for the short-run in Mongolia.

Table 24. The home bias value result

Vegetable name	Short-run		Long run	
	Import share	Domestic share	Import share	Domestic share
Potato	21.6	78.4	7.8	92.2
Tomato	27.5	72.5	36.1	63.9
Garlic and onion	4.5	95.5	18.9	81.1
Cabbage	10.8	89.2	24.4	75.6
Carrot and turnips	11.2	88.8	3.8	96.2
Cucumber	41.1	58.9	-	-

Source: Own calculation

The long-run home bias value was estimated lower than the short-run value of all vegetables with the exception of potato, carrot, and turnips. For example, the tomato's home bias value is decreasing from 0.73 to 0.64 (Table 24). Blonigen and Wilson (1999) primarily discussed home bias value with Armington elasticities. They found that 66 percent of total industries take a higher home bias value of 0.85 or higher.

I calculated vegetable price elasticities using the home bias values. Price elasticity of demand measures the change in consumption of vegetables as a result of a change in price. Thus, I calculated vegetable price elasticities are depending on import price and domestic price. Using averaged price presents at table 25. Overall, the domestic price of the 1 ton for vegetables is higher than the import price of vegetables. For example, the potato domestic price for 1 ton is 2.7 higher than the import price.

Table 25. Average price between 1995 and 2019, by ton, thousand MNT

Types of vegetables	Import price	Domestic price
Potato	249.9	677.6
Tomato	426.1	3343.6
Onion and garlic	235.5	841.4
Cabbage	216.5	828.4
Carrot and turnips	224.7	904.0
Cucumber	393.2	2322.3

Source: Own calculation based on statistic information

Table 26 shows that vegetable price elasticities result. Overall average vegetable price elasticities are -0.625 and -0.306 in the short-run and long-run. In other words, vegetable price elasticity of demand is lower than 1 which means that vegetable is a normal good.

Vegetable domestic price elasticity is lower than import price elasticity. On the other hand, elasticities for import price are higher than domestic price elasticities in Mongolia. It means that with a 1 percentage increase in price, consumers prefer import vegetables more than domestic vegetables.

Table 26. Price elasticities

Vegetable name	Short-run		Long-run	
	P_M elasticity	P_D elasticity	P_M elasticity	P_D elasticity
Potato	-0.622	-0.378	-0.485	-0.246
Tomato	-0.677	-0.324	-0.591	-0.409
Garlic and onion	-1.193	-0.089	-0.804	-0.017
Cabbage	0.144	-0.144	-1.184	-0.642
Carrot and turnips	-0.890	-0.127	-0.656	-0.373
Cucumber	-0.226	-0.774	-	-
Average elasticities	-0.625	-0.306	-0.744	-0.337

Source: Own calculation

The elasticities of import price for garlic and onion in short-run which has highest one elasticity. The elasticity of cabbage import price is the lowest elasticity but insignificant. In the long run, cabbage price elasticity is highest, which is higher than one (-1.184). Potato elasticity is lowest in compared to other vegetables.

The elasticities of the domestic price for cucumber in the short run which has the highest (-0.774) in compared to other vegetables. Garlic and onion’s domestic price elasticity is lowest (-0.089). In the long run, the price elasticity of garlic and onion is keeping the lowest elasticity. And cabbage price elasticity is highest in compared to others. Overall estimated vegetables price elasticities are lower than one, which confirmed by previous some of researchers result. For example, Nzaku et al., (2010) found that fresh fruit and vegetables price elasticities range between -0.541 and -1.099 in United States, while Wunderlich and Kohler, (2018) revealed that fruits and vegetables price elasticities are approximately between −0.6 and -0.5 in Switzerland.

4.2 Estimating technical efficiency of vegetable household production in Mongolia

This part shows that some main characteristics of vegetable household production and estimation of technical efficiency for vegetable production in Mongolia. The previous part revealed that Mongolian consumers more prefer home-growing vegetables using Armington elasticity. Thus, this part has determined the what is the technical efficiency level of vegetable household production to increase vegetable domestic production.

4.2.1 Some main characteristics of vegetable household production

My study data collected 300 vegetable household production in Khovd and Selenge provinces in Mongolia. The response rate was 86.7%. The main characteristic of vegetable household production is smallholder farm activities. Thus, there is not enough financial source compared to the large-scale producer. Some basic characteristics of the sampled vegetable household production based on field survey are presented in Table 27 (other main indicators see in the detail part of data descriptive statistics). The main characteristics of vegetable household production are consisting the following indicators. For example, vegetable household production has a greenhouse production or not, warehouse or not, agriculture small and medium-sized tractor, other agriculture equipment or not, truck, car or not, non-farm income or not, and credit or not.

Table 27. Some main characteristics for vegetable household production based on field survey

Main characteristics	Percentage of the total sampled household
Greenhouse production	10.2
Warehouse (storage)	51.9
Agriculture tractor	16.9
Other machinery and equipment (thresher machine, seeder, pumping machines, etc.)	40.4
Pesticide prayer	27.3
Water equipment	45.8
Truck	61.2
Car	51.5
Non-farm income	36.9
Credit	73.5

Source: Vegetable household survey result

According to table 27 some main characteristics of sampled vegetable household production:

1. Greenhouse production: The implication of this result is 10.2 % of the total sampled vegetable household production. In other words, 89.8 % of the sampled vegetable household has not greenhouse production. These households used a greenhouse to prepare some vegetable seeds. For example, transplanting of cabbage.
2. Warehouse (storage): From the result of the field survey it is that half of the household (51.9%) has a warehouse.
3. Agriculture tractor and other equipment (thresher machine, seeder, pumping machines, pesticide prayer, and water equipment, etc.): Only 16.9% of total sampled vegetable household had an agriculture tractor. In other words, most of the households responded that they rent a tractor during cultivation and harvesting period. For other equipment, the 40.4% of the sampled households responded that they had a thresher machine, seeder, pumping machines, pesticide prayer, and water equipment. Also, 27.3% of household had a pesticide prayer, while 45.8% of the sampled household had a water equipment.
4. Truck and car: The majority of the household (61.5%) responded that they have a truck. Because the truck is main necessity equipment during harvesting period to the transportation. In addition, half of vegetable household (approximately 51.5 % of sampled vegetable household) have a car.
5. Non-farm income: This result described that 36.9 % of the sampled vegetable household has a non-farm income. Non-farm income is including other income with exception of vegetable production activities. For example, other activities income such as, livestock activity, who work in other organization or sector to get a salary, etc.
6. Credit: Credit is one of the main financial instruments in vegetable household production. Because vegetable household production is smallholder farm and they do not have enough money for production activities. They need to purchase agriculture some inputs occur during the vegetable growing period. Thus, these vegetable households need to access credit. The implication of this result is that majority of the sampled vegetable households (73.5%) have credit.

In Mongolia, vegetable household production has a relatively small land of vegetable production compared to other large-scale farmers (company). Based on the responses of vegetable household production, the household sowing land size was grouped into three categories small (land size between 0 and 2 ha), medium (2 ha≤ land size<5 ha), and large (more than 5 ha). Majority of the household (49.6 %) in the sampled household was 0-2 ha land, 43.5% of the sampled household in medium-sized category (2-5 ha land) and the remaining (6.9 %) were having large-sized (more than 5 ha) category in Table 28. In other words, the majority of the sampled vegetable household (86%) land size was lower than 5 ha.

Table 28. Land size categories for vegetable household production

Types	Percentage of the sampled household
Small (0-2 ha)	49.6
Medium (2-5 ha)	43.5
Large (more than 5 ha)	6.9

Source: Vegetable household survey result

Land is one of the main input in agricultural production. Thus, vegetable household producers fully used to land, which is main condition to more harvesting, gain more income and make more profit. From the research, 68.5% of the respondents were could not fully use the land for vegetable production. Vegetable household producers responded that could not be fully used land for the following challenges including seed cost is higher, scarcity of machinery, tractor and other equipment, inadequate financial resource, limited water resources, lack of labor, and land's characteristics (such as stone, bush, etc.). My survey results are similar to some previous studies and reports. Such as Erdenebolor (2015) mentioned that vegetable household producers faced challenges to their operation and access to market. For example, low of productivity, lack of market linkage, lack of local capacity for storage and lack of financial incentives, lack of capital of vegetable household producers, lack of local structures, lack of policies and institution problem, under developed infrastructure, etc.

Figure 13 illustrates determining the main challenges based on the survey. Following Figure 13, the most important main reason is the inadequate financial resource (the majority of the vegetable household (76.5%)), followed by lack of labor (72.2%), land characteristics (60.1%), scarcity of machinery and tractor (18.7%), the higher price of seed (15.6%) and poor water supply availability (access to water, 8.2%).

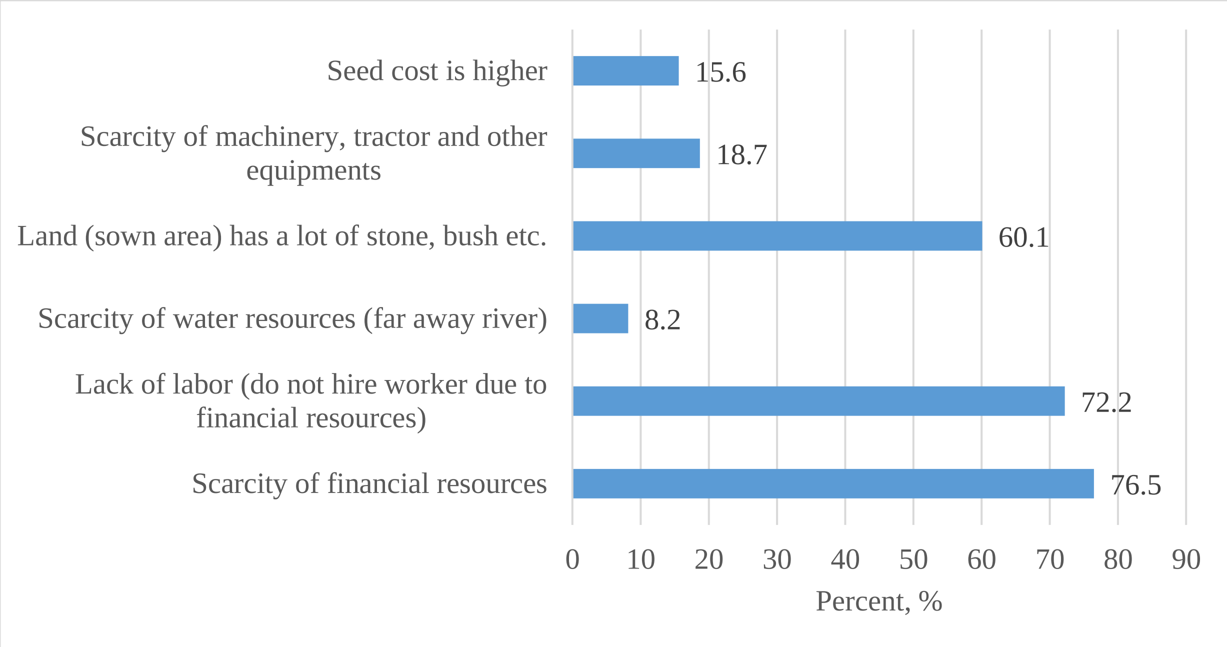

Figure 13. Main challenges for cannot fully use total land, percentage of the sampled household production

Source: Vegetable household survey result

Total income, total cost, and profit of the 1 ha for vegetable household production

This part presents the calculation of total cost, income, and profit for the sampled household production. I have used the "Standard technological card for vegetable" to the calculation of cost (see detail appendices). For example, the cost of the 1 ha has been divided into six categories including seed cost, organic fertilizer cost, pesticide and herbicide cost, diesel cost, labor cost, and capital cost. The capital cost was including payment of machinery and tractor rent, maintenance cost, and labor safety cost. Table 29 described details regarding the percentage of cost types for 1 ha. Capital cost is one of the main expenses for sampled vegetable household production. For example, it shares 35.8 % of the cost for 1 ha. Following other costs are seed cost (23.7%), labor cost (23.8%), diesel cost (13.2%), and fertilizer, pesticide, and herbicide cost.

Table 29. Cost types percentage for the 1 ha, by household average

Types of cost	Percentage
Seed cost	23.7
Manure, pesticide, herbicide cost	3.5
Diesel cost	13.2
Labor cost	23.8
Capital cost (rented machinery cost + maintenance cost + labor safety cost)	35.8
The total average cost per hectare	100.0

Source: Own calculation based on vegetable household survey

<u>Total income for the 1 ha</u>

The sampled vegetable households are growing comparative many vegetables including potato, carrot, cabbage, onion, garlic, tomato, cucumber, watermelon, and melons. Most of the vegetable household was planting approximately five to six types of vegetables. For example, approximately 28.8-85.8 percent of the total sampled household planted potato, turnips, carrot, cabbage, watermelon, and onion, following tomato (16.6%), cucumber (16.2%), garlic (15.8%), and melons (14.3) (Table 30). The majority of the household (85.8%) was planting potatoes.

I grouped sales quantity into 2 categories due to differentiation of price to calculation sales income for the sampled vegetable household. Because the vegetable price is minimum level during the harvesting period. The first category is sales income for the harvesting period (fall season). The second category is another period (winter and spring season). Therefore, vegetable sales quantity and prices were gathered from the respondents. The calculated average sales income was 12.04 million MNT (see detail descriptive statistics).

Table 30. Percentage of the planting vegetable

Types of planting vegetable	Percentage of the household
Potato	85.8
Carrot	62.4
Turnips	40.4
Cabbage	33.8
Watermelon	43.2
Onion	28.8
Tomato	16.6
Cucumber	16.2
Garlic	15.8
Melons	14.3

Source: Own calculation based on vegetable household survey

Figure 14 shows the total sales income of the 1 ha for the sampled household. From this figure, the maximum sales income of the 1 ha was 6.7 million MNT from large scale household, following small scale household (land size between 0 and 2, sales income was 6.1 million MNT) and medium-sized household income (land size between 2 and 5, sales income 5.7 million MNT).

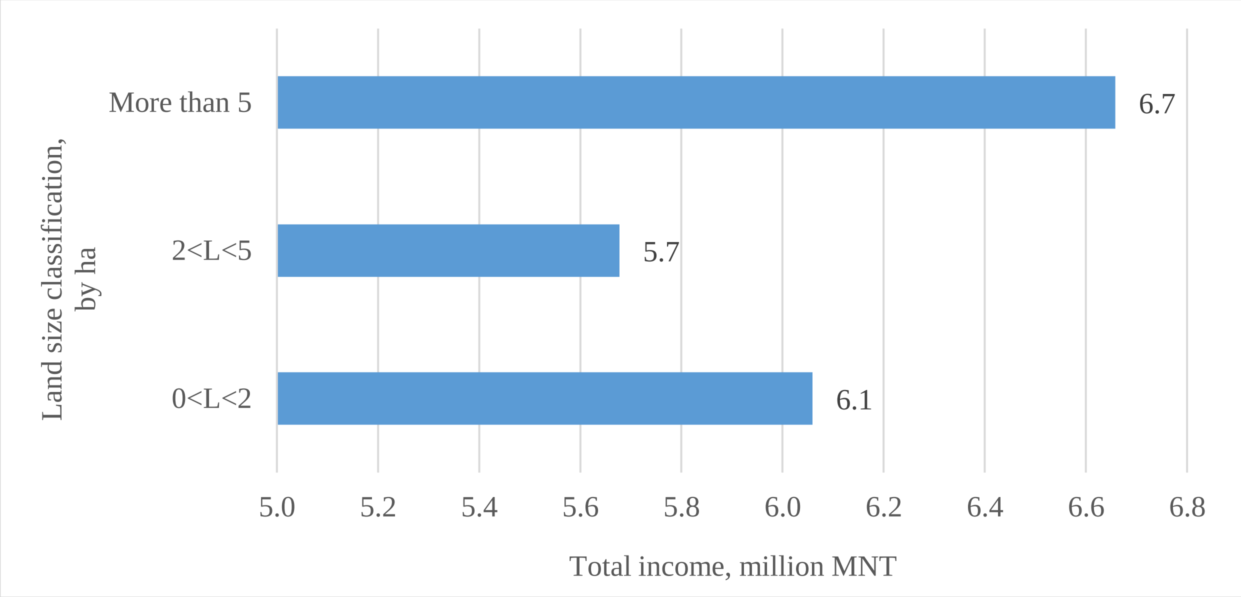

Figure 14. Total income from the 1 ha, million MNT
Source: Own calculation based on vegetable household survey
Here: L is the abbreviation of land size

Total cost for the 1 ha

Figure 15 illustrated the cost of the 1 ha for the sampled vegetable household. The majority of the vegetable household production's total cost were seed cost, labor cost, and capital cost. There is a positive relationship between land size and cost. For example, large-sized land (more than 5 ha) household cost for 1 ha was 5.0 million MNT followed by medium-sized land household (2< land size<5) was 4.9 million MNT and small-sized land (0<land size<2) household cost for the 1 ha was 4.8 million MNT.

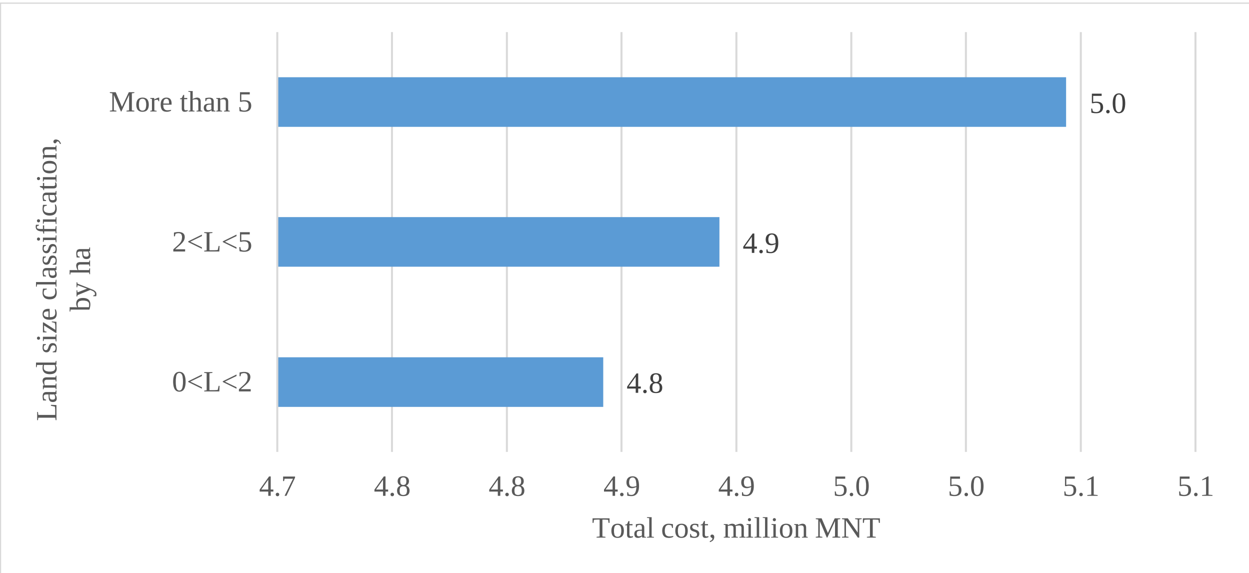

Figure 15. Total cost for the 1 ha, million MNT
Source: Own calculation based on vegetable household survey
Here: L is the abbreviation of land size

My next calculation is profit. Profit defines the difference between income and cost. Figure 16 shows the total profit for the 1 ha, by million MNT. Medium-sized household's profit from the 1 ha was 0.8 million MNT, which indicated minimum profit level. Vegetable household profit, which has more than 5 ha land was maximum profit.

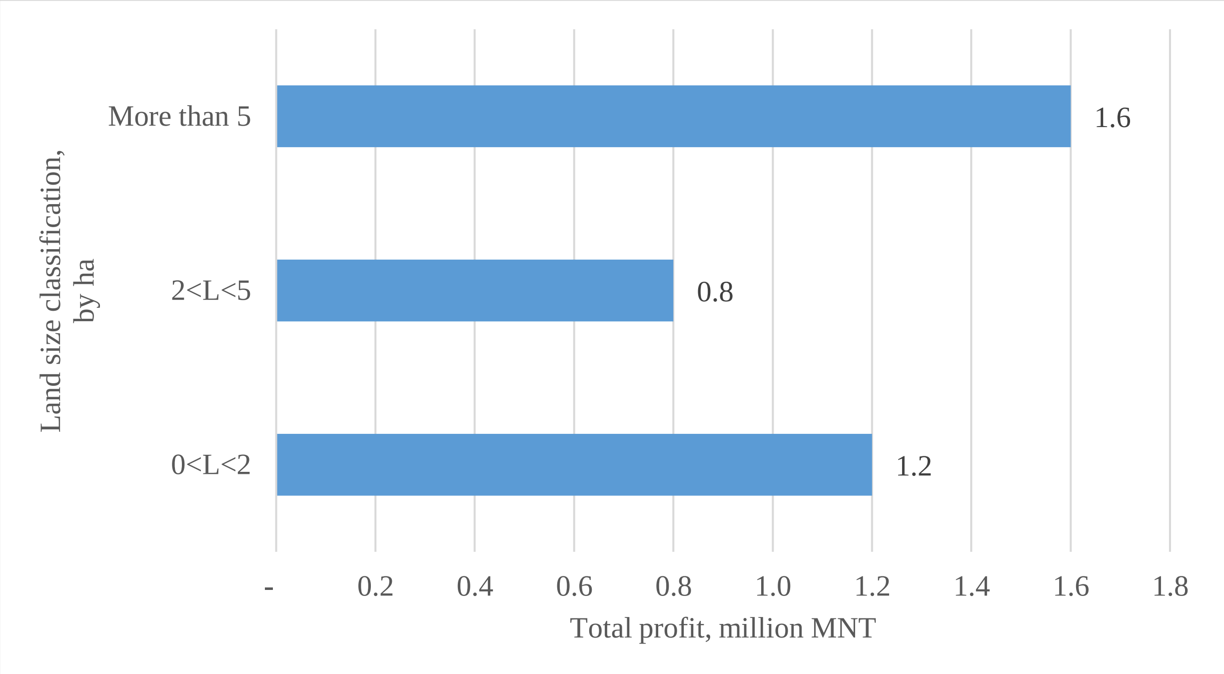

Figure 16. Total profit from the 1 ha, million MNT
Source: Own calculation based on vegetable household survey
Here: L is the abbreviation of land size

How to cost impacting the sampled vegetable production quantity regression result is presented in Table 31. In other words, which cost is high impacting vegetable production? Total vegetable production quantity and all input costs (seed cost, labor cost, capital cost, diesel cost and manure, pesticide, herbicide cost) were gathered from the respondents. The vegetable household production regression function is defined by the following equation.

$$lnq = \alpha_0 + \alpha_1 lnseed_{cost} + \alpha_2 lnlabor_{cost} + \alpha_3 lncapital_{cost} + + \alpha_4 lndiesel_{cost} + \alpha_5 lnmp_{cost} + e \quad (3.28)$$

Where ln is logarithm sign, lnq is vegetable household total production by the ton, $lnseed_{cost}$ is total seed cost by million MNT, $lnlabor_{cost}$ is total labor cost by million MNT, $lncapital_{cost}$is total capital cost by million MNT, $lndiesel_{cost}$ is total diesel cost by million MNT, and $lnmp_{cost}$ is total cost sum of manure cost and pesticide, herbicide cost by million MNT, e is the error term. $\alpha_0, \alpha_1, \alpha_2, \alpha_{3,}, \alpha_4, \alpha_5$ are estimating parameters.

Table 31. Ordinary least square (OLS) regression result

	Coefficient	Standard error	P value
Constant	2.142505	0.204291	0.000
lnseed_cost	1.747372	0.066815	0.000
lnlabor_cost	0.3453087	0.079795	0.000
lncapital_cost	-0.541666	0.069175	0.434
lndiesel_cost	0.006406	0.179766	0.722
lnmp_cost	0.0277823	0.020108	0.168
Ad.R square	0.947		
Number of observation	260		

Source: Stata result

It is clearly presented that these costs have had to effect on vegetable production quantity. Seed cost and labor costs are significant and main impacting factors to vegetable production. For example, the seed cost coefficient is $\alpha_1 = 1.74$, which means that more impact on production than labor cost.

My questionnaire was included an open-ended question which was;

"What is your opinion to increase productivity and improve the efficiency of vegetable production?"

There is some main result from the respondents in Table 32.

Table 32. Open-ended question result

#	Question responses	Description
1	Lower interest rate credit	Most of the households accessed credit with a higher interest rate. Even though Mongolian government support to lower interest rate credit for small and medium-sized producers, this credit does not adequate household producer. Also, the household producer does not have enough capital. Therefore, most of the respondents wanted to support credit accessibility and reliability.
2	Price volatility	Vegetable price is lowest during the harvesting period in Mongolia. Vegetable price is able to increase in other periods especially, winter and spring. But most of the households cannot be sold during these periods due to lack of a warehouse.
3	Limited machinery and tractor	The household producer has scarce of the tractor and other machinery. Most of the households used to rent tractors and machinery during the cultivating and harvesting period. Soum has a tractor which is owned by soum government. Thus, the household producer has rented this tractor during the cultivating and harvesting period. Some of soum does not have a tractor. Therefore, most of the households wanted to supply tractors and machinery for public property.

4	Water resource	Some of the respondents could not fully use to land associated with the accessibility of water resources
5	Inadequate fertilizer and herbicide, pesticide in the countryside	In the countryside, fertilizer and other pesticides, herbicides do not adequate for vegetable production. Also, the quality of fertilizer is lower.
6	Seed quality and innovation problem	To improve seed quality and to increase adaptable seed in extreme climate.
7	Greenhouse production support	Currently Mongolian government support and advocacy in greenhouse production to supply fresh vegetables to consumer. Most of the household producer want to enhance own production.
8	The quota for import vegetable quantity	Vegetable import price is lower than domestic vegetable price. Thus, there is a necessity for the quota of import quantity.
9	Lack of warehouse	Lacking storage facilities, farmers generally sell all their produce at once, close to harvest time when prices are weakest.
10	Cooperative	Most of the respondents responded that become a member of cooperatives to get more opportunity. One of the main examples, a cheaper rent tractor.
11	Allowance for diesel price	Most household producers have negative cash flow in cultivating period. Diesel cost is one of the main expenses.
12	Value chain	Vegetable household producers are faced with the challenges of vegetable value chain problems and supply chain problems. Household producers sell vegetables in complex value chains.
13	Training for agrotechnical	Some of the household producer's knowledge is lower about the agrotechnical. They want to participate in training to enhance knowledge and skills.
14	Sales problem (middle man)	Most household producers choose to sell products to traders and intermediaries because traders arrive at farms in their vehicles and purchase vegetables in exchange for cash at farm gate prices.

Source: Vegetable household survey result

4.2.2 Measuring the technical efficiency and determining the inefficiency determinants

In this analysis, I estimated the technical efficiency (inefficiency) for vegetable household production in Mongolia using the stochastic frontier production function. A stochastic production frontier model with output-oriented technical efficiency (inefficiency) function was estimated in this analysis. The results of the estimated stochastic frontier function are presented in Table 33. I used the Maximum Likelihood Estimation method to estimate the parameters of the stochastic production frontier and inefficiency effect models jointly in a single-stage estimation procedure. The single-stage estimation procedure is solved the econometric problem which is the assumption of independence. The estimated value of γ close to 1 (γ=0.89), indicating that an inefficiency exists.

Based on the likelihood ratio (LR) test was higher than the critic value (LR=36.28) and the LR test rejected the null hypothesis (Kumbhakar et al., 2015). In other words, there are inefficiency effects that exist and stochastic.

The result of the estimation showed an expected sign of variables in the frontier function. For the frontier function, all variables were significant. For example, the estimated values of land, labor, seed cost, manure, and capital were 0.26, 0.42, 0.13, 0.12, and 0.14, respectively. It showed that returns to scale were increasing (sum of elasticity>1). The land and labor elasticity were highest in our estimation result. It means that land and labor are major effects inputs in total vegetable production. This finding confirmed the result of (M.Bozoglu and Ceyhan, 2007; Abdulai and Eberlin, 2001; Aruna, 2018).

The technical efficiency score was estimated between 43.2% and 99.9% (average 0.646). It is implied that the vegetable household produces 64.6 percent of the maximum output, or about 35.4 percent of the potential output is lost due to technical inefficiency. This mean of technical efficiency confirmed as “poor but efficient” defined by (Schultz, 1964).

Table 33. Maximum likelihood estimation of the Cobb-Douglas stochastic frontier model

	Variables	Coefficient	Standard error
Frontier function	lnland	0.256***	0.054
	lnlabor	0.418***	0.032
	lnseedcost	0.131***	0.035
	lnmanure	0.122***	0.033
	lncapital	0.135***	0.049
Inefficiency effect	Family size	0.131*	0.069
	Household head's age	-0.232	0.153
	Household head’s sex	-0.02	0.133
	Education	0.012	0.063
	Household head's experience	-0.102**	0.052
	Non-farm income	-0.155**	0.066
	Credit use	-0.078	0.067
	Land fragmentation index	0.205***	0.065
	Constant	1.526**	0.632
	Observations	260	
	σ_u^2	1.68	
	σ_v^2	0.2***	
	Log-likelihood	-160.19	

Source: Stata ‘s result with truncated normal distribution

*Notes: *, **, *** are 10, 5 and 1% significance levels respectively. A negative sign for a parameter in the inefficiency model indicates that the associated variable has a positive impact on technical efficiency.*

I defined technical efficiency for clarified household’s land size (Table 34). My study results showed that larger farms (more than 5 ha land) are more efficient than smaller farms in my research result. These results are confirmed by (Battese and Coelli, 1996; Abdulai and Tietje, 2007;). Some of the authors reported that small-sized farms are more efficient than the large-sized farm. For example, Bozoglu and Ceyhan, (2007) stated a negative relationship between technical efficiency and farm size.

Table 34. Mean efficiency level, by household's land size

	Technical efficiency
Small (0-2 ha)	0.64
Medium (2-5 ha)	0.65
Large (more than 5 ha)	0.67

Source: Calculation result

Figure 17 illustrated the technical efficiency distribution of sample vegetable household production in Mongolia. The 5.8 percent of the sample households had technical efficiency below 0.5(or 50%), whereas 8.8 percent of the household had technical efficiency between 0.81-1.00 (or between 81-100%), the rest of households (85% of sample vegetable household) had technical efficiency level between 0.51 and 0.8 (or between 51-80%).

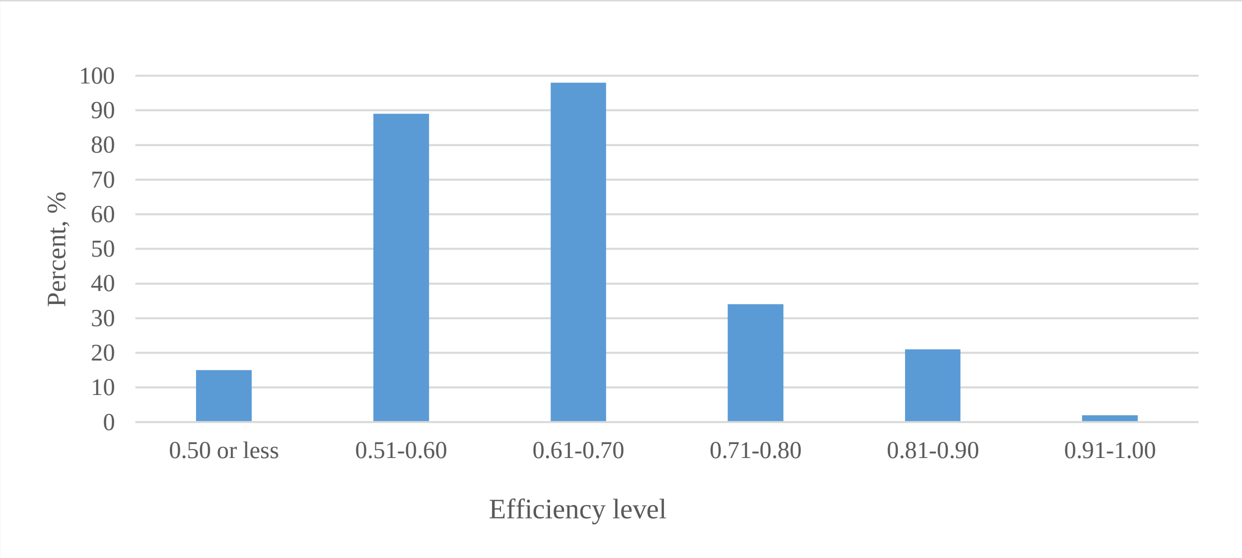

Figure 17. Technical efficiency distribution of vegetable household's production in Mongolia, 2019

Source: Estimation result

The result of the inefficiency model (Table 33) indicated the effect of explanatory variables on technical inefficiency, and the number of the variables including family size, household head's experience, non-farm income, and land fragmentation index were significant with the exception of the household head's age, sex, education, and credit use. A negative sign on a parameter that is explaining technical inefficiencies means that the variable is decreasing technical inefficiency (or improving efficiency), while for a positive sign the reverse is true. The family size positively affected technical inefficiency. This means that a smaller family (fewer members) is more efficient than a larger family. Some empirical studies result show smaller families appear to be more efficient than larger families. This finding is consistent with the work (Bozoglu and Ceyhan, 2007). The negative sign for experience, which indicated that households head had more experience led to improving efficiency, a finding that is consistent with the results reported by (Bozoglu and Ceyhan, 2007; Anang et al., 2016). Non-farm income had a negative coefficient and highly affected technical inefficiency more than other variables. In other words, if a household earns more non-farm income that is causing more efficient production. For our sampled household answered to non-farm income (including salary, pension, and other activity income) spend on vegetable production activities. But most of the empirical results have shown a positive relationship between non-farm income and technical inefficiency (Laha, 2006; Asefa, 2011; Anang et al., 2016; Abdulai and Eberlin, 2001; Addai and Owusu, 2014).

Besides, the land fragmentation index also has a significant and positive sign of the coefficient. It means that larger plots may cause an increase in inefficiency. But if the management is better, it causes a positive impact on technical efficiency (Tan et al., 2010; Kiprop et al., 2015). Household head's age, sex, education, and credit use were negative and insignificant. But the negative relationship between age, sex, and inefficiency, a finding similar result reported by (Battese and Broca, 1997; Abdulai and Tietje, 2007). The Mongolian government implements low-interest-rate credit with long-term machinery loan programs to increase vegetable production. Thus, we examined that credit how affected vegetable household technical efficiency. The credit use coefficient sign was negative but insignificant, this means that credit is showed that gives good opportunities for improving technical efficiency. For example, most of the sample households access to credit-only cultivating period to purchasing seed and financing for other costs (rent a tractor to cultivation). These findings were very similar to the result from (Bozoglu and Ceyhan, 2007; Asefa, 2011; Laha, 2006; Addai and Owusu, 2014).

Table 35 shows the differences between technically efficient and inefficient vegetable household production characteristics. The technically efficient vegetable household level is more than 90 percent, otherwise technically inefficient vegetable household level lower than 90 percent. There is a small difference between technically efficient and inefficient vegetable households. For example, the land size of the technically efficient vegetable household is higher (7.2 %) than the technically inefficient vegetable household land size. Family member for the technically efficient vegetable household is approximately 4 members which fewer than technically inefficient vegetable household.

Table 35. The differences between technically efficient and inefficient vegetable household production

Characteristics	Technically efficient <90 %	Technically efficient ≥90 %	Differences (%)
Land size, ha	2.04	2.18	+7.2
Sales income, million MNT	12.00	13.14	+9.5
Family size, (member)	4.35	4.00	-7.9
Household heads sex	0.82	1.00	+21.5
Household head's age (years)	46.71	47.67	+2.05
Household head's experience (years)	15.31	16.83	+9.9
Non-farm income (%)	37.00	33.00	-10.8
Credit use (%)	73.00	100.00	+37.3
Land fragmentation index	0.54	0.48	-12.3

Source: Own illustration based on own technical efficiency estimation

The household head's age and more experience are confirmed that the household head has an older and more experience cause to increase technical efficiency. The credit non-used vegetable household is that 27 percent of technically inefficient vegetable household.

V. NEW SCIENTIFIC RESULTS

My study's main characteristic is the first time attempting to complex analysis of vegetable production in Mongolia. Some below findings are investigated based on the results of my studies.

1. In my empirical research, it has been revealed that vegetable substitution elasticities in long run higher than vegetable substitution elasticities in the short run. A greater elasticity shows that closer the degree of substitution between domestic produced vegetables and importing vegetables in the long run.
2. Another important result is found that the overall estimated vegetable substitution elasticity value is lower, which means that Mongolian consumers more prefer domestic vegetables than importing vegetables. Also, this result is confirmed by the home bias value.
3. My study result is proved that the elasticity of import price for vegetables higher than the elasticity of domestic price for vegetables. On the other hand, importing vegetables are more sensitive than domestic vegetables in relation to change its price.
4. In my empirical research result, land and labor inputs have evidenced that main influencing factors in vegetable household production in Mongolia.
5. In my study result, farm size (depend on land size of household vegetable production) was found to have a positive relationship with technical efficiency in Mongolia.

VI. CONCLUSION AND RECOMMENDATION

Vegetables are one of the more important components of a more balanced healthy diet. Currently, Mongolian vegetables' consumption has been 6 times lower than the recommended intake by the World Health Organization (WHO). Thus, increased vegetable production will provide to opportunity for increased vegetable consumption. In 2019, potato consumption has supplied 100 percent of domestic production. However, the vegetable supply is still has been imported (vegetable self-sufficient rate 53%). Mongolian government attention to this situation, there has been implementing many projects to increase vegetable domestic production and enhance to supply domestic consumption.

The main objective of this study is to estimate substitution elasticity between domestic vegetables and imported vegetables and to determine technical efficiency and exploring inefficiency determinants of the vegetable household production in Mongolia. My study has divided into 2 sections. The first section was estimating substitution elasticity using the Armington model, the second part was analyzing technical efficiency using the Stochastic Frontier Analysis model (SFA). I conclude the following conclusions in my study results.

- On average substitution elasticity for vegetable, the long-run estimates are approximately two times larger than short-run estimates.
- The estimated home bias value is higher, which means that consumer's consumption is reflected a higher relative weight on the domestic vegetables.
- Averaged vegetables' price elasticity is lower than one, which means that vegetables are low elastic.
- The mean technical efficiency of vegetable household production was 0.646. The vegetable household producer produces 64.6% of the maximum output or approximately 35.4% of the potential output is lost associated with technical inefficiency. This level of efficiency is confirmed as "poor but efficient".
- The land and labor inputs had the highest elasticity value which means that land and labor are the main influencing factors in vegetable household production.
- The positive effect of farm size, household head's experience, and non-farm income on technical efficiency indicate that increase in household production will improve technical efficiency. For example, larger-scale vegetable household producer appears to be more efficient than small scale household producer. The positive relationship between non-farm income and technical efficiency suggests that increases in non-farm income improve the vegetable household financial ability.

- The relationship between family size (number of the family member) and technical efficiency is a negative effect on technical efficiency. In other words, fewer families are more efficient than large families.
- Household head's age, household head's sex, and credit access variables were positive to technical efficiency but insignificant.
- The education variable was insignificant. The negative sign for the education variable indicates that higher levels of education decrease technical efficiency.

The following hypotheses evidenced on the study result of vegetables in Mongolia.

Table 36. The verification of hypotheses

Number	Hypotheses	**Overall elasticity**	Potato	Tomato	Garlic and onion	Cabbage	Carrot	Cucumber
H1	Long-run substitution elasticity higher than short-run substitution elasticity of vegetables	**Accepted**	Rejected	Accepted	Accepted	Accepted	Accepted	Rejected
H2	Home bias value in long-run is higher than short-run home bias value in vegetables	**Accepted**	Accepted	Rejected	Rejected	Rejected	Accepted	Rejected
H3	Vegetable import price elasticities are higher than domestic price elasticities.	**Accepted**	Accepted	Accepted	Accepted	Rejected	Accepted	Rejected

6.1 Recommendations

Based on my study result, I suggested the following recommendations.

- Result of the Armington substitution elasticity, Mongolian consumers exhibit more preference for home-growing vegetables. Increased domestic production will provide the opportunity for increased vegetable consumption. Therefore, policymakers should focus on increasing domestic vegetable production. For example, improving the quality of vegetable seeds, supporting subsidy especially, diesel consumption, increasing storage of vegetable household producers, improving irrigation system, etc.
- Technical efficiency for vegetable household production was 64.6%, which means that vegetable household production is carried out 35.4 % lower than their maximum production. Efficient vegetable household production had a smaller family, household head's age older, more experience, greater non-farm income, and better access to credit than inefficient vegetable household production. Thus, the vegetable household producer needs another source of income such as livestock production and greenhouse production, etc.
- It is organized training to enhancing household producer's education and skills should be provided in vegetable producer agrotechnical knowledge for improving the technical efficiency.
- Inclusive providing access to credit would require government support through a law. The Mongolian government has been implementing a low-interest rate credit program to support small and medium enterprises. Unfortunately, this credit could not be adequate. Thus, it is necessary to increase the sufficiency of credit.

6.2 Limitation of the study and the area of recommendations for future researchers

This study explored that vegetable substitution elasticity for importing vegetables, vegetable price elasticity, home bias value for vegetables, technical efficiency of vegetable household production, and effecting some main factors to the technical inefficiency in Mongolia due to the fact that the production of vegetable provides the increasing of human consumption in vegetables. My dissertation sheds some insight into the constraints of substitutability between domestic and imported vegetables and efficiency analysis in the context of the crop sector and provides policy recommendations for the future implementing program. There were several limitations in this study.

First, the Armington model is a key parameter used to assess the impacts of trade policy changes. Indeed, this study should be expanded entirely crop sector to evaluate the impact of trade policy changes in future research. On the other hand, the expanded substitution elasticity will more helpfully support implementing complex policy for the crop sector.

Second, the study focus on only vegetable household production which located in two main grown area. The dataset is not the whole representative of Mongolia. Therefore, future researchers should be repeated the dataset at other grown areas in order to generate more information on the overall efficiency analysis of vegetable production in Mongolia.

Third, the study could not have defined vegetable production productivity analysis and technological changes due to the using cross-section data. Future researchers should use panel data in order to estimate productivity and technological changes in vegetable production.

Finally, this study identifies and analysis the factors that could explain the impact in technical efficiency (inefficiency) of vegetable household production. It excluded affecting many factors to technical efficiency associated with a lack of information. Further research could extend the number of exogenous variables with respect to explaining the determinants of the technical efficiency (inefficiency) of vegetable production in Mongolia.

VII. SUMMARY

This dissertation focuses on the substitution elasticity of main vegetables (hereafter vegetable) for importing vegetables and the technical efficiency of vegetable production. Using the Armington model, which indicates the degree of substitutability between domestic vegetables and importing vegetables. Additionally, my study explored to determine the technical efficiency of vegetable household production.

Agriculture is a traditional sector of Mongolia and it is still a dominant role in its economy. It has been providing food for the population and raw materials for manufacturing industries. The crop sector is one of the main sectors to supply the population with safe and quality food. After shifted to political and economic transition in 1990, the crop sector had been dropped in 2005. Mongolian Government started to pay attention to this situation and implemented the 3rd Land Rehabilitation Programme between 2008 and 2010. As a result, the crop sector was substantially revived, the total sown area increased to a fully supplied level for wheat, potato demand, and over 60 % supplied for vegetable demand. But until now, the vegetable sector has a high reliance on imported vegetables. Therefore, population vegetable consumption is 6 times lower than the recommended intake by WHO. Increased vegetable production will provide the opportunity for increased vegetable consumption. The aim of this study is to estimate substitution elasticity of vegetables for importing vegetables using the Armington model and measure technical efficiency and determine influencing factors inefficiency on vegetable household production in Mongolia by using Stochastic production frontier analysis (SFA).

The first part of the dissertation is to estimate the Armington substitution elasticity for vegetables. Secondary data was used to estimate the substitution elasticity of vegetables between 1995 and 2019. The empirical result shows that the Armington elasticities in the long-run higher than the short-run with exception of potato which means that products are similar in the long-run. Therefore, my study has determined home bias value using substitution elasticity. We found that the home bias value is high, this appears to be a higher relative weight on home vegetables. Also, we identified that vegetable price elasticity was lower than one.

The second part of the dissertation is to measure technical efficiency and to determine influencing factors inefficiency on vegetable household production. Primary data was collected from randomly selected 260 vegetable households of Mongolia in 2019. The empirical result indicated that the average technical efficiency of the sampled vegetable household was 64.6 % (range between 43.2% and 99.9%) or they lost about 35.4% of the potential output due to technical inefficiency. We found that land and labor are the main influencing input factors of the household’s vegetable

production. Also, the result of the technical inefficiency model, variables of age, sex, experience, and credit use obtained a negative relationship with inefficiency. The other variables are family size, education level, land fragmentation index were positively affected by technical inefficiency.

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9.3 Technical efficiency distribution of the sampled vegetable household

My study used a multi-stage clarified random sampling technique to select the vegetable household producer. First, I choose the dominant two regions in vegetable production namely, the Western and Central regions. Second, I selected the dominant two provinces namely Khovd and Selenge. Finally, I determined the 4-5 soums in these provinces. Table A.1 shows the respondents' soum[2] distribution.

Table A.1 Number of respondents involved in soum field survey

Provinces	Soum	Number of respondents
Khovd	Jargalant	22
Khovd	Buyant	56
Khovd	Myangad	26
Khovd	Khovd	31
Selenge	Zuunburen	23
Selenge	Mandal	22
Selenge	Sant	48
Selenge	Sukhbaatar	15
Selenge	Khushaat	9
Selenge	Tsagaannuur	3
Selenge	Shaamar	6
Total		260

Source: Own conducted field survey

Mean technical efficiency in provinces is presented in Figure A1. Khovd province's vegetable household producers are more efficient than Selenge province.

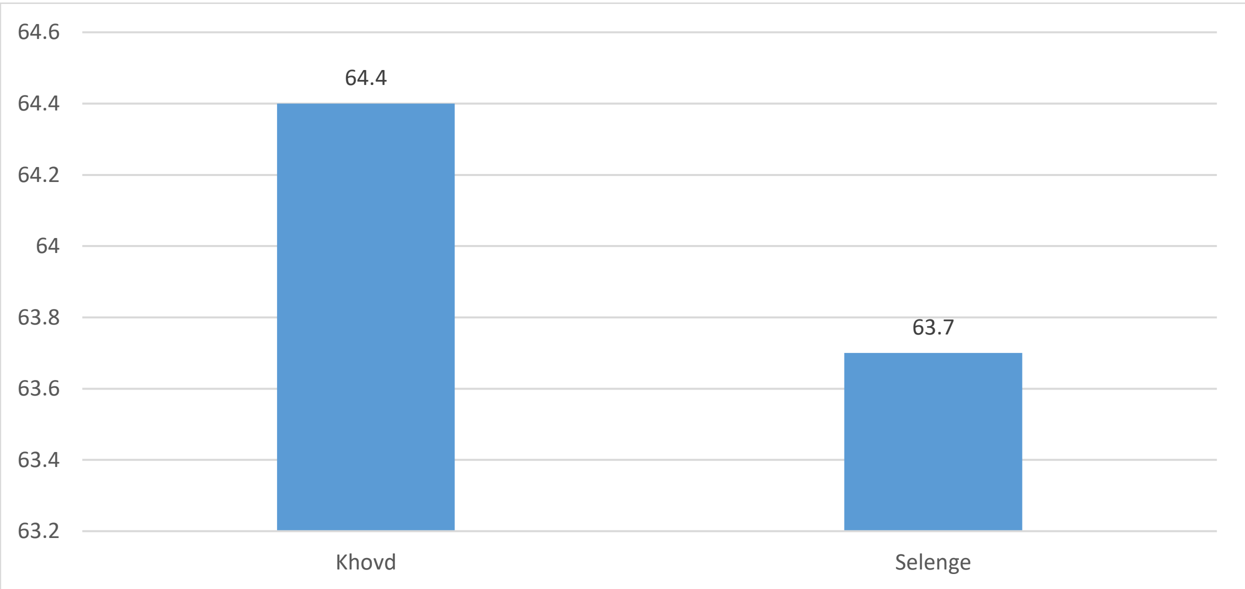

Figure A1. Mean technical efficiency by provinces

Source: Own conducted field survey

[2] - soum is minimum unit in municipal administration in Mongolia

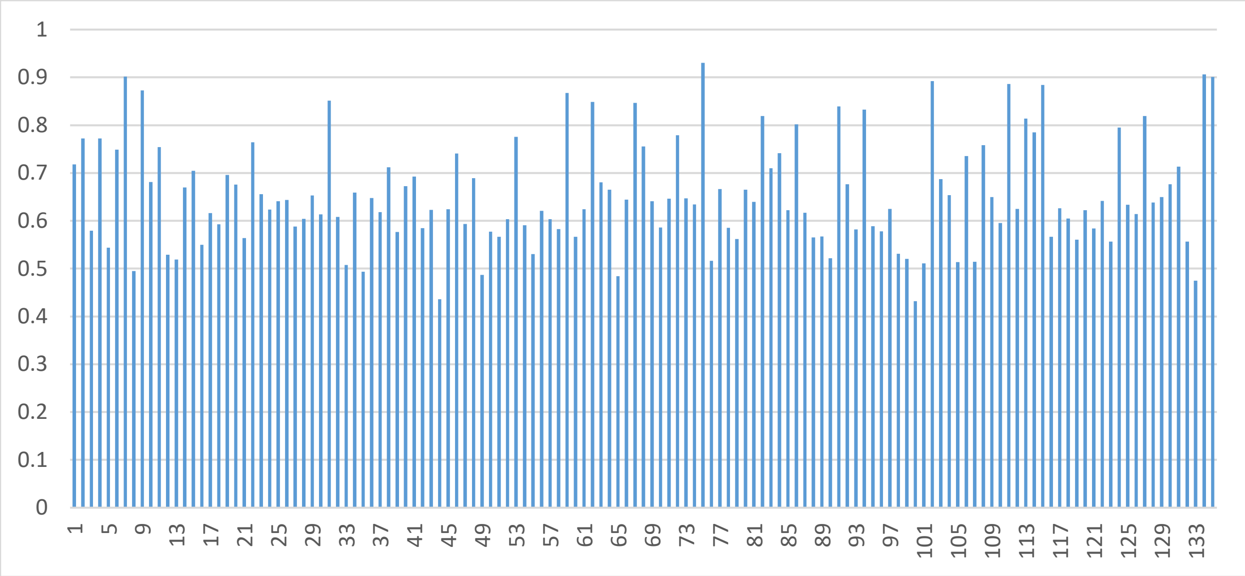

Figure A.2 Technical efficiency of respondents in Khovd province

Source: Own conducted field survey

The plots in Figure A2 illustrate the technical efficiency of the vegetable household producers in Khovd province. The findings revealed the overall mean of technical efficiency in Khovd province is estimated at 0.64 (ranged between 0.43 and 0.93).

Figure A3 shows the technical efficiency of the vegetable household producers in Selenge province. Mean technical efficiency was estimated to varied from 0.44 to 0.99.

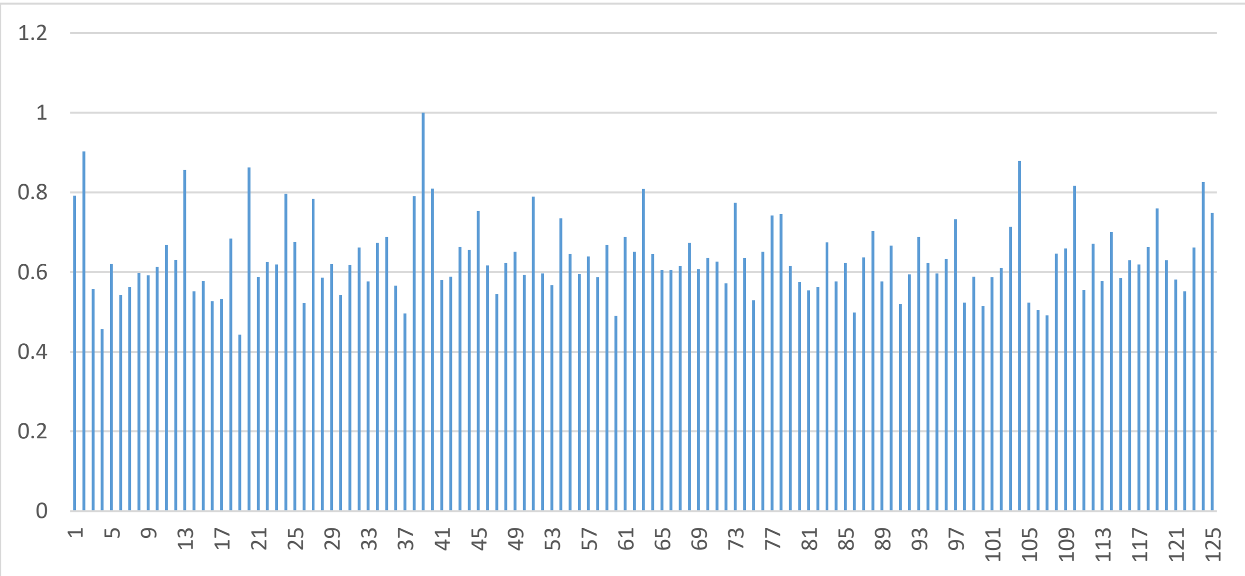

Figure A.3 Technical efficiency of respondents in Selenge province

Source: Own conducted field survey

9.4 Research questionnaire

Questionnaire number...

Research objective

Nowadays, food safety and food sufficiency are very important concepts in every country. These concepts are defined as being able to meet population consumption needs from domestic production rather than by importing. In recent years, every country cannot fully supply the consumption of population by domestic production. Also, every country meets to supply of population consumption by food hygiene standard and healthy food. One of the concepts to solve this problem the increase of domestic production. For example, the Mongolian government has implemented many projects namely, the “Mongol potato” program, “Mongol vegetables” program, and “Mongol fruit” program for this situation. In 2018, one hundred percent of potato consumption has supplied by domestic production and 60 percent of vegetable consumption has been supplying by domestic production. The remained of consumption is supplying by import. This study objective is based on the ability to substitute the vegetable’s import by the domestic vegetable production. In other words, we calculate the elasticity of substitution using the Armington model. Therefore, we focus on how to increase vegetables domestic production. Especially, we pay attention to the below questions. What is the technical efficiency level of vegetables’ household production? What are the main influencing factors to efficiency? What is the facing main problem with vegetable production?

Your opinions are very important to us, and to deep help formulate my dissertation thesis. Thank you for kindly participating in this questionnaire.

A. General information

1. Please write your province, soum and bag’s name: ...., soum: ...., bag: ....
2. Please record your age: ...., your sex: ....
3. How long are you running your own vegetable? ………………………………………………….
4. Please mark your highest education:
   a. Graduate university b. Graduate college c. Secondary school d. Primary school e. Illiterate
5. How many members in your family (or how many member work in your family business):
   Male: ....   Female: ....

B. Sowing information

1. How long-running your own vegetable production? …...
2. Please write your family’s owned total land? - ……...
3. How many hectares of land your family using for used area?...
4. Please write your reason for not fully used land
   ……
5. How many km your family’s sowing area from the center of province and soum? From soum: …………………….....   from province: ....
6. How many km your sowing area from the source of water? ....
7. Please write your sowing vegetables?

№	Vegetable's name	Cultivated area (ha)	Total harvest (ton)		Per hectare (centner)
			For seed	For sale	
1	Potato				
2	Turnips				
3	Carrot				
4	Cabbage				
5	Tomato				
6	Cucumber				
7	Onion				
8	Garlic				
9	Watermelon				
10	Pepper				
11	Others...				

8. Do you have greenhouse production? (Please mark)

   a. No b. Yes (to move question 9)

9. What's vegetable sowing in your greenhouse? (Please write the name of vegetables)

№	Vegetable's name	Cultivated area (ha)	Total harvest (ton)	Per hectare (cn)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

C. Family's cost information

1. How many kg seeds use your family for sowing?

№	Seed's name	Used quantity	Here of amount drawn of own resources	Purchased amount	Cost of 1 kg (MNT)	Total cost (MNT)
1	Potato					
2	Turnips					
3	Carrot					
4	Cabbage					
5	Tomato					
6	Cucumber					
7	Onion					
8	Garlic					
9	Watermelon					
10	Sweet melon					
11	Others ………………….					

2. Did you rent machinery for cultivating and harvesting period? If yes, please write things that belong to the below table.

№	Rented machinery name	Rented machinery name	Rented hours/season	Cost per hour/day (MNT)	Total cost (MNT)
1	Plowing				
2	Sowing				
3	Digging				
4	Irrigation				
5	Weeding harrow				
6	Harvest				
7	Transportation				
8	Transportation cost of manure				
9	Others				

3. Did your family hire workers for cultivating, sowing, growing, and harvesting periods? If yes, please fill out the below table.

№	Hiring workers for	Number of hiring the worker	Cost of hours (MNT)	Total cost (MNT)
1	Cultivating			
2	Sowing			
3	Grubbing			
4	Irrigation			
5	Harvesting			
6	Transportation			
7	Weeding harrow			
8	Transportation cost of manure			
9	Others ……………………………….			

4. How many kg fertilizers do you use belong to the growing period? Please write fertilizers' names.

№	Fertilizers' name	Amount of using (ton)	Here of amount drawn of own resources (manure)	Purchased amount	Cost of the unit (MNT)	Total cost (MNT)
1	Manure					
2	Others					
3						

5. How many kg/liter pesticides do you use belong to the growing period? Please write pesticides' names.

№	Pesticides' name	For which vegetables	Used quantity (kg, liter)	Unit cost for kg, liter (MNT)	Total cost (MNT)
1	Pesticides for disinfection				
1.1					
1.2					
2	Pesticides for vermin				
2.1					
2.2					
3	Pesticides for disease of vegetables				
3.1					
3.2					

6. Do you have a warehouse/storage? a. Yes b. No (to move question 8)

7. If yes, what is the cost belongs to the warehouse?

№	Cost of belong to warehouse	Please fill out
1	Capacity of warehouse	
2	Monthly utility cost (MNT)	
4	Monthly operation cost (MNT)	
5	Other cost	
6		

8. Does your family rent a warehouse for storing vegetables? If yes, what is the cost of the rent a month?
   Monthly rent: .... MNT, during …………………………….. months.
9. How much labor safety cost is spending belong to cultivating, sowing, growing, and harvesting period?

№	Cost name	Purchasing amount (piece, set)	Unit cost (MNT)	Total cost (MNT)
1	Shovel			
2	Set of instruments for disinfection and cleaning			
3	Water boots			
4	Gloves			
5	Others_____________			
6				
7				
8				

10. What assets has your family? Please fill out the below table (to calculate depression)

№	Asset's name	Purchased years	Purchased cost	Purchased unit	Total cost	The present value of assets
1	Small and medium-sized tractor – depending on horsepower					
2	Tractor for cultivating					
3	Truck					
4	Automobile					
5	Motorbike					
6	Pesticide spray					
7	Irrigation facility					
8	others ________					
9						
10						
11						
12						
13						
15						

11. How much of the diesel cost is spending belong to cultivating, sowing, growing, and harvesting period? And, belong to transportation to market.

№	Fuel cost for	Used amount	Price	Total cost (MNT)
1	Cultivating and sowing period			
2	Harvest period			
3	Transportation for sales			
4	others ____________			
5				
6				
7				
8				

12. Does your family spend replacement and spare cost for machinery? If yes, how much cost for it? ....

13. Does your family has any credit? a. Yes b. No

14. What is the cost belong to the greenhouse?

№	Cost belong to greenhouse	Please fill out
1	Capacity of greenhouse	
2	Monthly utility cost (MNT)	
3	Monthly operation cost (MNT)	
4	Other costs	
5		
6		

15. What is your non-farm activities cost within a year?

…………………………………………………………………………………………

D. Family's income information

1. How much income did your family earn in last 2019? Please write below the table.

№	Vegetable's name	Total harvest (тон)	Harvest for sell (ton)		Market price	
			Retail	Wholesale	Retail	Wholesale
1	Potato					
2	Turnips					
3	Carrot					
4	Cabbage					
5	Tomato					
6	Cucumber					
7	Onion					
8	Garlic					
9	Watermelon					
10	Pepper					
11	Others..					

2. How to sell vegetables to the market?

a. Wholesale directly b. Retail c. Both

3. How many km nearest market from your sown area? ....

4. Does your family has below income? If yes, please write it.

№	Rent income	Unit price	Total rent income
1	Cultivating tractor		
2	Harvesting tractor		
3	Land rent		
4	other income ――――――		
5			

5. Does your family has non-farm income? If yes, please write it within a year

....

6. What is your opinion to improve productivity and efficiency in vegetable production? Please write it.

....
....
....
....
....
....
....

Thank you for cooperation and valuable time.

Thank you, for devoting your valuable time in helping to conduct this research. This study in case, you are interested to know about the result of this research please write down my e-mail address.

E-mail: amar.uuld@gmail.com

9.5 Technological card (seed card)

This part shows that vegetables seed card for 1 hectare to calculating the cost of 1 hectare. These cards indicate working man/days.

Table A.2 Carrot seed card

№	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	4	8.6
3	Spread manure on the field	tn	30	8	3.8
4	Harrowing	ha	1		
5	Prepare for seed	ha	1	3	0.3
6	Track in field	ha	1	3	0.3
7	Ploughing	ha	1	6	0.2
8	First irrigation	ha	1	30	0.0
9	Next irrigation (4 times)	ha	1	50	0.0
10	Hoeing	ha	1	5	0.2
11	First deceleration	ha	1	1	1.0
12	Next deceleration (2 times)	ha	1	4	0.3
13	Spraying fertilizer	ha	1	20	0.1
14	Harvesting	kg	1,667	200	8.3
15	Prepare to sell	tn	16.7	1	13.9
16	Load sack of carrot	kg	1,667	4,000	0.4
17	Keeping to storage	sack	55	250	0.2
18	Load to selling carrot	tn	16.7	4	4.4
19	Transportation to selling carrot	tn/km	183		
20	Sorting, packing (2 times)	sack	110	50	2.2
21	Seed cost	kg	5		
22	Fertilizer cost	kg	50		
23	Herbicide cost	kg	4		
24	Firewood cost	m3	5		
25	Coal cost	tn	2.5		
26	Labor safety cost				
27	Packing sack	piece	612		
28	Electricity cost	kwh	83		
29	Diesel cost	liter	33		
30	Heating cost	days	83		
31	Sell	tn	16.7		
	Total				47.19

Table A.3. Potato seed card

	Main activities	Unit	Working unit	Working man/days
1	Plowing	ha	1	4.74
2	Transportation manure	tn/km	2000	6.04
3	Praying manure	ha	1	2.74
4	Cultivating	ha	1	2.74
5	Sowing seed	ha	1	2.74
6	Harrowing	ha	1	2.74
7	Hoeing	ha	1	2.74
8	Water		1	2.74
9	Praying herbicide	ha	1	7.74
10	Spraying fertilizer	ha	1	5.25
11	Harvesting	ha	1	11.71
12	Transportation to warehouse	ha	1	6.78
13	Separator			21.49
14	Other			9.54
15	Diesel	liter	246.6	
	Total			89.74

Table A.4 Turnips seed card

№	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	4	8.6
3	Spread manure on the field	tn	30	8	3.8
4	Harrowing	ha	1		
5	Prepare for seed	ha	1	3	0.3
6	Track in field	ha	1	3	0.3
7	Ploughing	ha	1	6	0.2
8	First irrigation	ha	1	30	0.0
9	Next irrigation (4 times)	ha	4	50	0.1
10	Hoeing (5 times)	ha	5	5	1.0
11	First deceleration	ha	1	2	0.5
12	Next deceleration (2 times)	ha	2	4	0.5
13	Spraying fertilizer	ha	1	20	0.1
14	Spraying herbicide (4 times)	ha	4	100	0.0
15	Harvesting		7	1	5.5
16	Packaging	tn	17	1	13.8
17	Sacking	Sack	117	120	1.0
18	Load to selling carrot	tn	17	4	4.3
19	Transportation of selling carrot	tn/km	210		
20	Keeping to storage	sack	117	253	0.5
21	Sorting, packing (2 times)	sack	34	100	2.3
22	Seed cost	kg	3		
23	Fertilizer cost	kg	50		
24	Herbicide cost	kg	2		

25	Firewood cost	m3	5		
26	Coal cost	tn	3		
27	Labor safety cost				
28	Packaging	piece	700		
29	Electricity cost	kwh	50		
30	Diesel cost	liter	20		
31	Heating cost	days	50		
32	Sell	tn	17		
	Total				45.7

Table A.5 Cabbage seed card

	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	T	30	10	3.0
2	Load manure	T	30	4	8.6
3	Spread manure on the field	T	30	8	3.8
4	Harrowing	ha	1	20	0.1
5	Prepare for seed	ha	1	3	0.3
7	Prepare seed	thous.piece	33	1	47.1
14	Harrowing	ha	4	5	0.8
15	Spraying fertilizer	ha	1	20	0.1
16	Irrigation (5 times)	ha	5	50	0.1
17	Spraying herbicide (4 times)	ha	4	100	0.0
18	Prepare mother seed	thous.piece	13	0	44.0
24	Harvesting	tn	16	3	5.3
25	Sorting and packaging	tn	16	4	4.0
26	Transportation of selling cabbage	tn/km	160		
27	Fertilizer cost	kg	60		
28	Herbicide cost	kg	2		
29	Seed cost	kg	1		
30	Firewood cost	m3	5		
31	Coal cost	tn	3		
32	Labor safety cost				
33	Packaging	piece	533		
34	Electricity cost	kwh	100		
35	Diesel cost	liter	20		
36	Heating cost	days	50		
37	Sell	tn	16		
	Total				117.2

Table A.6 Onion seed card

№	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	3.5	8.6
3	Spread manure on the field	tn	30	8	3.8
4	Harrowing	ha	1	20	0.1
5	Prepare for seed	ha	1	3	0.3
14	Purge seed for onion	kg	70	50	1.4
16	Track in field	ha	1	2	0.5
17	Ploughing by hand	ha	1	4	0.3
18	First deceleration	ha	1	4	0.3
24	Harrowing	ha	1	3	0.3
25	First irrigation	ha	1	30	0.0
26	Next irrigation (3 times)	ha	3	50	0.1
27	Spraying fertilizer (2 times)	ha	2	20	0.1
28	Spraying herbicide (3 times)	ha	3	100	0.0
29	Prepare baby onion for harvesting	ha	1	10	0.1
30	Harvesting baby onion	ha	1	3	0.3
31	Sorting baby onion	centner	100	4	25.0
32	Sorting and packaging	ц	30	3	10.0
33	Transportation of onion	т/км	130		
22	Packaging onion	centner	70	2.5	28.0
23	Seed cost	kg	70		
24	Herbicide cost	kg	1.2		
25	Fertilizer cost	kg	50		
26	Firewood cost	m3	5		
27	Coal cost	tn	3		
28	Labor safety cost				
29	Packaging	piece	350		
30	Electricity cost	kwh	100		
31	Diesel cost	liter	20		
32	Heating cost	days	50		
33	Sell	tn	3		
	Total				82.1

Table A.7 Garlic seed card

	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	3.5	8.6
3	Spread manure on the field	tn	30	8	3.8

4	Harrowing	ha	1	20	5.0
5	Prepare land for seed	ha	1	3	33.3
6	Tracking in field	ha	1	2	50.0
7	Prepare for seed	kg	360	15	24.0
8	Sowing seed	ha	1	1	100.0
9	Repeating soil after sowing	ha	1	5	20.0
10	Harrowing	ha	1	1.36	73.5
11	First irrigation	ha	1	30	3.3
12	Next irrigation (4 times)	ha	4	50	8.0
13	Spraying fertilizer	ha	1	20	5.0
14	Purging of garlic spot	ha	1	2	50.0
15	Spraying herbicide (2 times)	ha	2	100	2.0
16	Exposing ratoon	ha	1	4	25.0
17	Disposing stalk of garlic	ha	1	6	16.7
18	Harvesting garlic	centner	50	8	6.3
19	Knitting garlic	centner	50	2.5	20.0
20	Suspending garlic	centner	50	4.5	11.1
21	Separate ratoon	centner	50	4	12.5
22	Bring to storage	centner	40	6	6.7
23	First separation	centner	40	5	8.0
24	Second separation	centner	40	3	13.3
25	Packaging	tn	1	4	0.3
26	Transportation	tn/km	3		
27	Seed cost	kg	360		
28	Herbicide cost	kg	36		
29	Firewood cost	m3	9		
30	Coal cost	tn	4.5		
31	Labor safety cost				
32	Package	piece	60		
33	Electricity cost	kwh	300		
34	Diesel cost	liter	60		
35	Heating cost	days	150		
36	Sell	tn	0.9		
	Total				509.3

Table A.8. Cucumber seed card

	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	3.5	8.6
3	Spread manure on the field	ha	1	20	5.0
4	Harrowing	ha	1		
5	Prepare for seed	ha	1	3	33.3

6	Track in field	ha	1	3	33.3
7	Ploughing	ha	1	8	12.5
8	First irrigation	ha	1	30	3.3
9	Next irrigation (4 times)	ha	400	50	80.0
10	First deceleration	ha	1	2	50.0
11	Second deceleration	ha	2	4	50.0
12	Harrowing	ha	5	10	50.0
13	Spraying fertilizer	ha	2	20	10.0
14	Spraying herbicide (3 times)	ha	3	100	3.0
15	First sample harvesting	centner	16.7	0.6	27.8
16	Second sample harvesting	centner	16.7	1.2	13.9
17	Harvesting seed of cucumber	centner	200	3	66.7
18	Transportation of selling cucumber	tn/km	1833.3		
19	Filtering seed	tn	20	0.33	60.6
20	Seperating seed	kg	166.7	5	33.3
21	Wetting for drought seed	kg	166.7	50	3.3
22	Seed cost	kg	5		
23	Fertilizer cost	kg	60		
24	Herbicide cost	kg	1.3		
25	Diesel cost	liter	66.7		
26	Labor safety cost				
27	Packaging	piece	800		
28	Sell	tn	6		
	Total				547.7

Table A.9. Tomato seed card

	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	3.5	8.6
3	Spread manure on the field	tn	30	20	1.5
4	Harrowing	ha	100		
5	Prepare for seed	ha	100	5	20.0
6	Track in field	ha	100	8	12.5
7	First deceleration	ha	100	4	25.0
8	Second deceleration	ha	100	6	16.7
9	Harrowing	ha	200	10	20.0
10	First irrigation	ha	500	30	16.7
11	Next irrigation (3 times)	ha	100	50	2.0
12	Spraying fertilizer	ha	3000	20	150.0
13	Stinting tomato (3 times)	thous.piece	90	1.5	60.0
14	Spraying herbicide (3 times)	ha	300	2	150.0
15	First harvesting	tn	2.5	2.5	1.0
16	Second harvesting	tn	5	3	1.7
17	Third harvesting	tn	7.5	100	0.1
18	Fourth harvesting	tn	3.75	0.4	9.4

19	Transportation of selling cucumber	tn/km	1375		
20	Filtering seed	tn	5	0.3	16.7
21	Separating seed	kg	30	4	7.5
22	Wetting process for drought seed	kg	30	50	
23	Seed cost	kg	0.3		
24	Fertilizer cost	kg	60		
25	Herbicide cost	kg	1.5		
26	Diesel cost	liter	50		
27	Labor safety cost				
28	Packaging	piece	600		
29	Sell	tn	15		
	Total				522.2

Table A.10. Watermelon seed card

	Main activities	Unit	Working unit	Standard norm	Working man/days
1	Prepare manure	tn	30	10	3.0
2	Load manure	tn	30	3.5	8.6
3	First irrigation	ha	1	30	3.3
4	Spread manure on the field	tn	1	20	5.0
5	Harrowing	ha	1		
6	Prepare land for sowing	ha	1	3	33.3
7	Sowing seed	ha	1	8	33.3
8	Repeat irrigation	ha	1	30	13.3
9	Next irrigation	ha	1.2	50	24.0
10	Deceleration	ha	1	10	10.0
11	Stinting	ha	1	30	3.3
12	Spraying herbicide (3 times)	ha	2	100	2.0
13	Hoeing	ha	5	5	100.0
14	Spraying fertilizer	ha	2	20	10.0
15	Harvesting seed	tn	11.6	2.3	5.1
16	Separating seed	tn	11.6	0.7	16.7
17	Drying seed	kg	33.3	2.8	11.9
18	Seed cost	kg	5		
19	Fertilizer cost	kg	70		
20	Herbicide cost	kg	1.6		
21	Diesel cost	liter	66.6		
22	Labor safety cost				
23	Sell	tn	11.6		
	Total				282.9

ACKNOWLEDGEMENT

I wish to thank all the people whose assistance was a milestone in completion of my PhD journey.

First of all, I would like to express my deepest thanks and appreciation to my supervisor *Dr. Prof. Robert Magda*, who accepted me as his PhD student. He gave me countless advice, encouragement, support and always guided me in the right direction. I cannot imagine having a better advisor and mentor for my PhD study. I am also very grateful to my second supervisor *Dr. Prof Yuriy Bilan*, for his scientific advice, knowledge, comments and corrections, which helped to challenging of article writing.

I thank for Hungarian Government and Tempus Foundation awarding me Stipendium Hungaricum Scholarship program. My PhD dream would have not been possible without the funding from the Stipendium Hungaricum Scholarship.

I would like to thank, Hungarian University of Agriculture and Life Sciences for providing excellent student services and financing to participate conferences. I especially thank to *Dr. Prof Maria Fekete* for encouragement and motivation.

Also, I am thankful to my colleagues of the Agricultural and Applied Economics department, School of Economics and Business, Mongolian University of Life Science (MULS). I especially thank to *Mr. Lkhagvadorj.D* and *Mrs. Khandaa.N*, who supported and encouraged words to me.

I am thankful for my dad *Uuld Deleg*, my mom *Zagdsuren Bazar*, my brothers *Zusemkhuu Uuld*, *Myagmarjav Uuld* and my sister *Sainbileg Uuld*, their family, whose encouragement words, support and love. I love them so much and I would not have made it this far without them. Also, I would like to thank my uncle *Batsukh Bazar* and my aunt *Tsendsuren Deleg*, who have always supporting me.

Especially thanks to my husband, *Ankkhbayar Tsolmon,* as well as my father-in-law *Tsolmon Natsag*, my mother-in-law, *Urantsetseg Gombo* and my sister-in law *Ariunchimeg, Ariunjargal*, *Ariunzaya*, *and Ariunzul* who have been helping and caring me. My husband has been true and great supporter for me.

Finally, I thank to my friends in Mongolia and Hungary, who are supporting and helping me on my studies.