AN ECONOMIC ANALYSIS OF AGRICULTURAL PRODUCTION FUNCTION IN THE MUDA AGRICULTURAL DEVELOPMENT AREA IN KEDAH, MALAYSIA

KAMARUDIN BIN OTHMAN

DOCTOR OF PHILOSOPHY
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AN ECONOMIC ANALYSIS OF AGRICULTURAL PRODUCTION FUNCTION IN THE MUDA AGRICULTURAL DEVELOPMENT AREA IN KEDAH, MALAYSIA

By

KAMARUDIN BIN OTHMAN

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(Date)

Nama Pelajar (Name of Student) : **Kamarudin Bin Othman**

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ABSTRACT

Paddy sub-sector is an important agricultural sector and it has become the main contributor of rice for Malaysia. Rice is Malaysian's staple food and the main source of calories. The development of paddy sub-sector manages to guarantee the sustainability of food security for Malaysians. The government has undertaken various measures to ensure the productivity of this sector continues to grow. This is to accommodate the demands of society, as well as to reduce imported rice. This study has selected four paddy production regions under *Muda Agricultural Development Authority* (MADA) as the research locations. This is because MADA is the major rice production in Malaysia. The study is undertaken to investigate factors that influence Malaysia paddy sub-sector, and also to examine the growth of total factor productivity (TFP). In addition, this research also investigates the capital-labour and young-old famers' elasticity of substitution. The study employed time series data from the main seasons of 1996 (1996H1) to 2011 (2011H1). Autoregressive distributed lag (ARDL) approach was employed to determine the long-run relationship between responding variable and regressor. For a model that does not indicate any long-run relationship, the researcher may employ the vector autoregression (VAR) approach. The total factor productivity (TFP) is employed to investigate paddy productivity growth. Present research employs constant elasticity of substitution (CES) production function to determine capital-labour and young-old farmers' elasticity of substitution. Empirical result indicates that each MADA production region has different factors that influence the paddy production. For both main and off seasons the TFP growth is fluctuating below 5 per cent. Empirical estimation also indicates that an average production in off-season has a negative productivity growth (declining productivity levels). The elasticity of substitution between the capital and labour is found inelastic. Meanwhile, the elasticity of substitutions of the young and old farmers is said unitary. From the above findings, this research strongly suggests that the increase in productivity growth is important for paddy sub-sector in Malaysia. The study makes several practical inferences in designing suitable macroeconomic policy and undertaking measures to promote high productivity growth. A few policies are recommended such as to increase research and development (R&D) fund allocation, improve the efficiency of land management and encourage more young people to join paddy sub-sector.

Keywords: ARDL, CES, elasticity of substitution, MADA, total factor productivity (TFP).

ABSTRAK

Subsektor padi merupakan sektor pertanian yang penting dan ia menjadi penyumbang utama beras untuk Malaysia. Beras juga menjadi makanan ruji dan sumber utama kalori. Pembangunan sektor ini dapat menjamin kelangsungan keselamatan makanan untuk rakyat Malaysia. Kerajaan telah mengambil pelbagai langkah untuk memastikan produktiviti sektor ini terus berkembang. Ini adalah untuk menampung permintaan masyarakat dan mengurangkan import beras dari negara-negara asing. Bagi tujuan kajian ini, empat kawasan pengeluaran padi di bawah Lembaga Kemajuan Pertanian Muda (MADA) dipilih sebagai lokasi kajian. Ini kerana MADA merupakan kawasan pengeluar beras utama di Malaysia. Kajian ini menggunakan data siri masa dari musim pengeluaran utama tahun 1996 (1996H1) hingga musim pengeluaran utama 2011 (2011H1). Kajian ini telah dibangunkan untuk menyiasat faktor-faktor yang mempengaruhi sektor padi Malaysia. Tambahan pula, kajian ini juga mengkaji pertumbuhan produktiviti faktor keseluruhan (TFP). Di samping itu, kajian ini juga mengkaji keanjalan penggantian modal-buruh dan petani muda-petani berusia. Kaedah autoregrasi taburan lat (ARDL) telah digunakan untuk menentukan hubungan jangka panjang antara pemboleh ubah bebas dan pemboleh ubah bersandar. Jika tidak wujud hubungan jangka panjang, pendekatan vektor autoregrasi (VAR) digunakan. Kaedah produktiviti faktor keseluruhan (TFP) digunakan bagi menyiasat pertumbuhan produktiviti padi. Penyelidikan ini juga telah menggunakan fungsi pengeluaran keanjalan pengantian tetap (CES) untuk menentukan keanjalan penggantian bagi modal-buruh dan petani muda-petani berusia. Dapatan empirik menunjukkan setiap kawasan pengeluaran MADA mempunyai faktor-faktor pengeluaran yang berbeza. Bagi kedua-dua musim didapati kadar pertumbuhan TFP turun naik di bawah aras 5 peratus. Kajian empirik juga mendapati purata pengeluaran bagi luar musim mencatatkan pertumbuhan produktiviti yang negatif (penurunan tahap produktiviti). Keanjalan penggantian antara modal dan buruh adalah tidak anjal. Manakala keanjalan penggantian petani muda dan petani berusia adalah uniti. Daripada dapatan di atas, kajian ini mencadangkan bahawa peningkatan dalam pertumbuhan produktiviti adalah penting dalam subsektor padi. Kajian ini membuat beberapa kesimpulan praktikal untuk mereka bentuk langkah dasar dan aku janji ekonomi makro sesuai untuk menggalakkan pertumbuhan produktiviti yang tinggi. Beberapa dasar telah dicadangkan seperti meningkat alokasi dana penyelidikan dan pembangunan (R&D), meningkatkan kecekapan pengurusan tanah dan menggalakkan lebih ramai orang muda untuk menyertai subsektor penanaman padi.

Katakunci: ARDL, CES, keanjalan penggantian, MADA, produktiviti faktor keseluruhan (TFP).

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributed Lag Model
AIC	Akaike Information Criterion
CD	Cobb Douglas Production Function
CES	Constant Elasticity of Substitution Production Function
DEA	Data Envelopment Analysis
DGP	Data Generating Process
ECM	Error Correction Model
IADP	Integrated Agricultural Development Projectsiat
KPSS	Kwiatkowski, Phillips, Schmidt, and Shin Unit Root Test
MADA	Muda Agricultural Development Authority
NKEA	Agricultural National Key Economics Areas
OLS	Ordinary least squares
PP	Phillips-Peron Unit Root Test
SBC	Schwarz Bayesian Criterion
SSL	Self Sufficiency Level
VES	Variable Elasticity of Substitution

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CHAPTER 1

INTRODUCTION

1.0 Research Background

Oryza Sativa is the scientific name for paddy. This crop is closely associated to South, Southeast, and East Asia. These three locations produced 90 per cent of the world's rice production for every year (Nur Badriyah, Jamal, Zakirah & Kamal, 2013). Asian countries like China, India, Indonesia, Bangladesh, Vietnam, and Thailand are among the largest world rice producers. The emergence of these countries is closely associated to the early history of the world's rice cultivation. From the archaeological discoveries, the world rice cultivation was started in Asian region around 10,000 B.C. Countries such as Thailand and China are believed to be the first countries that have planted paddy in the world. In Thailand, it is believed that paddy was grown since 10,000 B.C. in Non Nok Tha, the Korat area of Thailand. Meanwhile, in China, archaeologists have discovered that paddy was planted, dating back at least 10,000 to 8,000 B.C., in some areas such as Chekinag Province and Yangtse Valley (International Rice Research Institute [IRRI], 2011). Since then, paddy farming has spread throughout the Asian region and became the main food crop for Asia population. The significance of rice as the main food crop and a major source of a calorie remain until today. This was verified by Timmer (2010) in his literature highlights. According to him, the Asian population consumes 30 to 80 per cent of rice to fulfil their daily calorie intake.

Parallel to many other Asian countries, Malaysia was also influenced by paddy farming development from its neighbouring countries such as Thailand and Indonesia. As a result, paddy was brought and planted in the Malay Peninsula in the 14^{th} century[1]. In the centuries that follow, it rose to become a highly important food crop in Malaysia where it becomes a source of single staple food[2] for Malaysians (Nik Fuad, 2005; Daño & Samonte, 2005; Fatimah, Nik Mustapha, Bisant & Amin, 2007, Rabu & Shah. 2013). In 2001 the domestic consumption of rice in Malaysia was about 2.7 million tonnes. This was approximately 33 to 44 per cent of the daily calorie needs. However, per-capita rice consumption has dropped from 147.9 kg in 1960 and was expected to drop to 94.8 kg in 2013 (Vengedasalam, Hariss & MacAulay, 2011; U.S. Department of Agriculture [USDA], 2013). This is because Malaysians also consume other foods such as wheat and meat to gain calorie and energy needs.

Nevertheless, the average spending on rice in Malaysia is still high, and on the average, Malaysians have allocated around 12 per cent of their monthly income on rice consumption (Nik Fuad, 2002). Hence, the big allocation on rice shows that rice remains a major staple food and a source of calorie in Malaysia. Basically, the consumption of rice has provided more than one-third of daily calorie intake for Malaysians for every year (Warr, Rodriguez & Penm, 2008; USDA, 2012).

Apart from being a staple food and a source of calorie, paddy sub-sector is vital in influencing the Malaysian political environment[3] (Gomes, 2007; Wong, 2009). In the

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[1] Malay Peninsula had been colonised by several European powers such as Portuguese, Dutch, and British. Long before that, in 14^{th} century, the Malay Peninsula was demoted by the Srivijaya and Majapahit Empire, and in 15^{th} century, the Malay Sultanate was formed in Malacca. During British colonisation in 20^{th} century, Malaya was formed, consisting of Malay Peninsula and Singapore. Malaya was then restructured in 1948 as the Federation of Malaya and gained independent in 1957. In 1963, Malaysia was formed, consisting of Malaya, Sabah, and Sarawak. Later in 1965, Singapore was expelled from this Federation.

[2] Single staple food refers to the single (one) food that is eaten regularly as a source of diet and a bulk supply of energy and nutrient requirements.

[3] Political environment involves the political system that is adopted by a country, the provisions of the constitution, the political party system, and the political events taking place in a country.

Malaysia political perspective, the government has formulated several policies involving subsidies and incentives, a target of 10-tonne productions per-hectare programme and paddy mini-estate. All of the above policies are tools to achieve multi-racial unity in Malaysia, which will be achieved if the government can reduce poverty and income gap between agricultural (paddy farmers) and non-agricultural sectors. Thus, through unity, Malaysia can create political stability and a stable government which promotes national development.

In addition, in 2009, this sector also provided employment opportunities to 316,000 Malaysian farmers (Norsida & Sami, 2009; Fahmi, Samah & Abdullah, 2013). There were about 116,000 full-time farmers who have made this sector as the main source of income. Meanwhile, there were more than 200,000 paddy farmers that have made this sector as the second source of income (Tengku & Ariffin, 1999; Norsida & Sami, 2009; Norsida, 2009; Terano, Zainalabidin & Golnaz, 2013a).

Apart from providing employment opportunities, this sector also becomes a source of income for farmers (Terano & Fujimoto, 2010). However, the total incomes earned by paddy farmers are relatively low, which has contributed to the high rate of rural poverty (Alavi, 2011). In 1980, the rural poverty rate was about 37.4 per cent. Approximately 73 per cent of the rural poverty is contributed by paddy farmers. Most of these farmers have an average monthly income of less than RM1,500 per month (National Economic Advisory Council [NEAC], 2009; Terano & Zainalabidin, 2012; Kamaruddin, Ali, & Saad 2013). However, in 2009, the rural poverty rate has decreased to 8.4 per cent. To some extent, this shows that there is an improvement in the rural poverty rate in Malaysia. Nevertheless, in 2009, the rural poverty rate (8.4 per cent) was still high compared to the urban poverty rate (1.7 per cent). A majority of the poor people in rural areas are associated to the paddy farming (Norsida & Sami, 2009). For MADA, the total poverty rate was recorded about 1.4 per cent out of the amount, which is 1 per cent under hard-core poor. If we assume that the poverty rate for all granary and non-granary areas[4] equals to 1.4 per cent, therefore, the total poverty rate in paddy sub-sector exceeds 11 per cent. As mentioned by Wodon (1999) and Cervantes-Godoy & Dewbre (2010), poverty has a positive relationship with a total production. Therefore, it is assumed that 11 per cent poverty will cause a large fall in production.

Among the identified factors that contribute to the high poverty rate is the age factor. On the average, the farmers' age that is involved in paddy farming is more than 60 years (Harriss, 2007; Alam, et al., 2010; Economic Transformation Programme [ETP], 2011). At this age, farmers are no longer effective to execute any physical works in paddy fields. This has contributed to the low level of productivity in the paddy sub-sector. Another factor that has contributed to higher poverty rate is the low level of education among paddy farmers (Buarque, Mohorčič Špolar & Zhang, 2006). Low education levels contributed to paddy farmers with the problems in obtaining lucrative income from the farming activities (Nhamo & Nhamo, 2006).

Several studies have shown that the economic situation has a direct relationship with a poverty rate (Mills & Ernesto, 1994; Wodon, 1999). This is because the economic growth will reduce poverty rates whereas the economic slowdown will lead to the

[4] Granary areas refer to major irrigation schemes (above 4,000 hectares) and are recognised by the government in the National Agriculture Policy as the main paddy-producing areas. There are eight granary areas in Malaysia, namely, Muda Agricultural Development Authority (MADA), Kembubu Agricultural Development Authority (KADA), IADA Kerian-Sungai Manik, IADA Barat Laut Selangor, IADA Penang, IADA Seberang Perak, IADA KETARA, and IADA Kemasik-Semerak. Meanwhile, non-granary areas refer to areas in minor irrigation schemes and areas outside irrigation schemes.

increase of farmers' poverty rates. This is true for the Malaysian case in which we cannot reduce poverty rates especially those of farmers' poverty when they were paired with economic slowdown in 1997 (United Nations Development Programme [UNDP], 2005)[5].

Various policies and programmes have been carried out by the government to ensure farmers get high returns from paddy-farming activities. These directly affect the farmers' income level and, perhaps, could drive them out of continuous poverty. However, the government has also needed to ensure that the prices paid by rice consumers are at the affordable level (Nik Fuad, 2005). Basically, all the government's paddy-and-rice policies are to make sure that Self Sufficiency Level (SSL) for rice increases and are enough to meet the local rice demand. Additionally, the important objective in every policy and programme is to increase farmers' productivity. This is because when farmers' productivity increases, their income would also increase. This will enable the country to achieve rice self-sufficiency rate (Nik Fuad, 2005).

Table 1.0
Productivity of Paddy Production for Selected Years (kg/hectare)

Areas/Years	2009	2010	2011	2012[p]	2013[e]
Granary	4646	4540	4773	4821	4717
Non-Granary	2687	2647	2817	2771	2714

Note: [p] Provisional
[e] Estimate

Source: Ministry of Agriculture and Agro-Based Industry [MOA], (2011a) and MOA (2013a)

However, in spite of many policies and programmes that have been formulated by the government, the productivity level still remains low. According to Table 1.0, the productivity of paddy can be grouped into granary and non-granary paddy areas. Paddy

[5] Malaysia faced Asia Financial Crisis in 1997.

productivity in the granary areas decreased from 4646 kg per hectare in 2009 to 4540 kg per hectare in 2010. Furthermore, the productivity of paddy in granary areas increased from 4773 kg per-hectare in 2011 to 4821 kg per-hectare in 2012. Meanwhile, the productivity was expected to grow at around 4717 kg per hectare in 2013.

On the other hand, the productivity in the non-granary areas decreased from 2687 to 2647 kg per-hectare from 2009 to 2010. The level of productivity in the non-granary areas experienced an increase of 6.4 percent in 2011 compared to 2010. These improvements increased the total production of 2817 kg per-hectare during 2011. The productivity level in 2012 was projected to be around 2771 kg per-hectare, while it was expected to continue to decline to 2714 kg per-hectare in 2013. This indicates that the productivity levels are still low although there were many policy policies assistance programmes that were provided by the government.

One of the factors that has contributed to the low productivity level is due to the farmers' age pattern. On the average, Malaysian paddy farmers relatively aged around 60 years old. Therefore, there are many obstacles that occur especially to the rate of technology and modern-technique absorption. Basically, the level of technology absorption is low among paddy farmers in Malaysia. Therefore, most Malaysian paddy farmers operate as traditional farmers with the assistance of old machines such as tractors and harvesting machines. These consequently lower down paddy yield received by farmers as well as its competitiveness. As a result, the circumstances may affect the farmers' income received, which causes them to live in endless poverty.

1.1 Problem Statement

In Malaysia, paddy is a strategic crop. It is also crucial in influencing the country's political, social, and economic landscapes (Mutert & Fairhurst, 2002; Suleiman, Abdullah, Shamsudin, & Mohamed, 2014). The growth of the Malaysian paddy sub-sector involves many stakeholders such as politicians that act as policy-makers, government agencies as government task force, and farmers as implementers of government policy. Since it involves many parties and a huge amount of the government's budget, hence, it becomes an important sub-sector for Malaysia (Fahmi, Samah, & Abdullah, 2013). Often it becomes a concerned subject for the government to make sure that the sub-sector has the capacity to fulfil a local rice demand. However, Malaysian paddy yield is still below the national paddy production target (Food and Agriculture Organization [FAO], 2002; Othman, 2008; Department of Agriculture [DOA], 2011; Faruq, Taha, & Prodhan, 2014).

In order to fulfil the local demand, the government has to make sure local paddy self-sufficiency level (SSL) is increased. The highest paddy SSL was achieved in 1970 at 95 per cent, meanwhile the lowest paddy SSL attained was 65 per cent in 1992 (Fatimah & Amna, 2009: Tobias et al., 2012). Recently in 2012 Malaysia paddy SSL was 73.5 per cent, this means that Malaysia depended approximately 30 per cent of rice from abroad (Hassim, Am-On, Sontichai, Nongnooch & Chariensak, 2013, Khidzir, Malek, Ismail, Juneng, & Chun, 2015). The dependency on rice import from abroad had given a negative impact to paddy SSL in Malaysia especially during food crisis.

If Malaysia continues to depend on rice imports, we may face with further shortages of rice supply. To overcome these problems, the government has to establish several policies to ensure that the paddy supply is adequate for Malaysia. Policies such as National Paddy and Rice Industrial Development and Agricultural National Key Economic Areas (NKEA) are among the initiated policies to increase the paddy self-sufficiency level (SSL)[6]. National Paddy and Rice Industrial Development was aimed to increasing SSL from 72.37 per cent in 2005 to 90.58 per cent in 2010 (MOA, 2011b; Economic Planning Unit [EPU], 2006). Meanwhile, the agricultural NKEA aimed national paddy production to achieve 85 per cent SSL in 2020. If we compare the targets, it presents a dissimilarity in paddy SSL objective. These problems do not pose any serious problems for Malaysia. The only difference is in the form of percentages. The most important thing is that the above paddies SSL between 85 to 100 per cent were relatively high. This clearly showed that the paddy sub-sector is important to Malaysia. In order to realise this aim, the government must ensure that all subsidy programs such as fertilizer, seeds and pesticides are effective in improving the productivity.

To increase the paddy production, farmers have to increase their productivity. This is because an increase in productivity level plays an important role to improve the country's paddy production (Schreyer & Pilat, 2001; Mohd Salim, 2010). However, to ensure an effective increase of paddy production efficiently, we need to identify the significant factors that affect the production. Through the production input information, we can measure the efficiency of each of the input used. When a significant input of the

[6] Paddy SSL refers to conditions that do not require any reliance from outside. There is no fixed standard can be used to indicate the appropriate level of SSL. It depends on the responded of economic developments from inside and outside of Malaysia. Therefore the government is making on SSL's evaluation from time to time.

paddy production is determined, the total factor productivity (TFP) measurement can then be carried out.

Total factor productivity (TFP) is also associated with labour and technological progress. Therefore it is important to measure the elasticity of substation between labour input and technological progress. Estimate of the elasticity of substitution in paddy production is useful because it can determine whether the production is labour-intensive or capital-intensive. In addition, paddy production also involved various age of farmers. Therefore it is also important to determine the elasticity of substitution between young and old farmers. This finding is particularly important to improve the productivity of farmers. Through increased productivity of farmers, it will also indirectly increase TFP paddy sub-sector.

It can be concluded here that productivity plays an important role to improve the country's paddy production (Mohd Salim, 2010). Hence the productivity must be measured to determine whether paddy production had reached the high level of productivity or vice versa. There are different ways to measure productivity. It depends on the type of information related to the productivity itself. According to Schreyer & Pilat (2001) and Grimes et al., (2012), the systematic way to measuring TFP is by using production function approach. For that reason, this research intends to investigate the factors that determine the paddy production in Malaysia. Subsequently, these factors may be used to measure the TFP of the paddy production in Malaysia. Furthermore, this study may also measure the elasticity of substitution between labour and capital. In addition, this study also keen to investigate the elasticity of substitution between young and older farmers. It is hoped that the finding of the study would provide an appropriate input and policy suggestions to increase the productivity of paddy sub-sector in Malaysia.

1.2 Specific Research Questions

The specific questions that are addressed are as follow:

1. What are the important inputs that influence the paddy production of Malaysia?
2. What is the percentage of total factor productivity (TFP)?
3. How does capital input substitute for labour? Specifically what is the elasticity of substitution of capital input to labour input?
4. What is the elasticity of substitution between young and older farmers?

1.3 General Research Objective

Given the problem statement above in section 1.1, this research plans to meet all the above objectives. The first objective is to investigate the factor that determines the paddy production in Malaysia. This study utilised the Cobb-Douglas production function. Besides, the values of coefficient of determination and standard error were used to identify the significant regressors.

The second objective of this study is to investigate the total factor productivity (TFP) growth in the Malaysian paddy sub-sector. The most common function used in estimating TFP is the Cobb-Douglas production function. Given data on labour and capital inputs as well as their respective value share, it is possible to calculate the TFP as the residual between the growth of the output or added value and the respective growth.

The third objective is to look into the elasticity of substitution between labour and capital, and between young and old farmers in the paddy production. This is because calculating the elasticity of substitution in paddy production is useful since it has its implications on the relative use of labour and capital in production. Meanwhile, the fourth objective is to look into the elasticity of substitution between young and old farmers in the paddy production.

1.4 Specific Research Objective

Specifically, this study intends to answer the following objectives:

1.1.1. To determine the variables that influence the sub-sector paddy production in Muda Agricultural Development Authority (MADA) regions.

1.1.2. To investigate the Total Factor Productivity (TFP) growth in paddy sub-sector in MADA region.

1.1.3. To examine the elasticity of substitution between capital and labour in MADA region.

1.1.4. To examine the elasticity of substitution between young farmers and old farmers in MADA region.

1.5 Significance of the Research

This study may be useful for the future policy-makers and the farmers. The impact of this study is in the form of top micro and macro planning. To enlighten further, macro planning involves inter-government agencies as the policy-makers to formulate the policies. Meanwhile, the micro planning involves the mobilisation of farmers at the production level. The government has to implement these polices in the form of specific actions at the farm level where the actual production takes place. Farmers may obtain an indirect effect through a set of policies that the government may introduce. A list of significant effects to both policy-makers and farmers can be represented by the following argument:

1.5.1 Identify the effective factors of paddy production

Through this research, farmers and government agencies such as Agricultural Department will be able to identify the key factors that influence paddy production. All this while, many inputs such as fertilisers, seeds, machines, pesticides, and irrigation cost were all subsidised by the government. For example, the Malaysian Government has been funding 100 per cent of the cost of fertilisers to farmers through subsidies. Therefore, government needs to know how effective the fertiliser input in increasing the paddy production. By knowing this, the government can maximise every Ringgit that they spent.

1.5.2 Identify the paddy farmers' productivity level

Through the empirical study, researcher can examine the farmers' productivity level. This is because the productivity level may affect the total output produced as the higher productivity level would lead to the higher total paddy production.

1.6 Scope of Study

This study may employ main season and off season time series data from 1996 to 2011. This study may only focus on the MADA granary area as shown in Figure 1.0.

According to the *Malaysian* Meteorological Department (MetMalaysia), the soil and climate of MADA production areas are suitable for paddy crops. Specifically, this research may focus on four major areas in MADA regions. MADA Region 1 is located in Perlis, meanwhile MADA Region 2 is located in Jitra. MADA Region 3 is located in Alor Star and MADA Region 4 is located in Yan. This study may employ the data from main season and off season that were published by MADA.

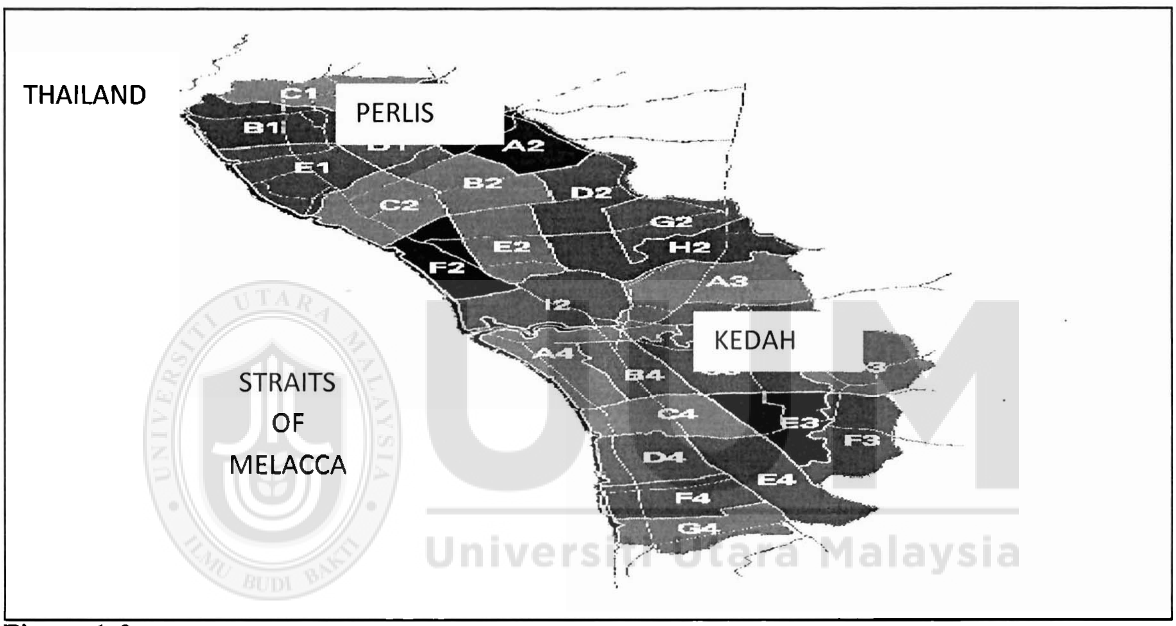

Figure 1.0
MADA Paddy-Growing Areas
Notes:

MADA Region 1	MADA Region 2	MADA Region 3	MADA Region 4
A1 – Arau	A2 – Kodiang	A3 – Hutan Kampung	A4 – Batas Paip
B1 – Kayang	B2 – Sanglang	B3 – Alor Senibong	B4 – Pengkalan Kundor
C1 – Kangar	C2 – Kerpan	C3 – Tajar	C4 – Simpang Empat Kangkong
D1 –Tambun Tulang	D2 – Tunjang	D3 – Titi Hj. Idris	D4 – Permatang Buluh
E1 – Simpang Empat	E2 – Kubang Sepat	E3 – Kobah	E4 – Bukit Besar
	F2 – Jerlun	F3 – Pendang	F4 – Sungai Limau Dalam
	G2 – Jitra		G4 – Guar Chempedak
	H2 – Kepala Batas		
	I2 – Kuala Sungai		

Source: MADA, 2009.

1.7 Operational Definitions

This section provides the definition of the terms that apply for the purpose of this study.

1.7.1 Paddy sub-sector

Paddy sub-sector refers to the paddy industry of Malaysia as a whole. This sub-sector is a major contributor to the country's rice self-sufficiency level (SSL). The production of the paddy sub-sector has been contributed by granary and non-granary areas. The total paddy farmers from those granary and non-granary areas are approximately 300,000 farmers.

1.7.2 Farmer

In this study, farmers refer to small-holder farmers. On the average, they work on the size of 1 to 2 hectares of paddy land. The average production is around 3000 kilograms per hectare (DOA, 2008 & 2012; Cervantes-Godoy & Dewbre, 2010; Chand, Prasanan & Singh, 2011). The farm is cultivated by family members by using small machineries. Meanwhile, basic facilities and marketing are provided by the government. These farmers receive 100 per cent fertiliser subsidy. Not only that, they also enjoy the paddy price subsidy from the government.

1.7.3 Total Factor Productivity (TFP)

Basically, the productivity concept refers to the ratio between outputs to inputs. In a single input production model, this output to input ratio is called a partial productivity. In a single input, the productivity measurement will not cause any problems. However, problems will occur if there are various combinations of input that are used in the production. One of the problems is how the weight of each input should be employed in measuring the productivity. To overcome this problem, Total Factor Productivity (TFP) was introduced, which is the change in output due to the change in production technology or by the factors other than labour and capital. In other view, TFP is determined by how efficiently and intensely the inputs are utilised.

1.7.4 Main Season

Main season is a period whereby paddy planting is very suitable. In this season, there is enough rainfall for paddy to grow. Meanwhile, planting activities also do not depend totally on an irrigation system. The season typically starts from 1st August and ends at 28th /29th February of the following year.

1.7.5 Off Season

The off season is a period in which paddy production starts, namely from March to July in the same year. In this season, the total of rainfall is less. Therefore, the irrigation system is needed to irrigate the paddy-growing areas.

1.8 Organisation of Study

This study was organised into six chapters. Chapter 1 is an introduction. The main body of this chapter contains the research background, problem statement, research objectives, and scope of the study. This chapter also covers the operational definitions and the organisation of the study.

Meanwhile, Chapter 2 discusses briefly about the paddy sub-sector in Malaysia. The purpose of this chapter is to give some general ideas related to the paddy sub-sector in Malaysia. In the early discussion, the researcher discusses briefly about the economics of agriculture in Malaysia. In the meantime, the chapter also contains briefly some paddy sub-sector history. The chapter also includes a discussion on Malaysia paddy and rice policy and subsidisation policy. The researcher also discusses the importance of Malaysia climate and topography to paddy-growing. The chapter also brings the discussion about the paddy areas harvested, production, and yields. Finally, Chapter 2 discusses the framework of paddy production system in Malaysia.

Literature review is presented in Chapter 3. The first part of this chapter focuses on the developments in production function analysis. The researcher also discusses the developments of the agricultural production function and the paddy production function analysis. The chapter further focuses on the productivity and efficiency in agricultural production and some productivity issues in the Malaysian paddy sub-sector and paddy pricing in Malaysia. Based on the literature review, the researcher draws a research framework on the Malaysian paddy sub-sector, and the hypotheses.

In Chapter 4, the methodologies of the study are presented. The chapter starts its discussion with some basic concepts that are related to the production function. The chapter also discusses the research methodology. The last section of the chapter explains about data gathering and variable definitions.

The analysis is presented in Chapter 5. The main purpose of this chapter is to answer all the hypotheses that have been highlighted in Chapter 3. The first part of this chapter is related to the descriptive analysis and followed by the unit root test. The further analysis is related to the determinant variables that influence the paddy production by using the ARDL method. Furthermore, the chapter also includes the analysis that is related to the Total Factor Productivity (TFP), the elasticity of substitution between capital-labour and the elasticity of substitution between old and young farmers.

Finally, Chapter 6 includes the summary of findings. The chapter also discusses the researchers' contributions towards the body of knowledge. Besides, the researcher also lists down some implications and policy recommendations of the study. Moreover, the chapter also highlights some limitations of the study which are faced by researchers. The final part of this chapter is the suggestions for further research.

CHAPTER 2

OVERVIEW OF MALAYSIA PADDY SUB-SECTOR

2.0 Introduction

Chapter 1 emphasises on the introduction and some motivations to conduct this research. Meanwhile, Chapter 2 puts its emphasis on the Malaysian paddy sub-sector. The chapter begins with an introduction in Section 2.0. Second section (2.1) contains a general review on the role of agricultural industry in the Malaysia's economy. This section discusses five roles of agricultural sector in the Malaysia's economy. Agriculture is the backbone of the national economic development, food supply, job opportunities, and poverty eradication. It provides the raw material for agro-based industry. Consequently, in Section 2.2, the researcher discusses about the history of the paddy sub-sector. The section discusses the history of paddy cultivation before and after independence. Section 2.3 is about Malaysia's paddy-and-rice polices and incentives. A few major policies are discussed in this section, such as production, subsidy and incentive, investment, price, and development polices. A detailed account of the climate and topography are presented in Section 2.4. In section 2.5, the researcher discusses about the paddy statistics such as areas of harvested production and yield. In this section, the researcher equips a discussion with some statistics on harvested paddy areas, production, and yields from selected years. Meanwhile, Section 2.6 is related to food security and rice self-sufficiency level (SSL).

2.1 The Role of Agriculture Sector in Malaysia's Economy

Generally, Malaysia has undergone several transformations since the pre-colonial era to the new millennium (Siwar & Surtahman, 2003). Although Malaysia aims to become a developed nation by 2020, the agricultural sector remains one of the main engines of the economic growth. The sector becomes the third engine of the economic growth for Malaysia. In addition, the sector also plays an important role in social and economic development of Malaysia. Although the contribution of the agricultural sector is declining, it is still a significant contributor to the economic growth of Malaysia (Murad, Nik Hashim & Siwar, 2008). Below are some discussions on the role of agricultural sector in Malaysia:

2.1.1 Backbone of the economy

The agricultural sector has been the backbone of the economy since before independence. In the initial stage, the plantation of food crops such as paddy, vegetables, fruits, and fish-rearing activities were to provide foods to the local communities demand. In the early stages, the agricultural growth is based on the subsistence and traditional activities. The development of international trade and the conquest by British has increased the contribution of the agricultural sector to the economic growth. For example, in early 20^{th} century, the demand for rubber increased due to the increase in demand from the United States and Britain. As a result, the British were encouraging the companies from Britain to open new rubber plantations such as Dunlop and Guthrie. Hence, rubber has become the main agricultural commodity for Malaya (Ahmad & Suntharalingam, 2009).

In 1957, the contribution of the agricultural sector to the gross domestic product (GDP) was about 39.3 per cent and the contribution continued to increase each year. This in turn has made the sector as a foundation to the economic growth. After 1970s, the agricultural contribution declined due to the diversification of the economic sector. Manufacturing and services sectors have then become dominant in Malaysia's economic growth. Although the contribution of the agricultural sector has declined, the sector still becomes the third engine for the economic growth in Malaysia since 2006 (Wong, 2007).

Table 2.0
Gross Domestic Product (GDP) by Economic Sectors Activity in Malaysia (%).

Industry	**Year**									
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015[f]**
Agriculture, Forestry and Fishing	18.7	13.6	8.7	8.2	7.8	7.7	7.3	7.1	7.0	6.6
Mining and Quarrying	5.7	7.4	6.6	6.6	5.9	8.8	8.5	8.1	8	7.7
Manufacturing	27.0	33.1	33.4	31.4	3.9	25.1	25	25	24.6	24.5
Construction	3.5	4.4	3.3	2.7	2.4	3.0	3.3	3.8	3.9	4.1
Services	42.3	44.1	52.6	58.1	59.2	54.2	54.5	55	55.3	55.6

Note: [f] forecast
Source: Ministry of Finance [MOF] (1980, 1985, 1990, 1995, 2000, 2013)
Economic Planning Unit [EPU] (2006, 2010, 2015)

Based on Table 2.0, the contributions of the agricultural sector to GDP showed a decline trend from 18.7 per cent in 1990 to 7.7 per cent in 2011 and 7.3 per cent in 2012. In 2015, the agricultural sector was projected to contribute around 6.6 per cent to GDP. Meanwhile, the services sector recorded a robust performance which contributing 42.3

per cent to GDP in 1999 and 54.5 per cent in 2012. The sector is expected to continue to be a major contributor to GDP in 2015 about 55.6 percent.

2.1.2 Food Supply

Malaysia is a net food-importing country. Most of the major food items for Malaysians are imported from abroad such as Thailand, Vietnam, Indonesia, and India. This is because the cost of local food production is not competitive. Due to the reliance on imported food, Malaysia is experiencing near foods shortages in many products such as rice, live-stocks, dairy, vegetables, and fruits.

Responding to this problem, the government has taken several steps to streamline the agricultural sector, hence, introduced three agricultural policies. The First National Agricultural Policy (1984-1991) was introduced in 1984 with the emphasis to develop an export-oriented agricultural sector. Meanwhile, the Second National Agricultural Policy (1992-1997) emphasised on the increase of productivity, efficiency, and competitiveness. The Third National Agricultural Policy (1998-2010) was then presented to improve the competitiveness of the agricultural sector following the liberalisation of international trade. These policies have resulted in an increase in food production. Farmers also became more skillful and implemented good agricultural practices (Indrani, 2001; Hassim et al., 2013). Therefore, the local production of the major food commodities increased. These might lead to increasing domestic food supply.

2.1.3 Job Opportunities

In the beginning of independence until early 1970s, agriculture became the main contributor to employment opportunities for Malaysians (Indrani, 2001; Azmariana, Jeffrey, Bahaman, Norsida & Hayrol, 2013). Over time, Malaysia's economic structure has changed. The structural changes include the introduction of industrial and services sectors. This situation has resulted in the decline of the contribution of the agricultural sector to employment. However, the sector has continued to be important, mainly as a source of employment, especially for the rural population. In addition, the sector has also contributed to forex saving and sources of national investment (Kutty & Nekooei, 2013).

Table 2.1
Employment by Economic Sector in Malaysia (%).

Industry	**Year**										
	1980	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014[1]**
Agriculture, Forestry, and Fishing	37.2	31.3	27.8	18	15.2	12.9	11.1	11.3	12.6	12.7	12.4
Mining and Quarrying	1.3	0.8	0.6	0.5	0.4	0.4	0.4	0.3	0.7	0.7	0.6
Manufacturing	15.5	15.2	19.5	25.9	27.6	29.5	30	28.7	17.4	16.8	16.4
Construction	5.6	7.6	6.4	8.3	8.1	8.1	6.4	6.3	9.1	9.4	9.1
Services	39.5	45.1	45.7	49.3	48.2	50.0	52.2	53.4	53.5	59.2	60.5

Notes: [1] January to June 2014
Source: MOF (1985, 1990, 1995, 2000, 2013)
EPU (2001)

Based on Table 2.1, the employment opportunities in the agricultural sector recorded a significant decrease from 37.2 per cent in 1980 to about 18 per cent in 1997. Meanwhile, in 2000, the employment opportunities were about 12.9 per cent. This figure gradually declined to 11.1 per cent in 2010. However, in 2012 the employment opportunities slightly increased by 1.3 per cent from 2011 and 12.6 per cent in 2012. In 2013, the agricultural sector was expected to provide additional 0.4 percent jobs opportunities compared to the previous year. The manufacturing sector showed an increase from 15.5 per cent in 1980 and 30 per cent in 2010. In 2014, job opportunities were expected to decline about 16.4 per cent. The declining in manufacturing sector is due to rapid development in services sector lately.

Table 2.2
Malaysia's Poverty Gap in Rural and Urban Area (%)

Year	Rural Poverty (%)	Urban Poverty (%)
2004	2.9	0.5
2007	1.6	0.4
2009	1.8	0.3
2012	0.6	0.1

Source: MOF, 2013
World Bank, 2011

2.1.4 Poverty Eradication

The number of Malaysian poor households still remains high particularly in the rural sectors. In general, poverty in rural areas is often associated with the agricultural sector. Based on the World Bank statistical report, the Malaysian rural poverty rate is much higher compared to the urban poverty (World Bank, 2011). Nevertheless, based on Table 2.2, it is clearly shown that the poverty rate in rural areas is relatively high compared to the urban poverty rate. However, the rural poverty rate has decreased over the last few years. This has been attributed to a variety of policies and the provision of infrastructures by the government. This is because there are projects and programmes of agricultural development which have offered employment opportunities for the rural people. This has directly raised the farmers' income and contributed to poverty reduction.

2.1.5 Source for Agro-Based Industry

Agricultural products are important inputs for agro-based industries in Malaysia. For instance, Malaysia has numerous agricultural resources such as rubber, palm oil, timber, and cocoa to support certain industries. All these materials can be used as the inputs in the agro-based industries which have been identified as a potential sector to develop under the Third Industrial Master Plan (IMP3). Through the agro-based industry development, the linkages between agricultural and manufacturing sectors can be strengthened. As recorded by the Ministry of Agriculture and Agro-Based Industry in 2006, there were about 3,445 agro-based entrepreneurs in Malaysia. In 2007, a total of 4,500 agro-based entrepreneurs were created (MOA, 2008). Hence, from the above facts, it clearly indicates that the agricultural sector can generate many entrepreneurs and has so much potential to be developed.

2.2 Paddy Sub-Sector Brief History

Paddy has been cultivated in Malaysia for a few centuries. This agricultural sector is synonymous with the rural Malay community as they have become among the early paddy farmers in Malaysia. Paddy farming has been characterised by the traditional nature of its economic activities. Basically, the term 'traditional' in paddy production refers to labour's cost which representing about 79% of the total cost of production per hectare (Najim, Lee, Haque & Esham, 2007). Since this section emphasises the history of paddy cultivation in brief, for the purpose of the discussion, the section is divided into two phases; before and after independence.

2.2.1 Before Independence

Usually, it is hard to get a precise fact about paddy cultivation in Malaysia. However, scholars believed that paddy cultivation probably begun in 10^{th} century in the Muda and Merbok Rivers in Kedah and the lower valley of Kelantan as well as

Terengganu rivers. Paddy cultivation in the three states, for instance, Kedah, Kelantan, and Terengganu, were influenced by the culture of Thailand (Mohd Kasri, 2011). This is because paddy crop has been brought into Malaya by the Thai people. Besides, paddy cultivation in Malaysia was also influenced by the Minangkabau migrants from Sumatra, Indonesia. The Minangkabau people have introduced paddy cultivation in the valleys of the inlands of Malacca and Negeri Sembilan. In 15th century, paddy cultivation was practised on a small scale in the coastal Malacca. However, it was restricted in the areas under the Portuguese and Dutch administrations. Meanwhile, in the 17th century, Minang people introduced paddy cultivation in the western area of Pahang and several parts of Peninsula Malaysia.

Comparatively, Kedah was the largest paddy producer in Malaya. According to Amanjit (1991); Mohd Isa, (2001); Badriyah & Tan (2006); Mohd Kasturi (2011), Kedah was able to supply rice to Penang and other neighbouring states. Basically, Kedah was able to export 2,000 koyan or 4,838 metric tonnes of rice to Penang per annum. However, in 1820s, these exports fell to 100 koyan or 241.9 metric tonnes of paddy. During 1820s, Kedah was in war with Siam (Thailand). This war has resulted in huge damage in paddy production areas and these, in turn, might have caused the decrease of paddy production yield (Noriah et al., 2006; Jabil, Noriah & Ahmad, 2010).

In 1837, Abdullah bin Abdul Kadir Munsyi stated in his book "Kisah Pelayaran Abdullah" that the yield of paddy cultivation in Kelantan was for domestic use and export to Singapore. According to him, other states such as Perak and Terengganu have also become the paddy and rice exporters. Until 1889, Kedah became the largest paddy producer in Malaya. This was proven through the notes written by Frank Swettenham during his visit in Kedah in 1889. He has stated that the paddy fields in Kedah were broader than other states in the peninsula.

British officially invaded Malaya in 19^{th} century by dominating several states, for instance, Malacca, Penang and Singapore. These states later became Straits Settlements. During the British colonial era, they introduced the concept of divide and rule. According to the division by the British government, Malay community geographically lived in rural areas and got involved in agricultural activities including paddy farming. This led to the situation where the Malays dominated paddy planting. The activity was also often associated with poverty. This was the effect of the decision which has been made by the British government that was not interested in increasing the domestic paddy production. According to them, the current production was sufficient to meet domestic needs in Malaya.

However, Malayan population at that time has increased due to the increase of the domestic population. The influx of immigrants from China and India has caused the increase of Malayan population, consequently, led the increase of rice demand. Therefore, in 1933, the British government has set up the Rice Commission that functioned as a regulatory body for Malayan rice. The Rice Commission has recommended that the government needed to import rice mainly from Thailand to meet the rice demand.

Ironically, they found that the cost of imported rice was lesser compared to that of local rice production. This has led the British government to focus more on the development of the infrastructures for rubber plantations and tin-mining. This is because these two sectors could contribute much more to the total income on their investments especially to the investors from the United Kingdom.

However, during the Second World War (WW II) and the World Great Depression in 1933, the cost of the imported rice has increased. To tackle this problem, the British government has finally taken a drastic step to improve the paddy production via productivity. Many strategies were undertaken such as economic incentives, regulation of land use, and improved facilities for paddy cultivation. Meanwhile, the British government has also set self-sufficiency as the main agenda in its agricultural policy development. To some extent, this was a reaction towards the food security issues during the war and post-war periods. The British government has become more concerned about the welfare of the paddy farmers in Malaya. This was very different from the previous government policy that was more concerned about the British investor's interest.

2.2.2 After Independence

After independence in 1957, the Malayan government became more serious in developing the paddy sub-sector in Malaya. This was because paddy is the main food crop of the population. Furthermore, it has had a significant impact on the values and the cultures of the local communities, especially that of Malays. Besides, it also became a major contributor to the source of staple food in Malaya (Department of Statistics [DOS], 2010). On top of that, there were also various policies and programmes which have been designed to assist the development of this sector, which was the assurance that productivity and paddy yield would be increased.

Through the Ministry of Agriculture (MOA), the Integrated Agricultural Development Projects (IADP) was introduced in granary areas. The aim of IADP is to increase the productivity and maximise the farmers' income (Nor Diana, Siwar, Talib & Berma, 2012). There are at least eight granary areas that were developed in Malaysia from 1965 to 1992 (Alam, Siwar, Wahid & Mohd Ekhwan, 2011). In 1965, the first IADP project was developed in Kedah, which was known as Muda Agricultural Development Authority (MADA). The success of the above projects has led to the creation of other IADP projects nationwide. In 1967, the government established IADP Kemubu Agricultural Development Authority (KADA), followed by IADP Kerian-Sungai Manik (1979), IADP Northeast Selangor (1979), IADP Seberang Perak (1981), IADP Kemasik-Semerak (1982), IADP Penang IADP (1983), and IADP North Terengganu Agricultural Development Project (1992). However, Malaysia still imports roughly 30 per cent the rice supply from outside for the domestic consumption (Ibrahim, 2010).

2.3 Malaysia Paddy and Rice Policies

Recognising the importance of paddy crop, the government of Malaysia has considered it as a "strategic item", which means that paddy has become one of the important instruments to sustain national and political stability. Nevertheless, this sub-sector also had its own opponent such as commercial development. The development of a commercial district in a paddy cultivation neighbourhood, for instance, has reduced the size of paddy land.

The constraint of paddy land that is used in Malaysia just allows paddy production to meet only 70 per cent of the national rice needs. Aware of this fact, the governments has sought to encourage increased national paddy production from existing acreages. Therefore, there are many incentives and assistance programmes that have been initiated by the government (Snodgrass, 1980). These government incentives and assistance programmes can be divided into several parts, namely subsidy, incentive policies, investment policies, and price-and-production policies. Table 2.3 shows the summary of the paddy policies that were implemented in Malaysia.

Table 2.3
A Summary of Paddy Policies in Malaysia

Policy Instrument	Year	Objective of the Intervention
Production Policy	1949	to increase paddy production
Subsidy and Incentive		
Paddy Fertiliser Scheme	1952	to encouraged farmers to use fertilisers in the earlier years to reduce cost of production and increase their income
Paddy Price Subsidy Scheme	1980	Income-support programme
Paddy Production and Revenue Incentive	2009	To stimulate paddy yield (assistance programme).
Certified Paddy Seeds Incentive	2009	to encourage use of quality and durable seeds to increase yield.
Investment		
Irrigation and Infrastructure	1970	To realise double cropping, increase income and production.
Credit facilities	1969	To finance double cropping of paddy and purchase of input.
Price		
Guaranteed minimum price (GMP)	1949	Income support programme by supporting paddy price.
Development		
10-Tone Programme	2002	to increase production to 10 metric tonnes and paddy SSL.
Paddy mini estate	2007	Good agricultural practice

		Increase Production and Paddy SSL.

Sources: Tan (1987); World Bank (1988); Tobias, Molina, Valera, Mottaleb & Mohanty (2012), Rosnani (2015).

2.3.1 Production Policy

Paddy production policy in Malaysia has consistently been guided by three main objectives namely food security, equitable distribution of income, and price stability. The level of food security has varied over time. From 1900 to 1903, the level of food security in Malaysia was very low. However, Malaysia did not face any shortage of food supply in the 1900s. Later, in the 1930s to 1940s, food security was at a medium level. In this period, the first world economic recession occurred, which was followed by World War II. The most significant implication of the economic recession and war was the decrease of food security level.

During World War II, Japan occupied Malaya. As a result of this occupation, Malaya had to face severe economic pressures. Japan has also implemented the monopoly of economic policies that caused suffering to the Malayan people. Mining and business were both dominated by Japannese and this led the Chinese and European people to lose their rights for business. Not only that, Japan also controlled the main agricultural comodities such as palm oil, coconut, rubber, and rice. This has impeded the growth of the agricultural sector in Malaya. The situation became worse when Japan has implemented the closed-door policy to the external parties. This caused the non-occurrence of international trade between Malaya and the outside world. The absence of trade relations with foreign powers has caused Malaya to have faced two major problems; food shortage and loss of foreign exchange.

To overcome the problem of food shortage, Japan has focused on the agro-food sector activities where local residents were encouraged to engage in subsistence farming such as planting vegetables, fruits, and cassava. However, the efforts that were made by Japan to recover the economy of Malaya were paralysed due to the lack of response from local society. Alternatively, Japan implemented the price controls in 1942. In April 1943, Japan has embarked on the purchase of rice rations where each family was only allocated seven kilograms of rice for every month. As a result, local residents had to turn to other foods such as cassava, sweet potatoes, and yams. Food shortage has led to price increase and created the inflation problem.

After World War II up to the new millennium, Malaysia's target level of food security is high. The food security is to ensure that all the residents obtain sufficient food supply for their daily use. The issue of food security is also closely related to the amount of the increase of the population in Malaysia. In the millennium era, the issue of food security has been closely related to the increasing food price. This was felt when the price of food, especially rice, increased dramatically in 2008. Rising food prices can be seen from the increase in the Consumer Price Index (CPI). Malaysia's CPI for food increased from 100 in 2005 to 124.1 in 2010. Besides, the uncertainty of climate, the competition factors of production, and the increasing input prices were also the major challenges that contributed towards the uncertainty of the national food security.

A key strategy to ensure sufficient domestic supply of paddy and rice was the rice stockpile scheme which was introduced in 1949. The purpose of having the rice stockpile was to meet the emergency requirements. In the 10^{th} Malaysia Plan, Malaysia planned to build up rice stockpile to bolster the national food security, seeking to maintain an equivalent of 45 days of consumption (Bloomberg, 2011).

The serious efforts to increase the paddy production continued to be undertaken by the Malaysian government. Several programmes, targets, and projects were undertaken such as the 10-metric-ton project, paddy estate, and used valid seeds. The 10 metric-ton project was successful in Sungai Nipah under the Integrated Agricultural Development Northwest Selangor. From 889 farmers involved, half of them attained at least 10 tonnes in Season 1/2010 (MOA, 2011b).

2.3.2 Subsidy and Incentives Policies

The Malaysian government has adopted a series of subsidy policies. The purpose of the subsidy polices was basically to reduce the costs of production and boost up farmers' income through price supports. In addition, there were also subsidies that were given to reduce consumers' price burden. There were a few instruments that were implemented under the subsidy policy including the fertiliser scheme, paddy-price subsidy scheme, paddy production and revenue incentive and valid paddy seeds incentive. A summary of a major paddy subsidy and incentive allocation are shown in Table 2.4.

The fertiliser subsidy was introduced in the early 1950s. In the early stages, the government stopped the fertiliser subsidies when the price of fertiliser decreased. Nonetheless, in 1979, the government had to resume the policy when the price of fertiliser increased and, to date, the fertiliser becomes 100 per cent subsidised and it was only given to the operators. From Table 2.5, the average fertiliser allocation for every year (2003-2007) were approximately RM222 millions.

Table 2.4
Subsidies and Incentive in Paddy Production and Rice Industry (RM Million)

Subsidy Instruments	**Year**					
	2003	**2004**	**2005**	**2006**	**2007**	**2009**
Fertiliser Subsidy Scheme	142	187	178	376	226	275
Paddy-Price Subsidy Scheme	438	448	448	445	488	448
Transportation Incentive	-	-	-	-	43	-
Paddy Production Incentive	-	-	-	-	163	150
Paddy-Seed Price Incentive	-	-	-	-	29	-

Sources: EPU (2006); Vengedasalam et al., (2011)

Meanwhile, paddy-price subsidy scheme was introduced in 1980. The purpose of this scheme is to increase the farmers' productivity and income (Tan, 1987; Tengku & Ariffin, 1999). The scheme was stemmed from the realisation that the paddy-farming sector has recorded the highest poverty incidence in Malaysia. On the average, the paddy-price subsidy increased over the years except in 2006. However, the allocation gap between 2005 and 2006 were only in minor difference about 0.6 per cent. The paddy-price subsidy becomes the major instrument to boost the farmers' income.

Since 2007 to 2013, the government has granted new subsidies and incentives such as a paddy-transportation incentive, production incentive, paddy-farmer incentive, paddy-seed price incentive, subsidy on paddy price, subsidy on paddy fertilisers, incentives to increase paddy yield, and subsidies on price of rice. These subsidies and incentives amounted to RM235 millions from the Federal Government Budget in 2007. Meanwhile, in 2013, all the subsidies and incentives that were allocated by the Federal Budget amounted to RM 2.4 billion (MOF, 2013).

2.3.3 Investment Policy

Basically, the investment policies were related to development of the infrastructure and facilities in the agricultural areas. Good infrastructures and facilities such as irrigation and drainage systems are essential to ensure high paddy yield. The Malaysia's irrigation development can be traced back to the end of the 18th century. The first and largest irrigation scheme was developed in Perak under British Government, known as Kerian Irrigation Scheme in 1892 (Toriman & Mokhtar, 2012). In 1932, the government formed the Department of Irrigation and Drainage as the main planner to establish the irrigation scheme in Malaysia. Around 1970s, the development of the irrigation scheme got into this track and became the most important turning point for Malaysia's paddy-farming. Since that period, several irrigation schemes were built especially in paddy-planted areas such as the Northwest Selangor Project (NWSP) in Selangor; Muda Irrigation Project (MADA) in Kedah; Kemubu Irrigation Project (KADA) in Kelantan; Kerian Irrigation Project (KEIP), Sungai Manik Irrigation Project (SMIP) and Trans-Perak Irrigation Project, all in Perak; Besut Irrigation Project (BIP) in Trengganu; and Seberang Prai Irrigation Project (SPP) in Pulau Pinang.

The purpose of the irrigation schemes was to increase the local paddy production (Abdullah, 2002). Besides, the aim of building the irrigation systems was to achieve double cropping and expand the areas of paddy cultivation (Toriman & Mokhtar, 2012). This is because the government was aware that the double cropping may result in a remarkable increase in the paddy production and income of the farmers. In 1970s, double cropping was implemented in Malaysia's paddy farming. The result was that the paddy production increased and rice imports declined from 423,000 metric tonnes in 1960 to

196,000 metric tonnes in 1986 (Faridah & Sulaiman, 1995).

Under the 1^{th} and 10^{th} Malaysia Plans, an irrigation scheme in paddy-growing areas was raised. Starting from 7^{th} irrigation scheme in 1970s, Malaysia has developed 952 irrigation schemes that covered the peninsula, Sabah, and Sarawak (Malaysia, 2006). From the total schemes, the irrigated areas covered 290,000 hectares in Peninsula Malaysia, 17,000 hectares in Sabah, and 15,000 hectares in Sarawak. This development could indirectly ensure double-cropping systems to remain. Therefore, it could increase the farmers' productivity level and reduce the rice imports from outside.

2.4.3 Price Policy

In 1946, the full self-sufficiency policy was introduced. The main step in this direction was the implementation of the guaranteed minimum price (GMP). This was implemented in 1949. The GMP aimed to provide incentives and income support for the paddy farmers. GMP perhaps could increase the farmers' income and paddy self-sufficiency level. In 2005, self-sufficiency level (SSL) recorded 72.37 per cent and it increased to 90.58 per cent in 2010 (Taufik, 2007; EPU, 2006).

2.3.5 Development Policies

Under the development policies, the researcher may only concentrate and discuss two main policies, namely 10-metric-ton project and used certified seeds. General discussions are given below.

2.3.5.1 10-Metric-Ton Project

The government has implemented the 10-ton-production project for the entire granary areas. It was started in the first season of 2002. The aim of this project was to increase paddy yield to the level of 10 metric tonnes per hectare. This was the core project in the development of paddy in the 9th Malaysia Plan. In 2010, the government managed to successfully increase the cultivated areas to 201,200 hectares. In this programme, the government has introduced the mini-estate concept. Since 1987, the mini-estate idea has become popular in the Northern and Central Seberang Perai, Penang. A comprehensive effort was to make the mini estates as one of the instruments for increasing paddy production. It has been carried out by the government since 2005. Since then, the areas of mini estates have increased from 28,284 hectares in 2006 to 35,724 hectares in 2010 (MOA, 2013a).

2.3.5.2 Use of Certified Seeds

Certified seed was issued under the Rice-Seed Certification Scheme. It was operated by the Department of Agriculture. Currently, the varieties offered are MR211, MR219, MR220, and MR 232. Certified seed was completely enforced starting from the main season in 2009 (1/2009). The Department of Agriculture, the Federal Land Consolidation, and Rehabilitation Authority (FELCRA), the National Company Padi and Beras (BERNAS) and the District Farmers Association (PPK) Lahar Bubu were appointed to become the seed producers. Paddy-seed production increased from 26,082 metric tonnes in 2005 to 74,000 metric tonnes per hectares in Peninsula Malaysia in 2010 (MOA, 2013b).

To increase the paddy-farmers' productivity level, numerous inputs such as seeds and planting materials, labours, fertilisers, irrigation, crop protection, and others must be used efficiently. Hence, seed is considered as a key starting point in any agricultural productions (Wan Jusoh, 2006). In Malaysia, the assurance of quality seeds under Rice Seed Certification Scheme is guaranteed by the government. Seeds that were produced under this scheme are able to overcome the problems of grassy weeds and weedy rice. Besides, the seeds should also be resistant from disease such as stained leaves, tungro, and brown planthopper. Therefore, farmers should never compromise with the use of quality seeds to ensure the increase of their productivity.

2.4 Climate and Topography

Malaysia's land area is about 329,758 square kilometres consisting of the peninsula, Sabah, and Sarawak. Malaysia is located at the horizontal line 1^0 and 7^0 north and 100^0 and 199^0 west of the equator. The location of Malaysia is right in the area of humid tropical climate with heavy rainfall that averaging 3,000 mm annually, which is equivalent to 990 billion cubic meters of water and 2,200 hours or approximately 275 days of brightness. This is suitable for many species of plants to grow and fruit. A total of 360 billion cubic meters or 36 per cent of the rainfall may be lost via evapotranspiration in the atmosphere. In the meantime, the other 566 billion cubic meters or 57 per cent of the quantity of the water may stagnate at a surface of the earth. Meanwhile, the other 64 billion cubic meters or 7 per cent of the amount of the water may be recharged as groundwater. From 566 billion cubic meters of the surface runoff, there are 147 billion cubic meters that are found in Peninsula Malaysia, 113 billion cubic meters in Sabah, and

306 billion cubic meters in Sarawak (International Commission on Irrigation and Drainage [ICID], 2010).

The climate of Malaysia is divided into two monsoon regimes, namely southwest monsoon and northeast monsoon. Generally, the average daily temperature is from 21°C to 32°C. Furthermore, Malaysia has acidic soils with pH 4.0 to pH 4.5. The land is flat and the type of soils is alluvium, which is fertile as the soils contain adequate proportion of potash, lime and phosphoric, which are ideal for the growth of crops. In some areas, the type of soils is ferralsols (oxisol), which is not fertile because of its low nitrogen content. To increase the soil pH, liming by using Effective Calcium Carbonate (ECC) are needed. The climate and topography conditions in Malaysia are suitable for growing paddy.

There are two types of paddy planted, which are known as wetland paddy and upland paddy. Wetland paddy is the most commonly planted one because it is able to produce high yield. However, wetland paddy requires much water and fertiliser. Furthermore, it should be planted an orderly manner. Basically, the major wetland-paddy planting areas are located in the West Coast of Peninsula Malaysia, particularly in the northern areas. The flat, swampy areas, wet season with an average annual rainfall exceeding 3,000 mm and a lot of sunlight are among the significant factors that significantly contribute to the growth of wetland paddy in these areas.

Meanwhile, the upland paddy is planted in highland areas. It requires less water compared to the wetland paddy. The upland paddy yield is relatively lower and basically produces a poorer quality of paddy. This is due to the traditional method used by farmers with no machine involved. Meanwhile, the low yield is also attributed by the lack of fertiliser and low quality seed used. Another factor which contributes to the low paddy yield is the incorrect supervision by the farmers.

The upland paddy-growing areas are basically located in the rural areas of Sabah and Sarawak. Usually, the upland paddy is planted by the original communities such as Murut and Iban. The merit of the upland paddy is that it does not require an extensive amount of water yet can be planted in areas where water is not stagnant.

2.5 Areas of Harvested Production and Yields

Malaysia is a small paddy-grower in the world. Malaysia accounts 0.4% per cent of the total world's paddy production (Tengku & Ariffin, 1999). Although the contribution to the world's production is less than 0.5%, the cultivation of paddy has become strategic in Malaysia. Even though the national contribution is small, paddy is the third important crop in Malaysia after palm oil and rubber. The planting areas of paddy cover almost 6 to 10 per cent of the total agricultural planted areas in Malaysia (EPU, 2001 & 2006).

In Malaysia, paddy cultivation is mostly done on small holdings (Muhammad Alias, 1982). The average paddy fields size is from 1 to 2 hectares. Wet-land Paddy is the main paddy crop planted, which covers 86% of the acreage. The paddy is usually planted in the main and off season. The main season is the season that is traditionally regarded as the most suitable period for paddy-planting. In the main season, rainfall is adequate for the paddy to grow. Meanwhile, the irrigation systems function as a flood-storage plan. This season starts in August each year until February in the following year. Besides, the paddy is also planted during the dry season or off season. However, the paddy cultivation in that particular time framework quite depends on the irrigation system. In the meantime, the off season starts from March to July in the same year. Meanwhile, dry-land paddy is planted either in upland or lowland. The dry-land paddy does not need much water

Table 2.5
Hectarage of Planted Areas of Paddy by Season and State in Peninsular Malaysia, 2013

State	Main Season, 2012/2013 (Hectare)	Off Season, 2013 (Hectare)	Total (Hectare)
Johor	1,525	1,435	2,960
Kedah	104,205	106,122	210,327
Kelantan	40,746	15,534	56,280
Melaka	1,424	1,359	2,783
N. Sembilan	1,062	924	1,986
Pahang	5,955	4,402	10,357
Perak	41,030	40,606	81,636
Perlis	26,031	26,054	52,085
Penang	12,782	12,782	25,564
Selangor	18,899	18,934	37,833
Terengganu	11,387	7,892	19,279
Sabah	28,474	10,508	38,982
Sarawak	133,836	424	134,260
Malaysia	427,356	246,976	674,332

Source: DOA (2014)

Table 2.5 shows the hectarage of the planted areas of paddy by season and state in Peninsula Malaysia. In 2013, there are about 674,332 hectares of land that are planted with paddy. About 427,356 hectares or 62 per cent of the land are planted during the main season while 246,976 hectares or 38 per cent of paddy areas are were planted during the off season. The main paddy-growing areas are located in northwest and east coast of Peninsula Malaysia. The northwest areas consist of Selangor, Kedah, Perlis, and Perak. Meanwhile, the east coast paddy areas consist of Kelantan and Terengganu.

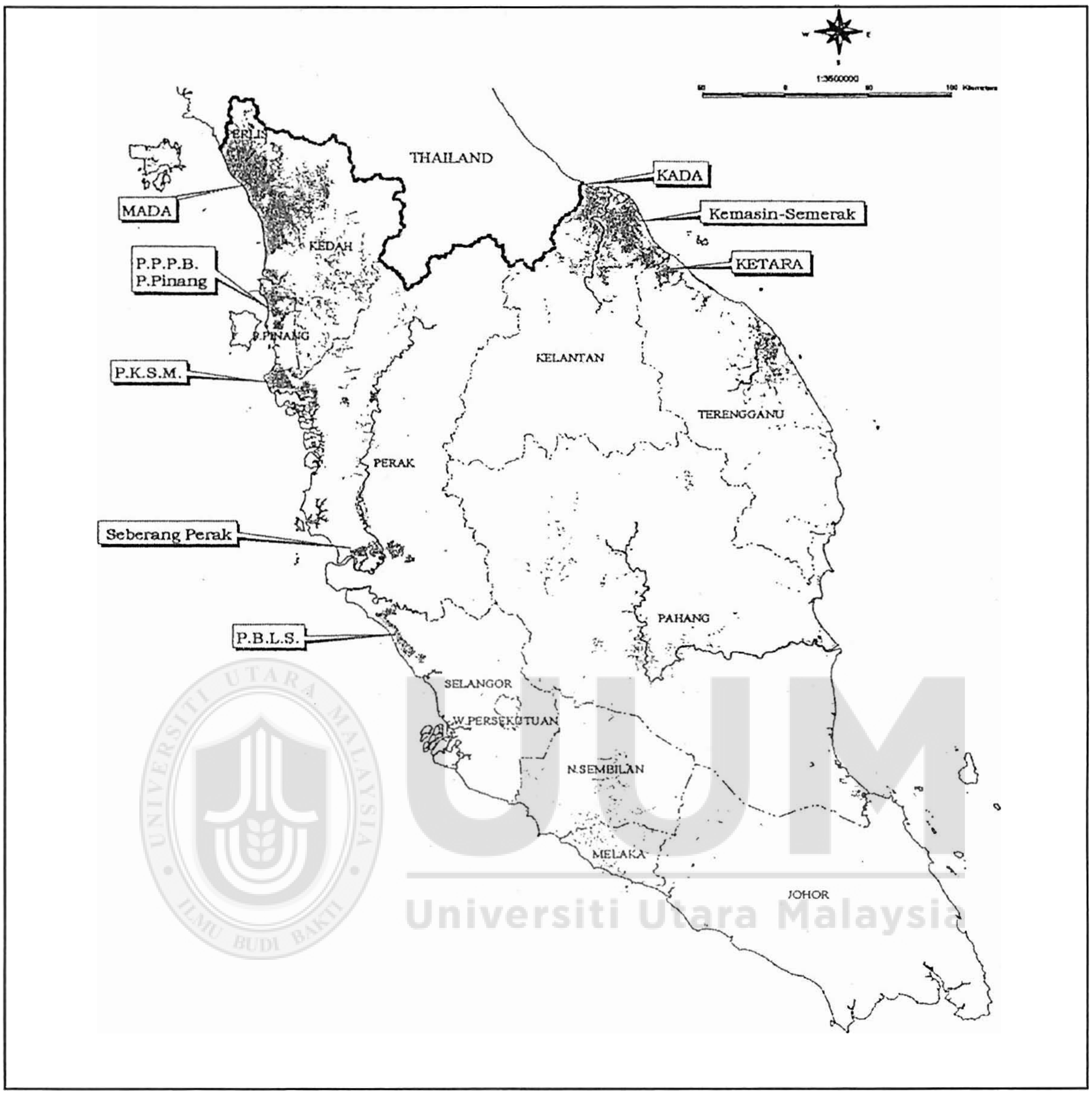

Figure 2.0
Paddy-Planted Areas in Peninsula Malaysia in 2013
Source: DOA (2014)

In Peninsula Malaysia, Kedah becomes the main paddy-growing state of the nation. The total paddy areas in Kedah are approximately 210,327 hectares in 2013. It is also known as "Malaysia's Rice Bowl". The second largest contributor is Perak with the total paddy areas about 81,636 hectares and Kelantan with 56,280 hectares of the paddy-growing areas respectively. Meanwhile, Sarawak becomes the largest dry-land paddy-planted areas with roughly 134,260 hectares (MOA, 2014).

Meanwhile, Figure 2.0 shows the paddy areas of Peninsula Malaysia in 2013. Almost all the states of Peninsula Malaysia have paddy cultivation. However, the size of cultivation areas differs by state. Kedah, Selangor, Perak, Kelantan, Penang, and Terengganu are among the largest paddy-producing states.

Table 2.6 shows the time-series data on paddy-planted areas in Malaysia. Based on the general observation, the difference in the size of paddy-planted areas in Malaysia is almost constant. The size of the planted areas increases or decreases between 0 to 3 per cent (MOA, 2008).

Table 2.6
Malaysia's Total Areas of Paddy-Planting from 1993 to 2013 ('000 Hectares)

Years	Main Season	Off Season 2005	Dry-land Paddy	Total
1993	360.2	233.6	99.6	693.4
1994	362.6	244.0	92.0	698.6
1995	352.8	239.0	80.9	672.7
1996	359.9	241.2	84.3	685.4
1997	357.6	251.0	82.4	691.0
1998	350.2	240.7	83.5	674.4
1999	360.8	248.1	83.5	692.4
2000	357.2	257.6	83.9	698.7
2001	342.7	253.6	77.3	673.6
2002	348.0	255.3	75.2	678.5
2003	347.3	249.7	74.8	671.8
2004	344.7	251.7	70.9	667.3
2005	346.2	249.6	70.9	666.7
2006	350.4	256.6	69.0	676.0
2007	345.6	260.3	70.2	676.1
2008	338.9	256.9	60.6	656.4
2009	345.9	262.5	66.4	674.8
2010	347.9	261.0	68.9	677.8
2011	350.3	266.6	70.9	687.8
2012	359.4	254.3	70.7	684.4

2013	359.8	246.9	67.4	674.1

Source: DOA (2008, 2012, 2014)

For nearly 17 years, the average total of paddy yield in Malaysia is around 3,000 kilograms per hectare (Table 2.7). The total yield for both main and off seasons is consistent, around 3,000 kilograms per hectare. Based on Table 2.8, the average yield of the upland paddy is less than a 100 kilogram per hectare. However, the upland paddy production is uncertain. In 1960s to 1980s, the up-land paddy recorded a decline in annual production. However, after 1999, the upland paddy production has increased. This increment, to a certain extent, was attributed by the higher production from Sabah and Sarawak.

Table 2.7
Malaysia: Average Paddy Production per Hectare 1986 to 2013 (kg / ha)

Years	Main Season	Off Season, 2005	Dry-land Paddy
1986	2,950	3,030	770
1987	2,940	2,490	720
1988	2,880	2,730	750
1989	2,870	3,050	720
1990	3,000	3,210	750
1991	3,110	3,250	740
1992	3,430	3,190	840
1993	3,380	3,380	970
1994	3,350	3,440	930
1995	3,420	3,560	880
1996	3,510	3,730	770
1997	3,340	3,450	730
1998	3,190	3,240	550
1999	3,030	3,570	700
2000	3,180	3,650	770
2001	3,240	3,650	790
2002	3,420	3,710	780
2003	3,680	3,680	770
2004	3,570	3,680	720
2005	3,670	3,950	810
2006	3,190	3,950	820

2007	3,640	4,060	860
2008	3,690	4,100	790
2009	3,850	4,280	870
2010	3,870	4,040	920
2011	3,860	4,370	890
2012	3,883	4,493	860
2013	3,835	4,758	900

Source: DOA (2008, 2012, 2014)

Based on Table 2.8, there are eight main paddy-growing areas or granary in Malaysia. They are MADA (Muda Agricultural Development Authority), KADA (Kemubu Agricultural Development Authority), PKSM (Integrated Agricultural Development Project Kerian-Sungai Manik), PBLS (Integrated Agricultural Development Project Northwest Selangor), Seberang Perak, KETARA (Integrated Agricultural Development Project North Terengganu), Kemasik-Semerak (Integrated Agricultural Development Project Kemasin Semerak) and PPPBP Penang (Penang Integrated Agricultural Development Project). Overall, the paddy-growing areas produced 70 per cent of the national paddy requirement in 2013. Among the eight paddies growing area in Malaysia, MADA is the largest contributor towards the national paddy production, accounting for 50.98 per cent of the production per annum in 2013.

Table 2.8
Malaysia: Hectare Planted and Harvested by Paddy-Growing Areas (2013)

Granary Area	Planted Area (Hectares)	Paddy Production (Metric Tonnes)
MADA	187,413	941,889
KADA	38,641	159,800
PKSM	41,955	188,586
PBLS	37,835	237,594
PPPBP PENANG	20,610	120,383
SEBERANG PERAK	27,686	126,027
KETARA	9,752	54,114
KEMASIN SEMERAK	5,977	18,815
TOTAL GRANARY	**369,273**	**1,847,208**

NON-GRANARY	**305,059**	**768,637**
MALAYSIA	**674,332**	**2,615,845**

Source: DOA (2014)

The increase in the paddy production was also assisted by the irrigation schemes that have been introduced by the government. In general, paddy growing areas were divided into irrigated and non-irrigated areas. Irrigation facilities have covered almost 48 per cent of the total planted areas. A majority of the irrigation areas, approximately 90 per cent, are located in Peninsular Malaysia. Meanwhile, 5.2 per cent of the areas are located in Sabah and another 4.8 per cent are located in Sarawak. However, the paddy cultivation areas are expected to shrink due to the development of other agricultural and non-agricultural activities, including township.

2.6 Food Security and Rice Self-Sufficiency Level (SSL)

Food security refers to situations where the people of a particular country have physical and economic access to meet the requirements of a nutritious diet (FAO, 2013). With the growing population, Malaysia certainly needs an adequate supply of food to meet the demand of the nation. Nevertheless, the situation is exacerbated by the influx of the tremendous number of foreign migrants. Furthermore, as the net importer of food, Malaysia is commonly exposed to the food crisis that often threatens the country's food security. During the food crisis in 2008, the world's food supply, especially rice, is unstable and always affected by some uncertainties such as weather conditions and natural disasters. Besides, the situation in the country also often endangers the stability of food supply. Many agricultural lands, particularly rice lands, have been turned into commercial and residential areas. As a result, the output is not able to accommodate the local demand. This has resulted in the increase of the local market prices. Therefore, the Malaysian government should ensure a greater emphasis on the importance of food security through its food policy.

The transformation of the agricultural sector has changed the agricultural composition of the food-based agriculture to crops industry such as rubber, cocoa, and palm oil. Palm oil, for instance, has contributed a large amount of income to the country. Thus, a variety of sources and investments was allocated to this commodity such as R&D, credit facilities, subsidised retail price, guaranteed minimum price, extension support, fertiliser subsidies, and irrigation investment (Fahmi et al., 2013). This has influenced the growth of the commodity. Overall, the crops industry has been using more than 80 per cent of the agricultural land compared to food crops commodities. In the food crops commodities, only paddy sub-sector received a huge allocation from the government. Since 1980s, the total amount of subsidy received by this sub-sector, was approximately RM10 billions. Although the amount of the subsidy for this commodity was higher, it is still not able to meet local demand.

In all Malaysia Plans (1st to 10th), the National Agriculture Policy, the Food Security Policy (2008), and the New Economic Model, the government has developed several strategies to increase the supply of rice to meet the domestic needs. Therefore, the rice security has been interpreted by the government through the achievement of self-sufficiency of rice. The main objective of the Malaysian food security is to increase the self-sufficiency level (SSL) of paddy production.

Table 2.9
Malaysia's Self-sufficiency Level of Rice

Policies	Period	SSL	SSL Achievement
First Malaya Plan	1956-1960	-	-
Second Malaya Plan	1961-1965	-	-
First Malaysia Plan	1966-1970	-	80
Second Malaysia Plan	1971-1975	-	87
Third Malaysia Plan	1976-1980	90	92
I National Agricultural Policy (NAP I)	1984-1991	65	76
Fourth Malaysia Plan	1981-1985	65	77
Fifth Malaysia Plan	1986-1990	65	75
Sixth Malaysia Plan	1991-1995	65	76
II National Agricultural Policy	1992-2010	65	65
Seventh Malaysia Plan	1996-2000	65	71
National Agriculture Policy III	1998-2010	65	71
Eighth Malaysia Plan	2001-2005	65	71
Ninth Malaysia Plan	2006-2010	65	72
National Food Security Policy	2008	80	72
New Economic Model	2010	85	72
	2011	70	73
	2012	70	73.5
	2015[e]	71.5	-
	2020[e]	69.8	-

Note: [e] Estimation
Source: MOA (2007, 2010, 2012)
Fatimah, Jani & Yusop (2002)
Siwar, Nor Diana, Yasar, & Morshed (2014)

Table 2.9 shows the changes and achievements of the rice SSL in Malaysia. It clearly shows that Malaysia has achieved the paddy SSL, however, it cannot afford to export. Through the rice self-sufficiency policy, the government may ensure the level of productivity, farmers' income, and food security increase (Bray, 2014). Furthermore, the government also puts the effort to ensure that the consumers pay for food at a reasonable price (Devendra & Abdul Aziz, 1994). To implement the objective, programmes and strategies have been formulated to achieve the target of increasing paddy production. This includes increasing the average production of paddy.

In 2010, the government has targeted an average production of paddy in the granary areas by 5.5 metric tonnes per hectare while the average production target at the non-granary areas by 3.34 tonnes per hectare. The next programme is to increase paddy-cropping intensity. For the granary areas, the government has expected the paddy cropping intensity to increase from 193 per cent to 199 per cent. Meanwhile, in non-granary areas, the government has targeted a paddy-cropping intensity to increase from 112 per cent to 120 per cent. To achieve this target, the government would increase the rice cultivation areas. In 2009, paddy area was about 681.819 hectares and was targeted to be increased to 720,757 hectares in 2010.

CHAPTER 3

LITERATURE REVIEW

3.0 Introduction

The previous chapter provides a comprehensive discussion on the paddy sub-sector in Malaysia. This chapter discusses on the related literature review. This chapter initially starts its discussion on the development of agriculture in Section 3.1. Meanwhile, Section 3.2 discusses the topic related to agricultural and economic development. In the meantime, Section 3.3 deals with the development of production function analysis. Besides, Sections 3.4 and 3.5 discuss the single production function and aggregate production functions. In the interim, the discussion on the development of agricultural production function analysis and development of paddy production function analysis are in Sections 3.6 and 3.7.

Finally, section 3.8 discusses about productivity and efficiency in agricultural production. On top of that, productivity issues in Malaysia paddy sub-sector are discussed in section 3.9. In addition, Sections 3.10 and 3.11 focus on the elasticity substitution between capital and labour and the elasticity substitution between young and old farmers theoretical framework, hypothesis on Malaysia's paddy production, and conclusions are presented in Sections 3.12, 3.13, and 3.14.

3.1 Characteristics of Agricultural Development

Agricultural sector is the oldest economic sector in the world and still significant to the economic, political, and social development in many countries. Each developing country has its distinctive experience that is associated with the history of agricultural development, which may be different to each developing country, but most of them share almost similar agricultural development characteristics. Generally, the contribution of the agricultural sector in most countries is decreasing. Although the contribution of the agricultural sector decreases and turns into the third engine of the economic growth, it is still significant to the national development.

Initially, the agricultural sector in developing countries is underperforming. This is because most of the farmers are operating in a small scale. Moreover, the agricultural activities that are undertaken are in the forms of traditional and subsistence. Therefore, returns to agricultural investment are low. Additionally, most farmers have a large family size. They obtain income that is below the poverty line. This makes them unable to support their family members financially, hence, causes them to live in hard-core poverty. These circumstances were highlighted by Falcon (1970), Singh, Kumar & Woodhead, (2002) and Chand et al., (2011) studies. According to them, the small-scale farmers in developing countries share the same characteristics such as being poor, inefficient, and not productive.

Essentially, the yield obtained is usually for family consumption. They only sell the surplus. Consequently, it does not only lower down the income earned by them but also affect their savings. As a consequence, small-scale farmers face difficulties to invest or purchase the agricultural machinery, quality seeds, and fertilisers. These are the reasons why many small-scale farmers in developing countries are still shrouded with debts (Schultz, 1978; Cervantes-Godoy & Dewbre, 2010).

There are several empirical studies that have been conducted in order to formulate strategies and approaches to increase the income of farmers. Researchers suggested and stressed the need to improve the living standards of small-scale farmers especially in developing countries. To address this problem, they have suggested the re-structuring and commercialisation of human capital in the agricultural sector to be more orderly and systematic (ul Haq, 1970).

The number of the agricultural training centres should be increased and equipped with modern laboratories. This can produce more highly skilled human capital for the agriculture sector. The results may directly improve the production, grade, and quality of agricultural products. This can improve the prices of agricultural products. However, these efforts are not comprehensive and there are often obstacles and challenges faced, particularly from the local communities themselves. There are still many people who regard agriculture as the third-class job, therefore, they do not wish to get enrolled in the agricultural sector especially youngsters. This has contributed to the high unemployment rate in the rural areas compared to the urban areas. In addition, enormous job opportunities in the city have also become an attraction for young people to migrate to urban areas. The influx of youths to urban areas has been able to fill the job opportunities available. These circumstances help to reduce the unemployment rate among youths. According to Wharton, (1963); Byerlee, De Janvry, & Sadoulet, (2009); Timmer, (2010), unemployment in the urban areas is less than 10 per cent per annum.

Most of developing countries still practice the economics of dualism. This means that traditional and modern sectors co-exist and become the major contributors to the economic growth. The industrial sector is typically capital intensive and requires skilled labour. Unlike the agricultural sector, there are many unskilled labours in this sector. Usually, most of the traditional farmers still use the old agricultural techniques. However, there are also farmers, especially for the large-scale farmers, that use the modern techniques. Therefore, the large-scale farmers normally enjoy the remarkable agricultural returns.

Fundamentally, there are differences in the multiplier effect between the traditional and modern sectors. Hence, the economic growth among these two sectors is not balanced. The growth in the traditional sector (agriculture) is low compared to that of the modern sector. However, both sectors have a close association. The agricultural sector is the main source of raw material for the manufacturing.

3.2 Agricultural and Economic Development

Adam Smith's essay entitled "An Inquiry into the Nature and Causes of the Wealth Nations" has discussed about the causes of the economic growth and the factors that determine the economic growth. To understand the process of wealth creation, Smith presumes that the division of labour is limited to the extent of the market size. The development of the market size may encourage entrepreneurship to do innovation. According to Adam Smith, major capital investment would create specialised labours. This would improve the productivity of the labours. Through the accumulation of capital and on-going savings, economic development may be enhanced (Holcombe, 1998; Pennsylvania State University, 2005).

Meanwhile, several other classical economists like Ricardo, Malthus, and Stuart Mill also have discussed the problems that are associated with the economic development. Ricardo, for instance, emphasised in his book "The Principles of Political Economy and Taxation" which published in 1971, that agriculture is the dominant sector of the country. Moreover, he has also classified people as capitalists or investors and labours (Holcombe, 1998). Besides, Ricardo has also stated that land is limited and there is always the existence of competition over its use. Competition generally takes place between the selections of land for agricultural or industrial use. Through his book, Ricardo has also stated that technology changes over time. The dynamism of the level of technology enables rapid economic growth to occur. In addition, changes in technology can also avoid the stationary state (Foley, 1999). Hence, the technological changes can speed up the economic development.

Furthermore, Ricardo has further added that labour is very important in agricultural development. The continuity of labour in the agricultural sector is dependent on the wages rate that is paid to them. In addition, the increase or decrease in the number of labour force is based on the minimum wage level. Accumulation occurs when the rate of return that is earned by the owners of capital exceeds the minimum benefit. This will attract the investors to make investments. With a limited land area and the increase in employment may result a decrease in the marginal product. To overcome this problem, Ricardo has suggested the accumulation of capital and technological use. This accumulation is very important to increase labours' productivity.

The idea of capital accumulation in economic development is also argued by Marx, and later by Harrod, Domar and Kaldor who are the members of neo-classical economics and neo-Keynesian. Although the neo-classical economics and neo-Keynesian thought that savings may increase agricultural productivity improvement, we must also ensure that investment is made in both the agricultural and the industrial sectors. This is because, according to Schumpeter, development should be promoted by some internal agents which serve to introduce a new combination of production factors. Schumpeter named them as entrepreneurs (Opie, 1969). Meanwhile, the development process occurs when employers affiliate their ideas with entrepreneurial talent. Besides, the process is also aided by the development of various infrastructures and facilities such as finance and other physical facilities.

Actually, the development of economic thought has long recognised that the agricultural sector has a major role in the economy especially in the early stages of the development (Lewis, 1954; Kuznets, 1964). The agricultural sector grows and produces a large surplus which is a prerequisite to begin the process of economic transformation. Contradictorily, non-agricultural sectors are generally too small to perform that role. Hence, the agriculture must be able to overcome the constraints which are often faced by the developing countries. As long as these constraints still exist, the development of the non-agricultural sectors will be hindered.

The growth in the non-agricultural sectors may lead to higher wages received by their employees. These enable them to spend more expenditure especially on food. As a result, the demand for food may increase. Nonetheless, the supply of food is relatively inelastic, which means that any increase or decrease in the price of good does not result in corresponding to the increase or decrease in its supply. At the same time, if the demand for food increases, it may cause food prices to rise. Raising food prices gives a negative impact to the community. Therefore, there is one alternative to solve the problem, which is through importing food. However, financial constraints make it an expensive alternative (Mellor, 1984). Therefore, a dynamic agricultural sector is necessary in rapidly growing states to encourage economic transformation (Timmer, 2010). In the early stages of economic transformation, agriculture plays an important role in several ways. The rapid growth of the agricultural sector may increase the income and welfare of residents in the respective countries. These enable them to increase their demand for goods and services which are produced by the non-agricultural sectors. (Tomich, Kilby & Johnston, 1995).

Meanwhile, the growth in the agricultural sector would encourage the development of the agro-based industry. Usually, the development of agro-based industry is related to downstream industries such as food, textiles, beverages, medicines, and fuel industries. The agro-based industry is important as they can provide the production input for agriculture, industries such as fertilisers, pesticides, and agricultural machinery industry (Otsuka & Reardon, 1998). The development of agro-based industry also causes more infrastructures to be built for urban and rural areas, which are provided by the government.

The use of technology is very important to the growth of the agricultural sector. Technological advancement in the agricultural sector may increase the productivity of the labour. The use of advanced technologies in agriculture may reduce the dependence on labour. The surpluses of labour in agricultural sector, in turn, become a source of cheap labour for non-agricultural sector (Timmer, 2010).

The technology utilisation in farming activities may ensure that farmers are able to operate in a competitive cost. This is because the lower cost of production may have a significant impact to the increasing farmers' income. In addition, the growth in the agricultural sector is followed by the increase in the income of rural residents, which may potentially increase their savings. These savings are the sources of financial capital for the development of non-agricultural sectors. The rapid growth of the agricultural sector generates financial resources for the country. The contribution of financial resources from the agricultural sector is obtained through increased export and increased import substitution of agricultural products. Therefore, generating incomes from the agricultural sector is a strategic tool for the industrialisation of a country.

The rapid growth of the agricultural sector is mainly due to the intensive cultivation of food and industrial crops. However, for certain countries, the state of the agricultural sector development is a catalyst for the growth in non-agricultural sectors that is biased. There are a few obstructions to allow this matter. In order to be a catalyst for non-agricultural sector growth, this sector should fulfil some features as outlined by Tomich et al. (1995). Among the characteristics are:

a) The government must reduce the excessive protection to the industrial sector.

b) Financial and banking sectors should provide efficient credit facilities to farmers by offering an efficient credit product. In addition, the structure of credit repayments should not burden the farmers.

c) The government should provide good transportation infrastructures to facilitate the delivery of agricultural products to domestic and international markets.

d) The benefits of the economic growth are attributable to both the agricultural and non-agricultural sectors. The small-scale farmers will spend their earning to purchase goods or services that are labour-intensive while the large-scale farmers will buy the non-tradable (Mellor, 1984). One of the conditions for balanced growth in the agricultural sector is through the distribution of land to actual producer or tillers.

The rapid economic transformations lead to the agricultural sector role decline in the economic development. The government gives more focus to the industrial and services sectors because both sectors have large multiplier effect to the economic growth. Therefore, the government has introduced many investment incentives to attract more foreign direct investments (FDI) to this sector. This makes the agricultural sector lagged behind, which ultimately reduces the overall sector that contributes to the economic growth. The following are various explanations which could cause the decrease in the role of agricultural sector to the economic development:

a) Engel's Law

In economic discipline, the Law of Engel states that when incomes rise, the proportion of income spent on food reduces, even the actual expenditures for food increase. In other words, the income elasticity of food is always between 0 and 1. The law was named after the statistician, Ernst Engel (1821-1896).

However, the law does not indicate that the Engel's food expenditure remains unchanged as income rises. This law shows that the proportion of consumers' expenditures for food products (in gratuities) increase but lesser than the increase in revenue. One of the Engel's law enforcement is to distinguish the standard of living of a country. If "Engel's coefficient" is high, it means that a country is classified as a poor country. On the other hand, if the coefficients are small, it implies that the country has a high standard of living.

b) The Demand Elasticity of Off-Farm Products

The demand for non-agricultural products is more elastic than the demand for the agricultural products. This means that the demand for non-agricultural products is more sensitive to the changing in price. A small change in price may cause the quantity of demand for non-agricultural products to change vastly. These conditions help non-agricultural sector to grow rapidly. Meanwhile, the agricultural products are inelastic. These indicate that the quantity of the agricultural products is not sensitive to the price changes. The difference in the degrees of elasticity of demand of both sectors shows that the non-agricultural sector is more competitive compared to the agricultural sector. The low level of competitiveness in the agricultural sector has shifted the local and foreign investments to the non-agricultural sector. This, in turn, reduces the contribution of the agricultural sector to the economic growth.

c) Level of Technology

Technology is a key element in the economic growth and development. Besides, technology has a capability to boost income levels and living standards of a particular group. It has been identified as a significant source of economic growth, productivity, and competitiveness. The use of new technology can indirectly produce better quality products as well as being cost effective. The rapid growth of the non-agricultural sectors such as industrial and services sectors has made this sector more technology-friendly.

Compared to the industrial sector, the use of technology in agricultural sector is fairly neglected. Therefore, this situation has made the agricultural sector the uncompetitive one. The uncompetitive agricultural sector has then resulted in farmers' low income. The situation becomes a major obstacle for farmers to absorb modern technology. Thus, although modern technology provide ample opportunity to the agricultural sector, farmers are still unable to grab the opportunity. As a result, this sector still remains the traditional cultivation with out-dated technology.

d) Low Labour Productivity

The accumulation of capital and its effect on capital-labour contribution of the agricultural sector results in a decrease in the relative labour-intensive compared to non-agricultural sector, which is likely to be capital-intensive (Martin & Warr, 1992). The decline in the contribution of agricultural sector is followed by a similar decline in the labour force. This results in average productivity per worker to decline. Besides, it also represents a decline in farmers' income. The direct effects of declining income of the farmers may create a huge gap in the productivity between agricultural and non-agricultural sectors.

3.3 Developments in Production Function Analysis

Production functions have expanded over the years. It is an important tool in the economic analysis. There are two opinions about the pioneers of the production function. The first view states that Philip Wicksteed and the second opinion said that Johann von Thunen was the first pioneer of the production function (Humphery, 1997). The concept of production is related to the engineering knowledge and it is not a tool to represent the result of economic choices. However, it is only a tool that is used to get the entity that influences economic decision-making.

The concept of economic efficiency is the key question and often highlighted in the analysis of the production function. Basically, there are two main types of economic efficiency, which are technical and resource allocative efficiencies (Leibenstein, 1966; Chukwuji, Inoni & Oyaide, 2006). The concept of efficiency is related to the engineering knowledge. However, many researchers have often presumed that the production functions are always free from engineering and managerial technical efficiencies. Based on this assumption, many studies have emphasised on the allocative efficiency of resources (Bravo-Ureta & Pinheiro, 1997; Chukwuji et al., 2006; Inoni, 2007). According to Leibenstein (1966) and Shepherd (2015), the allocative efficiency of resources can portray the optimum combination of technical and resource allocation efficiencies.

Generally, there exists a physical relationship between input and output, for example a combination of one labour and one machine will produce several units of output. Frequently, in literature, financial values are used to represent the relationship between input and output. However, there are also some literatures that measure the input and output relationship in a different physical unit. This may create difficulties in the empirical analysis especially when it involves undivided units such as people. Nevertheless, Faber, Proops & Baumgartner (1998) have a different opinion about the issues. According to them, the production process is to produce various outputs. In order to capture the difference between one product and another, the weighted price can be used. Thus, we can isolate the error and wastage in the process of physical production.

We often assumed that the production function has a capability of solving the firms' technical-efficiency problems. However, in reality, this statement is false. This is because the unit of measurement that is used for each variable is different. Besides, we must also remember that the production function is not a business model. As such, it ignores many parts of the management and cost aspects. Therefore, to overcome this problem, Farrell (1957), Charnes, Cooper & Rhodes (1978), Charnes, Cooper & Banker (1984), Lyroudi & Angelidis (2006), and Angelidis & Lyroudi (2006) highlighted the non-parametric approach which known as "Data Envelopment Analysis" or DEA. The advantages of DEA are that it does not require any mathematical forms for the production function (Emrouznejad & Thanassoulis, 2001). Besides, it is also capable of measuring the multiple input-output analyses.

Starting from 1940s until the late of 1970s, the development of the production-function literature is vast. The results of many studies and various researches have been recorded by using a production function as a tool of an empirical study (Mishra, 2007). Early economic scholars such as Smith, Ricardo, and Malthus have developed a general hypothesis on the production function. Since then, a great extent of literatures has been added to the production functions, which is related to the microeconomic or macroeconomic research.

In the field of agricultural economics, Knut Wicksell was the first person to formulate the hypothesis of algebraic to physical agricultural production functions. He has concluded that the increasing returns to capital and labour are positive if the fertiliser is applied to infertile soil. Through this hypothesis, Knut Wicksell has shown that agricultural output is dependent on the quantity and quality of the inputs used. He has further indicated that the agricultural growth is dependent on the land, labour, and capital inputs. According to Knut Wicksell, agricultural output and input nexus can be expressed in mathematical equations. He has further indicated that if the input for a certain period is denoted by X_1, X_2, X_3 and the total output is P, then the production function can be defined as:

$$P = f(X_1, X_2, X_3) \tag{3.1}$$

Tough, Wicksell was the key person who has formulated a basic production function, the first empirical estimation which was performed by Charles W. Cobb and Paul H. Douglas in 1928. The production function was later known as Cobb-Douglas Production Functions (CD). The origin of certain functions can be traced back to the work of Wicksell.

$$P = X_1^{\alpha} X_2^{\beta} X_3^{\gamma} \tag{3.2}$$

According to Wicksell, the coefficient for Equation 3.2 above can be unity and have a constant return to scale.

In Charles W. Cobb's and Paul H. Douglas's study, a similar production function was used by them as proposed by Wicksell. They used the data on the U.S. manufacturing industries from 1899-1922. Cobb's and Douglas's work was the first empirical work using time-series data. Generally, the form of production function is as follows:

$$P = bL^{k}C^{1-k} \tag{3.3}$$

where P is output, L is labour and C is capital input in the industry.

The estimation was resulted from the production function model which used by Charles W. Cobb and Paul H. Douglas, as follows:

$$P = 1.01L^{.75}C^{.25} \tag{3.4}$$

From Equation 3.4 above, Cobb and Douglas have indicated that a combination among labour and capital coefficients equals to one. They also indicated constant returns to scale. This finding has confirmed the Wicksell's earlier hypothesis. If the coefficient is greater or lesser than one, then the total product may be larger or smaller than the number of combinations of input used. Therefore, we can identify whether the firms enjoy an increasing or decreasing marginal productivity[7].

In another study, Cobb and Douglas have stressed on the unitary degree of elasticity or the amount of elasticity of resources which are equivalent to one. They have employed the function, $P = bL^kC^j$ where the coefficient j and k can take a non-zero value. The Cobb-Douglas's production function has become popular until today. This is because the Cobb-Douglas's production functions are the simplest production function.

After the development of a production function that was highlighted by Cobb & Douglas (1928), the study of the production function became popular among numerous researchers (Fraser, 2002). There are various forms of estimation which can be carried out by using the production functions. The study of production function can be broken down into several types of data, such as the cross-sectional, time series, and panel data.

In addition, there are also some other alternatives of the production function which is essentially used in empirical estimation. Among them are Constant Elasticity of Substitution (CES), Variable Elasticity of Substitution (VES), and translog and other flexible production functions (Arrow, Chenery, Minhas & Solow, 1961; Lu & Fletcher, 1968; Christensen, Jorgenson & Lau, 1973).

[7] Equations 3.3 and 3.4 are based on Cobb and Douglas (1928) , page 152.

3.3.1 Basic Concept

In the neo-classical production functions, the analysis can be divided into five areas:

i) The variation in unit costs of production with respect to changes in scale.

ii) The degree of substitutability among the factors of production.

iii) The rate of technological progress and its biasness towards labour using or capital using innovations.

iv) The sources of technological progress

v) The spatial distribution of mobile economic resources.

3.3.2 Production, unit, input and output

Economists have long discussed on the production process which is associated with the various economic agents that are known as variables. A production unit is usually described as a well-defined activity in which the production of analysis is performed. Agricultural production units usually take the form of physical, technical, socioeconomic, and policy.

3.3.3 Scale, elasticity of scale and elasticity of substitution

Scale is the economic equivalent of size. Therefore, it is usually defined in terms of the amount of output per production time period of an economic unit. Meanwhile, the elasticity of scale is the measure of the concept of economies of scale, which are defined as the increase of output that is corresponding with an increase in inputs. However, both increases may or may not be equal. Economists used to saying that the economics of scale do exist when the equal expansion or the increase in the inputs of production is greater than the proportional increase in output. The elasticity of substitution is a measure of the substitution among the inputs or factors of production. The quantitative value of the elasticity of substitution varies according to each production function for each specific study. Nevertheless, some general conclusions have been achieved. A study by Bosworth on the validity of the neo-classical production function has pointed out that some results of the elasticity of substitution between inputs centres on a value of one-half are mostly in time-series studies, while in cross-sectional studies, it is closer to unity.

3.4 Single Output Production Functions

The production function knowledge has grown enormously since 1970s. During this period, the development of the knowledge has brought a number of prominent scholars. Among them were Turgot, Johann von Thunen, Philip Wicksteed, Malthus, Cobb and Douglas. Since then, the production-function development has been a crucial tool in empirical analysis in all economic schools of doctrine. Returning to the historical development of the production functions, many scholars believed that Turgot was the first scholar to have introduced the production functions knowledge around 1767.

According to Schumpeter (1954) in Humphery (1997), Turgot has argued how the dissimilarity in factor proportions affects the marginal productivity of production. Based upon Turgot's observations, the utility of consumption of one product may reduce if the supply of the product increases. The increase in quantity of production input may increase the productivity up to a maximum point. After this point, the increasing in the unit of input used may decrease the marginal productivity level to zero. Eventually, if there are more input units added, the productivity may turn to negative. Consequently, after a maximum point, additional input may be unproductive. Subsequently, more than thirty years after Turgot, the production functions knowledge has evolved. Several scholars have successfully connected to this development such as Johann von Thunen and Philip Wicksteed (Humphery, 1997; Mishra, 2007).

The numerical concept of the production functions has been introduced by Malthus. Towards this, Malthus introduced the logarithmic production function in 1978. The idea of logarithmic production functions is to capture the law of diminishing returns. To facilitate the description of his model, Malthus specified that the population increases by the geometric ratio (1, 2, 4, 8, 16, 32,…) while land increases the arithmetic ratio (1, 2, 3, 4, 5…). Malthus has then presumed that labour may experience diminishing returns when combined with land.

Following Malthus, David Ricardo introduced the idea of a quadratic production function in 1817. According to Ricardo, the growth may stop when diminishing return of capital is combined with limited land. At this point, the investment may drop. This is because the economic growth may have reached the stationary phase (Hummpary, 1997).

After Malthus and Ricardo, Johann von Thunen has introduced the exponential production function. In fact, he was the first person to have used this function. Von Thunen exponential production function can be written as follows (Mishra, 2007):-

$$P = f(F) = A\prod_{1}^{3}(1 - e^{-a_i,F_i}) \tag{3.5}$$

where F1, F2, and F3 are the labour, capital, and fertiliser, a_i is a parameter. P is the von Thunen's production function (Lloyd, 1969; Blaug, 1985). According to Lloyd (1969), von Thunen was probably the first economist to have applied the theory of differential calculus in calculating the level of productivity. Lloyd has also believed that von Thunen was perhaps the first person to use calculus to solve the problems of economic optimisation. He further added that von Thunen also has used calculus to interpret the marginal productivity of economic production function. He was the first to formulate that algebraic production functions as Equation 3.6.

$$p = hq^n \tag{3.6}$$

p is the output per worker (Q / L), capital per worker (C / L) is q, meanwhile, h is a parameter that represents the fertility of land and labour efficiency. The exponent n is a parameter where its value lies between zero and unity. Multiplying both sides of a von Thunen's production function with L (labour) such as:

$$Lp = hq^n L$$

We can prove:

$$\therefore P = hC^n L^{1-n} \tag{3.7}$$

Based on the above equations, we can conclude that the von Thunen's production function is a hidden Cobb-Douglas's production function (Lloyd, 1969; Blaug, 1985).

Based on Equation 3.7, von Thunen has discovered that labour alone cannot be an effective production input. Von Thunen has then transformed Equation 3.7 to be Equation 3.8 (Mishra, 2007).

$$P = h(L + c)^n L^{n-1} \tag{3.8}$$

Nevertheless, after a long review process, von Thunen corrected his early notation about labour. In his new discovery, he has found that labour alone can produce product (Humphery, 1997). However, modern economists have never formulated a production function by using labour as the sole factor of production. In addition, in 1923, another scholar named Wicksell introduced a production function that is similar to Cobb-Douglas's production function with an exponential of up to unity.

Based on the previous work, Samuelson (1979) presumed a Cobb-Douglas's production function as merely a special case for other production functions. The Coob-Douglas's production function can be written as follows:

$$Y = AL_i^{\beta_1} K_i^{\beta_2} e^{\mu} \quad i = 1,2, \ldots\ldots n$$

(3.9)

where, Y is output, L is labour, K is capital, μ is a stochastic disturbance term. β_1 and β_2 are the elasticises of output with respect to the input of production respectively. Given the marginal product

$$MP_L = \frac{\partial Y}{\partial L} = \frac{\beta_1 Y}{L} \qquad MP_K = \frac{\partial Y}{\partial K} = \frac{\beta_2 Y}{K}$$

(3.10)

Meanwhile, the Marginal Rate Technical of Substitution (MRTS) can be written as follows:-

$$MRTS = \frac{MP_K}{MP_L} = \frac{\beta_2 L}{\beta_1 K}$$

(3.11)

Equation 3.12 and 3.13 define the total cost (C) and the isocost line, respectively, in terms of the quantity of labor (L), the quantity of capital (K), the wage rate (w), and the rental price of capital (r).

$$C = wL + rK \tag{3.12}$$

$$K = \frac{C}{r} - \frac{w}{r}L \tag{3.13}$$

Equations 3.14 and 3.15 are the alternative ways of expressing the necessary condition for the optimal combination of inputs. The first states that the optimum combination is found where the absolute value of the slope of an isoquant (MRTS) is equal to the absolute value of the slope of the isocost line. The second notes that the marginal rate of technical substitution is equal to the ratio of the marginal products of labor and capital and is therefore equal to the absolute value of the slope of the isocost line at the optimum. The last rewrites the second to show that it implies that the optimum combination of inputs is found where the marginal product of an input divided its cost per unit is the same for all inputs.

$$\frac{MP_L}{MP_K} = \frac{w}{r} \tag{3.14}$$

$$MRTS = \frac{MP_L}{MP_K} = \frac{w}{r} \tag{3.15}$$

The elasticity of substitution of the Cobb Douglas's production function can be expressed as follows:

$$\sigma = \frac{\%\Delta(L/K)}{\%\Delta MRS} = \frac{d\ln(L/K)}{d\ln w/r} = 1$$

(3.16)

If $\sigma = 1$, means that any changes in L/K will be matched by a proportional change in w/r and the relative income that is earned by capital and labour will stay constant.

After 33 years, Cobb-Douglas's production function was introduced. Arrow et al., (1961) made some modifications to the function. However, the changes were only an extension of the Cobb Douglas's production function, not an alternative paradigm. One of the Cobb-Douglas's production function properties is that the elasticity of substitution between capital and labour is constrained to unity. However, the production function that was formulated by Arrow et al., (1961) allows the elasticity of substitution labour and capital to be flexible and the value lies between zero and infinity. This function is known as a Constant Elasticity of Substitution (CES). The CES value lies between the Cobb-Douglas's, Leontief's, and linear production functions. Therefore, we said that the CES production function is a special case for those three production functions above. Nevertheless, its value remains fixed along and across isoquant and ignores the size of output or input into the production process.

The CES function can be written as follows:

$$Y_i = \gamma\{\delta K_i^{-\rho} + (1-\delta)L_i^{-\rho}\}^{-/\rho} e^{u_i}, i = 1,2,\ldots\ldots,n$$

(3.17)

where Y_i is value-added, K_i is capital, and L_i represents labour. Notations γ, δ, and ρ are the efficiency, distribution, and substitution parameters. Meanwhile, the random errors are U_1, U_2 and U_n. Basically, we assume that the random errors are independent and normally distributed. The number of sample was represented by n. Under the perfect competition, the elasticity of substitution for CES production function is $= (1+\rho)^{-1}$.

Transformed Equation 3.9 to log functions as follows:

$$log(Y_i/L_i) = \beta_0 + \beta_1 \log w_i + U_i, \quad i = 1.2 \ldots., n$$

(3.18)

w_i is wage for labour while β_1 is the CES elasticity of substitution. If the CES elasticity substitution value is 1 ($\sigma = 1$), then we have a Leontief production function. If the elasticity substitution of CES approaches zero, then we get the linear homogeneous Cobb-Douglas's function. Meanwhile, if σ approaches negative infinity, then we get the Leontief's function. Conversely, there are two problems that are related to the CES production function. The first problem is the elasticity of substitution that is constant along and across the isoquant. The second problem is that the researcher used more than two inputs. For example, if there are three inputs of CES production function that may yield three values of elasticity. However, according to the impossibility theorems of Uzawa and McFadden, it is impossible to get the value elasticity if the number of inputs used is more than two (Mishra, 2007).

The next production function is the Variable Elasticity of Substitution (VES). Scholars such as Hildebrand & Liu (1965) and Lu & Fletcher (1968) generalised the CES production function to allow the Variable Elasticity of Substitution (VES). The VES production function can be written as follows:

$$Y = \gamma \left\{ \delta K_i^{-\rho} + (1-\delta)\eta L_i^{-\rho} (K_i/L_i)^{-c(1+p)} \right\}^{-1/\rho} e^{U_i} \quad i = 1.2, \ldots .. n$$

(3.19)

where Y_i is value-added, K_i is capital, L_i represents labour and U_1 ,U_2,….,U_n are random errors. The random error (U) is independent and normally distributed. Equation 3.19 is then transformed to log as follow:-

$$log(Y_i/L_i) = \beta_0 + \beta_1 \log w_i + \beta_3 \log(K_i/L_i) + U_i, \quad i = 1.2 \ldots., n \tag{3.20}$$

where $\beta_1 \equiv (1+\rho)^{-1}$ and $\beta_3 \equiv c$. β_3 is the coefficient of the logarithm of capital-labour ratio. If the value is zero, then the model is reduced to Constant Returns to Scale (CES) production function as Equation 3.14. The elasticity of substitution for the VES production function can be expressed as follows:

$$\sigma = \beta_1(1 - \varepsilon\beta_3)^{-1} \tag{3.21}$$

where $\varepsilon \equiv (wL+rK)/rK$ is the ratio of total factor costs to the rental cost of capital.

In mid-1970s, the generalised Cobb-Douglas's production function and the CES were almost complete. Both of these functions assume that the marginal rate technical of substitution (MRTS) of factors of production is contributed by changes in a factor price. In addition, both Cobb-Douglas's and CES production functions are free from the technical progress. These mean that any technological progress may not affect the labour and capital change in the production function. In technical terms, this situation is called Hicks-neutral.

Basically, there are three types of neutrality; Hicks, Harrod, and Solow. Nonetheless, changes in technology may cause changes in production possibilities. Hicks-neutral situation is related to changing in technology. However, the changes in technology may not affect the capital–labour ratio if a factor price is unchanged.

Meanwhile, a technological change is assumed to be Harrod-neutral if the changes in technology do not affect a capital-labour ratio when capital price is unchanged. In the meantime, the technological change is Solow-neutral if the labour is unchanged. The unchanged labour may cause a capital-labour ratio to be unchanged.

3.5 Aggregate Production Functions

In dealing with the issues of supplies of products and services, we should be sensitive to the economies of aggregate production. This process requires a balance between demand and supply. Before we get there, we need to know how the producers fabricate their products.

The supply measurement has become the dynamic subject of research. In the real world, every producer has their own production function. In this discussion, we just presume that there is only one production function which is known as the 'aggregate'. Although we assumed only one production function, the model still allows us to have a high predictive power.

For further discussion, we assumed that the producers only used three inputs, which are labour, capital, and technology. Hence, the production function can be written as follows:

$$Y = Af(K, L) \tag{3.22}$$

where *Y* represents a firms' output, *K,* and *L,* are the capital and labour respectively. The aim of the producers is to maximise profit. This can be done by increasing the quantity of *Y* produced or by reducing the cost of production for *Y.* The production function shows the maximum amount of the goods that can be produced through the combination of K and L. Meanwhile A is equals to Total Physical Product (TPP). This relationship can be portrayed in several forms, such as liner functional, polynomial function, and Cobb-Douglas's. Later, all the forms can be transformed into transcendental and translog functions by adding one more unit input. Holding other inputs constant, therefore, an additional output can be produced. This is known as the Marginal Physical Product (MPP). For example, the MPP of labour:

$$MPP_L = \frac{\partial F}{\partial L} > 0, = MPP_K = \frac{\partial F}{\partial K} > 0$$

(3.23)

The above equation has been derived from the first derivative of the production function. The equation has shown that the marginal product for capital and labour are positive. In a short-run, if more labours are added to the fixed variables, it may result in a diminishing marginal productivity. The increase in the capital and labour use may lead to the increase in output at a decreasing rate. These mean that the more labours that we add, the less output that we get. Consequently, an increase in the labour input may lead to lower productivity level. Hence, the second derivative is less than zero:

$$MPP_L = \frac{\partial^2 F}{\partial L^2} < 0, = MPP_K = \frac{\partial^2 F}{\partial K^2} < 0$$

(3.24)

The Average Physical Product (APP) is a measure of efficiency, which depends on the level of other input employed.

$$APP_{L=} \frac{Y}{L} = \frac{f(K, L)}{L}$$

(3.25)

The idea of returns to scale is to show how output responds to an increase in all inputs mutually. It can either be constant, decreasing, or increasing.

The elasticity of supply of an input measures how the output responds to the changes in inputs used. This is derived by dividing the MPP by the APP.

$$E = \frac{MPP_L}{APP_L} \tag{3.22}$$

Additionally, the Total Value Product (TVP) and Marginal Value Product (MVP) can be derived by multiple with output price *(P_y)*:-.

$$TVP = TPP \cdot (P_y) \tag{3.23}$$

$$MVP = MPP \cdot P_y \tag{3.24}$$

3.6 Developments of Agricultural Production Function Analysis

As reported by Abeysekara (1976) and Ortega & Lederman (2004), the estimated agricultural production function has been first introduced and used since long time ago. Abeysekara (1976) further added that Tolley, Black, and Ezkiel were among the earliest scholars who were responsible for the empirical observation. They have used companies cross-sectional data in the empirical analyses. From their empirical findings, it was found that the firms have experienced a diminishing marginal productivity from resources.

As an extension to Tolley's, Black's, and Ezkiel's works, Tintner in 1944 also employed the production functions in his empirical worked. In his study, Tintner has used data from 609 farm fields in Iowa State. He has used six independent variables that affected the agricultural output. Besides land and labour, Tintner has also included other endogenous variables such as expenditure, liquidity of assets, working assets, and cash operating. Both the physical values and financial values have been used in this empirical measurement. In his estimation, Tintner has shown that farms faced decreasing returns to scale.

In 1944 and 1946, Heady has run a Cobb Douglas's production function analyses by using a random-sample survey. The purpose of using the random sample is to avoid biasness in his estimation. Among the input variables that were used by Heady were the real estate, machinery and labour equipment, and the cost of livestock. Like Tinter, Heady has also used the physical and financial input variables to measure the endogenous variables. Heady has carried out a preliminary research to ensure that the correlations between factors are stable. This is to ensure that he has obtained the best results through the estimation. He has further mentioned that if high correlations were present between factor inputs, these might lead a biased estimation.

The high correlations between independent variables indicate the presence multicollinearity. This means that the independent variables have a perfect linear relationship. The multicollineraity causes the standard deviation of the estimator to increase. Furthermore, the multicollineraity makes independent variable to contain the same information and create the trend that move together. Moving trend together will cause the Ordinary Least Squares *(*OLS*)* difficult to separate the variables estimators. This makes the estimators not exact and larger. In addition, the value of *t* will be smaller. The above conditions cause biased estimation to occur.

Subsequently, the production function literature continues to evolve with the use of aggregate data. Bhattacharjee (1955) was among the early scholars who believed that all the output observations are generated from the identical production function. Therefore, he has used a fix cross-country aggregate data to the production function model. Based on this belief, Bhattacharje was successful in his empirical estimation. However, the role of technology was never settled by Bhattacharje and other scholars (Heady & Dillon, 1961). By 1970s, the production function literature evolved further. Many researchers have given their contribution to the development of production-function literature. From this time on, the production-function estimation has not only focused on the regional issues but also reached the global issues like Hayami's & Rutan's (1970) estimation.

The inter-country analysis of the agricultural production functions was initiated by Hayami (1969) and Hayami & Ruttan (1970). The purpose of these studies is to determine the roots of cross-country differences in agricultural productivity and growth. Hayami (1969) and Hayami & Ruttan (1970) presumed that all countries have common production functions that are meta-production. This production function was then used to represent the envelope of all known and potentially available in production activities. (Hayami & Ruttan, 1971).

Cobb-Douglas's production functions were estimated by using cross-country data on agricultural output and inputs such as land, labour, fertilisers, tractors, and livestocks. Their study has also measured the contribution of the human capital to agricultural production. To represent the human capital input, Hayami (1969) and Hayami & Ruttan (1970) have then employed data on general education and technical education.

Subsequent studies were primarily the modifications of the Hayami's (1969) and Hayami's & Ruttan's (1970) studies. Therefore, the subsequent studies used almost common in terms of the composition of the sample, the specification of the model, and the set-up of the variables. However, the later researchers have employed more time periods in their analysis as compared to Hayami and Ruttan. Furthermore, they have also employed a different measurement of human capital. Besides, there were also some researchers who have introduced new variables in production-function studies, such as research and extension done by Evenson & Kislve (1975) and later infrastructured by Antle (1983).

Table 3.0 below shows the results which were obtained from the cross-sectional studies. The variables were measured based on the per-workers or the aggregated data. All these studies have used a single year. This suited with between countries studied for the given years. This has also been the case of panel data in which the dummy country is not included. The study of panel data and dummy country estimates has produced the "within-country" coefficients. The ranges of the elasticity of labour and land are 0.23 to 0.16, machinery varies around 0.10, and livestock is in between 0.23 to 0.33.

Furthermore, in Kawagoe's, Hayami's & Ruttan's (1985) study, it was discovered that the elasticity for labour and livestock, to some extent, is outside the previously mentioned range. Besides, Lau & Yotopoulos (1989) have estimated a translog production function by using the first difference that is allowed for country-specific productivity differences. This is to address their concerns about low land productivity. However, they have obtained much higher land elasticity and lower elasticity on machinery and livestock. In a latter study conducted by Hu & Antle (1993), the infrastructure and agricultural policy were introduced, for instance, taxation and subsidisation, in their agricultural production functions analysis. Based on the empirical analysis, they have found a high elasticity of livestock and a low elasticity on machinery. Trueblood (1996) has done some improvements in the methodology and data used. He has estimated a random-effect model by using the data from four-time periods from 89 countries. They have discovered that the elasticity of land is much higher than that of previous studies while the elasticity of labour and livestock is low.

The production functions studies that were started from Bhattacharje to Trueblood have presumed that all countries employed a homogenous production technology. Nonetheless, the actual development for each country is different. This indicates that the level of technology that is employed by each country is also dissimilar. Therefore, if the study still assumes that the production technology for all countries is homogeneous, it may generate a bias regression result.

Recognizing this issues, some researchers have extended the analysis by introducing the concept of heterogeneous technology. In their analysis, they have presumed that all countries have the access to the same technology. However, they differ in the implementation of the technology. According to them, a producer has a capability to choose which technology to employ. All the technology selections are dependent on producers' decision on the level of inputs. In addition, the choice of technology is determined partially by the economic environment in which producers operate.

Table 3.0

Cross-Country Production Functions: Comparison of Results (Based on Hayami-Ruttan's Study)

	Bhattacharje	Hayami & Ruttan	Evenson & Kislev	Yamada & Ruttan	Antle	Hayami & Ruttan	Nguyen
Year Of study	1955	1970	1975	1980	1983	1970	1979
Sample:							
Number of countries	22	37	36	41	43	36	40*
Time Period	1949	1960	1955, 1960 1965, 1960	1970	1965	1955, 1960	1955, 1960, 1970, 1975
Estimation Method	OLS	OLS	OLS	OLS	PCR	OLS	OLS
Data Specification	S;N	M;N	M;N	M;N	S;N	M;PW	M;N
Fixed Effect Included						year	year
Elesticities							
Land	0.42	0.08**	0.04**	0.02*	0.16	0.07	0.02**
Labour	0,23	0.41	0.23	0.33	0.38	0.4	0.3
Equipment/Machinery/Tractor		0.12	0.1	0.11		0.11	0.14
Fertiliser	0.29	0.12	0.1	0.24	0.07**	0.14	0.1
Livestock and Ochardsllivestock		0.23	0.3	0.23	0.14**	0.28	0.33
Irrigation							
Schooling/General Education		0.32**		0.08**	0.25**	0.24	0.10**
Technical Education		0.14	0.04	0.14		0.12	0.17
Research and Extension			0.14		0.17		
Infrastructure					0.21		
Policy Variable							
Research							
Sum of Input elasticises	0.99	0.96	0.77	0.93	0.75	1.00***	0/98

	Mundlak & Hellinghausen	Kawagoe, Hayami & Ruttan	Lau & Yotopoulos	Hu & Antle	Trueblood
Year of Study	1982	1985	1989	1993	1996
Sample:					
Number of Countries	58	43	43	24*	89
Time Period	1960, 1965, 1970, 1975	1960,70,80	1960,70,80	1960,70,80	1970,75,80,85
Estimation Method	PCR	PCR	OLS	OLS	RE
Data Specification	M;N	M; PF	M; PF;	M; PF	M; N
Fixed Effect Included	country	LDC, year	country, year	year	LDC, year
Elesticities					
Land	0.16	0.09	0.67	0.17	0.32
Labour	0.46	0.44	0.33	0.24	0.07
Equipment/Machinery/Tractor	0.07	0.11	0.06	0.04**	0.09
Fertiliser	0.11	0.19	0.06	0.13	0.08
Livestock and Ochardsllivestock	0.19	0.2	0.13	0.43	0.13
Irrigation	0.01				0.01
Schooling/General Education		0.25	0.24	0.03	0.25
Technical Education		0.06	0.1		
Research and Extension		0.17			
Infrastructure				0.2	
Policy Variable				1.5	
Research					0.07
Sum of Input elasticises	1.00***	1.03	1.25	1.01	0.69

Notes: *Sample is not balanced, n= 183 for Nguyen study, ** Not significant at P=0.05 for one-tailed test, *** Linear homogeneity imposed, # Country effects on slopes and intercept, OLS and PCR are ordinary least squares and principal components regressions, S and M represent single-year observations and multi-year averages. PW represents per-worker averages of national aggregated data, N represents national aggregates.

Sources: Ortega & Lederman, 2004

Tables 3.0 shows the state variables that are included in the production function analysis[8]. The admission of the state variables could affect the intercept and the slopes directly or indirectly[9]. These are due to the state variables have a large impact on cross-country. Therefore, the regression estimations are expected to change based on state variables magnitude. Thus, the result generated from the analysis is not robust.

To overcome the effect of state variables, Mundlak, Larson & Butzer (2004) utilised the panel-data set. In this study, Mundlak et al. (2004) employed a new data set on agricultural capital, which included fixed capital to capture the capital, livestock, and treestocks in value terms (Crego, Larson, Butzer & Mundlak, 1998).

Mundlak, Butzer & Larson (2012) used an updated version of the data set on agricultural capital stock to extend the analysis of heterogeneous technology to 2000. The set of state variables was expanded to include institutional measures. What was most striking was the relative importance of capital. They have estimated the elasticity of fixed capital and land to be much higher than those from the Hayami-Ruttan era studies. In particular, the coefficient on fixed capital is three times larger. Conversely, the coefficient on labour decreases by as much. The coefficient on the composite livestock and tree stock measure is 0.13 and 0.06 respectively. In addition to the new data on agricultural capital, the sample coverage differed from the Hayami-Ruttan's studies. The number of countries was determined by data availability, hence, the country coverage varied. The Hayami-Ruttan's studies were conducted in 1970s and 1980s. The data

[8] State variables refer to variables that characterise the initial conditions that influence producers' choices but are exogenous from the perspective of the firm or household.

[9] Directly - through a change in the composition of implemented techniques; Indirectly - through the change in inputs used in a given technique

available covered the period of 1955-1980. The time period of Mundlak et al., (2012) study was 1970-1990 and 1972-2000. As discussed earlier, which was under heterogeneous technology, the estimates were expected to vary across samples.

Mundlak et al., (2012) used the latest version of the data set on agricultural capital to expand the analysis of heterogeneous technologies. The set of state variables was expanded to include institutional measures. What was the most important in their research was the capital input. The results of their study have discovered that the elasticity of fixed capital and land are much higher than that of previous study which was conducted by Hayami and Ruttan. In particular, the coefficient of fixed capital is three times larger than that of previous studies. In contrast, the coefficient of labour decreases tremendously. Since the data employed was panel data, therefore, the data coverage varied. Therefore, the result generated is more robust compared to the previous study done by Hayami and Ruttan.

Based on the previous study, we could conclude that there are three main patterns that contribute to the literature. Firstly, the literature has shown that a low estimate of the output is associated with the land. Almost all the studies indicated that soil is not significant. Secondly, most studies have found that there is high degree of elasticity for labour. Thirdly, the majority of studies have shown that the number of the input elasticity is less than one. This suggested that there are diminishing or constant returns to scale.

3.7 Development in Paddy Production Function Analysis

Table 3.1 shows the selected paddy production-functions studies for Malaysia, Asia, and African countries. Based on the table, Heady is among the economists who has used the production function in his investigation. This is based on his empirical work in

1950s[10]. In 1969, Rao & Heady (1969) have conducted an investigation on the paddy sub-sector in India. The purpose of Rao and Heady research was to investigate the rate of substitution between technology, land, and labour. They have employed cross-sectional data analysis. The investigation has established that fertiliser becomes a substitute to labour. In the meantime, they have also discovered that the use of efficient fertiliser can reduce dependency on land and labour.

Ismail (1972) is among the earliest researchers that employed the production functions analysis to the paddy sub-sector in Malaysia. He has divided the investigation in to four main areas such as Sabak Bernam, Kuala Selangor, North Malacca, and Kota Baharu. He has employed unpublished survey data which conducted by the Malaysia government from 1966 and 1976. He then employed the Cobb-Douglas production function to estimate paddy production. The result indicated that land is significant in all areas. Meanwhile, fertiliser and labour are both significant in North Malacca only.

The study performance between ethnic groups of farmers was conducted by Huang (1974). Huang has estimated production functions of double cropping paddy in Tanjung Karang, Selangor. His study has involved the Malay and Chinese farmers. He has discovered that the variables such as hired labour, family labour, fertiliser, seeds, pesticide, area cultivated, and income from other crop are significant to determine the output production. He has further discovered that Chinese farmers are more effective compared to Malay farmers.

[10] For further information please refer to Earl O. Heady, (1950), "Application of Recent Economic Theory in Agricultural Production"

After 1974, the production function studies in Malaysia has further grown. Apart from variables such as labour, capital, land, and machine (Othman & Jusoh, 2001; Nazirudin, 2002; Nordiana & Mook, 2009), some new variables were added, such as real money balance. Habibullah (1988) found that real money balance is a significant factor that determines paddy production in Malaysia. Meanwhile, Baharumshah (1989) and Idris et al., (2012) found that technology is also significant in Malaysia's paddy production. Meanwhile, Darham, Noh, Farhana, & Idris (2009) found that lagged paddy planted area, lagged dependent variable, lagged paddy domestic, lagged price, lagged paddy yield, and government support are significant for Malaysia's case.

Studies from a number of Asia countries have also enhanced the literature of production function in paddy sub-sector. To explore various economic issues in paddy production, numerous researchers have used various forms and types of production function. Jayaraman (1983) employed a time-series data from 1972 to 1981 in Indonesia. He discovered that all eight variables that he has employed in his analysis are significant to have determined paddy production in Indonesia. A study by Sachchamarga & Williams (2004) in Thailand found that planted areas, average rainfall, and expected price are significant and have a right sign. Meanwhile, a study by Wan, Griffiths & Anderson (1992) established that organic and chemical fertilisers, sown areas, and irrigation cost are significant variables in determining the paddy production in China. In addition, there are also a number of studies that were carried out in some Asian countries, such as the studies conducted by Tiongco & Dawe (2002) in Philippines, Kwon & Lee (2004) in Korea, Baikuntha & Jeetendra (2006) and Bhujel & Ghimire (2006) in Nepal, Revilla-Molina et al., (2008) in China, Basavaraja, Mahajanashetti & Sivanagaraju (2008) in

Table 3.1

Paddy Production Functions Studies: Selected Evidence

Author/Year	Sample Period /Country	Estimation Method / Data set	Variables	Findings/Conclusion
Rao V.Y. & Heady E.O. (1969)	1969 India	Cross-Sectional	Land, Labour, and Fertiliser	Fertiliser - substitute to labour. The use of efficient fertiliser can reduce a dependency on land and labour
Ismail, A.H. (1972)	1966/1967 Malaysia	Unpublished Survey Data Cobb Dougles- Translog	Labour, Land, and Fertiliser	four areas of study Land is significant in all areas Labour and fertiliser are significant in North Malacca
Huang, Y. (1974)	1966 Malaysia	Survey	Hired labour, Family labour, fertiliser, Seeds, Pesticide, Cultivated Area, Other Income from Other Crop	All variables are significant Chinese farmers are more effective compared to Malay farmers
Masakatsu Akinoh & Yujiro Hayami (1974)	Multi-years Malaysia	Cross-Regional Estimation Aggregate Production Function Cobb Douglas's Log Linear OLS	Capital, Labour, Paddy Field in Units, Fertiliser, Research and Extension, Rural Education, and Dummy Region	In a long-run, agricultural growth is explained by the land, labour, capital, fertiliser, rural education, and increase in research
Fujimoto, A. (1976)	May 1973 – August 1974 Malaysia	Personal Interview with All Farmers Engaged with Double Cropping OLS Cobb Douglas's Production Function	Total Family Labour, Cultivated Land, Total Material Inputs (Seeds, Pesticide and Fertiliser), Farmers' Ability Index (Educational Experience and Knowledge) Damaged Rice Acreage	Only farmers' ability is not significant

T.K. Jayaraman (1983)	1972-1981 Indonesia	Time Series Two Stage LS	Fertiliser, Rainfall, Ratio of Paddy Support, price to Fertiliser, Ratio of Rice to Secondary Food Crops, Harvested Area, Net Irrigable Areas under Devoted Paddy Cultivation	It used too small sample size. The output will not be reliable or questionable. The t value for small sample 2SLS is not reliable but the output showed all the sign coffections. Same as what the theory said. For him, all 8 variables can be used to determine the paddy production in Indonesia
Habibullah, M.S. (1988)	1987 Malaysia	Cobb Douglas and Translog Model OLS	Labour, Area Planted, and Real Money Balance	All variables are significant Real money balance plays a significant role in production function.
Baharumshah, A.Z. (1989)	1960-1987 Malaysia	Time Series OLS	Malaysia's Production of Rice, Guaranteed Minimum Price for Producers, Malaysia's Rice Production, Time Trend (technological change) and Price of Natural Rubber (dummy variable)	Dummy and lagged dependent variables are significant at 1% Time trend (techno) is significant at 5% Minimum price guaranteed is not significant
G.H. Wan, W.E. Griffiths & J.R. Anderson (1992)	1980 – 1983 China	Panel Data (Seemingly Unrelated Production Function)	Organic Fertiliser, Chemical fertiliser, Sown Area, and Irrigation Cost	This study estimated the risk effect All variables are significant
Baharumshah, A. Z. (1993)	1960 – 1987 Malaysia	Seemingly Unrelated Regression (SUR) The empirical model consists of four behavioural equations -	Endogenous variables: Malaysian production of rice Domestic demand for rice Malaysian net import of rice. Malaysian stocks of rice.	Presence of significant price effects for rice. Income elasticities obtained from the present study are negative for rice indicated rice is inferior good

		a domestic supply equation, a domestic demand for rice, a domestic demand for wheat and an import equation	Exogenous variables: Guaranteed minimum price for producer. Price of natural rubber Time trend (technological change) Malaysian per-capita income World price of rice Domestic retail price of rice	
Ephraim W Chirwa & Welbon M.K. Mwafongo (1998)	1998	Survey Technical Efficiencies (Used -CD Stochastic Frontier Approach)	Value of Implements, Total Family Labor, Land Holding, Fertilizer and Pesticides	This study used two approaches. The first one used stochastic CD and the second one used socio-macroeconomic characteristics of farmers – All the variables are significant
Viveka P. Kudaligama & John F.Yanagida (2000)	1960, 1970 and 1980 Used Hayami-Rutan's data with some modification	Pool Data OLS Meta Production Function Frontier Production Function	Machinery, Labour, Fertiliser, Livestock and Technical Eeducation	Labour becomes a larger contributor
I.M Revilla-Molina, L. Bastiaans, H. van Keulen, T.W. Mew, Y.Y. Zhua & R.A. Villano	July and October 2000	Cobb-Douglas from Stochastic Frontier Function	Labour, Amount of Fertilizer, Glutinous and Hybrid Seeds, Amount of Pesticides and Dummy (adoption of rice inter-planting)	Used three models Labour and pesticides are not significant
Othman, J. & Jusoh, M.	1960-1996 Malaysia	Time Series OLS- Cobb Douglas	Capital, Labour, and Land	Labour is not significant Capital elasticity is high

(2001)				Land and labour elasticity decline
Baikuntha Aryal & jeetendra Parkash Aryal	1974 – 2001 Nepal	Panel Data Fixed Effect Random Effect	Labour, Fertiliser, Seeds, Irrigation, Credit, and Dummy Region	Test fixed and random effect by using liner and log liner productions. The problems with this study is that the researcher did not test the best model
Abdullah, N. (2002)	1980-1990 Malaysia	Time Series Translog Cost Function	Capital, Labour, Land, and Machinery	This researcher is related to the changing in technology substitution factor for rice-sub sector in Malaysia All the variables are significant In this research, the author used cost function
Shane M. Sherlund, Christopher B. Barrett & Akinwumi A. Adesina (2002)	1993 – 1995	Plot-Level Panel Data Production Frontier	Annual Tractor, Adult Family Labor, Adult Hired Labour, Child Labour, Land, Soil Fertility, Fertiliser, Pesticide, Weed, Rainfall, and Rain Day	Significant – pest, weed, rain fall, rain day, labor (This paper investigated the efficiency)
Marites Tiongco & David Dawe (2002)	1979,82,86,90, 94 (CL) 1978, 81,84,87,90,95 (L)	Farm Level Panel Data OLS	Tractor, Labour, Area planted, Nitrogen, Seeds, Irrigation, and Dummy year	This paper studied TFP and they found that fertiliser, irrigation, seeds, pesticide and area planted are significant at 1%. Labour is significant at 5%
Kwon, O.S & Hyunok, L. (2004)	1993-1997 Korea	Panel Data Parametric and Non-Parametric	Land, Labour, Capital, Fertilizer, Pesticide and Others	

Kwinarajit Sachchomarga & Gary W. Williams (2004)	1971-1999 Thailand	Time Series Data OLS	Planted Areas, Average Rainfall and Expected Price	Normal price model has right sign and significant
Amaza P.S. & Maurice (2005)	Nov 2002 – Jun 2003 Negeria	Cross-Sectional -CD Stochastic Production Function	Land, Amount Spent on Fertiliser, Family Labour, Hired Labour, Amount Spent on Seeds, Amount Spent on Agro-Chemical and Irrigation	All variables are significant except family labour and amount spent on agro-chemical
Reddy, G.P. (2005)	2003-2004 India	Cross-Sectional Cob Douglas	Expenditure on Labour, Area under the Crop, Expenditure on Fertiliser and Expenditure on Seeds	This research focused on water management
Ram B. Bhujel & Surya P. Ghimire (2006)		Survey Cobb-Douglas's Production Function	Tractor Hours, Man Day Labor Day Nitrogen, Phosphorous, Potash Area and Irrigation	Manpower and labour day are not significant
A.A. Tijani (2006)	2002/2003 Nigeria	Cross-Sectional Stochastic Frontier Model	Man Day, Farm size, Fertiliser, Farmer's Specific Characteristics,	Labour is not significant
Elsamma Job (2006)		Survey Technical Efficiencies (Used –CD Stochastic Frontier Approach)	Man Day Per-Hectare, Chemical Fertilizer and Plan Protection Cost	All variables are significant
A Suresh & T.H. Keshava Reddy (2006)	India	Cross-Sectional OLS Cobb Douglas	Cost of Human Labour, Cost of Chemical Fertiliser, Area, Value of Seeds, Tractor Charge Cost of Farm, Cost of Plant Protection, Amount of Water	Only area, human labour, fertiliser and dummy for supplementary are significant

			Applied, Dummy of Water Stress, and Dummy of Availability of Supplementary Irrigation	
Oladeebo, J.O. & A.A. Fajuyibe (2007)	2002/2003 Nigeria	Cross-Sectional Survey OLS CD Frontier Production Function (FPF)	Family Labour, Hired Labour, Firm Size, Quantity of Fertiliser, Seeds, Agro Chemical, and Age of Farmers	This paper focused on technical efficiency between men and women in Nigeria
I.C. Idoing, E. Christian Onyenweaku, B. Susan Ohen & I. Damian Agon (2007)	June 2004 – January 2005 Nigeria	Survey OLS Stochastic Frontier Production Functions	Capital, Labour, Farm Size, Fertiliser, and Seeds	All variables are statistically significant
Moses, J. & Adebayo, E.F. (2007)		Survey	Man Day, Farm Size, Fertiliser, Seeds, Herbicides, Age of Farmers, and Experience	All the fi carried positive, significant values except experience
Goni, M., Mohammed, S. & Baba, B.A. (2007)	2005 Nigeria	Cross Sectional Data Double Log Semi Log Exponential Liner	Labour, Firm Size, Fertiliser, and Seed	Farmers are technically inefficient
Idris, N., Shamsudin, M. N., Arshad, F. M., & Farha, E. (2012).	1980 – 2009 Malaysia	The time-series data	Paddy yield Rice production Border price Paddy farm price Paddy area planted Apparent rice demand Paddy Guaranteed Minimum	Fertilizer and technology are important determinants in estimating paddy yield

			Price Price support to producers Time trend (Technology) Fertilizer Per capita consumption of rice Import of rice Domestic retail price Domestic retail price of wheat Population Gross national income per capita	
H. Basavaraja, S.B. Mahajanasheeti & P. Sivanagaraju (2008)	2005/2006 India	Cross-Sectional Multi Stage Sample Design	Man Day, Fertiliser, Seeds, Farm Yard Manure, Plant Protection Chemicals, and Miscellaneous Expenditure	They tested 2 models – traditional and SRI models
M.O. Oniah, O.O. Kuye & I.C. Idiong (2008)	2004 Nigeria	Cross-Sectional OLS Employed Functional Forms 1.Exponential 2.Double Log 3.Semi-Log	Capital Man Day, Fertiliser, Farm Size, and Seeds	Only capital is not significant
Nordiana Ibrahim & Low Seng Mook (2009)	June-September 2008 Malaysia	Cross-Sectional ANOVA	Gender, Age Group, Years Of Experience, Education Level, Fertiliser, Field Condition (Irrigation, Drainage), Cost Of Production, Perception as Business and Perceived Future	All variables are significant

Yeong-Sheng, Tey (John), Darham, Suryani, Mohd Noh, Aswani Farhana & Idris, Nurjihan, (2009)	2008 Malaysia	Time Series ADF Normal Regression	Lagged Paddy Planted Area, Lagged Dependent Variable, Lagged Domestic Paddy Price, Lagged Paddy Yield, and Government Support	All variables are significant
YuYu Tun & Hye-Jung Kang, (2015)	December, 2012 Myanmar	Cross sectional data Stochastic frontier production function	Age of the farm household head, Educational level, Off-farm income dummy, Labor ratio, Mechanical tools used in farming operations	Farm mechanical tools significantly improve the Myanmar rice production efficiency.

India and Tun & Kang, (2015). The results of their studies showed that there are many factors that affect the paddy production despite land, capital, labour, fertilisers, seeds, pesticides, irrigation, climate, and rainfall.

Further discussion examines a number of related researches in selected African countries such as Malawi, Nigeria, and Cote d'Ivoire. Researchers such as Chirwa & Mwafongo (1998), Sherlund, Barret & Adesina (2002), Amaza & Maurice (2005), Tijani (2006), Oladeebo & Fajuyigbe (2007), Idoing, Onyenweaku, Ohen & Agom (2007), Moses & Adebayo (2007), Goni, Mohammed & Baba (2007) and Oniah, Kuye & Idiong (2008) have discovered that there are many factors that affect paddy production in Africa such as fertilisers, seeds, pesticides, irrigation, climate, and rainfall.

From the above discussion, it appears that there are many factors that affect paddy production. However, there are a few dominant factors that should be included in any paddy production studies such as labour, land, and capital. Bias estimation occurs if the researcher excluded one of these factors in their analysis (Echevarria, 1998). However, for some analyses especially in manufacturing and service sectors, some variables can be excluded such as land. The rationale behind this is that the contribution of land may be small to the overall production. Therefore, many researchers believed that it is possible to include land in the capital variable. However, in the agricultural sector, land and capital are complimentary inputs.

There are a few researchers that used these three variables in their studies, for instance, Chirwa & Mwafongo (1998), Echevarria (1998), and Kristensen (1999). All of them have used a different type of data set in their empirical estimates. For example, Ephrain and Welbon have used a cross-sectional data in Malawi. Meanwhile, Echevarria has used time-series data on Canadian, and Kristensen has used a panel data on Danish, Denmark. These three studies have produced almost the same results. They have discovered that all three exogenous variables are significant. This means that all these three variables are playing a vital role in the agricultural production.

There are numerous studies that have used more than these three key variables intensively. Variables are frequently used mutually with the three main variables. Among them are fertilisers, seeds, pesticides, irrigation, climate, and rainfall (Deolalikar & Vijverberg, 1987; Widawsky, Rozelle, Jin, & Hung, 1998; Carrasco-Tauber & Moffitt, 1992; Fulginiti & Perrin, 1998; Gerdin, 2002). As time changes, the methodology also changes. Therefore, numerous methodologies were used to produce different results. Indirectly, these helped to enrich the existing production-function literature.

3.8 Productivity and Efficiency in Agricultural Production

The concept of productivity has been widely used in the agricultural studies. Agricultural productivity measures the firms' performance and provides a guide to the efficiency of the sector (Kirsten & Vink, 2003; Thirtle, Piesse & Gouse, 2005; Conradie, Piesse, & Thirtle, 2009). Increased productivity may indirectly increase the effectiveness of the input used. Technically, productivity is a ratio of output to input. Usually, the same amount of the input may increase the total output. This means that operating costs, particularly cost of production, can be decreased. This would increase income of farmers.

Among the earliest studies on the agricultural productivity was a study which was conducted by Hayami & Ruttan (1970). They have believed that the growth of agricultural productivity may help an economy to meet the demand of food and raw materials. On top of that, many researchers have believed that productivity is one of the basic variables that drive economic activity (Stefan, 2002). In addition, productivity concept is also related to the creation of added value in the production process. Basically, the high level of productivity may create high value-added products as well as reducing the wastage of resources.

Numerous researchers have agreed that the total factor productivity or TFP occurs with the advancement of technology used in production system (Katz, 1969; Ismail, 2000). According to Katz (1969), advanced technology may contribute to the growth of output and labour. Hence, technology becomes a key determinant for labour productivity. In the meantime, the capital-labour ratio can also be used to demonstrate the level of productivity. This ratio is typically used as a variable to proxy the level of technology. As the capital-labour ratio increases, the level of technology also increased. From this evidence, therefore, we could say that the technological advancement has a close link with the capital input. Generally, if the firm is a capital-intensive, it may create a high productivity level in its production. The above statement has been proven true by Yokoyama (1991). In his study, Yokoyama (1991) discovered that the capital-intensive firm has a higher level of technology compared to the labour-intensive firm.

Increasing productivity not only reflects to the increased level of technology but it also involves the use of input quality that has been identified as another factor that influences the productivity level. If the quality input increases, the same amount of input can produce more outputs. Therefore, the cost of production can be reduced. Meanwhile, other factors such as change in socio-demographic, human resource development, human resource management, institutional restructuring, work and working convenience, socio-economic, and socio-political may also affect the level of productivity.

Every process of the economic transformation involves labour, capital, material and energy as the inputs of production. Basically, the transformation process may produce more than one output either intermediate or end product. The agricultural sector is also not spared from this process of transformation. Every single transformation involves the change in productivity level. This indicates that the combination of inputs may influence a different level of productivity. Fundamentally, a change in productivity level can be measured by two approaches; partial productivity and total factor productivity (TFP). For a single input, a productivity notion is (Y/L). This notion may not cause any problems in measuring the productivity level. In the meantime, the ratio of output to input is called a partial productivity. However, if a combination of various inputs is used in the process of agricultural production, then, there is the question of how each affects the productivity on its own and in relation to other inputs. Thus, to overcome this problem, the total factor productivity (TFP) is used (Amir, 1975; Sabir & Ahmed, 2003).

TPF is a neo-classical concept. There are two main functions of TFP. Firstly, it is used to measure the productivity of all factors. Secondly, TFP is used to associate with the aggregate production function. The standard form of the total ratio index arithmetic productivity is as follows:

$$A = \frac{Y}{\alpha L + \beta K} \tag{3.25}$$

where A is the index of productivity that shows the efficiency of production inputs used. Y, L and K are output, labour, and capital respectively while α and β are the weights. To solve the problem of determining the weights, the ratio of productivity is associated with the aggregate production function used. The relationship allows the weight to be taken and interpreted. The aggregate production function can be written as follows:

$$Y_t = F(K_t, L_t, t) \tag{3.26}$$

The equation above reflects the output, the stock of capital, labour employment, and shift factor (t), where t represents the productivity impact and technical progress. The subscript t also represents time. Assuming that the argument "t" is separated from the K and L, then:

$$Y_t = A_t F(K_t, L_t,) \tag{3.27}$$

then

$$A_t = \frac{Y_t}{F(K_t, L_t)} \tag{3.28}$$

where A_t is exogenous, and Hick-neutral disembodied technical progress. It is measured by how output is changed with time from the constant inputs (Felipe, 2007).

Another important concept that emerges from the above equation is the efficiency concept. The efficiency measurement has been discussed long time ago. It can be generally expressed in terms of elasticity of production, which can be expressed as below:

$$e = \frac{Percentage\ change\ in\ the\ production\ or\ output}{Percentage\ increase\ of\ the\ factor\ of\ production\ or\ input} \tag{3.29}$$

$$e = \frac{\Delta Y}{Y} \Big/ \frac{\Delta X}{X}$$

(3.30)

where Y and X are the units of output and units of input respectively. According to Amir (1975), there is a direct relationship between the elasticity of production and marginal productivity of resources. Based on the definition, marginal product has increased despite small change in total output.

$$e = \Delta Y / \Delta X$$

(3.31)

where Δ is the change of output and input units.

According to the earlier definition, the elasticity of production can be calculated as below:

$$e = \frac{\%\ change\ in\ output\ (Y)}{\%\ change\ in\ input\ (X)}$$

$$= \frac{\Delta Y/Y}{\Delta X/X}$$

$$= \frac{\Delta Y}{Y} \cdot \frac{X}{\Delta X}$$

$$= \frac{\Delta Y}{\Delta X} \cdot \frac{X}{Y}$$

(3.32)

This indicates that the elasticity of production is simply the marginal product $\frac{\Delta Y}{\Delta X}$ which multiplied by the ratio of the total input to the total product.

Marginal product can be derived from the elasticity of production or scale coefficient as follows:

$$Marginal\, product = \frac{\Delta Y}{\Delta X} = e\frac{Y}{X}$$

(3.33)

There are some good input-output relationships. The coefficient of determination is the elasticity of production. It can be used to indicate the return to scale. In addition, it can also be used to calculate the marginal productivity of inputs.

Subsequently, to show the relationship between efficiency and productivity, Stefan (2002) developed a Triple P-Model Productivity (Figure 3.0), which integrated five terms; productivity, profitability, performance, effectiveness, and efficiency. This model also portrayed how the five terms are related to each other.

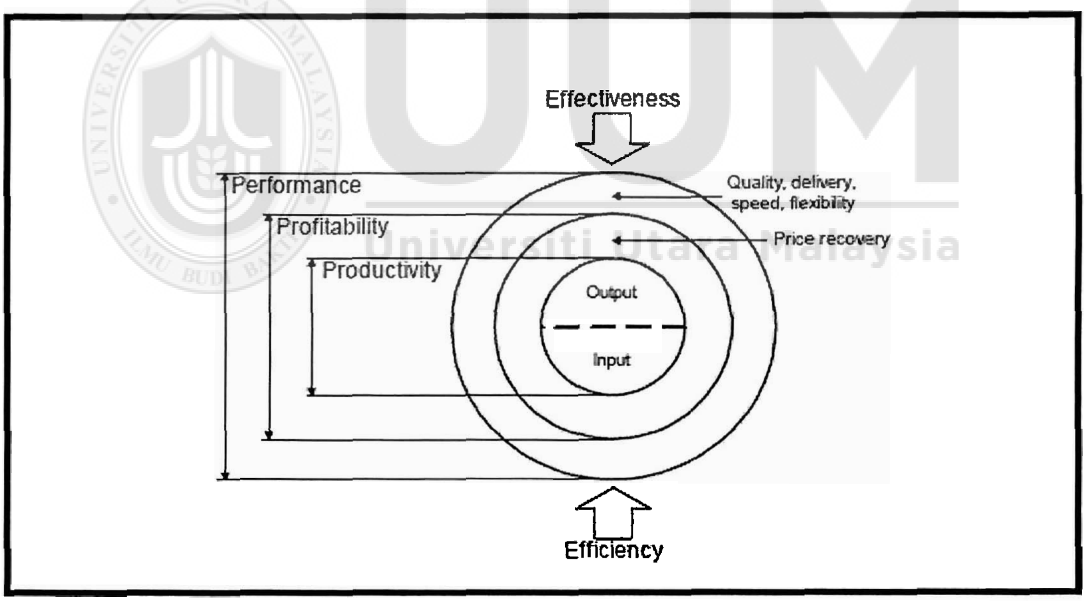

Figure 3.0
The Triple P-Model Productivity
Source: Stefan, 2002.

This model began with productivity terms. It became a main part in this model. Being located at the central of the Triple-P-Model is the productivity of inputs. It has a straightforward operational definition as an output-input ratio. If the ratio is high, it represents high productivity level and vice versa. The next term is profitability which is still related with the output and input price relationship. This time, the relationship is influenced by the price factor (i.e. price recovery). Basically, when the price input is low, then the cost of production is also low. Therefore, the profit of the farm may increase. Besides, profit also becomes one of the farm-performance measurements. If the farm can maintain the profit at all time, this means that the farm performance is excellent. According to Tangent, the performance plays a vital catalyst for the firms to achieve high level of excellence. In addition, a good performance may help the firms to maximise profit and non-cost factors such as quality, speed, delivery, and flexibility. Meanwhile, effectiveness is a term used when the involvement of the process to fabricate output is efficient. The farm is said to be effective when it has achieved its production targets. Meanwhile, the efficiency represents how well the input of the resources is utilised.

3.9 Productivity Issues in Malaysia Paddy Sub-sector

Malaysia has to improve the level of paddy productivity if it wants to achieve high SSL. This is because a high level of productivity requires efficient resource allocation. Khusro (1964) stated that marginal productivity can be used to emphasise the resources allocation efficiency. Through the marginal productivity concept, we can establish the output maximisation of a farming system. Resources are said to be efficiently used if the marginal cost equals to marginal revenue (MC=MR).

Nevertheless, the increase in productivity occurs when the output increases, given the same other inputs. The increase of productivity may occur due to improvements in technical efficiency of input used or may be due to technological innovation (Fulginiti &

Perrin, 1993). However, productivity measurement is extremely important to all fields including paddy cultivation. This is important especially for farmers in order to identify their level of efficiency and production sustainability.

Given a fixed land area, the increase in paddy productivity is essential to ensure that food security and country basic self-sufficiency are attained. However, the Malaysia's paddy production is not cost-competitive compared to the neighbouring countries such as Myanmar and Thailand. In Malaysia, the cost of paddy production is approximately RM1,350 per ton compared to the cost of paddy production in Thailand, which is only RM 760 per ton (Najim et al., 2007). Furthermore, the equatorial climate that is experienced by Malaysia, to some extent, affects the country's total paddy production (Lai, Ahmad & Zaki, 1996). One of the characteristics of the equatorial climate is short daylight. This has therefore restricted the amount of the aggregate yield of paddy production. In addition, Malaysia also does not have fertile soil sediment like delta soil in Myanmar and Thailand (Kawaguchi & Kyuma, 1974).

Average paddy production in major production area is roughly lower than the potential yield (Othman, 2008). From 1950s to 1960s, most of the paddy-growing areas have recorded a low production capacity for about 1 to 2 tonnes per hectare. Nonetheless, in 1970s, the paddy production has increased about 2.5 tonnes per hectare. This increment is more than some traditional rice-exporting countries like Thailand and Myanmar. This performance is due to the large-scale investment in an irrigation project in the country. This large-scale investment in irrigation was also called blue revolution as opposed to green revolution (Palmer, 1976).

Nevertheless, paddy production in Malaysia has faced a new development era. Quality seeds and modern cultivation techniques were introduced to boost up this sub-sector. Consequently, the total production of paddy sub-sector increased from 15 to 100 per cent in granary areas. However, the increment in granary and non-granary areas did not achieve the potential yield that was targeted by the government (Othman, 2008).

In addition, paddy sub-sector has also faced the problems of poor management practices. These problems often became an obstacle for many paddy farmers in Malaysia. This is because most of them are small-scale farmers who work in less than two hectares of a paddy field. Additionally, most of the Malaysian paddy farmers are old and have a low education level. Therefore, the level of technological absorption, transformation of knowledge, and cultivation techniques are relatively sluggish. There are a lot of the government-supported programmes that were designed for them. However, the productivity level per farmer still stays low. This is especially farmers who operate outside the granary areas.

3.10 Elasticity of Substitution between Labour and Capital

In economic theory, it is essential to examine the substitution between capital and labour employed. To measure the substitution between labour and capital, we may employ the elasticity of substitution approach. This approach was the original work of Hicks in 1932 (Stern, 2011; Chirinko & Mallick, 2011). The elasticity of substitution between capital and labour can be defined as:

$$ES_{KL} = \frac{dln(k/n)}{dln(MPL/MPK)} \qquad (3.34)$$

The elasticity of substitution is the basic tool to measure the substitution between capital and labour. The elasticity of substitution is used to estimate the amount of labour input to be replaced by capital input without increasing or decreasing the output (Vengedsalam, Karunagaran, & Rohana, 2008). When the value is large, the firms can easily substitute between capital and labour. Geometrically, it measures the curvature of the isoquant. In general, the elasticity of substitution depends on the amount of capital and labour employed. According to Paterson (2012), the elasticity of substitution plays an important role in economic policy, particularly involving the substitution between capital and labour. There is a range of possible production functions that can be used to measure elasticity substitution such as Cobb-Douglas's, Leontief's function, and Constant Elasticity Substitution (CES).

3.11 Elasticity of Substitution between Different Group Age of Farmers

The effects of changes in population structure have attracted many agricultural economics scholars. Changes in age structure of farmers may have an impact on the effectiveness, the level of productivity, and the profitability of farming activities (Dlova, Fraser, & Belete, 2004). Scholars have grouped the age groups into categories such as young and old farmers. However, Amanda (1997) categorised labours into more specific grouped such as young adults (18-35) middle-aged adults (35-54) young old (55-66) and older adults (65 and above). Basically, young adults' groups are more energetic compared to the old groups. In the developed or developing countries, the young people rather prefer to migrate to the urban areas while the elderly live in countryside.

Similar to many other countries, Malaysia is also facing dramatic changes in populations' structure, especially in the agricultural sector. Many young adults have migrated to the urban areas because of lucrative jobs earnings. In addition, the educational attainment also becomes a key factor that is conducive for the youths to migrate to the cities. Therefore, the traditional sector such as paddy sub-sector was abandoned and the farm was undertaken by the elderly farmers (Abdullah, 2007). Despite that, there are also young and middle-aged farmers who still cultivate paddy in Malaysia. However, the percentages of young and old farmers are not balanced. According to Zarinah (2011), the proportion of elderly workers in Malaysia has increased from 2.8 per cent in 1957 to 4.7 per cent in 2010. This phenomenon also reflects the farmers' age structure in the granary areas. For instance, there are approximately more than 60 per cent of the active farmers are elderly farmers in MADA's granary areas with their age ranging from 50 to 75 years old and above (MADA, 2009).

The issue is to determine the substitutability rates between farmers at different age groups. According to Hamermesh (2001), there are numerous studies that ignored all the issues of substitution between age groups of farmers. These studies presumed that the degree of substitution of all farmers' age groups is the same and treated them as homogeneous inputs. However, Hamermesh (1993) noted that the view that the different age groups are homogenous is unrealistic. Additionally, he believed that the more similar are the skills of two age groups of farmers, the greater the degree of the substitution between them. This indicates that different age groups are substitute inputs in the production system. If the elasticity of substitution between age groups with respect to homogeneous skill is less than infinite, which is not perfectly elastic, then the impact of age groups on the production rate may differ across the various age groups of workers (Mérette, 2007).

In his writing, Hamermesh (2001) again highlighted the issues of the elasticity of substitution between different age groups of farmers. He stressed that the different age groups of farmers are the substitutes in the production systems. However, he indicated that there is a substantial imperfect substitution between different age groups of farmers. Other scholars such as Card & Lemieux (2001) discovered that the elasticity of substitution between different age groups in the U.S. and the U.K. are imperfect. The value of elasticity of substitution is larger, which is about 4-5 range. This means that if the young and older workers are in the same skill group, additional young workers may reduce contributions by older workers.

However, in practice, a variety of circumstances should be taken into consideration in measuring the elasticity of substitution between age groups of farmers such as level of education, experience, and skills. If these factors are ignored, then the results produced may be inaccurate. Wasmer (2001) conducted a research and incorporated all the elements above in his empirical study. He has discovered that, when the above elements were added, the elasticity of substitution value becomes inelastic. Therefore, Wasmer's (2001) study supported the findings of other researchers. He has also noted that the different age groups of farmers are not perfect substitutes.

From the previous empirical findings, we can conclude that the elasticity of substitution for different age groups does not reflect the perfect substitution. Whether labour with different age groups is assumed homogeneous or not, the value of the elasticity varies and is lower than infinity values. This indicates that the different age groups responded differently to the production process. The lower the elasticity of substitution reflects that one age group is difficult to be replaced by another group.

CHAPTER 4

METHODOLOGY

4.0 Introduction

The previous chapter provides an inclusive review of the literature about the development of several propositions and hypotheses. This chapter provides an overview of the research methodology applied in testing propositions and hypotheses. Section 4.1 is a discussion about the Malaysia's paddy production framework. Section 4.2 starts the discussion about the model specification. Under Section 4.2, we briefly discuss the Cobb-Douglas's and CES production functions. Meanwhile, in Section 4.3, measurement of total factor productivity is discussed. Data Description and Data Gathering are discussed in sections 4.4 and 4.5. Method of analysis is discussed in Section 4.6.

4.1 Malaysia's Paddy Production Framework

A Malaysia's paddy production system framework is shown in Figure 2.1. The framework contains four main categories, which are input, farmer, paddy production, and international trade. The international sector is the complementary part that completes the rice supply and rice demand circles.

The framework is presented to distinguish the process of input transformation. Basically, the input of paddy production can be divided into four main categories, which are technical, economic, socio-economic, and public policies. The process of input transformation may generate partial productivity and total factor productivity (TFP).

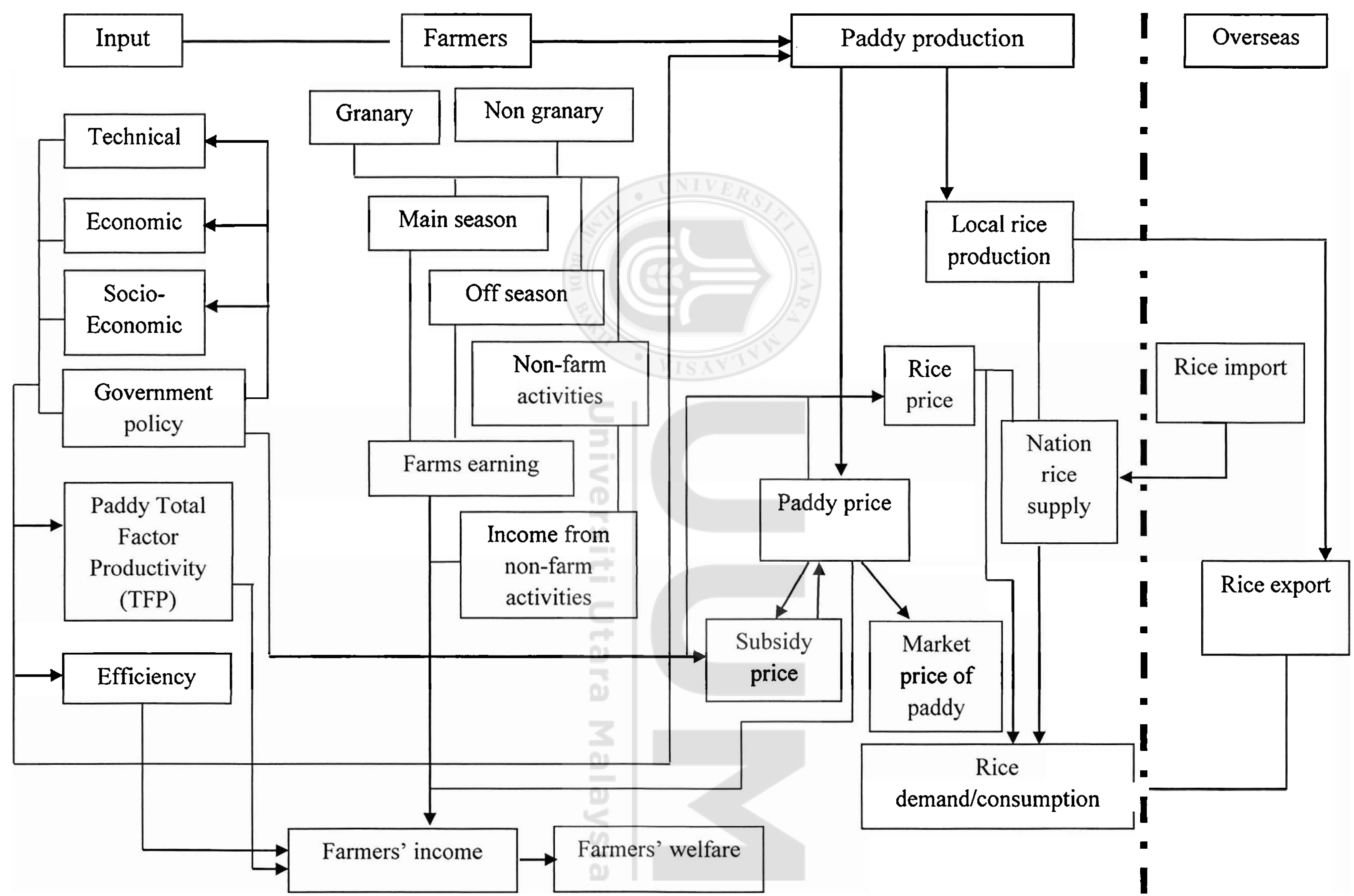

Figure 4.0

Malaysia's Paddy Production System Framework

High level of TFP may be contributing to the increase of farmers' total production and income. Meanwhile, a combination of input production may generate the elasticity of production. Elasticity can be used to measure the farmers' efficiency level. When the combination of input is efficient, it means that the farmers have utilised all the inputs effectively. Hence, the farmers can produce a higher volume of production for the same lands, thus, increase their incomes.

About 30 per cent of the Malaysia's domestic rice supply has been sustained by the rice import. Paddy price is controlled by the government through Guaranteed Minimum Price (GMP). Under the GMP, the government offers a subsidy. Furthermore, to ensure that the consumers of rice can afford this staple, a subsidy is initiated. The government also controls the price of local rice in the market.

The transformation of input to output involves a complex process. However, the final goal from this process is to attain a high level of income among farmers. This is because, if farmers' income is low, they may switch to non-farm activities and abandon their rice-growing activities. This may affect the country's future rice supply. Consequently, consumers may have to pay higher prices for rice that they purchase in the local market.

4.2 Model Specification

The previous chapter shows that many functional forms and approaches can be used to estimate production function and productivity. In this chapter, there are two sections that describe the methodology used to estimate production function and productivity. The first section is Cobb-Douglas's production function and CES production function.

4.2.1 Cobb Douglas Production Function

The relationship between production inputs and paddy yield output can be explained by using the following Cobb-Douglas's production function:

$$Y = AL^{\beta_1}K^{\beta_2}e^{\mu} \tag{4.1}$$

where, Y is paddy yield, L is labour, K is capital that influences the paddy yield, μ is a stochastic disturbance term. β_1 and β_2 are the elasticity of output with respect to the two inputs of production labour and capital respectively.

From the above equation, it is clear that the relationship between output and inputs of production is nonlinear. Thus, in order to run the analysis, we then transformed this model into natural log.

$$lnY = lnA + \beta_1 lnL + \beta_2 lnK + \mu \tag{4.2}$$

Based on Equation 4.2, we could calculate the values of marginal product.

For the purpose of the empirical analysis, the researcher then employed Equation 4.3. The choice of suitable functional form for this analysis is subjected to define as follows:

$$Y_{it} = A\, LN_{1t}{}^{\beta 1} LK_{2t}{}^{\beta 2} LL40_{3t}{}^{\beta 3} LL41^{\beta 4} LF_{5t}{}^{\beta 5} LP_{6t}{}^{\beta 6} e^{\mu} \tag{4.3}$$

where

Y_t = Average output or paddy output

LN_{1_t}= Land

LK_{2_t} = Capital

$LL40_{3_t}$ = Young Farmers

$LL41_{4_t}$ = Old Farmers

LF_{5_t} = Fertiliser

LP_{6_t} = Paddy Price

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$, and β_6 are the parameters.

After the transformation of the function by using double log, the following model can be derived:

$$lnY_t = lnA + \beta_1 lnLN_{1t} + \beta_2 lnLK_{2t} + +\beta_3 lnLL40_{3t} + \beta_4 lnLL41_{4t} + \beta_5 lnLF_{5t} + \beta_6 lnLP_{6t} + \mu_t \quad (4.4)$$

$$lnY_t = \beta_0 + lnA + \beta_1 lnLN_{1t} + \beta_2 lnLK_{2t} + +\beta_3 lnLL40_{3t} + \beta_4 lnLL41_{4t} + \beta_5 lnLF_{5t} + \beta_6 lnLP_{6t} + \mu_t \quad (4.5)$$

For further analysis, the researcher may apply the time-series data to estimate the paddy sub-sector production function.

4.2.1 Constant Elasticity of Substitution Production Function

We embark on by assuming that the aggregate production in all MADA regions can be represented by a constant return to scale. The constant return to scale of production function can be characterised by a Constant Elasticity of Substitution (CES) between the two factors. Under the CES assumptions, the change in relative factor inputs and prices do not alter the elasticity value, which is primarily determined by the underlying technology. Specifically, CES function also allows the measurement of changes in the efficiency of a technology, economics of scale, extent of capital intensity, and in the rate of substitution of factor input capital and labour. The advantage of this function is that it has one less restrictive assumption by allowing the elasticity to take values other than zero or one. In a sense, CES function is a generalisation of the Cobb-Douglas's function that allows for any non-negative constant elasticity of substitution (Henningsen & Henningsen, 2011). Arrow et al., (1961) showed that the assumption of a constant elasticity of substitution (CES) implies the following functional form for the production function:

$$Y_t = \gamma[\delta K_t^{-\rho} + (1-\delta)L_t^{-\rho}]^{-v/\rho}$$

$$(\gamma > 0, 1 > \delta > 0, v > 0, \rho \geq -1) \tag{4.6}$$

where:

Y_t= Average Yield

K_t= Capital

L_t = Labour

v = Returns to scale parameter

γ = Efficiency parameter

δ= Distribution parameter

ρ = Substitution parameter

Equation above can be expressed in the form of logarithm (ln) as follows:

$$lnY_t = \ln\gamma - v/\rho \ ln[\delta K_t^{-\rho} + (1-\delta)L_t^{-\rho}] + \varepsilon_t \tag{4.7}$$

The CES is a non-linear production function and, basically, we cannot straight away use the linear estimation analysis on this function. Therefore, to employ the linear estimation techniques on the CES function, we apply “Kmenta approximation” (Henningsen & Henningsen, 2011). Alternatively, it can be estimated by non-linear least-squares by using different optimisation algorithms, as follows:

$$lnY_t = ln\beta_1 + \beta_2 lnK_t + \beta_3 lnL_t + \beta_4 (lnK_t - lnL_t)^2 + \epsilon_t \tag{4.8}$$

Equation 4.8 estimated by using the Ordinary Leas Squares (OLS). According to Green (2003), the elasticity of substitution can be calculated by the following equation:

$$\sigma = \frac{1}{1 + \rho} \tag{4.9}$$

The elasticity of substitution (σ) is a measure of proportional change in the K / L relative to the proportional change in the rate of technical substitution along the isoquant curve (Nicholson, 2005). An important feature of the production is the existence of substitution between inputs such as labor and capital replacement.. Along the isoquant is assumed that the rate of technical substitution decreases when the ratio of K / L decreases.

To calculate the elasticity of substitution between young and old farmers, we employed the same function as Equations 4.6 to 4.8 above. We changed the notation of labour and capital to young and old farmers.

4.3 Total Factor Productivity (TFP)

TFP examined in this study is to determine the contribution to production by the specified variables such as labour, capital, land, fertiliser, and paddy price to the paddy production. The information about their contribution and rates of technical change are useful for all stakeholders in paddy production.

Below are some assumptions for the TFP measurement:

1. The production function exhibits constant returns to scale
2. The input market is in perfect competition. The factors of production are paid according to their marginal product and the elasticity of output with respect to inputs that equal to the value of input shares in output.

The development of Total Factors of Productivity measurement by using production function was pioneered by the works of a few authors such as Solow (1957), Denison (1967) and Jorgenson, Gollop & Fraumeni (1987). It assumes that for each production functions model exists a transcendental logarithms (translog) production function. Based on the assumption, the natural logarithmic production function of paddy in MADA areas is as follows:

$$lnY_t = lnA + \beta_1 lnLN_{1t} + \beta_2 lnLK_{2t} + +\beta_3 lnLL40_{3t} + \beta_4 lnLL41_{4t} + \beta_5 lnLF_{5t} + \beta_6 lnLP_{6t} + \mu_t \quad (4.10)$$

By total differentiating Equation 4.10 above, we obtained

$$dy_t = d\lambda_t + \frac{\partial Y_t}{\partial LN_{1_t}} \cdot \frac{LN_{1_t}}{Y_t} dln_{1_t} + \frac{\partial Y_t}{LKX_{2_t}} \cdot \frac{LK_{2_t}}{Y_t} dlk_{2_t} + \frac{\partial Y_t}{\partial LL40_{3_t}} \cdot \frac{LL40_{3_t}}{Y_t} dll40_{3_t}$$

$$+ \frac{\partial Y_t}{\partial LL41_{4_t}} \cdot \frac{LL41_{4_t}}{Y_t} dll41_{1_t} + \frac{\partial Y_t}{\partial LF_{5_t}} \cdot \frac{LF_{5_t}}{Y_t} dlf_{1_t} + \frac{\partial Y_t}{\partial LP_{6_t}} \cdot \frac{LP_{1_t}}{Y_t} dx_{lp}$$

(4.11)

where $y_t, ln_{1_t}, lk_{2_t}, ll40_{3_t}, ll41, lf_{5_t}$ and lp_{6_t} are the logarithms for $Y_t, LN_{1_t}, LK_{2_t}, LL40_{3_t}, LL41_{4_t}, LF_{5_t}$ and LP_{6_t}

$\frac{\partial Y_t}{\partial LN_{1_t}} \cdot \frac{LN_{1_t}}{Y_t}$ = input share of LN_{1_t} in total output

$\frac{\partial Y_t}{\partial LK_{2_t}} \cdot \frac{LK_{2_t}}{Y_t}$ = input share of LK_{2_t} in total output

$\frac{\partial Y_t}{\partial LL40_{3_t}} \cdot \frac{LL40_{3_t}}{Y_t}$ = input share of $LL40_{3_t}$ in total output

$\frac{\partial Y_t}{\partial LL41_{4_t}} \cdot \frac{LL41_{4_t}}{Y_t}$ = input share of $LL41_{4_t}$ in total output

$\frac{\partial Y_t}{\partial LF_{5_t}} \cdot \frac{LF_{5_t}}{Y_t}$ = input share of LF_{5_t} in total output

$\frac{\partial Y_t}{\partial LP_{6_t}} \cdot \frac{LP_{6_t}}{Y_t}$ = input share of LP_{6_t} in total output

dy_t= growth rate of output = d (log Y)

dln_{1_t} = growth rate of land = d (log LN_1)

dlk_{2_t} = growth rate of capital = d (log LK_2)

$dll40_{3_t}$ = growth rate of young farmers = d (log $LL40_3$)

$dll41_{4_t}$ = growth rate of old farmers= d (log $LL41_4$)

dlf_{5_t} = growth rate of fertiliser = d (log LF_5)

dlp_{6_t} = growth rate of paddy price = d (log LP_6)

$d\lambda_t = TFPG = d(logA)$

Equation 4.10 can be rewritten as:

$TFPG_t = d\lambda_t =$

$$= dy_t - \frac{\partial Y_t}{\partial LN_{1_t}} \cdot \frac{LN_{1_t}}{Y_t} dln_{1_t} - \frac{\partial Y_t}{\partial LK_{2_t}} \cdot \frac{LK_{2_t}}{Y_t} dlk_{2_t} - \frac{\partial Y_t}{\partial LL41_{3_t}}$$

$$\cdot \frac{LL40_{3_t}}{Y_t} dll40_{3_t} - \frac{\partial Y_t}{\partial LL41_{4_t}} \cdot \frac{LL41_{4_t}}{Y_t} dll41_{4_t} - \frac{\partial Y_t}{\partial LF_{5_t}} \cdot \frac{LF_{5t}}{Y_t} dlf_{5_t}$$

$$- \frac{\partial Y_t}{\partial LP_{6_t}} \cdot \frac{LP_{6_t}}{Y_t} dlp_{6_t}$$

(4.12)

The above method is based on a growth accounting approach. Output growth is attributed to both the two input growth and productivity growth. The latter is the unexplained portion of output growth, which was obtained as the residual of the output growth after the inputs growth were accounted. By using Equation 4.13 and applying it to paddy production, we have

$$dlnY_t = d\lambda_t + \frac{\partial Y_t}{\partial LN_{1_t}} \cdot \frac{LN_{1_t}}{Y_t} dln_{1_t} + \frac{\partial Y_t}{\partial LK_{2_t}} \cdot \frac{LK_{2_t}}{Y_t} dlk_{2_t} + \frac{\partial Y_t}{\partial LL41_{3_t}} \cdot \frac{LL40_{3_t}}{Y_t} dll40_{3_t}$$

$$+ \frac{\partial Y_t}{\partial LL41_{4_t}} \cdot \frac{LL41_{4_t}}{Y_t} dll41_{4_t} + \frac{\partial Y_t}{\partial LF_{5_t}} \cdot \frac{LF_{5t}}{Y_t} dlf_{5_t} + \frac{\partial Y_t}{\partial LP_{6_t}} \cdot \frac{LP_{6_t}}{Y_t} dlp_{6_t}$$

(4.13)

where Y is paddy output. $LN_{1_t}, LK_{2_t}, LL40_{3_t}, LL41_{4_t}, LF_{5_t}$ and LP_{6_t} are inputs (land, capital, young farmers, old farmers, land, fertiliser, and paddy price). $d\lambda_t$ is TFP growth (Changkid, 2006).

By using discrete points in time and the usual assumptions listed above which imply that income share of the respective input are equivalent to the respective output elasticity, Equation 4.29 can be expressed as follows (Solow, 1957; Dension 1967; Jorgenson et. al., 1987; Changkid, 2013).

$$TFP\ growth = (lnY_t - lnY_{t-1}) - LN_{1_t}\left(lnLN_{1_t} - lnLN_{1_{t-1}}\right) - LK_{2_t}\left(lnLK_{2_t} - lnLK_{2_{t-1}}\right) - LL40_{3_t}(lnLL40_{3_t} - lnLL40_{3_{t-1}}) - LL41_{4_t}(lnLL41_{4_t} - lnLL41_{4_{t-1}}) - LF_{5_t}(lnLF_{5_t} lnLF_{5_{t-1}}) - LLP_{6_t}(lnLP_{6_t} - lnLP_{6_{t-1}}) \quad (4.14)$$

Where LN_{1_t}= average share of land = $0.5(LN_{1_t} + LN_{1_{t-1}})$

LK_{2_t}= average share of capital = $0.5(LK_{2_t} + LK_{2_{t-1}})$

$LL40_{3_t}$= average share of young farmers= $0.5(LL40_{3_t} + LL40_{3_{t-1}})$

$LL41_{4_t}$= average share of old farmers = $0.5\left(LL41_{4_t} + LL41_{4_{t-1}}\right)$

LF_{5_t}= average share of fertiliser= $0.5\left(LF_{5_t} + LF_{5_{t-1}}\right)$

LP_{6_t}= average share of paddy price = $0.5\left(LP_{6_t} + LP_{6_{t-1}}\right)$

4.4 Selected Variables

In this section, we have highlighted several selected variables that influence the paddy production function in MADA areas. The discussion is based on the previous studies that were conducted by numerous researchers. Furthermore, all the following variables were chosen because of the accessibility of the data from the Muda Development Authority (MADA).

4.4.1. Capital

Capital is one of the most basic inputs in neo-classical production functions. It comprises raw materials and intermediate products. In various empirical studies, numerous researchers have found that capital is significant in determining the paddy production (Oniah et al., 2008; Shweta, Mahajanashetti, & Kerun, 2011; Idris et al., 2012). Kristensen (1999) discovered that the elasticity of production and return on capital for an agricultural sector are high. High elasticity and return to capital investment mean that a small change in capital may cause a high paddy yield. This proves that capital has a significant impact on agricultural production. Therefore, to increase the output, farmers should increase their capital investment such as buying or leasing a new physical capital product like a new machine.

Nevertheless, a study conducted by Chirwa & Mwafongo (1998) found that the contribution of marginal capital to output with ceteris paribus is low although it is significant. This indicates that the additional input increases but the output increases at diminishing rate. However, through the cross-sectional study by Idiong et al., (2007), they discovered that the capital and output relationship is positive. Conversely, they have found that capital does not affect the total production of paddy at all.

Meanwhile, for Malaysia's case, Habibullah (1988) determined that capital is an important input in the paddy production. According to Habibullah, the investment in agricultural capital is elastic. This means that an increase in paddy productivity is driven by the growth in capital employed. Othman & Jusoh (2001) discovered that the capital elasticity in a Malaysia's paddy sub-sector is inelastic, especially in the early 1970s. This happened after an economic transformation from agricultural-based to a manufacturing-and services-based in the mid-1980s. Manufacturing growth momentum has slowed down the agriculture growth. Therefore, many young workers have begun to migrate to the urban to work in factories and service sector compared to the agricultural sector. This condition has made the cultivation of paddy was left to the elderly who were not able to absorb new technology. Therefore, this situation has caused the low output produced by the Malaysia paddy sub-sector.

4.4.2 Land

Several studies have found that land and labour are significant and they had a right sign. In addition, there are also some researchers who considered capital input and lands as the substitutes. However, these cases may be true for manufacturing but not for the agricultural sector (Echevarria, 1998). Some researchers such as Akino & Hayami (1974), Jayaraman (1983), Sachchamarga & Williams (2004), Moses & Adebayo (2007), Oniah et al. (2008), and Balde, Kobayashi, Nohmi, Ishida, & Esham (2014) found that land has a significant impact on paddy production. However, the degree of elasticity is small. This means that the large increase in acreage paddy cultivation may lead to a small increase in output. Nevertheless, many researchers have yet to consider land as part of the agricultural production system. Therefore, it should be used as a variable in the empirical analysis. Failure to do so will result in biasness in empirical analysis. In addition, Suresh & Ready (2006) found that the allocative efficiency for land in India is 3.04. This shows that an increase in land creates the economies of scale and produces high productivity. In another study conducted by Sherlund et al., (2002), it was found that paddy output has a significant relationship with land in the Cote d `Ivoire.

Nevertheless, for Malaysia, Ismail (1972) has confirmed that land is very influential in determining paddy production. He has also discovered that land is significant and has a degree of elasticity more than 1. This shows that for the area that is less fertile, the use of fertilisers is required. He further stressed that if the land productivity growth is high, therefore, less fertiliser is required. In other studies, Othman & Jusoh (2001) also supported the finding obtained by Ismail (1972). However, this case is only true for the agricultural development in 1970s. This was attributed from the land development schemes that were undertaken by the government such irrigation scheme, granary areas, and land rehabilitation scheme. Othman & Jusoh (2001) also found that the contribution of land decreased around mid-1980s. This situation has been attributed from the rapid development in industrial and service sectors. During this transformation, a lot of agricultural land has converted to industrial, commercial uses, and the residential areas such as Bayan Lepas area which became Industrial Free Trade Zone (FTZ) in Penang.

4.4.3 Labour

Labour refers to the total number of people employed who are paid or unpaid to work. It becomes a primary instrument for increasing production especially in a traditional agricultural framework. Wages paid to workers are included in the cost of production. In addition to capital, labour also plays an important role in agricultural production. Numerous researchers such as Battese & Coelli (1992), Baikuntha & Jeetendra (2006), Goni et al., (2007), Oniah et al., (2008), Basavaraja et al., (2008), Chaudhry, Khan & Anwar (2009), and Adamu, Adama, & Adama, (2015) proved that labour is a significant factor in agricultural production. In general, the above studies used various estimation techniques such as cross-sectional, time series data, and panel data. Although it is significant, the supply of labour is inelastic. This means that supply of labour is competitive. If the non-agricultural sector offers higher wages, labour supply in agricultural sector may be shrinking because the effective labour may migrate to manufacturing and services sectors.

To represent the labour inputs, various proxies have been used such as family labour, hired labour, child labour, man-days per hectare, human hours, and bullocks. This proxy is often found especially in cross-sectional studies. In the meantime, there are also those who use an aggregate labour force data. This is especially for those who use time series data and panel data in their empirical estimation. In time-series analysis, the use of aggregate labour data are probably due to the difficulty to obtain data on details.

In a Battese's & Coelli's (1992) study, human hours and bullock are used to represent labour. In this study, they have employed a micro-farm panel data study. They found that bullock significantly affects production through a negative sign. Meanwhile, there are also a few researchers that found that labour does not affect the total paddy production. Study by Bhujel & Ghimire (2006) discovered that human labour and bullocks per day are not significant in the paddy production in Nepal.

However, Oladeebo & Fajuyigbe (2007) found that most of the family labour is insignificant compared to the hired labour in Nigeria. This because the time spent by a family labour is lesser compared to hired labour. Nonetheless, study by Xiaosong & Jeffrey (1998) showed that labour was insignificant especially on farms with hybrid paddy-planting practices in China.

3.4.4 Fertiliser

Among the most important inputs in agricultural production is fertiliser. Generally, fertilisers are classified into two types, namely organic fertilisers and chemical fertilisers. Fertiliser is additional nutrients supplied to the plant. It is very important especially to increase the volume of production among paddy farmers. Fertiliser is substances with additional nutrients, which is supplied to improve the soil fertility. Fertiliser may increase the nutrients such as nitrogen, phosphorus and potassium in soil. The effective use of fertilisers may increase productivity and profit of farmers (Evenson & Douglas, 2003; Idris et al., 2012; Liverpool-Tasie, Barrett, & Sheahan, 2014). Therefore, fertiliser is crucial especially to increase the soil fertility in infertile paddy-growing area.

Heady (1950) and Heady & Dillon (1961) were among the earliest researchers who have done investigation on agricultural production and its relationship to fertiliser. They found that fertiliser has a significant relationship with output yield. After Heady's and Dillon's study on fertiliser, literature became vast. As a result, various studies were carried out. Many researchers concluded that fertiliser inputs are complementary to the land input. In other words, to increase the paddy production, farmers had to make sure that they use an effective and correct schedule of fertiliser.

In a preliminary study of paddy production in Japan, Akino & Hyami (1974) have identified that the soil and current inputs[11] are the dominant factors in the paddy production. Similarly, Jayaraman (1983) also found that fertiliser is an important input in the paddy production in Indonesia. Meanwhile Krishna, Yamamoto, Yasuhiro & Kano (2010) discovered that fertilisers are the extremely important factor for family farms in

[11] Current input included fertiliser, machinery, and pesticide

Nepal. Chaudhry et al., (2009) also discovered that fertiliser is significant in agricultural production.

Inefficiency study conducted by Sherlund et al., (2002), discovered that labour is a substitute to chemical fertilisers. Furthermore, Suresh & Ready (2006) found that the allocative efficiency for land in the district of Kerala, India is approximately 3.04. This means that land is significant as a determinant factor in paddy production. However, the size of cultivated areas is small and this lowers down the average output. Therefore, to increase paddy production, Ready (2005) has suggested that farmers in Kerala to employ fertilisers. Furthermore, the study results indicated that one-rupee increase in the fertiliser expenditure may increase yield by about 2.83 rupees in the Kerala district of India. Meanwhile, Ismail (1972) found that one-per cent increase in fertiliser consumption in the Northern Malacca has increased paddy production by about 17 per cent. All the above literature becomes a strong evidence to support that fertiliser is very important to increase the yield.

3.4.5 Paddy Price

The agricultural sector output prices also affect the allocation of resources to production (Fulginiti & Perri, 1993). Mundlak (1988) in his article stressed the importance of price as an input to determine the choice of techniques used. Furthermore, price also plays a vital role in influencing the level of productivity (Mundlak, 1988). Basically, when the price of agricultural output is high, it may give an incentive for farmers to improve their earning. This can indirectly help to increase the supply of agricultural output (Huq & Arshad, 2010). Several studies showed that price and productivity are positively related. For instance, Schultz (1978) found that high prices in the United State's agricultural sector have helped to increase productivity speedily.

Basically, price plays two major roles. Firstly, it reflects the level of consumption especially among the poor. Secondly, the prices also affect the supply through an increased production as an incentive to producers (Timmer, Walter & Scott, 1983). In reality, there are two distinct desires among consumers and agricultural producers. Consumers want a lower price of goods but farmers expect high price for their product. Therefore, incentives should be given to increase the domestic product and investment in the cultivation of paddy. In the case of Malaysia, this difference was offset by the role of the government by providing price subsidies for both consumers and agricultural producers (Abdullah, 2000).

4.5 Unselected Variables

Despite the variables above, we also discussed other variables that influence the production function. This is to show that following variables are also important in production function analysis. The main reason for these variables were not selected because of difficulty in obtaining data. The variables are as follows:

4.5.1 Pesticides

Pesticides are any substances that are used to kill or inhibit the growth of pests such as insecticides and rat poison. They may consist of chemicals, biological agents (such as viruses and bacteria), infection barrier material, or device used against any pest organisms. In agricultural science, insects, plant pathogens, weeds, birds, mammals, fish, worms, and microbes are classified as pests. The pesticides are often used in agriculture to protect agriculture from diseases and weeds that affect the paddy growth (Chen, Juneau & Qiu, 2010). In addition, pesticides are also able to increase crop yields by reducing crop damage. According to Inao, Ishii, Kobran & Kitamura (2001), pesticides are used to control insects and pests of paddy plant in Japan. Pesticides have been applied in over than 50 per cent of paddy areas. Meanwhile, Dung & Dung (1999) found that the use of pesticides increases paddy productivity in Vietnam.

4.5.2 Irrigation

Irrigation schemes are very important in determining the paddy crop productivity. Irrigation is a method of draining water to agricultural areas that have been built by humans. It is a method where water is channelled to the soil to help the growth of crops. Irrigation is extremely useful to improve crop yield (Khan, Tariq, Yuanlai, & Blackwell, 2006). Benu (1996) in her study found that an increase in the irrigation area has increased the harvested area in Indonesia. General phenomena that occur in undeveloped and developing countries in Africa and Asia showed that 75 per cent of water used for agricultural activities is not efficient. Therefore, improving an irrigation scheme is a strategic way to solve the above problem. This is important for the agricultural sector (Rosegrant & Pasandaran, 1995).

However, Benu (1996) discovered that when the irrigation area increases, the productivity reduces. Therefore, Benu has suggested that the authorities use the existing irrigation channel in order to increase the efficiency of paddy production. This may reduce the costs to the government. Furthermore, the government can channel that saving to the other urgent programmes to increase farmer's productivity.

4.5.3 Weather and Climatic

Weather is a term used to describe various phenomena that occur in the planet's atmosphere. The term usually refers to the activities of this phenomenon over a short period of time, usually not more than a few days in length in a month. Average atmospheric conditions for a longer period are known as climate. These two concepts are often overlapping and a closely related concept.

Climate is very important for paddy growth. It plays a significant role in a crop productivity Toriman at el., (2013). In Lains's (1978) study, he stressed that climate is an important factor that determining productivity compared to other economic variables. It is also important for crop cultivation (Siason, Prangkotanapan, & Hayami, 1978). This is true if we refer to the heat situation in Kedah in 2010. Heavy rain caused floods and destroyed many rice-planting areas and caused farmers and state government to bear the great loss. Consequently, the total paddy productivity decreased and it consequently affected the volume of paddy production in that particular season.

4.5.4 Seeds

To obtain a maximum efficiency in paddy production, farmers had to use quality seeds. Actually, a quality seed is the backbone of agricultural development (Shah, 1993 & 2012). Generally, seeds refer to young plants. It consists of three parts, namely the radicle (embryonic root), hypocotyl (embryonic stem), and cotyledon (seed leaf). Other thing being equal, the use of seeds is important to farmers regardless whether they are small-scale, intermediate-scale, or large-scale farmers.

It is undeniable that inputs such as machinery, chemical fertilisers, pesticides, labour, and others are essential to increase the agricultural yield. Without quality seeds, definitely farmers cannot produce more output. Therefore, seeds are very crucial in agricultural production. Nonetheless, seeds have been identified as a major contributor to increase the agricultural yield (Patel & Gabani, 1973; Goni et al., 2007; Ready, 2005; Moses & Adebayo, 2007). Verma & Sidhu (2009) confirmed that all the above investments may be unsuccessful if farmers have not used high-quality seeds. According to Shah (2012), quality seeds can increase crop yield more than fifteen per cent per annum.

However, some other researchers discovered that seeds are not significant in affecting the agricultural growth output (Suresh & Ready, 2006; Oladeebo & Fajuyigbe, 2007). However, this situation is true for the ordinary seeds compared to the hybrid seed. It was found that the hybrid seeds produce a better output compared to the ordinary seeds. Furthermore, hybrid seeds are more resistant to diseases, insects, and pests. The use of the hybrid seeds is very significant to increase farmer's productivity and this indirectly may increase a yield.

4.5.5 Other Variables

There are other variables which were examined by numerous researchers. Basically, these entire variables are related to time-series aggregate data. In 1988, Habibullah did an investigation on the relation of real money balance to the paddy production. He has discovered that the real money balances (M1, M2, and M3) are significant at the 1 per cent significance level. However, the degree of elasticity is small. According to Habibullah, an increase of 1 percent in M1, M2, and M3 results in increased paddy yield by less than 16 per cent.

Another variable is the lagged in a dependent variable and time trend (technological change). Mohammed (1988) and Baharumshah (1989) found that the effect of a lagged in dependent variable and time trend (technological change) is significant. They also found that the production is affected by the short-term and long-term adjustments. However, the estimated time-trend coefficient is small. This means that the adjustments speed in paddy sub-sector is slow.

There are other variables used in the estimation of paddy production functions in Malaysia. Among them are income from other crops and income from non-agricultural sector (Huang (1974), the damage paddy acreage (Fujimoto, 1976), machinery (Abdullah, 2002) and gander (Nordiana & Mook, 2009), and government policy (Yeong-Sheng et al., 2009).

4.6 Data Description

The study used the semi-annual data from main season of 1996 (1996H1) to main season of 2011 (2011H1). The empirical paddy production function analysis is based on the following data sets (Table 4.0). :

Table 4.0
Data Description

Name of Variable	**Variable Description**	**Source of Data**
LY	The dependent variable in natural logarithm of average paddy yield for main and off season in metric ton per hectare.	MADA
LN	Natural logarithm areas of paddy	MADA

	cultivation (hectare) per season.	
LL40	Natural logarithm labour age below 30 to 60 years old ('000) per season.	MADA and computed by the researcher based on min or mod of data
LL41	Natural logarithm labour age 61 to 71 years old and above ('000) per season.	MADA and computed by the researcher based on min or mod of data
LK	Natural logarithm cost of capital used (Ringgit) per hectare.	MADA
LF	Natural logarithm average fertiliser used (240 kg compost fertiliser per hectare and 100 kg urea fertiliser per hectare)	MADA and computed by the researcher
LP	Natural logarithm average local paddy price (RM per 100kg)	MADA
$(\ln K_t - \ln l_t)^2$	The capital and labour differences squared	Computed by the researcher
$(\ln YF_t - \ln OF_t)^2$	The young and old farmers' differences squared	Computed by the researcher

Notes:

1. The study used semi-annual data for main and off seasons from 1996 to 2011
2. MADA is Muda Agricultural Development Authority

4.7 Data Gathering

Based on assumptions formulated above, the main data required for this research are time-series data. Basically, there are two main seasons for paddy cultivations in MADA, namely main and off seasons. The main source of data collection is from MADA, the Ministry of Agricultural and Agro-Based Industry [MOA] and the Department of Statistic [DOS].

4.8 Theoretical Framework

Based on the literature review regarding the paddy production as shown in the previous discussion, Figure 4.0 (refer page 108) reveals the major relationship to investigate in this study. There are seven variables used in this study. The variables examined are average paddy yield as a dependent variable. Labour, capital, land, fertiliser, and local paddy price become the regressors. Based on the study by Alam et al., (2010), labour inputs are grouped into 25 to 59 years old and 60 to 85 years old. After this, the age group below 25 to 59 years old may refer to as young farmers and the age group 60 to 85 years may refer to old farmers.

We assumed that all the regressors have a positive impact on Y (output) and are significant with the average paddy production except the old farmers. We presumed that old farmers and average paddy yield have a negative relationship and are significant. This means that the increase or the decrease in input use may increase and decrease the total output. In addition, we also presumed that the elasticity of a regressor such as capital, young famers, fertiliser, price, and seeds are positively elastic. This means that one per cent of the increase in input used is followed by more than 1 per cent of the increase in production.

4.9 Development of Study Hypotheses

Based on the literature and previous empirical works on the production functions in Chapter 3, this study attempted to determine the factors that influence paddy production in Malaysia. Finally, all the information from the first steps was used to measure the total factor productivity in paddy sub-sector. Towards this, the current study planned to explore the following hypotheses:

4.9.1 Capital and output

Previous empirical works discovered that capital and output have a positive relationship (Habibullah, 1988; Kristensen, 1999; Idiong et al., 2007; Narayanan, 2010; Idris et al., 2012). For the purpose of this research, we presumed that capital and output have a positive and significant relationship. The positive relationship indicates that the increase in the use of capital may increase the output of a production. If the relationship is not significant, this indicates that farmers may employ old equipment such old machines. For the purpose of empirical testing, we developed null and alternative hypotheses, as follow:

H_o= There is no significant relationship between capital and paddy yield

H_a= There is a significant relationship between capital and paddy yield

4.9.2 Land and Output

Land is considered as part of the agricultural system. Numerous researchers such as Masakatsu (1974), Jayaraman (1983), Sachchamarga & Williams (2004), Moses & Adebayo (2007), Oniah et al., (2008), and Balde et al., (2014) discovered that land has a significant influence on output production. They also revealed that the degree of elasticity is small (inelastic). If the degree of elasticity is small (inelastic), then the increase in areas of cultivation increases only a small amount of output production. Therefore, we developed the hypotheses to enable us to measure the degree of elasticity of land, as follows:

H_o = There is no significant relationship between land and paddy yield

H_a = There is a significant relationship between land and paddy yield

4.9.3 Labour and Output

Labour also plays a very significant role in paddy production. Many researchers such as Battese & Coelli (1992), Baikuntha & Jeetendra (2006), Goni et al., (2007), Oniah et al., (2008), Basavaraja et al., (2008), and Adamu et al., (2015) proved that labour is significant. For this empirical test, we developed the hypotheses, as follows:

H_o = There is no significant relationship between young farmers and paddy yield

H_a = There is a significant relationship between young farmers and paddy yield

H_o = There is no significant relationship between old farmers and paddy yield

H_a = There is a significant relationship between old farmers and paddy yield

4.9.4 Fertilizer and Output

Fertiliser played an important role in paddy production. Scholars such as Suresh & Ready (2006), Krishna et al., (2010) and Ramli, Shamsudin, Mohamed, & Radam (2012) proved that fertiliser have a positive and significant effect on yield. This indicates that fertiliser use may increase the soil fertility and stimulate the health and growth of tillers seeding to higher yield. We than constructed the following hypotheses:

H_o = There is no significant relationship between fertiliser and paddy yield

H_a = There is a significant relationship between fertiliser and paddy yield

4.9.5 Paddy Price and Output

As mentioned by Fulginiti & Perrin (1993) and Huq & Arshad (2010), price is significant in determining the output production. The higher price may motivate farmers to produce more output. The hypotheses below were developed to test the empirical relationship between price and output:

H_o =There is no significant relationship between paddy price and paddy yield

H_a = There is a significant relationship between paddy price and paddy yield

4.9.6 Total Factor Productivity (TFP)

TFP growth will help to explain the growth of conventional factors of production such as labour and capital. It may also indicate the technological change in paddy farming. To test the effect of TFP on paddy production, we constructed the hypotheses, as follows:

Ho = The TFP growth of main season is less than 5 per cent

Ha = The TFP growth of main season is more than 5 per cent

Ho = The TFP growth of off season is less than 5 per cent

Ha = The TFP growth of off season is more than 5 per cent

4.9.7 Capital and Labour Elasticity of Substitution

Calculating the elasticity of substitution in paddy production is useful since it shows the flexibility of labour and capital in production. They are also related to the distribution of income between capital and labour and to the changes in this distribution over time. If the empirical test accepts the null hypothesis, this implies that the different groups of labour age are relatively difficult to substitute with capital.

H_o= The elasticity of substitution between capital and labour is lower than one

H_a = The elasticity of substitution between capital and labour is more than one

H_o= The elasticity of substitution between young and old farmers is not equal 1

H_a = The elasticity of substitution young and old farmers is equal 1

4.9.8 Elasticity of Substitution between Labour Age Group

If the empirical test rejects the null hypotheses, this implies that young farmers and old farmers have an identical impact on paddy production function.

H_o = The elasticity of substitution between young and old farmers does not equal to 1

H_a = The elasticity of substitution between young and old farmers equals to 1

Studies concerning the paddy production function are not new for agricultural economics scholars. However, for Malaysia, this type of study is limited. Up to researcher's knowledge, there are only a few researchers such as Ismail (1972), Baharumshah (1993), Nordiana & Mook (2009), and Idris et al., (2012) who have conducted the paddy production function analysis. In his empirical study, Ismail employed aggregate time-series data and Nordina & Mook (2009) employed cross-sectional study. In Ismail's (1972) study, it was revealed that capital, labour, and land are significant variables as determinants for paddy production function analysis.

Based on the earlier studies, we have discovered that there is a dissimilarity of result concerning the relationship between selected variables and yields. The aforementioned hypotheses are based on our review of related literature (Chapter 3). The above hypotheses formation enables the researcher to revisit the issues tested in the previous empirical studies by using Malaysia's data especially by using MADA paddy-production data. Additionally, the present study attempted to extend the pervious works by introducing (exploring) new variables such as the age group that has been made by Amanda (1997). This study proposed two main age groups, namely young and old farmers.

4.10 Method of Analysis

4.10.1 Data: Stationary vs Non-stationary

Since this empirical analysis employed time-series data, it is very crucial for the researcher to test the stationarity of series. If the data set is non-stationary, it may produce a spurious regression. The stationarity of time-series data is achieved when the mean, variance, and auto-covariance at different lags are constant. However, if the mean, variance, and auto-covariance are not time invariant, the time-series data are then supposed to be not stationary (Gujarati, 1995). We considered the AR (1) process as follows:

$$y_t = \alpha + \rho y_{t-1} + u_t \tag{4.15}$$

In Equation 4.15, α and ρ are the parameters and u_t is an independent and identically distributed with zero mean and variance σ^2. A series is said to be stationary when $-1 < \rho < 1$. When the series is stationary, then the t test, F test, and measurement R^2 are reliable. Meanwhile, if the ρ equals to 1, then the process is not stationary because the series presents a unit root. These situations are also known as a random walk[12]. In this situation, the problem of false regression may present. False regression may give inaccurate long-run relationship information to empirical analysis. This makes all the research acuteness be inexact and erroneous.

The stationarity of time-series data allows the OLS method to be used in detecting the long-run causal relationship between variables. Nonetheless, if the data series is not stationary, we can still obtain the long-run relationships by using other methods such as ARDL and Structural VAR. According to Harris (1995); Virmani (2004), and Azlina & Rokiah (2011), if two or more series are non-stationary and integrated of the same order, they will move closely together over time and the difference between them is stable or stationary. This is possible when the variables are co-integrated.

4.10.2 The Unit Root Test of Stationarity

The first stage of testing time-series data is to investigate the stationarity of the series. The main purpose is to identify the presence of unit roots in individual series. Each individual series that presents a unit roots indicates that the series is not stationary. If the non-stationary series is used in the regression execute, it would produce the superior regression. The implications of the superior regression result in the incorrect inferences of causal economic relationship (Harris, 1995). Various tests can be used to confirm the presence of null hypothesis of non-stationarity in individual series. Some

[12] According to Gujarati (2011), a random walk is oftentimes compared to the way a drunkard walks. When he or she leaves a bar, he or she moves a random distance u_t at a time t. If he or she continues to walk indefinitely, he or she will drift farther and farther away from the bar.

useful tests are Dickey-Fuller test, CDRW test based on Durbin Watson statistic, and Phillips-Perron non-parametric test.

The most popular test is the Dickey_Fuller (DF) test. According to Haris (1995) and Gujarati (1995), the DF test gains popularity because of its straightforwardness. The DF test assumed the AR(1) process as below:

$$\Delta y_t = (\rho - 1) y_{t-1} + u_t \text{ where } u_t IID(0, \sigma^2)$$

(4.16)

Where u_t are the stochastic or random walk residuals with zero mean, constant variance and non-autocorrelation. This process is also known as white noise.

$$\Delta y_t = \gamma y_{t-1} + u_t \text{ where } \gamma = \rho - 1$$

(4.17)

The null hypothesis for DF is $H_0 : \gamma = 0$ for non-stationarity. The acceptance and rejection of the null hypothesis is based on the computed t-statistics. If the value of computed t-statistic exceeds the critical values from the t distribution table, therefore, non-stationary can be rejected. This indicates that the series is stationary. However, if the computed value is less than the critical value, therefore, the series is non-stationary. If the series stationary at level the variables are stationary or integrated of order zero or I(0). Nevertheless, if the DF cannot reject the null hypothesis at I(0), the series needs to be differencing for d times. Therefore, if the series is stationary at d times, then the variables are said to be stationary or integrated at I(d).

There is a presence of some polemic related to unit roots test especially when it involves a small number of observations. As mentioned by Stock (1994), there is an occurrence of a trade-off between the size and power of the unit roots. However, questions arise when a series of data is nearly stationary in data generating process (DGP). If this case happens, there is a high possibility to accept the null hypothesis. Therefore, if this trade-off problem occurs, we should treat any results obtained from the test with caution.

The DF is only valid if GDP for y_t follows the AR (1) process with assumptions zero mean and no trend. Equations 4.16 and 4.17 are valid when the overall mean of the series is zero (Harris, 1995). Usually, the underlying DGP is infrequently known. To overcome these problems, the constant term and time trend are induced in the model, as follows:

$$\Delta y_t = \mu + \xi_t + \gamma y_{t-1} + u_t \text{ where } u_t IID(0, \sigma^2) \qquad (4.18)$$

Constant and deterministic time trend induced in the model would increase the possibility of accepting the null hypothesis of non-stationarity when the true DGP is actually stationary. Instead of DF test, there also another alternative tests for unit root. The tests that were used in the present study are explained in the following sections.

4.9.1.1 Augmented Dicky-Fuller Test

The Augmented Dickey-Fuller (ADF) test is a modified version of the DF unit roots test. It was used to indicate the presence of unit root in the series of studied. ADF is almost the same with DF version, except it allows the inclusion of an unknown number of lagged at the first differences of the dependent variable in the model. By allowing the above event, ADF can capture any auto-correlated excluded that might affect the disturbance (u_t) term. The following equation represents the ADF model:

$$\Delta y_t = \theta + \xi_t + \gamma y_{t-1} + \sum \mu_i \Delta y_{t-1} + u_{it} \tag{4.19}$$

4.9.1.2 Phillips-Peron Test

Philips (1987) and Phillips & Peron (1988) introduced another alternative to test the stationarity of the variables known as Phillips-Peron (PP) unit root test. Phillips-Peron (PP) unit root test is different from the ADF test. PP test only makes some corrections on the non-parametric t-test statistics. The PP test also takes into account the auto-correlation when the underlying DGP does not meet an AR(1) process. PP asymptotically tests that ρ_b equals to 1, which is not necessarily AR(1) process. This AR(1) process is given by the value of Phillips Z test. Same as other stationarity tests, the PP test use the t-statistic (τ_μ) to test the null hypothesis $\rho_b = 1$. Therefore, the critical values for the test are similar as those for the DF and ADF tests. According to Harris (1995), the PP test has a tendency to over-reject the null hypothesis. This is true especially when the underlying DGP has large negative moving average (MA) components.

4.9.1.3 Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test

Another unit root test that is often used in determining the stationary of series is KPSS test. However, this test is often used to obtain additional information about the presence or absence of unit roots in series. KPSS test differs from the ADF and PP tests. KPSS unit root test is different because it assumes that the series y_t is considered stationary in level and trend stationary under the null hypothesis. Therefore, the null hypothesis for KPSS test is the level-stationary and trend-stationary (Kwiatkowski, Phillips, Schmidt, & Shin, 1992). When ADF and PP test failed to reject the null hypothesis while KPSS test rejected the null of stationarity, therefore, the series presents unit root (Cheung, Lai, & Tran, 1994). This indicated that the data-generating process of a series can be strongly suggested (Lee & Schmidt, 1996). However, if all tests failed to reject their null hypotheses respectively, it indicates that the data have no enough information to suggest the presence of unit roots or not.

Kwiatkowski et al., (1992) derived the asymptotic distributions for two KPSS statistics; one which has null hypothesis of a level-stationary and another which has null hypothesis of trend-stationary (Cheung et al., 1994). The approach of the KPSS tests for level stationary is as Equation 4.20:

$$\eta_1 = \frac{T^{-2}\sum_{t=1}^{T} S_t^2}{s_T^2(l)} \tag{4.20}$$

where S_t is the partial sum of the residuals from the regression of y on 1 where $y = [y_1, \ldots, y_T]'$ and $1 = [1, \ldots, 1]'$ and $s_T^2(l)$ is the Newey-West or Gallant estimator for the long-run variance $\sigma^2 = \lim_T T^{-1} IE(S_T^2)$ and l represents the truncated lag parameter (Chen, 2002). The statistic approach of the KPSS tests for trend stationary as Equation 4.21:

$$\eta_2 = \frac{T^{-2}\sum_{t=1}^{T} S_t^2}{s_T^2(l)} \tag{4.21}$$

where S_t is the partial sum of residuals from regression of *y* on 1 and the time trend t = $[1, 2, \ldots, T]'$.

Based on the above discussion, there are three types of unit root tests that can be used to determine the stationarity of the series. ADF and PPP used to determine order of integrated such as I(0) or I(1). Any inconsistencies resulted by the order of integrated by ADF and PP resolved through the PP test (Chang & Park, 2002 and Maamor & Sahlan (2005). This is because the ADF test is based on the assumption that the series is generated by an AR process. Meanwhile, the PP test is based on the more general autoregressive integrated moving average (ARIMA) process (Tang, 2005). Nonetheless, the KPSS test results are considered when there are conflicting results from the ADF and PP tests.

4.10.3 ARDL Technique

There are several methods that are available to test the long-run relationship between regresor (Verma, 2007) such as residual model by Engle-Granger (1987), Johansen (1988), and Johansen & Juselius (1990). However, the present study employed the autoregressive distributed lag (ARDL) approach developed by Pesaran, Shin, & Smith (2001). This technique has been popular for recent years and is often used to analyse the long-run relationship between the regressor in the empirical model. This technique also allows the dynamic interactions among the variables. There are a few reasons why this technique is chosen.

First, ARDL model gives power and testing of the long-run relationship for the different order of integration, while the other method required all the explanatory integrated in the same order. Therefore, ARDL method is not required for pre-testing of the order of integration of the variables in the model. Hence, ARDL approach to co-integration can be applied regardless of whether the underlying explanatory variables are purely I(0), purely I(1) or mutually co-integrated (Narayan & Narayan, 2006; Verma, 2007). However, for the accurate result, the response variable needs to be integrated at order one I(1). According to Cavanagh, Elliot & Stock (1994), Pesaran et al., (2001), when pre-testing is involved, a certain degree of uncertainty (I(0), I(1) or mutually co-integrated with regard to the analysis of level relationships is created. Therefore, this situation may create problems to the researcher in selecting the appropriate method of analysis. Furthermore, numerous scholars claim that unit root tests lack power and have poor size property especially in small sample size series (Harris, 1995; Virmani, 2004).

Although the ARDL technique does not require pre-testing of the series order of integration, it is prudent to test each series in the suggested model. This is to make sure that the dependent variable has to be an I(1) series and the explanatory variables must be either I(0) or I(1) series (Kouakou, 2011). The conformation of order integrated of the series is important for the results of the regression to be valid. Moreover, if the series that is an I(2) variable will render the results of the regression invalid. This because the bounds test is based on the assumption that the variables are either I(0) or I(1) (Fosu & Magnus, 2006; Thai-Ha Le & Youngho, 2011).

Second, the Error-Correction Model (ECM) in ARDL method provided better statistical properties compared to the Engle-Granger approach (Kohansal, Torabi, & Dogani, 2013). This is because the Engle-Granger approach does not push the short-run dynamics into the residual term (Tang, 2005). In addition, the ARDL approach can deal with the endogenous variables and it can adjust the residual from the serial correlation. Meanwhile, the Johansen & Juselius (1990) technique is more suitable for large sample sizes. Furthermore, if Johansen-Juselius carried out to the small sample size, it was feared that the results generated are incorrect.

The long-run equations form the production functions model were analysed in the present study, which can actually be portrayed as a general vector autoregressive model of order p in z_t as follows[13]:

$$z_t = a_0 + \beta t + \sum_{i=1}^{p-1} \phi_i z_{t-i} + \varepsilon_t, t = 1,2,3,\ldots,T \tag{4.22}$$

where a_0 represents a (k+1) vector that contain intercepts and β is a (k+1) vector of trend coefficients. Following this, a Vector Equilibrium Error-Correction Model (VECM) is derived as shown below:

$$\Delta z_t = a_0 + \beta t + \Pi z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta z_{t-i} + \varepsilon_t \qquad t = 1,2,3,\ldots,T \tag{4.23}$$

where the (k+1) x (k+1) matrices $\Pi = I_{k+1} + \sum_{i=1}^{p} \Psi_i$ and $\Gamma_i = -\sum_{j=i+1}^{p} \Psi_j$ with $i = 1,2, \ldots, p-1$ have both the long-run multipliers and short-run dynamic coefficients of the VECM. z_t contains the vector of variables y_t and x_t. y_t is the dependent variable and x_t reflects the 'forcing' I(0) and I(1) variables. Assuming that there is a unique long-run relationship among the variables of interest, the VECM above can be written as:

[13] The VAR model is adopted from Fosu and Magnus (2006) who summarised Pesaran et al., (2001).

$$\Delta y_t = a_{y0} + \beta t + \delta_{yy} y_{t-1} + \delta_{xx} x_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \xi_i \Delta x_{t-1} + \varepsilon_{yt,} t = 1,2,...,T$$

(4.24)

Adapting the above specification to the variables in the present study yields, Equations 4.25 and 4.26 for production function model of paddy sub-sector are as follows:

$$\begin{aligned}\Delta lnY_{it} = c_{i0} &+ \delta_1 lnY_{i,t-1} + \delta_2 lnN_{i,t-1} + \delta_3 lnK_{i,t-1} + \delta_4 lnL40_{i,t-1} + \delta_5 lnL41_{i,t-1} \\ &+ \delta_6 lnF_{i,t-1} + \delta_7 lnP_{i,t-1} + \sum_{j=0}^{q1} \omega_j \Delta lnN_{i,t-j} + \sum_{k=0}^{q2} \gamma_k \Delta lnK_{i,t-k} \\ &+ \sum_{l=0}^{q3} \emptyset_l \Delta lnL40_{i,t-l} + \sum_{m=0}^{q4} \vartheta_m \Delta lnL41_{i,t-m} + \sum_{n=0}^{q5} \mu_n \Delta lnF_{i,t-n} \\ &+ \sum_{o=0}^{q6} \tau_o \Delta lnP_{i,t-o} + \varepsilon_t\end{aligned}$$

(4.25)

$$\begin{aligned}\Delta lnN_{i,t} = c_{i0} &+ \delta_1 lnN_{i,t-1} + \delta_2 lnY_{i,t-1} + \delta_3 lnK_{i,t-1} + \delta_4 lnL40_{i,t-1} + \delta_5 lnL41_{i,t-1} \\ &+ \delta_6 lnF_{i,t-1} + \delta_7 lnP_{i,t-1} + \sum_{j=0}^{q1} \omega_j \Delta lnN_{i,t-j} + \sum_{k=0}^{q2} \gamma_k \Delta lnK_{i,t-k} \\ &+ \sum_{l=0}^{q3} \emptyset_l \Delta lnL40_{i,t-l} + \sum_{m=0}^{q4} \vartheta_m \Delta lnL41_{i,t-m} + \sum_{n=0}^{q5} \mu_n \Delta lnF_{i,t-n} \\ &+ \sum_{o=0}^{q6} \tau_o \Delta lnP_{i,t-o} + \varepsilon_t\end{aligned}$$

(4.26)

In the equations 4.25 to 4.26 above, i refers to the paddy sub-sector, δ are the long-run multipliers, a represents the constant, and ε is the white noise errors.

The OLS technique was used to conduct the F-test for the above equations, which tests the null hypothesis $H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ are against the alternative hypotheses $H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$. The rejection of the null hypotheses indicates that there exists a long-run relationship among the variables. Therefore, the variables in the model are co-integrated. The F-statistic obtained was a statistic in a generalised Dickey-Fuller type regression that was used to test the significance of lagged level variables in a conditional unrestricted equilibrium correction model (Pesaran et al., 2001). F-statistic was then compared with two sets of critical values which created a band. Basically, the first value presumed all the variables are I(1) while the other presumed all are I(0). Critical values for I(1) series are known as upper bound while the critical values for the I(0) series are known as lower bound.

If the computed F-statistic excessed the upper bound level, the null hypothesis can be rejected. This indicates that there is co-integration among the variables. However, if the F-statistic is below the lower bound value, the null hypothesis cannot be rejected. This demonstrates there is no co-integration between variables. If the statistic falls between the upper and lower bound, a conclusive inference cannot be made without knowing the order of integration of the independent variables (Narayan, 2004). If the variables are integrated I(1), then the upper bound is taken as the critical value. If the variables are integrated I(0), then the lower bound becomes the critical value.

There are present alternative ways to capture the existence of co-integration for the inclusive case. As mentioned by Kremers, Ericsson & Dolado (1992), the alternative way to capture the co-integration is by using Error-Correction Term (ECT). Additionally, ECT value must be negative and significant. This condition indicates that the presence of adjustment towards the long-run equilibrium, therefore, the series is co-integrated.

The bounds table by Pesaran & Pesaran (1997) and Pesaran et al., (2001) has generated for the sample size of 500 and 1,000 observations and 20,000 and 40,000 replications respectively. However, the present study just employed 31 observations, therefore, the F-statistic obtained is compared with the critical values generated by Narayan (2004), which are more suitable for small sample sizes[14]. After establishing the presence of co-integration, the long-run relationship among the variables is estimated via the following conditional ARDL (p, q_1, q_2, q_3, q_4, q_5, q_6) long-run model for paddy sub-sector production function in Equations 4.27 and 4.28 below:

$$\Delta lnY_t = c_0 + \sum_{i=1}^{p} \delta_1 \Delta lnY_{t-i} + \sum_{i=0}^{q1} \delta_1 \Delta lnN_{t-i} + \sum_{i=0}^{q2} \delta_2 \Delta lnK_{t-i} + \sum_{i=0}^{q3} \delta_3 \Delta lnL40_{t-i} + \sum_{i=0}^{q4} \delta_4 \Delta lnL41_{t-i} + \sum_{i=0}^{q5} \delta_5 \Delta lnF_{t-i} + \sum_{i=0}^{q6} \delta_6 \Delta lnP_{t-i} + \varepsilon_t \quad (4.27)$$

$$\Delta lnN_{i,t} = c_{i,0} + \sum_{j=1}^{p} \delta_1 \Delta lnN_{i,t-j} + \sum_{k=1}^{q1} \delta_1 \Delta lnY_{i,t-k} + \sum_{l=0}^{q2} \delta_2 \Delta lnK_{i,t-l} + \sum_{m=0}^{q3} \delta_3 \Delta lnL40_{i,t-m} + \sum_{n=0}^{q4} \delta_4 \Delta lnL41_{i,t-n} + \sum_{o=0}^{q5} \delta_5 \Delta lnF_{i,t-o} + \sum_{p=0}^{q6} \delta_6 \Delta lnP_{i,t-p} + \varepsilon_t \quad (4.28)$$

The optimal lag for each variable (p, q_1, q_2, q_3, q_4, q_5, q_6) is selected based on Schwarz Bayesian Criterion (SBC) or Akaike Information Criterion (AIC).

[14] Narayan (2004) generated a different set of critical values by using the same GAUSS code as Pesaran et al., (2001) but tailored to his study with 31 observations. These new critical values were calculated by using stochastic simulations for T=31 and 40,000 replications for the F-statistic.

After we confirmed the regression model presence the long-run relationship, we then tested the short-run dynamic coefficients by using the OLS through the error-correction model that is associated with the long-run estimates. The error-correction models are corresponding to paddy sub-sector production functions that are presented in Equations 4.29 and 4.30 below:

$$\Delta lnY_{i,t} = \beta_i + \sum_{j=1}^{p} \phi_1 \, \Delta lnN_{i,t-j} + \sum_{l=0}^{q1} \varpi_2 \, \Delta lnK_{i,t-l} + \sum_{m=0}^{q2} \varphi_3 \, \Delta lnL40_{i,t-m} + \sum_{n=0}^{q3} \gamma_4 \, \Delta lnL41_{i,t-n} + \sum_{o=0}^{q4} \eta_5 \, \Delta lnF_{i,t-o} + \sum_{p=0}^{q5} \eta_6 \, \Delta lnP_{i,t-p} + \vartheta ecm_{i,t-1} + \varepsilon_{i,t} \quad (4.29)$$

$$\Delta lnN_{i,t} = \beta_i + \sum_{j=1}^{p} \phi_1 \, \Delta lnN_{i,t-j} + \sum_{l=0}^{q1} \varpi_2 \, \Delta lnK_{i,t-l} + \sum_{m=0}^{q2} \varphi_3 \, \Delta lnL40_{i,t-m} + \sum_{n=0}^{q3} \gamma_4 \, \Delta lnL41_{i,t-n} + \sum_{o=0}^{q4} \eta_5 \, \Delta lnF_{i,t-o} + \sum_{p=0}^{q5} \eta_6 \, \Delta lnP_{i,t-p} + \vartheta ecm_{i,t-1} + \varepsilon_{i,t} \quad (4.30)$$

In Equations 4.29 and 4.30, the short-run coefficient estimates for the paddy sub-sector production function models are given by $\phi, \varpi, \varphi, \gamma, \eta, \varsigma$ as each model converges to its long-run equilibrium. ϑ reflects how fast equilibrium is achieved or the speed of adjustment.

4.10.4 Hypothesis and Diagnostic Testing

Hypothesis and diagnostic testing is very crucial in any empirical analyses. This is to make sure that the models that we employed are robust. Basically, there are numerous significant testing such as null and alternative hypotheses, test statistic, and p-value. In hypothesis testing, we have transformed the research questions into null and alternative hypotheses. We started with the null hypothesis (H_o), then followed by the alternative hypothesis (H_a). The null hypothesis started the notation with "no" and the researcher hopes to reject the hypothesis (Kochanski, 2005).

Meanwhile, the test statistics involved are such as t-statistic and F statistic. The t-test was employed to determine the significance of the long-run and short-run coefficient estimates. The null hypotheses for each long run coefficient, $H_0 : \delta_i = 0$ (where *i* refers to any of the explanatory variable) and short run coefficient $H_0 : \varpi = 0, H_0 : \varphi = 0, H_0 : \eta = 0, H_0 : \gamma = 0, H_0 : \varsigma = 0$ are tested. To test the hypotheses, the computed t-statistic of each explanatory variable is compared with the critical values at 1, 5, or 10 per cent of the significance level of the t-distribution. If the computed t-statistic exceeds the critical value, then the null hypothesis is rejected. This indicates that the coefficient of the explanatory variable is statistically significant or different from zero. This also means that the explanatory variable affects the dependent variable.

The F-test can be used to determine the overall significance of each estimated long-run and short-run regression. The null hypotheses for F-test are $H_0 : \delta_1 = \delta_2 = \delta_3 = ... = 0$ for the long-run regression and $H_0 : \varpi = \varphi = \eta = \gamma = \varsigma = 0$ for the short-run regression, which are tested against the alternative hypotheses of $H_a : \delta_1 \neq \delta_2 \neq \delta_3 \neq ... \neq 0$ for the long-run and $H_a : \varpi \neq \varphi \neq \eta \neq \gamma \neq \varsigma \neq 0$ for the short-run model. The computed F-statistic was then compared with the critical values which were given by the F distribution table. If the computed F-statistic is greater than the critical F value from the F table of 1, 5, or 10 per cent level of significance, then the null hypothesis can be rejected. This result implies that the total variation of the explanatory variables affect the dependent variable.

Besides, the coefficient of determination (R^2) is also an important statistic which reflects the goodness of fit of the model. It measures the proportion of total variation in the dependent variable that is explained by the regression equation. The value lies between 0 and 1. If none of the variation in the dependent variable is explained by the model, i.e. there is no relationship between the dependent and the independent variables, then the R^2 value is 0. If the R^2 value is 1, then the equation explains all the variations in the dependent variable. Therefore, the higher the R^2 value, the "better" is the regression equation. Another goodness of fit measure is the adjusted R^2. It allows for the degrees of freedom associated with the sum of squares as new explanatory variables are added, which causing the residual sum of squares to decrease or remain the same. If the added variable does not change the residual variance, this may produce a more accurate measure. For this reason, this study employed the adjusted R^2 to measure the goodness of fit of the model.

Being dependent on high value of R^2 as a measure of goodness of fit is sometimes inaccurate. High value of R^2 may be due to multi-collinearity problem that exists in the model. Multi-collinearity problem exists when R^2 is high but none or a few of the coefficients are statistically significant with respect to the usual t-test. The multi-collinearity problem may violate one of the assumptions of the classical linear regression model. The problem of multi-collinearity stems from the existence of highly correlated independent variables in the regression model.

Another problem that is usually encountered when running a regression model is the presence of heteroscedasticity. This problem also violates the usual assumptions of the classical linear regression model. The problem is more common in cross-sectional data relative to time series. It prevails when the variance of each error term u_i is not the same where symbolically:

$$E(u_i^2) = \sigma_i^2 \qquad \text{or } i = 1,2,\ldots,n \tag{4.31}$$

This is opposed to the assumption of homoscedasticity or equal variance in the classical linear regression model such as:

$$E(u_i^2) = \sigma^2 \qquad \text{for } i = 1,2,\ldots,n \tag{4.32}$$

The heteroscedasticity caused the OLS estimators to be no longer BLUE since they no longer have minimum variance (Gujarati, 1995). However, these estimators do still retain their unbiasedness and consistency properties. Should heteroscedasticity exists, the t and F tests are generally inaccurate and the inferences we make on the basis of these tests would be misleading. Given such consequences, it is important that the test for heteroscedasticity is conducted to ensure if it exists[15].

In time-series data analysis, the presence of autocorrelation or serial correlation is a more common problem that plaguing the regression model. Symbolically, the problem can be shown as below:

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[15] White's heteroscedasticity test is used to detect the presence of heteroscedasticity. If the F statistic exceeds the critical values from the F distribution table, then the null hypothesis of equal variance or homoscedasaticity is rejected in favour of the alternative hypothesis of heteroscedasticity.

$$E(u_i, u_j) \neq 0 \quad \text{for } i \neq j$$

(4.33)

which means that the disturbance term of an observation is dependent on that of another. Furthermore, one can postulate that the disturbance in one time period is generated as:

$$u_t = \rho u_{t-1} + \varepsilon_t$$

(4.34)

where $-1<\rho<1$ and ε_t is the stochastic disturbance that satisfies the standard OLS assumptions[16]. This formulation is known as AR(1) or first-order autoregressive scheme. It is important to detect auto-correlation as the OLS estimators, although unbiased and consistent, are inefficient and the usual t and F tests will be invalid. Additionally, its presence can signal specification biasness. The presence of auto-correlation can be detected by using the Breusch-Godfrey serial correlation LM test[17].

Another important test that was conducted is the test of model is misspecification or known as Ramsey's Regressions Specification Error Test (RESET). Specification error exists if the 'true' model exhibits non-linear relationships but we wrongly assumed it as linear. The test is designed as such because it can capture possible non-linear relationships. As in the serial correlation and heteroscedasticity tests, RESET test also has both an LM-form and an F-form. If the computed F-statistic exceeds the F critical value, then the null hypothesis of correct specification is rejected. Thus, the model is mis-specified.

[16] $E(\varepsilon_t) = 0, \text{var}(\varepsilon_t) = \sigma^2, \text{cov}(\varepsilon_t, \varepsilon_{t+s}) = 0$.

[17] An F statistic that exceeds the critical values of the F distribution table signals the presence of serial correlation as it rejects the null of no serial correlation.

The test for residual normality based on the test of skewness and kurtosis of residuals, which is known as the Jarque-Bera test, was also conducted. It tests whether or not the classical linear regression model's assumption of normally distributed residuals with a zero mean and constant variance has been violated. The presence of normality residual problem will render the statistical inference based on t-test and F-test invalid. The Jarque-Bera test statistic computed has a chi-squared distribution with 2 degrees of freedom[18]. If the statistic exceeds the chi-squared critical value, then the null hypothesis of the normality of residuals is rejected, which implies that the residuals are not normally distributed.

The tests for parameter instability were also carried out. This is because in time-series models, the estimated parameters may vary over time and lead to model mis-specification and biased results. Pesaran & Pesaran (1997) suggested the use of the CUSUM and the CUSUM of square tests (CUSUM-SQ) to determine the stability of the estimated coefficients over the sample period. Specifically, CUSUM test recognizes the presence of systematic changes in the regression coefficients while CUSUM-SQ test identifies sudden divergence from the stability of regression coefficients. The test results are depicted graphically. The movement of the CUSUM and CUSUM-SQ test statistics outside a pair of 5 per cent significance lines indicates instability in the equation during the period of analysis.

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18 $JB = n\left[\frac{\mu_3^2}{6} + \frac{(\mu_4 - 3)^2}{24}\right]$ where $\mu_2 = \frac{\sum \hat{u}^2}{n}, \mu_3 = \frac{\sum \hat{u}^3}{n}, \mu_4 = \frac{\sum \hat{u}^4}{n}$.

4.10.5 Vector Autoregressive Model (VAR Model)

If the F-statistic from the Bounds test is lower than the lower bound critical values, then the null hypothesis of no co-integration cannot be rejected. This implies that there is no co-integration or no long-run relationship among the variables concerned. If this occurs in the present study, then estimation of the model is carried out by VAR model in first differences. As the time series are expected to be non-stationary i.e. I(1), with no co-integrating vector present, the use of unrestricted VAR in first differences involving no long-run element is deemed to be most appropriate to establish the interrelations among the variables of interest. Moreover, even though there is no co-integration that implies that the variables do not share a long-run equilibrium and drift away from each other randomly, this does not preclude the existence of short-run dynamic interactions among them. The estimation of these short-run dynamics in a VAR model can be carried out by OLS technique. Basically, a VAR model is an n-equation and n-variable linear model in which each variable is explained by its own lagged values including the current and lagged values of other remaining variables (Stock & Mark, 2001). It is a simple method where the dynamics of the multivariate time series can be captured and interpreted. There is no distinction between endogenous and exogenous variables in the model. Thus, all variables are taken to be endogenous. As an example, in a model consisting of y and x variables, the first order VAR model can be specified as follows[19]:

$$y_t = \beta_{10} - \beta_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + u_{yt} \tag{4.35}$$

[19] Adopted from Asteriou and Hall (2007, p. 279). In the first order VAR model, the maximum number of lag is assumed to be one.

$$x_t = \beta_{20} - \beta_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + u_{xt}$$

(4.36)

In matrix form, the model is represented as:

$$\begin{pmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{pmatrix} \begin{pmatrix} y_t \\ x_t \end{pmatrix} = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix} + \begin{pmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{pmatrix} + \begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix}$$

(4.37)

or

$$Bz_t = \Gamma_0 + \Gamma_1 z_{t-1} + u_t$$

(4.38)

where $z_t = \begin{pmatrix} y_t \\ x_t \end{pmatrix}, B = \begin{pmatrix} 1 & \beta_{12} \\ \beta_{21} & 1 \end{pmatrix}, \Gamma_0 = \begin{pmatrix} \beta_{10} \\ \beta_{20} \end{pmatrix}, \Gamma_1 = \begin{pmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{pmatrix}$ and $u_t = \begin{pmatrix} u_{yt} \\ u_{xt} \end{pmatrix}$

When both sides are multiplied by B^{-1}, the following is derived:

$$z_t = A_0 + A_1 z_{t-1} + e_t$$

(4.39)

where $A_0 = B^{-1}\Gamma_0, A_1 = B^{-1}\Gamma_1$ and $e_t = B^{-1}u_t$.

The notation for a more generalized VAR form with a lag order (p) is $Z_t = A_0 + A_1(L)Z_t + E_t$ where Z is a vector of endogenous variables, A_0 is a vector of constants, A_1 is a polynomial in the lag operator L, and E is a vector of error terms.

There are several advantages of using a VAR specification to model the relationship among the variables. First, the technique is simple as there is no need to worry about which variables are endogenous or exogenous. Second, there is minimal theoretical restrictions imposed in the model and this is useful when there is lack of consensus regarding the interrelationships among variables. Third, the forecasts obtained from VAR models are said to be better than those provided by simultaneous equation models (Asteriou & Hall, 2007). Fourth, each equation in the VAR model may be estimated separately by OLS.

If all the variables in the model are expected to be non-stationary or I(1), an unrestricted VAR in first difference will be estimated according to the specification:

$$\Delta X_t = B_1 + B_2(L)\Delta X_t + E_t \tag{4.40}$$

where Δ denotes the first difference of vectors. X is a vector of endogenous variables, B_1 is a vector of constants, B_2 is a polynomial lag operator L, and E is a vector of error terms. Thus, all variables are in growth rates as they are in their first differenced form.

According to Stock & Mark (2001), the normal practice in VAR analysis is to conduct the Granger Causality test, impulse responses and forecast error variance decompositions. Since the dynamics of the VAR system is complicated, they are considered to be more useful and informative as compared to the estimated VAR regression coefficients or R^2 statistics, which are not usually reported. Furthermore, the purpose of VAR analysis is to study the inter-relationships among variables and not the coefficient estimates derived.

4.10.5 Granger Causality

If the cointegration test results reveal that the variables are cointegrated, we use the Vector Error Correction (VEC) model estimation as in Equations 4.41 to 4.47. Error Correction Model (ECM) can be used to test for Granger-type causality. The advantage of the ECM specification is that, it allowed the testing of short-run causality through the lagged differenced explanatory variables. In editions ECM specification also allowed the testing of long-run causality through the lagged Error Correction Term (ECT). A significant ECM confirms presence long-run causality from the explanatory variables to the dependent variable (Farajova, 2011). If the variables are not co-integrated, therefore first difference Vector Autoregressive (VAR) model estimation is appropriated. Thus, Equations 4.42 to 4.47 following the ECM was than employed to examine the Granger causality between variables.

$$\Delta LY_t = \alpha_{0Y} + \sum_{i-1}^{k} \delta_{1Y}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{2Y}\, \Delta N_{t-1} + \sum_{i-1}^{k} \delta_{3Y}\, \Delta K_{t-1} + \sum_{i-1}^{k} \delta_{4Y}\, \Delta LL40_{t-1} + \sum_{i-1}^{k} \delta_{5Y}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6Y}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{7Y}\, \Delta LP_{t-1} + \gamma_1 ECM_{t-1} + \varepsilon_t \qquad (4.41)$$

$$\Delta LN_t = \alpha_{0N} + \sum_{i-1}^{k} \delta_{1N}\, \Delta N_{t-1} + \sum_{i-1}^{k} \delta_{2N}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{3N}\, \Delta K_{t-1} + \sum_{i-1}^{k} \delta_{4N}\, \Delta LL40_{t-1} + \sum_{i-1}^{k} \delta_{5N}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6N}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{7N}\, \Delta LP_{t-1} + \gamma_2 ECM_{t-1} + \varepsilon_t \qquad (4.42)$$

$$\Delta LK_t = \alpha_{0K} + \sum_{i-1}^{k} \delta_{1K}\, \Delta K_{t-1} + \sum_{i-1}^{k} \delta_{2K}\, \Delta K_{t-1} + \sum_{i-1}^{k} \delta_{3K}\, YN_{t-1} + \sum_{i-1}^{k} \delta_{4K}\, \Delta LL40_{t-1} + \sum_{i-1}^{k} \delta_{5K}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6K}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{7K}\, \Delta LP_{t-1} + \gamma_3 ECM_{t-1} + \varepsilon_t \qquad (4.43)$$

$$\Delta LL40_t = \alpha_{0LL40} + \sum_{i-1}^{k} \delta_{1LL40}\, \Delta LL40_{t-1} + \sum_{i-1}^{k} \delta_{2LL40}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{3LL40}\, \Delta N_{t-1} + \sum_{i-1}^{k} \delta_{4LL40}\, \Delta LK_{t-1} + \sum_{i-1}^{k} \delta_{5LL40}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6LL40}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{7LL40}\, \Delta LP_{t-1} + \gamma_4 ECM_{t-1} + \varepsilon_t \tag{4.44}$$

$$\Delta LL41_t = \alpha_{0LL41} + \sum_{i-1}^{k} \delta_{1LL41}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{2LL41}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{3LL41}\, \Delta N_{t-1} + \sum_{i-1}^{k} \delta_{4LL41}\, \Delta LK_{t-1} + \sum_{i-1}^{k} \delta_{5LL41}\, \Delta LL40_{t-1} + \sum_{i-1}^{k} \delta_{6LL41}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{7LL41}\, \Delta LP_{t-1} + \gamma_5 ECM_{t-1} + \varepsilon_t \tag{4.45}$$

$$\Delta LF_t = \alpha_{0LF} + \sum_{i-1}^{k} \delta_{1LF}\, \Delta LF_{t-1} + \sum_{i-1}^{k} \delta_{2LF}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{3LF}\, NY_{t-1} + \sum_{i-1}^{k} \delta_{4LF}\, \Delta LK_{t-1} + \sum_{i-1}^{k} \delta_{5LF}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6LF}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{7LF}\, \Delta LP_{t-1} + \gamma_6 ECM_{t-1} + \varepsilon_t \tag{4.46}$$

$$\Delta LP_t = \alpha_{0LP} + \sum_{i-1}^{k} \delta_{1LP}\, \Delta LP_{t-1} + \sum_{i-1}^{k} \delta_{2LP}\, \Delta Y_{t-1} + \sum_{i-1}^{k} \delta_{3LP}\, \Delta N_{t-1} + \sum_{i-1}^{k} \delta_{4LP}\, \Delta LK_{t-1} + \sum_{i-1}^{k} \delta_{5LP}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{6LP}\, \Delta LL41_{t-1} + \sum_{i-1}^{k} \delta_{7LP}\, \Delta LF_{t-1} + \gamma_7 ECM_{t-1} + \varepsilon_t \tag{4.47}$$

Where ECM_{t-1} is the lagged error correction term.

The Granger causality testing procedure involves testing a significant of δ_{ij}s conditional on the optimum lags. The ECM Equations 4.41 to 4.47 is an alternative test of causality. The γ_{ij} zero, mean that the change in dependent variable does not respond to deviation in long-run equilibrium in period of $t-1$. Furthermore, for example, if γ_{ij} is zero and all δ_{ij} is zero, it can be implied that all the variables do not Granger-cause paddy production. The insignificance of t and F-statistic in Wald test imply that the dependent variable is weakly exogenous.

If presence co-integration among variables we presumed that at least one or all of the ECTs should be significantly non-zero. Granger causality between LY and other variables can be revealed by testing the following null hypothesis:

a) Short-run Granger causality:

$$(H_O: \delta_{2Y} = 0,\ H_O: \delta_{2N} = 0, H_O: \delta_{2K} = 0, H_O: \delta_{2LL40} = 0, H_O: \delta_{2LL41} = 0, H_O: \delta_{2LF} = 0 \ and \ H_O: \delta_{2LP} = 0,)$$

b) Long-run Granger causality:

$$(H_O: \gamma_1 = 0, H_O: \gamma_2 = 0, H_O: \gamma_3 = 0, H_O: \gamma_4 = 0, H_O: \gamma_5 = 0, H_O: \gamma_6 = 0 \ and \ H_O: \gamma_7 = 0)$$

c) Joint Granger causality:

$$(H_O = \delta_{2Y} = \gamma_1 = 0, H_{O=}\delta_{2N} = \gamma_2 = 0, H_{O=}\delta_{2K} = \gamma_3 = 0, H_{O=}\delta_{2LL40} = \gamma_4 = 0,\ H_{O=}\delta_{2LL41} = \gamma_5 = 0, H_{O=}\delta_{2LF} = \gamma_6 = 0 \ and \ H_{O=}\delta_{2LP} = \gamma_7 = 0)$$

4.10.6 Impulse Response Function

Besides the granger causality test, the generalized impulse responses of a variable to a change in one of the innovations in the study are also analyzed. It permits an examination of the dynamic relationships amongst the variables, as it depicts the response of a variable to an unexpected shock in another variable over a certain horizon. Specifically, it traces the effect on the current and future values of the endogenous variable from a one standard deviation shock in other variables. These dynamics are examined through the generalized impulse function as it builds an orthogonal set of innovations that does not depend on the ordering of the VAR[20]. The impulse response functions are normally shown graphically.

4.10.7 Variance Decomposition

Variance decomposition is also examined in this study. It separates the variations in an endogenous variable to shocks in the system including its own. As such, it permits more insight pertaining to the relative importance of the shocks in affecting the variables in the system. The variance decomposition analysis is sensitive to the ordering of the variables in the VAR. According to Ibrahim (2004), the most exogenous variables are generally placed first and the variables that are the most sensitive to shocks are placed last. Additionally, the magnitude of the correlation coefficients between residuals in the system can determine whether or not the way the variables are ordered is important (Enders, 2008). If the correlations are generally bigger than 0.5, ordering of the variables is important, and vice versa.

[20] Changing the ordering of the equations in the VAR system will result in different impulse responses.

CHAPTER 5

RESULT AND DISCUSSION

5.0 Introduction

The production functions, Total Factor Productivity (TFP) and elasticity of substitution are not new topics in economics discipline. Although this knowledge has been long introduced, it is still relevant in all economic sectors including agriculture. Thus, the present study attempts to investigate the factor influencing production, TFP, and elasticity of substitution based on Malaysia's paddy-production data. Specifically, these study focus on the MADA paddy production in Kedah State.

In Section 5.1, this chapter presents the descriptive analysis of the data employed in this research. The empirical findings on the analysis of paddy-production functions in MADA's paddy-production region are presented in Section 5.2. This section is divided into a few sub-sections such as 5.2.1, which discusses the unit root test result. Sub-section 5.2.2 discusses the selection of lag length trough AIC lag length criteria. Sub-Section 5.2.3 presents the discussion on long-run relationship between response and explanatory variables. The short-run relationship is discussed in Sub-Section 5.2.4 under the Vector Error-Correction Model (VECM). The diagnostic of the model is present in Sub-Section 5.2.5. After the diagnostic test, the VECM Granger analysis was performed and its result is presented in Section 5.3. Meanwhile, Sections 5.4 and 5.5 discuss the VECM impulse response function (IRF) and VECM variance decomposotations, respectively the unstructured VAR Granger analysis. The VAR impulse response function and variance decomposition are presented in Sections 5.7 and 5.8 respectively.

The result of Total Factor Productivity is discussed in Section 5.9. Meanwhile, Section 5.10 discusses the elasticity of substitution between capital and labour. The elasticity of substitution between young and old farmers finding are discussed in Section 5.11. The empirical analysis for overall MADA region is highlighted in Section 5.12. The last two sections are Summary of Findings in 5.13 and Conclusion in Section 5.14.

5.1 Descriptive Analysis

Basically this analysis has divided the MADA paddy production areas into four main regions, which are MADA Region 1, MADA Region 2, MADA Region 3, and MADA Region 4. MADA Region 1 comprises Arau, Kayang, Kangar, Tambun Tulang, and Simpang Empat in Perlis. Meanwhile, MADA Region 2 includes Kodiang, Sanglang, Kerpan, Tunjang, Kubang Sepat, Jerlun, Jitra, Kepala Batas, and Kuala Sungai. All these areas are located in Jitra, Kedah. Hutan Kampung, Alor Senibong, Tajar, Titi Haji Idris, Kobah and Pendang are among the areas that are comprised in MADA Region 3. Meanwhile, Batas Paip, Pengkalan Kundor, Simpang Empat Kangkong, Permatang Buluh, Bukit Besar, Sungai Limau Dalam, and Guar Cempedak are the areas that are located in MADA Region 4.

Table 5.0 shows the descriptive statistics for all MADA regions[21]. This analysis is very important to describe systematically the facts and characteristics of the series that were employed in this study. There are seven main variables that were employed in this study, such as average paddy yield (LY), land (LN), capital (LK), young farmers (LL40), old farmers (LL41), fertiliser (LF), and paddy price (LP).

[21] For descriptive overview by using graph, please refer to Appendix 2

Table 5.0
Descriptive Statistics for MADA Regions

Series	Obs	Region	Mean	Min	Max	Std. Dev.	sk	k
LY	31	1	8.61	8.30	8.75	0.12	-0.55	2.34
		2	8.56	8.30	8.74	0.11	-0.54	2.60
		3	8.50	8.28	8.66	0.12	-0.32	1.82
		4	8.63	8.30	8.78	0.13	-0.78	2.81
LN	31	1	9.83	9.83	9.83	0.00	-0.32	2.64
		2	9.97	10.35	10.36	0.00	-0.60	2.51
		3	9.96	9.96	9.97	0.00	-0.32	2.64
		4	10.12	10.11	10.12	0.00	-0.32	2.64
LK	31	1	6.19	6.10	6.92	0.32	0.64	1.63
		2	6.19	6.10	6.92	0.32	0.64	1.63
		3	6.40	6.10	6.92	0.32	0.64	1.63
		4	6.19	6.10	6.92	0.32	0.64	1.63
LL40	31	1	6.87	6.78	6.89	0.02	-0.98	4.29
		2	8.41	8.34	8.43	0.02	-0.64	3.27
		3	6.73	6.66	6.75	0.02	-0.62	3.24
		4	6.91	6.84	6.94	0.02	-0.65	3.31
LL41	31	1	9.16	9.09	9.18	0.02	-0.63	3.27
		2	9.72	9.65	9.74	0.02	-0.64	3.27
		3	9.02	8.95	9.04	0.02	-0.63	3.27
		4	9.19	9.13	9.22	0.02	-0.64	3.27
LF	31	1	11.23	10.55	11.67	0.37	-0.21	1.70
		2	11.23	10.55	11.67	0.37	-0.21	1.70
		3	11.17	10.55	11.67	0.37	-0.21	1.70
		4	11.23	10.55	11.67	0.37	-0.21	1.70
LP	31	1	4.47	4.37	4.91	0.18	1.18	2.68
		2	4.57	4.37	4.91	0.18	1.18	2.68
		3	4.47	4.37	4.91	0.18	1.18	2.68
		4	4.47	4.37	4.91	0.18	1.18	2.68

Note:
1. All the series are denoted in log
1. sk is skewness
2. k is kurtosis
3. MADA refers to MADA paddy-production areas that comprise MADA Regions 1, 2, 3, and 4 (refer Figure 1.0).

All statistics reported in Table 5.0 above are denoted in log. Based on the table above, the mean value of average paddy production (LY) for the whole MADA area is between 8.50 to 8.63 metric tonnes. Meanwhile, the high mean value was recorded by the fertiliser (LF) variable, which is between 11.17 to 11.23 kilograms for each MADA region. The second high mean value was recorded by land (LN) variable, which is between 9.83 to 10.12 hectares. The third high mean value was recorded by old farmers (LL41) with its mean value between 9.02 to 9.72 persons. In addition, the variable of young farmers (LL40) recorded a mean value of 6.87 to 8.41 persons. The variable capital (LK) has recorded a mean value 6.19 to 6.40 ringgit for each MADA region. Furthermore, the variable paddy price (LP) has recorded the lowest mean value between 4.47 to 4.57 ringgit per 100 kilograms. This shows that the fertiliser variable (LF) has recorded the highest mean values. Meanwhile the paddy price (LP) has recorded the lowest mean value.

In addition, the standard deviation of the analysis was carried out to determine the variation in the average production of paddy (LY) and selected variables. The findings indicated that all variables have a low variation. The highest variations were recorded by the capital variable (LK), and the variation is 0.32. Meanwhile, the standard deviation of land variables (LN) equals to zero. This means that all numbers in the series must equal to the mean value of all the numbers in the series. If all values of the variables are the same, this means that there is no deviation presented in land variable[22]. In the meantime, the present research has also found that the standard devotion in elderly farmers and young farmers is 0.02. This shows that the volatility in capital variables (LK) is higher

[22] During the period of study, the land size is fixed

than that of other variables, while changes in soil variables (LN) has recorded the lowest volatility.

Skewness analysis has found that variable capital (LK) and the paddy price (LP) has a positive skewness value. This means that the data are skewed to the right. These indicate that the tail on the right side of the probability density function is longer or fatter than that of the left side. While the average paddy production (LY), land (LN), young farmers (LL40), old farmers (LL41), and fertiliser (LF) have a negative skewness, therefore, the data is skewed to the left. This shows that the tail of left side is longer from the right side. From the skewness analysis, we have found that any deviations from mean, capital (LK) and paddy price (LP) are going to be positive. Meanwhile, any deviations from mean paddy production (LY), land (LN), young farmers (LL40), old farmers (LL41), and fertilizer (LF) are going to be negative.

Meanwhile, based on the analysis of the kurtosis, it was found that the variables old farmers (LL41) and young farmers (LL40) have a higher peak distribution from the normal distribution. Variables such as LY, LN, LK, LP, and LF have lower peak than the normal distribution. The value of kurtosis for a normal distribution equals to 3. Meanwhile, the kurtosis that is less than 3 has a flatter curve than that of the normal distribution. If the kurtosis values are greater than 3, it has a very high arch than the normal distribution. This analysis shows that the variables of young farmers (LL40) have the highest value of 4.29 for the MADA Region 1, followed by old farmers (LL41) of 3.27 for the entire areas of MADA. Meanwhile, growth capital variable (LK) has recorded the lowest value of 1.63[23].

[23] For correlation matrix, please refer to Appendix 4

5.2 Empirical Analysis

The underlying regression for this section is based on the log-linear production model in Equation 4.18. Then we derived Equation 4.18 to obtain Equation 4.20 by using natural log. Equation 4.20 is the underlying VAR that was used in the empirical analysis of all paddy production regions in MADA.

5.3 Unit Root Test

Before the regression analysis was conducted, the order of integration of each variable in the model was determined. For this purpose, the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests were employed. If the ADF and PP statistical result contradicted to each other, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was used to provide conformation of the stationarity of the series.

Table 5.1
Unit Root Analysis for MADA Regions

MADA Region	Variables	ADF Test	PP Test	KPSS Test	
		Constant Without Trend	Constant Without Trend	Constant Without Trend	Conclusion
1	LY ΔLY	-1.848 -10.828 *	-1.858 -14.74*		I(1)
	LN ΔLN	-0.932 -7.648*	-1.589 -8.049*		I(1)
	LK ΔLK	0.080 -4.465*	0.080 -4.465*		I(1)
	LL40 ΔLL40	-3.669** -5.187*	-3.504** -5.229*		I(0)
	LL41 ΔLL41	-2,083 -6.399*	-2.196 -6.354*		I(1)
	LF ΔLF	-1.433 -6.038*	-1.401 -8.981*		I(1)
	LP ΔLP	0.115 5.599*	-0.051 -5.599*		I(1)
	LY ΔLY	-1.468 -4.564*	-2.458 -23.42*		I(1)

2	LN ΔLN	-1.418 -7.232*	-1.832 -7.110*		I(1)
	LK ΔLK	0.254 -4.465*	0.080 -4.465*		I(1)
	LL40 ΔLL40	-2.084 -6.407*	-2.199 -6.360*		I(1)
	LL41 ΔLL41	-2.085 -6.404*	-2.201 -6.357*		I(1)
	LF ΔLF	-1.433 -6.037*	1.401 -8.981*		I(1)
	LP ΔLP	0.115 5.599*	-0.051 -5.599*		I(1)
3	LY ΔLY	-1.335 -5.648*	-4.154** -48.02**	-0.609* 0.153	I(1)
	LN ΔLN	-0.932 -7.648*	-1.588 -8.050*		I(1)
	LK ΔLK	0.254 -4.465*	0.080 -4.465*		I(1)
	LL40 ΔLL40	-2.065 -6.413*	-2.178 6.360*		I(1)
	LL41 ΔLL41	-1.973 -6.403*	-2.061 -6.358		I(1)
	LF ΔLF	-1.433 -6.037*	-1.401 -8.981		I(1)
	LP ΔLP	0.115 5.599*	-0.051 -5.599*		I(1)
4	LY ΔLY	-3.011** -5.169*	-2.144 -15.063*	-0.676** -0.500**	I(1)
	LN ΔLN	-0.932 -7.648*	-1.589 -8.050*		I(1)
	LK ΔLK	0.254 -4.465*	0.080 -4.465*		I(1)
	LL40 ΔLL40	-2.112 -6.358*	-2.173 -6.316*		I(1)
	LL41 ΔLL41	-2.085 -6.400*	-2.199 -6.355*		I(1)
	LF ΔLF	-1.433 -6.038*	-1.401 -8.981*		I(1)
	LP ΔLP	0.115 5.599*	-0.051 -5.599*		I(1)

Notes:

* and** donated 1% and 5% of significant level respectively.

The results of unit roots test are presented in Table 5.1. The result indicates that all the variables are non-stationary at level. However, the unit test result for paddy yield (LY) in MADA Regions 3 and 4 are contradicting. PP test indicated that paddy yield (LY) in MADA Region 3 is stationary at level. Meanwhile, ADF test showed that paddy yield (LY) is stationary at level in MADA Region 4. To confirm the order of integration of paddy yield (LY) in MADA Regions 3 and 4, researcher then employed the KPSS test.

After we proceeded with first difference for non-stationary series at level, the result shows that the null hypothesis of unit root is rejected for all the variables. KPSS test also confirmed that the paddy yield (LY) in MADA Regions 3 and 4 are stationary at first difference. Therefore, we concluded that all series are co-integrated at order one or I(1). Therefore, we continued to estimate the long-run relationship between dependent and independent variables. We then employed an Autoregressive Distributed Lag (*ARDL*) approach to validate the presences of co-integration among variables.

5.4 Lag Length Criteria

Before we proceeded with the analysis, the optimal lag length has been needed to be determined first. VAR estimation is very sensitive to the lag length used. The Akaike Information Criterion (AIC) suggestions were employed. According to Ng & Perron (2001), AIC runs well in the selection of the optimal lag length. The results of the determination of lag length are presented in Tables 5.2 to 5.5. We discovered that the AIC has suggested lag length of 1 for MADA Regions 1 and 3 and lag length 2 for MADA Regions 2, and 4.

Table 5.2

Lag Length MADA Region 1

Lag	LR	FPE	AIC	SC	HQ
0	NA	2.05e-27	-41.58804	-41.26110	-41.48345
1	216.8421*	3.09e-30*	-48.17784*	-45.56227*	-47.34109*

Notes:

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.3

Lag Length MADA Region 2

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.76e-26	-39.43434	-39.10430	-39.33098
1	218.5967	1.73e-29	-46.46440	-43.82410*	-45.63749
2	67.38678*	8.07e-30*	-47.89843*	-42.94787	-46.34798*

Notes:

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.4

Lag Length MADA Region 3

Lag	LR	FPE	AIC	SC	HQ
0	NA	2.70e-25	-36.70801	-36.37797	-36.60465
1	224.4763*	2.00e-28*	-44.01805*	-41.37775*	-43.19114*
2	45.50659	4.45e-28	-43.88921	-38.93865	-42.33876

Notes:

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 5.5

Lag Length MADA Region 4

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.29e-25	-37.44127	-37.11123	-37.33790
1	204.8353*	2.44e-28*	-43.81602	-41.17573*	-42.98911*
2	50.73477	3.75e-28	-44.06062*	-39.11007	-42.51017

Notes:

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

5.5 ARDL Bound Test

Previous unit roots test showed that all the data are integrated at the same order or I(1). Therefore, we have presumed the presence co-integration or long run-relationship among the variables. To confirm the presence of co-integration or long-run relationship in the model, the bounds test procedure and the Autoregressive Distributed Lag (ARDL) approach to co-integration were employed (Pesaran & Pesaran, 1997; Pesaran et al., 2001).

The long-run multiplier in Equation 4.24 was incorporated to develop a conditional ARDL model for the paddy production in MADA. In the present study, the F-statistic from the bounds testing procedure (Pesaran & Pesaran, 1997; Pesaran et al., 2001) was examined for the joint significance of the coefficients of the lagged levels of the variables. Since the sample size in the present study is only 31, the researcher may compare the compute Wald F-statistics with the critical values generated by Narayan (2004). This is because the critical value generated by Narayan is more suitable for small sample sizes.

Before we proceed with bound test procedure, we need to obtain Wald F-statistic value. The value is important to determine the present of co-integration among the variables in the model. If the Wald F-statistic falls above upper critical value, we said that the co-integrations exist. However, if the value falls below the lower bound critical value, therefore, the model does not present co-integration. However, if the Wald F-statistic test falls between the lower bound and upper bound critical value, therefore, the co-integration result is inconclusive. In order to compute the Wald F-statistic, we have employed the OLS technique. Table 5.6 shows the OLS result of the regression for all MADA Region.

Table 5.6
Ordinary Least Squares Estimation

Regressors	**MADA Region 1**	**MADA Region 2**	**MADA Region 3**	**MADA Region 4**
DLY(-1)	-0.6370* [-3.8968]	-0.7653* [-2.3511]	-1.0821* [-4.9840]	-1.0245* [-4.5532]
DLY(-2)		-0.2596 [-0.8623]	-0.5729** [-2.3661]	-0.8194* [-3.3358]
DLN(-1)	8.9719 [0.4310]	-26.0706 [-1.0246]	-43.5874 [-1.3802]	-18.5430 [-0.8305]
DLN(-2)		20.2523 [0.7476]	19.3781 [0.5904]	-11.3298 [-0.5152]
DLK(-1)	-0.5144** [-2.0291]	-0.3487 [-0.9047]	-0.2409 [-0.5779]	-0.6972*** [-1.8772]
DLK(-2)		0.4410 [0.1229]	0.5836 [1.5899]	0.3483 [1.1562]
DL40(-1)	-0.0054 [-1.2829]	0.0577 [0.9834]	-0.1544*** [-1.8651]	0.1303** [2.6057]
DL40(-2)		-0.0142 [-0.2524]	0.0105 [0.1354]	0.0113 [0.2278]
DL41(-1)	0.0005 [1.2491]	-0.0155 [-0.9772]	0.0159*** [1.8958]	-0.0134** [-2.5844]
DL41(-2)		0.0038 [0.2514]	-0.0009 [-0.1177]	-0.0013 [-0.2545]
DLF(-1)	0.0505 [0.2518]	0.2146 [0.6706]	0.2440 [0.8930]	0.4544*** [1.9561]

DLF(-2)		0.0471 [0.1721]	0.5533*** [2.0322]	0.2814 [1.3724]
DLP(-1)	0.0725 [0.2958]	0.2128 [0.7348]	-0.0832 [-0.2611]	0.1084 [0.4645]
DLP(-2)		0.1674 [0.5945]	0.3366 [1.1383]	-0.0653 [-0.2902]
C	0.0305 [1.5844]	0.0129 [0.4430]	-0.0257 [-0.8574]	0.0335 [1.3992]
R-squared	0.5195	0.7003	0.8681	0.7734
Adjusted R-squared	0.35937	0.3777	0.7262	0.5293
LM Test	0.3984 (0.819)	1.8896 (0.389)	1.4162 (0.493)	1.8237 (0.402)
Heteroscedasticity (1)	0.2745 (0.600)	0.0384 (0.845)	0.8206 (0.365)	0.3426 (0.558)
Ramsey's RESET(2)	0.4500 (0.502)	0.3586 (0.549)	2.2709 (0.132)	0.0096 (0.922)
Normality(2)	1.6500 (0.438)	1.0456 (0.593)	1.3327 (0.514)	1.4733 (0.479)

Notes: *,** and *** indicates significance at 1%, 5%, and 10% level.
Value in [ ] and ( ) are represented the t-statistics and the probability

Based on Table 5.6, the goodness of fit of the model in MADA Regions 1 to 4 is satisfactory as approximately 52 to 86 per cent of the variations in paddy yield are explained by variations in the regressors. The normality test showed that the residual that is normally distributed is rejected. In addition, the Ramsey's RESET test has discovered that the model employed is linear. Meanwhile, based on Autoregressive test using Breusch-Godfrey Serial correlation LM Test, this research has failed to reject the null hypothesis (not significant) for all variables at 1 per cent significance level. This means that the error is white noise with zero mean and constant variants, therefore, the OLS model is free from auto-correlation problems. The heteroscedasticity test by using the F statistic has also failed to reject the null hypothesis. These show that there is no problem of heteroscedasticity for all the variables. This also means that the entire data time series used are free from the problem of heteroscedasticity. Therefore, based on the diagnostic test, the OLS result model has passed the robust test. This indicates that the F-statistic which was computed from the entire model can be trusted.

Table 5.7
Results of Bounds Test and Critical Values for Case II with n = 30 observations

Region/lag length ( )	**Case II (intercept and no trend)**		
	Level of Significant	**Lower**	**Upper**
	1% Significance	3.976	5.691
	5% Significance	2.794	4.148
	10% Significance	2.334	3.515
	Computed F-statistic		
MADA Region 1 (1)	2.4189		
MADA Region 2 (2)	7.7493		
MADA Region 3 (2)	2.7359		
MADA Region 4 (2)	2.6196		

Notes:

The F-statistics are compared with the upper bound i.e. I(1) and lower bound i.e. I(0) critical values for zero restriction on the coefficient of the lagged level variables.

The F-statistics from the bounds test are reported in Table 5.7. The compute F-statistics were compared with the critical values developed by Narayan (2004) for k = 7 regressors in Case II (restricted intercept and no trend) at 1, 5, and 10 per cent of significance level. Based on the statistical result in Table 5.7, it appears that there is co-integration in the models specified to depict the relationship among average paddy yield (Y), land, capital, young and old farmers, fertiliser, and local paddy price in MADA Region 2. The F-statistics are more than upper bound critical values at 1, 5, and 10 per cent significance level. This means that the present stable long-run relationship among the variables concerned. Additionally, it can be inferred from these results that paddy yield (LY), land, capital, young and old farmers, fertiliser, and paddy price are the long-run factors that determine the paddy yield.

Based on the bound test performed above, it clearly shows that long-run relationship between variables at the same degree of integration for MADA Region 2 exists. Then the Error-Correction Terms (ECT) should be entered into the model before we perform the Granger causality test. Engle & Granger (1987) and Toda & Phillips (1993) argued that failing to take into account the Error-Correction Term (ECT) may cause misspecification model. Therefore, before we incorporated the ECT to Equation 5.0, we needed to generate the long-run equation for MADA Region 2. Therefore, the second column in Table 5.8 shows the long-run coefficient estimations for determinants of paddy production for MADA Region 2.

From Table 5.7 earlier, it appears that F-statistic in MADA regions 1, 3, and 4 are 2.4189, 2.7359, and 2.6196 respectively. This F-statistic value is between lower (2.334) and upper (3.515) bound value at 10 per cent significant level. This indicates that the presence of co-integration among the variables in the model cannot be ascertained. To confirm the co-integration between variables, we then followed Kremers et al., (1992) that tested the Error-Correction Term (ECT)[24]. To test the ECT, we first needed to generate the long-run equation for MADA Regions 1, 3, and 4. The negative and significant value of Error Correction-Term (ECT) indicates the presence of the long-run relationship between variables. The long-run estimation for MADA Regions 1, 3, and 4 are in the first, third, and fourth columns in Table 5.8.

[24] Co-integration analysis and the Error-Correction Term (ECT) are used to examine the long-run and short-run relationship between variables. They also consider the stationary aspects of the data. If time-series data are co-integrated, then the equation is said to be a long-run equilibrium at least in one direction. Due to the time-series data used, the possibility of long-run and short-run equilibrium are different. Therefore, long-run random error information can be used to describe the behaviour of short-run equilibrium variables and this is known as ECT. The ECT can avoid specification error model or model misspecification. The value of ECT must be negative.

Table 5.8
Long-Run Coefficient Estimations for the Determinants of the Paddy Yield in MADA Paddy-Production Regions 1, 2, 3, and 4

Regressors	**MADA Region 1** (0,0,1,0,0,0,0)	**MADA Region 2** (1,2,1,2,2,1,2)	**MADA Region 3** (2,2,0,1,1,2,0)	**MADA Region 4** (0,0,1,1,1,0,0)
LY(-1)		-0.7847* [-3.5439]	-1.1008* [-4.3651]	
LY(-2)			-0.5718** [-2.3724]	
LN	28.1261 [1.3685]	-12.5923 [-0.8361]	46.0147 [1.7404]	7.8511 [0.44193]
LN(-1)		-31.7095** [2.4098]	-18.7951 [-0.6795]	
LN(-2)		40.2508** [2.7112]	44.3847 [1.5339]	
LK	0.3258 [1.3611]	-0.4691 [-1.6320]	-0.3222 [-1.7450]	0.6453** [2.6596]
LK(-1)	-0.5474** [-2.3598]	-0.2545 [-1.1983]		-0.6162** [-2.7475]
LK(-2)				
L40	0.6038 [1.1589]	0.1731* [3.3963]	-0.0228 [-0.2926]	-0.0035 [-0.0825]
L40(-1)		0.06244 [1.7752]	-0.1445* [-2.1007]	0.0984 [2.2951]**
L40(-2)		0.1563** [2.8558]		
L41	-0.0610 [-1.1561]	-0.4643* [-3.3827]	0.0030 [0.3846]	0.4929 [0.1116]
L41(-1)		-0.0168 [-1.7810]	0.0150** [2.1505]	-0.0098** [-2.2298]
L41(-2)		-0.0424** [-2.8648]		
LF	0.2671** [2.1891]	0.7248* [3.6825]	-0.1248 [-0.5610]	0.13080 [0.9341]
LF(-1)		0.1676 [1.0722]	0.1048 [0.4308]	
LF(-2)			0.4524** [2.1728]	
LP	0.0914 [0.5123]	0.3231*** [1.8393]	-0.2276 [-0.8609]	-0.11990 [-0.7590]
LP(-1)		0.3166***		

		[1.8260]		
LP(-2)		-0.3501 [-2.1000]		
C	-271.4706 [-1.3449]	51.0633 [0.3115]	-702.0566 [-1.9554]***	-74.6063 [-0.4155]
R-squared	0.8202	0.9537	0.8894	0.8683
Adjusted R-squared	0.7631	0.8822	0.7789	0.8060
F-Stat	14.3452 (0.0000)	13.3386 (0.0000)	8.0463 (0.0000)	13.9279 (0.000)

Notes: ARDL Model Based on Akaike Information Criterion

*,** and *** indicate significance at 1%, 5%, and 10% level.
Value in [ ] and ( ) are represented the t-statistics and the probability.

The optimal lag for each variable (p_1, q_1,q_2,q_3, q_4,q_5) is selected based on Schwarz Criterion. They are (0,0,1,0,0,0,0) for MADA paddy-production Region 1, (1,2,1,2,2,0,2) for MADA paddy-production Region 2, (1,2,1,2,2,1,2) for MADA paddy-production Region 3 (2,2,0,1,1,2,0) for MADA paddy-production Region 4, (0,0,1,1,1,0,0). Based on Table 5.8, we have discovered that the factors that affected paddy production for each MADA production area are different. Thus, each MADA region requires different focus in order to increase paddy yield.

5.6 Short Run Relationship

Once the long-run coefficients for MADA region 2 were obtained, the short-run dynamic coefficients were estimated through the Error-Correction Term (ECT). Moreover, the uncertain long-run co-integration in MADA Regions 1, 3, and 4 can be confirmed by using the same approach. By using the long-run coefficients estimation shown in Table 5.8, we have then computed the Error-Correction Term (ECT) for MADA Regions 1, 2, 3, and 4. The Error-Correction Term (ECT) showed the speed which our model returns to equilibrium which follows an exogenous shock and it should be negatively signed. The significant ECT negative value indicates that the model is stable. The coefficient estimates of the short-run relationship for MADA region is obtained from the error-correction representation of selected ARDL model (p_1, q_1, q_2, q_3, q_4, q_5) as in Equations 4.29 and 4.30.

In the co-integration finding, we have found that the F-statistic for MADA production Region 2 exceeds the upper bound for the 1, 5, and 10 per cent of significant level. These indicate the presence of co-integration between variables. Table 5.9 shows the result of the short-run estimation for all MADA regions. Column two shows the short-run estimation for MADA Region 2. This research discovered that the ECT is not significant because computed t statistic is less than 2. This means that the adjustments of disequilibrium are caused by shocks in the system which cannot achieve convergence in the long-run.

By using the long-run estimation provided in Table 5.8 above, we have computed the ECT for MADA Regions 1, 3, and 4. From the estimation, we have found that the value of ECT is negative and significant in MADA Regions 1 and 4. Hence, there exist the long-run relationships between variables. Additionally, it can be inferred from these results that paddy yield, land, capital, young and old farmers, fertiliser, and local paddy price are the long-run that determine the paddy yield in MADA paddy-production Regions 1 and 4. From this result, we can make initial assumption of the presence of one-way causality between variables in MADA paddy-production Regions 1 and 4. Meanwhile, in MADA Region 3, there is no significant evidence that the variables are co-integrated.

Table 5.9
Error-Correction Representations for MADA Paddy-Production Regions

Dependent Variable: ΔLY

Regressor	MADA 1	MADA 2	MADA 3	MADA 4
C	0.010 [0.692]	-0.154 [-0.518]	-0.396 -0.419	-0.0002 [-0.019]
ΔLY_{t-1}	-	-0.691** [-4.447]	-0.655** -3.999	-
ΔLN_t	36.361** [2.330]	23.307 [-1.219]	59.796*** [1.826]	17.248 [1.313]
ΔLN_{t-1}	-	-50.033** [-2.491]	-	-
ΔLK_t	0.305 [1.484]	0.189 [0.721]	0.334 [0.819]	0.661** [3.530]
ΔLK_{t-1}	-	-	-	-
$\Delta LL40_t$	610.535* [5.976]	197.029 [0.973]	60.905 [0.9101	-2.502 [-0.075]
$\Delta LL40_{t-1}$	-	-	-	-
$\Delta LL41_t$	-610.455* [-5.982]	-197.406 [-0.973]	-59.740 [-0.891]	3.769 [0.111]
$\Delta LL41_{t-1}$	-	-	5.137 [1.713]	-
ΔLF_t	0.1879 [1.133]	0.4589*** [1.999]	0.054 [0.196]	0.106 [0.771]
ΔLF_{t-1}	-	0.331 [1.525]	-	-
ΔLP_t	0.168 [0.849]	0.014 [0.056]	0.087 [0.269]	-0.175 [-1.069]
ECT(-1)	-1.139* [-6.037]	-0.027 [-0.470]	-0.015 [-0.399]	-1.027* [-6.998]
R-squared	0.703	0.717	0.742	0.790
Adjusted R-squared	0.608	0.559	0.619	0.73
LM Test	0.88 (0.431)	-	-	1.14 (0.3383)
Heteroscedasticity (1)	0.86 (0.553)	-	-	1.00 (0.4548)
Ramsey's RESET(2)	2.26 (0.103)	-	-	0.52 (0.4795)
Normality(2)	1.39 (0.499)	-	-	0.54 (0.7625)
CUSUM	Stable	-	-	Stable
CUSUM-SQ	Stable	-	-	Stable

Conclusion	Presence Short-run Relationship	No Short-run Relationship	No Short-run Relationship	Presence Short-run Relationship

Notes:

[ ] parentheses denote the t-statistics while p-values are in ( ) parentheses. Breusch-Godfrey, White, Ramsey RESET, and Jarque Bera tests are used to test for the presence of serial correlation, heteroscedasticty, model miss-specification, and residual non-normality in the model. *, ** and *** denote significance at 1 per cent, 5 per cent, and 10 per cent levels. SR is short-run.

From Table 5.9, we have found that the ECT values are significant for MADA Regions 1 and 4. We have confirmed the presence of the long-run relationship in MADA Regions 1 and 4. This study discovered that land is significant in MADA Region 1. This finding is consistent with Ingabire & Bizoza (2013) and Balde et al., (2014) who discovered that land has a significant impact on paddy yield. The degree of elasticity of paddy yield with respect to land is elastic with positive sign. These mean that one per cent of the increase in paddy-planting area leads to approximately 36.36 per cent of increase in paddy yield for MADA Region 1. This indicates that, in the short-run, the increase in harvested area may increase the paddy yield in MADA Region 1.

The present research has also found that young and old farmers are also significant factors in influencing paddy production in MADA Region 1 in the short-run. The degree of elasticity of paddy yield with respect to young and old farmers is elastic. However, both variables have a different sign. Young farmers have positive effect on paddy yield; 1 per cent increase in young farmers, and paddy yield increases roughly by 611 per cent while the increase in old farmers reduces paddy production by about 611 per cent. These indicate that the paddy yield increases with the increase of young farmers that get involved in paddy cultivation. If the paddy sub-sector is too dependant on old farmers, then the productivity may reduce. According to Idris & Rahmah (2010), the different contributions by young and old farmers are also attributed by the differences in the quality of farmers.

In MADA Region 4, only capital is significant in the short-run. The degree of elasticity is found to be inelastic and having a positive sign. This is consistent with the finding by Narayanan (2010) and Idris et al., (2012). They have discovered that the capital and output relationship is positive. Based on empirical finding, 1 per cent of the increase in capital may lead to the increase of paddy yield about 0.66 per cent.

The lagged coefficient of the Error-Correction Term (ECT) reflects the speed of the adjustment of paddy yield to shocks in the system. The speed of adjustment of paddy production is higher for MADA Regions 1 and 4 compared to MADA Regions 2 and 3. From Table 5.9, the ECT values for MADA Regions 1 and 4 are -114 and -103 per cent respectively. The result suggested that any disequilibrium in paddy production is adjusted to achieve convergence faster.

5.7 Diagnostic Test

From the previous findings, we have found that the model from MADA Regions 1 and 4 presents long-run and short-run relationships. The next steps were to test the goodness of fit of the model. For this purpose, we might use the error in VECM model to test the goodness of fit of the model. This was to ensure that the VECM model employed are free from error-specification problem. Based on Table 5.9 above, the goodness of fit of the model in MADA Regions 1 and 4 is satisfactory as approximately 61 and 73 per cent of the variations in paddy yield are explained by variations in the regressors.

Based on Table 5.9 above, the Jarque-Bera normality test (JB) has showed that the data is normally distributed. In addition, the Ramsey's RESET test has discovered that the model employed is linear. Meanwhile, based on the Autoregressive test by using Breusch-Godfrey Serial correlation LM Test, this research has failed to reject the null hypotheses (not significant) for all variables at 1 per cent significance level. This means that the error is white noise with zero mean and constant variants. Therefore, the VECM model is free from auto-correlation problems.

The heteroscedasticity test by using the F statistic has failed to reject the null hypotheses. These show that there is no problem of heteroscedasticity for all the variables. This also means that the entire time-series data used are free from the problem of heteroscedasticity. Therefore, based on the diagnostic test, the VECM model is suitable for the purpose of policy formulation.

In addition, the tests of structural change that involved testing a recursive error Cumulative Sum (CUSUM) and CUSUM-Sq were employed to determine whether the VECM model error is relatively stable (Brown, Durbin & Evans, 1975). Based on Figure 5.0 below, the CUSUM test results for VECM model showed that the error resulting from the whole time series are stable. Thus, it can be concluded that the time-series data in this study do not undergo structural changes at the significance level of 5 per cent. These observations from main season of 1996 (1996H1) to main season of 2011 (2011H1) can be used for estimation purposes without the need to separate the time series to the period of time.

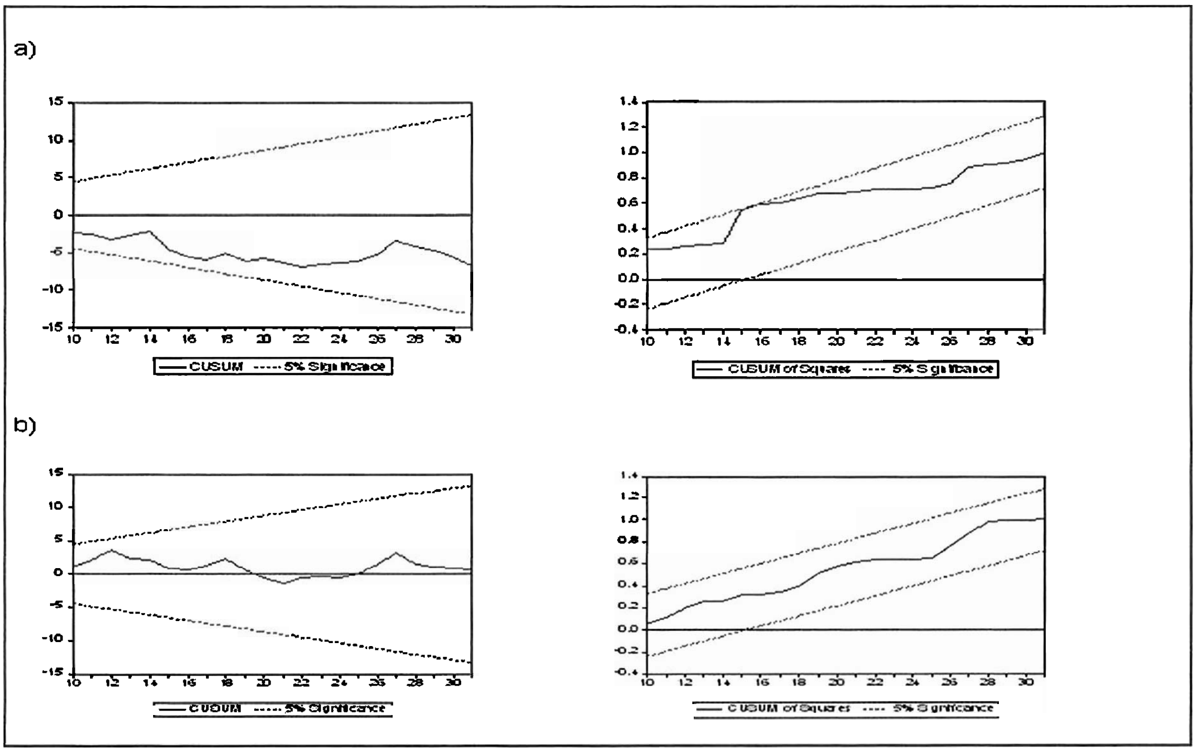

Figure 5.0
CUSUM and CUSUM-SQ Graphs for MADA Regions 1and 4
Notes:
a) refers to MADA Region 1
b) refers to MADA Region 4

5.8 VECM Granger Causality

The presence of co-integration or long-run relationship in MADA Regions 1 and 4 suggested that there must be Granger causality at least one direction. However, the co-integration test alone cannot portray the direction of temporal Granger causality between variables. To overcome this weakness, we then employed the Error Correction Model (ECM) to provide an indication of the direction of Granger causality. ECM linked the short-run dynamic imbalance relationship between the two variables. For the purposes of ECM analysis, Error Correction Term (ECT) value was employed. In addition, the ECT can distinguish between short-run and long-run Granger causality.

Table 5.10 shows the Wald F-statistic of lagged explanatory variable of the ECM. The Wald F-statistic gave an indication of short-run Granger casual relationship between dependent and independent variables. Table 5.10 also provides the t-statistic for the coefficients of the ECT. This is to capture the long-run Granger casual effect. Finally, Table 5.10 also demonstrates the joint or strong Wald F-statistic for interactive terms between ECT and the explanatory variables. The purpose of joint or strong Granger causality test is to identify which variables bear the burden of short-run adjustment to re-establish long-run equilibrium, given shock to the system (Asafu-Adjaye, 2000)

Table 5.10 shows the temporal Granger causality test for MADA Regions 1 and 4. Basically there are three types of Granger causality tests involved in the analysis, namely short-run, long-run, and joint Granger causality. The short-run results for MADA Region 1 showed that the F-statistic for land (in paddy yield equation) is significant at the 10 per cent level. However, none of the lagged explanatory variables in paddy-yield equation is statistically significant. Meanwhile, in the land equation, Wald F-statistic showed that paddy yield is significant at 10 per cent level.

The present research has also discovered that the explanatory variables are not significant in other equations. These results implied that, in the short-run, there is a bi-directional Granger causality between paddy yield and land. Additionally, from the equation of young and old farmers, we have found that both young and old farmers have bi-directional Granger causality in the short-run. Based on t-statistic, it can be seen that the coefficient of ECT is significant in the paddy yield equation.

However, this research has also found that ECT is not significant in land, capital, young farmers, old farmers, fertiliser, and paddy price equations. These imply that land size bears the burden of the short-run adjustment to the long-run equilibrium. The insignificant variables such as capital, fertiliser, and paddy price indicate that these variables are exogenous in the system.

The Wald F-statistic in joint Granger causality suggest that, in the long-run capital, land, young farmers, old farmers, fertiliser, and paddy price Granger cause paddy yield. This indicates that in any deviations of paddy yield from the long-run equilibrium, all seven variables interact in a dynamic fashion to restore the long-run equilibrium. Furthermore, the present research has also discovered that young and old farmers, capital, and paddy price have a bi-directional relationship in the long-run. This indicates that, in the long-run, a bi-directional causality could mean that both young and old farmers, capital, and paddy price affect each other in a feedback fashion.

For MADA Region 4, the results from Table 5.10 show that only capital is significant at 1 per cent level in paddy-yield equation in the short-run. Meanwhile, in capital equation, paddy yield is significant at 1 per cent level. These clearly show that paddy yield and capital have bi-directional Granger causality in the short-run. This finding is similar to Shahbaz et al., (2011). Additionally, we have also discovered that young farmers and capital, old farmers and capital, young farmers and old farmers, and paddy price and capital present feedback short-run Granger causality.

Based on p value, it can be seen that the coefficient of ECT is significant in the paddy yield, capital, and fertiliser equations. This implies that paddy yield, capital, and fertiliser bear the burden of the short-run adjustment to the long-run equilibrium. Meanwhile, ECT has found insignificance in land, young farmers, old farmers, and paddy price equations. The insignificance of variables such as land, young farmers, old farmers,

Table 5.10

Granger Causality VEC Model

Regions/ Variables	Short-Run Causality							Long-Run Causality	Joint Causality						
	ΔLY_t	ΔLN_t	ΔLK_t	$\Delta LL40_t$	$\Delta LL41_t$	ΔLF_t	ΔLP_t	ECT	ECT ΔLY_t	ECT ΔLN_t	ECT ΔLK_t	ECT $\Delta LL40_t$	ECT $\Delta LL41_t$	ECT ΔLF_t	ECT ΔLP_t
MADA 1	Wald F-statistics							t-Ratio	Wald F-statistics						
ΔLY_t	-	3.12*** [0.09]	1.49 [0.24]	0.002 [0.96]	0.002 [0.96]	0.87 [0.36]	1.05 [0.32]	-1.08** (-4.43)	-	10.59* [0.00]	9.83* [0.00]	9.84* [0.00]	9.84* [0.00]	10.62* [0.00]	10.32* [0.00]
ΔLN_t	3.74*** [0.06]	-	0.0009 [0.98]	0.22 [0.65]	0.22 [0.65]	0.05 [0.83]	0.82 [0.37]	0.005 (1.32)	1.97 [0.17]	-	0.97 [0.39]	0.96 [0.40]	0.96 [0.40]	0.87 [0.43]	1.07 [0.36]
ΔLK_t	1.84 [0.19]	0.002 [0.96]	-	0.31 [0.58]	0.31 [0.58]	0.04 [0.85]	2.03 [0.17]	0.52 (1.49)	1.18 [0.33]	1.24 [0.31]	-	1.21 [0.32]	1.21 [0.32]	1.18 [0.33]	3.29** [0.06]
$\Delta LL40_t$	0.02 [0.89]	0.28 [0.60]	0.25 [0.62]	-	1494141* [0.00]	1.47 [0.24]	0.008 [0.93]	0.00005 (0.31)	0.25 [0.78]	0.16 [0.32]	0.14 [0.87]	-	747143* [0.00]	0.74 [0.49]	0.06 [0.94]
$\Delta LL41_t$	0.005 [0.95]	0.47 [0.50]	0.35 [0.56]	1507153* [0.00]	-	1.19 [0.29]	0.003 [0.96]	0.00005 (-0.29)	0.18 [0.84]	0.24 [0.79]	0.18 [0.83]	75365* [0.00]	-	0.59 [0.56]	0.05 [0.95]
ΔLF_t	0.70 [0.41]	0.89 [0.36]	0.03 [0.87]	1.76 [0.19]	1.76 [0.19]	-	1.25 [0.28]	0.58 (1.39)	1.09 [0.35]	1.14 [0.34]	1.02 [0.38]	1.67 [0.21]	1.67 [0.21]	-	1.27 [0.30]
ΔLP_t	1.29 [0.27]	1.08 [0.31]	1.69 [0.21]	0.007 [0.93]	0.007 [0.93]	1.40 [0.25]	-	0.53 (1.43)	1.03 [0.38]	1.25 [0.31]	3.49** [0.05]	1.03 [0.37]	1.03 [0.37]	1.34 [0.28]	-
MADA 4															
ΔLY_t	-	1.24 [0.28]	8.12* [0.00]	0.004 [0.95]	0.009 [0.92]	0.45 [0.51]	1.04 [0.32]	-1.00** (-4.99)	-	12.64** [0.00]	13.13* [0.00]	12.49* [0.00]	12.49* [0.00]	15.96* [0.00]	12.49* [0.00]
ΔLN_t	1.36 [0.26]	-	0.0000002 [0.99]	0.56 [0.46]	0.56 [0.46]	0.11 [0.75]	0.235 [0.63]	0.003 (0.75)	0.72 [0.49]	-	0.38 [0.69]	0.66 [0.53]	0.66 [0.53]	0.37 [0.69]	0.47 [0.63]
ΔLK_t	11.44* [0.00]	0.13 [0.91]	-	3.72*** [0.07]	3.89*** [0.06]	0.07 [0.79]	6.74** [0.02]	0.57** (2.46)	5.72** [0.01]	3.18** [0.06]	-	5.51** [0.01]	5.59** [0.01]	3.05** [0.07]	6.91* [0.00]
$\Delta LL40_t$	0.04 [0.85]	0.28 [0.60]	5.03** [0.04]	-	14699* [0.00]	1.76 [0.19]	1.13 [0.30]	- 0.000004 [0.99]	0.05 [0.96]	0.14 [0.87]	2.98*** [0.07]	-	7441* [0.00]	0.88 [0.43]	0.57 [0.57]
$\Delta LL41_t$	0.05 [0.82]	0.28 [0.60]	5.31** [0.03]	14687* [0.00]	-	1.72 [0.20]	1.21 [0.29]	0.00005 (0.032)	0.05 [0.95]	0.14 [0.87]	3.13*** [0.07]	7438* [0.00]	-	0.86 [0.44]	0.61 [0.55]
ΔLF_t	0.44 [0.51]	1.05 [0.32]	0.07 [0.79]	1.54 [0.23]	1.49 [0.24]	-	0.24 [0.63]	-0.02** (0.04)	0.79 [0.47]	0.54 [0.59]	0.04 [0.96]	0.77 [0.48]	0.74 [0.49]	-	0.12 [0.89]
ΔLP_t	1.03 [0.32]	0.26 [0.62]	6.52** [0.02]	0.95 [0.34]	1.04 [0.32]	0.43 [0.52]	-	-0.22 [-0.63)	0.59 [0.56]	0.39 [0.68]	3.59** [0.05]	0.64 [0.54]	0.68 [0.52]	0.43 [0.66]	-

Notes: [ ] is p value. * 1 per cents significant level, ** 5 per cents significant level and *** 10 per cent significant level.

and paddy price in the short-run indicated that these variables are exogenous in the system[25].

Based on the paddy-yield equation, the Wald F-statistic in joint Granger causality suggested that, in the long-run, capital, land, young farmers, old farmers, fertiliser, and paddy price Granger cause paddy yield. This shows that, in any deviations of paddy yield from long-run equilibrium, all seven variables interact in a dynamic fashion to restore the long-run equilibrium. The result has further indicated the presence of bi-directional between paddy price and capital and young farmers and old farmers in the long-run equilibrium.

5.9 Impulse Response Function (IRF)

The dynamic behaviour of the VEC model can be seen in terms of the response of each variable to shocks from these variables and the other endogenous variables. In this model, the response of each variable with the new information was measured with a 1-standard deviation[26]. Horizontal axis is time in years next period after the occurrence of shock, while the vertical source is the response. Fundamentally, in this analysis, we can determine the positive or negative response from a variable to another. The response is usually short-term and it tends to change and is quite significant. In the long-run, the response tends to be consistent and continues to shrink. Impulse Response Function (IRF) provides an idea on how the response of one variable is in future if there is interference on other variables. For interpretation, we presented the result of IRF on paddy yield, land,

[25] Exogenous variables are one that comes from outside the model and is unexplained by the model.

[26] Standard deviation shows how much variation exists from the mean. A low standard deviation indicates that the data points tend to be very close to the mean and high standard deviation indicates that the data points are spread out over a large range of values. In This case, 1-standard deviation shows that the data point is close to the mean.

capital, young farmers, old farmers, fertiliser, and paddy price in 20 periods in Figures 5.1 and 5.2 below. If the bands do not encompass zero, then the responses are significant.

Graph in Figure 5.1 shows that the change in volume of the paddy yield is on a 1-standard deviation change in itself indicates a positive value. At first innovation or shock, the paddy yield is amounting to 1-standard deviation, which shows a positive response or equals approximately to 7.6. In this case, the data used are in log, therefore, the shock of the paddy yield amounting to 1-standard deviation has led to the increase in paddy yield approximately 7.6 per cent. After 10 periods, the impact of paddy yield shock has become stable. Based on the shock in land, paddy yield is positive and stable in the long-run. However, this research has found that a positive shock in capital leads to paddy yield responding negatively and being stable after 13 periods. Actually, there is an increasing use of machinery for paddy cultivation in MADA Region 1. However, according to Aziz, Ibrahim, Norizan & Hassan (2003), and Yohanna, Fulani, & Aka'ama (2011), the use of machine is still a problem for small-scale farmers. This problem occurs when there is an increasing demand to use the machinery during harvesting time. The delay in harvesting may cause paddy damage and this indirectly affect paddy production for MADA. Approximately, 17 to 19 per cent of small-scale farmers in the MADA Region 1 are facing this problem.

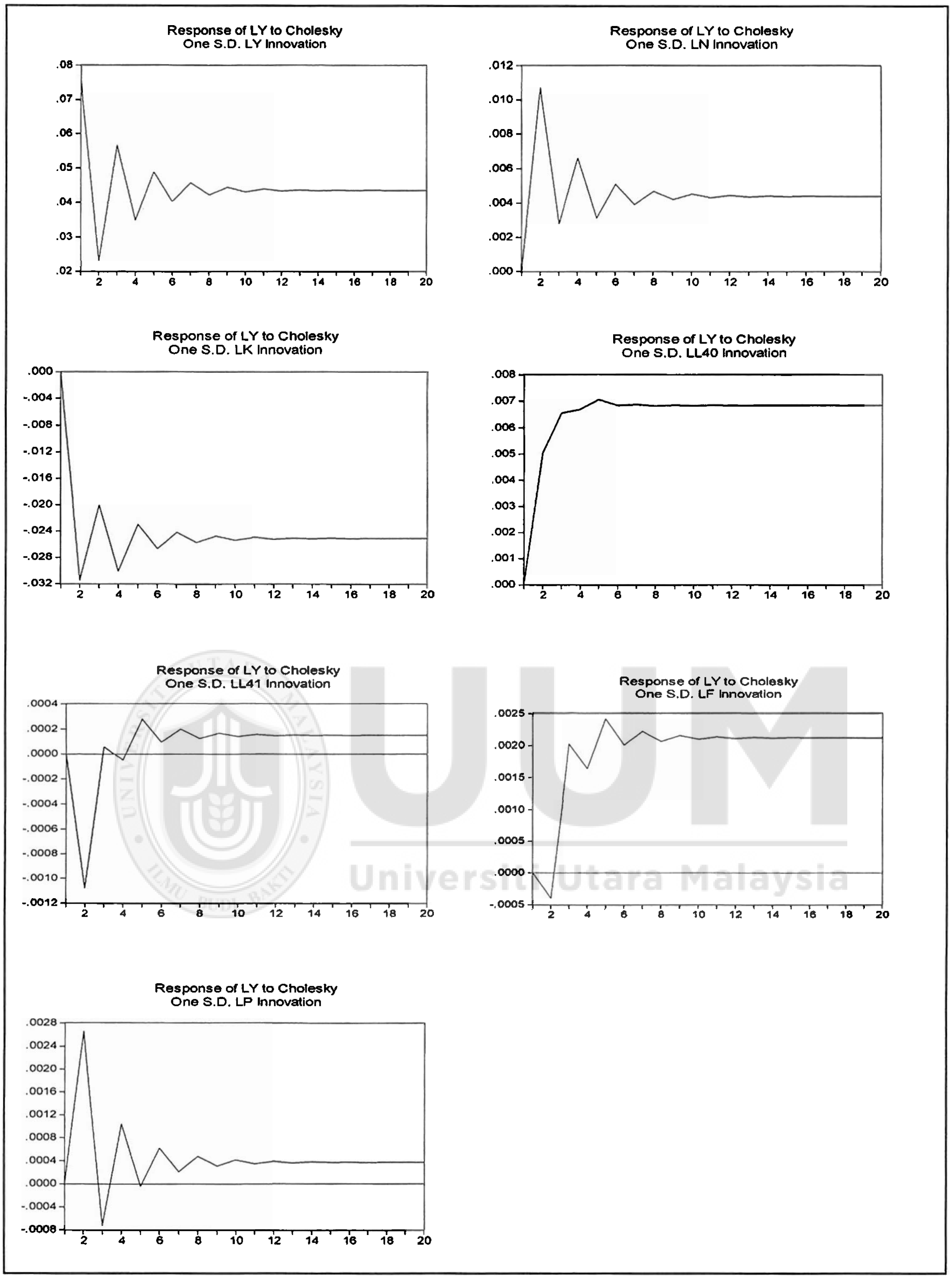

Figure 5.1

Responses to Cholesky One S.D. Innovations in MADA Region 1

Meanwhile, this research has also discovered that paddy yield has responded positively by shocks in young farmers. In initial stage, shock in fertiliser is not significant for paddy yield in the short-run. However, after 5 periods, innovation in fertiliser gives a small positive effect to paddy yield. Next, this research has found that shock in old farmers and paddy price gives a neutral result to paddy yield in the long-run. From this finding, we have found that paddy yield itself, land, young farmers, and fertiliser become the sources of change in paddy yield in the long-run.

Subsequently, Figure 5.2 shows the responses to 1-standard deviation in MADA Region 4. Volume paddy yield on a 1-standard deviation change in itself indicates a positive value. After 10 periods, the impact of paddy yield shock becomes stable. At the beginning, the shock in land is not significant to paddy yield. However, after 2 periods, the shock in land leads to paddy yield increase, and after 3 periods, the shocks lead to the paddy yield decrease. However, the long-run shock in land gives a small positive impact to paddy yield. Meanwhile, this research has also found that capital and paddy yield have a neutral effect initially. This is shown by the graph in Figure 5.2 where a positive shock in capital causes a paddy yield to be insignificant until periods 2. However, after periods 2, a shock in capital causes paddy yield to become negative. Consequently, after periods 4, the shock in land gives a positive and stable impact on paddy yield.

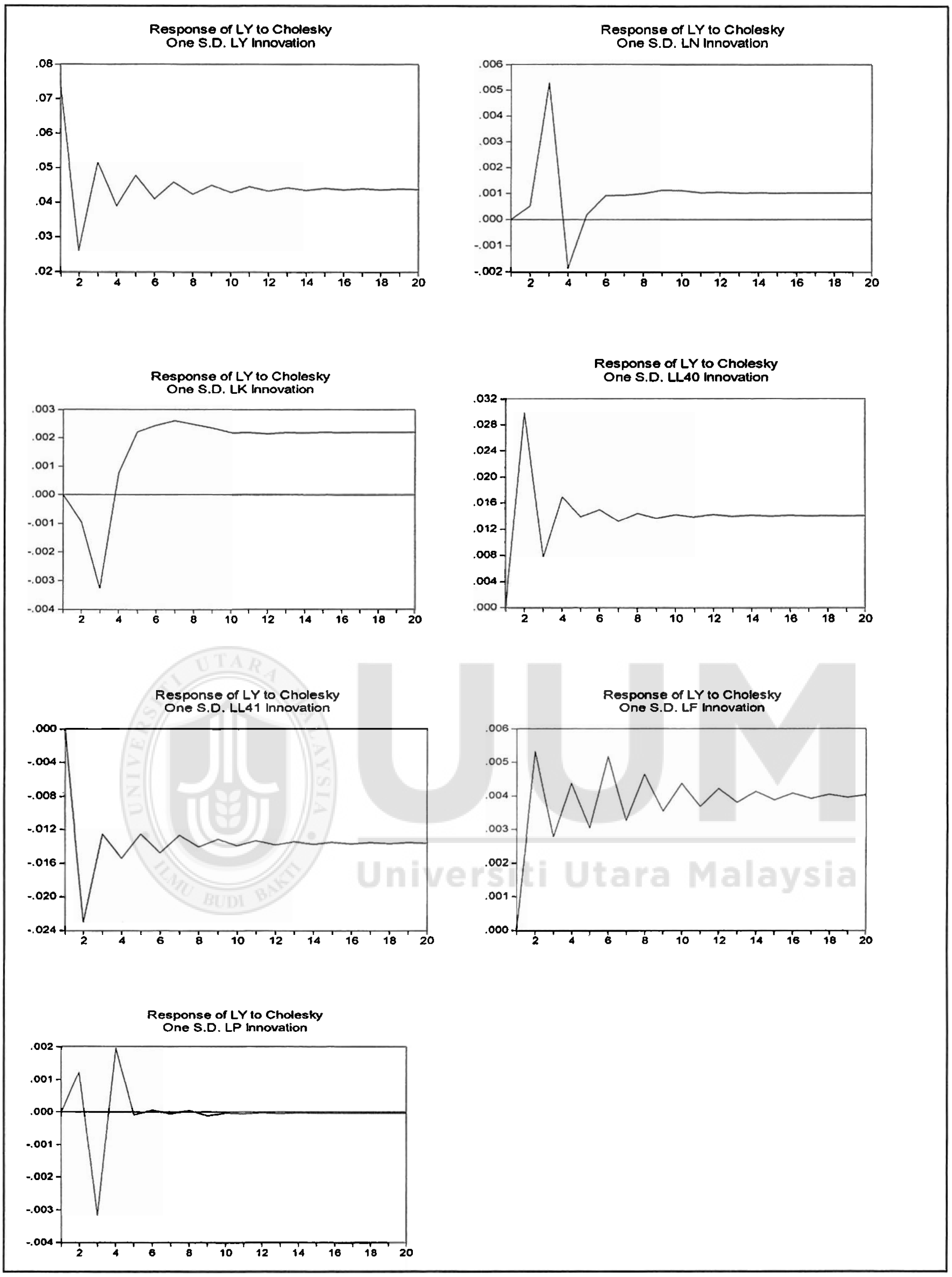

Figure 5.2
Responses to Cholesky One S.D. Innovations in MADA Region 4

Figure 5.2 shows that 1-standard deviation, shock in young farmers and fertiliser, gives a positive response to paddy yield. Both shocks gave a stable response in the long-run. The present research has also discovered that paddy yield has responded negatively by shocks in old farmers. Subsequently, this research has found that paddy price does not give a significant effect to paddy yield in the long-run. From this finding, we have found that paddy yield itself, land, young farmers, and fertilizer become the sources of change in paddy yield in the long-run.

5.10 Variance Decompositions (VDCs)

After the VECM estimation, we then proceed with the variance decompositions (VDCs). The purpose of VDCs is to assess the relative influences of the variables in paddy-production system in MADA production in Region 1. VDCs is an alternative method to IRFs to examine the effects of shocks on dependent variables. It explains how much the variance for any variables in a system is explained by innovations to each explanatory variable over a series of time horizons. Usually, own-series shocks explain most of the error variance although the shock will also affect the other variables in the system.

VDCs separate the variation in an endogenous variable into the component shocks the VECM. Table 5.11 presents the variance decompositions of paddy yield, land, capital, young farmers, old farmers, fertiliser, and paddy price for the periods of 10 years. At 1-period, none of the explanatory variables plays a significant role affecting paddy yield in MADA Region 1. Until the 10-period shock, paddy yield remains the main determination of the paddy production.

In the intermediate and long-run periods, the contribution of capital as a determinant of the variability of paddy yield increases about 18.89 per cent. This result has supported the findings of Granger causality test of the long run, where capital is significant in affecting the paddy yield. Shocks in variables such as young farmers, old farmers, fertiliser, and paddy price are insignificant in explaining the paddy yield. This indicates that most of the variations in paddy yield are accounted mostly by it owns variations and by shocks in capital input used. Based on this result, innovation affected and become the main factor that affects the paddy yield over time. Therefore, the paddy yield is an exogenous variable in MADA Region 1.

Table 5.11
VECM Variance Decomposition Paddy Yield in MADA Region 1

Variance Decomposition of ΔY:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	100	0	0	0	0	0	0
2	84.64	1.55	13.36	0.34	0.02	0	0.1
4	80.51	1.25	17.26	0.85	0.01	0.05	0.07
6	78.75	1.08	18.89	1.12	0.01	0.09	0.05
8	77.64	1	19.94	1.27	0.01	0.11	0.04
10	76.85	0.95	20.67	1.36	0	0.12	0.03
Variance Decomposition of ΔN:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	7.64	92.36	0	0	0	0	0
2	4.54	79.97	3.95	6.23	1.45	3.19	0.66
4	3.61	74.64	8.06	6.6	1.79	4.11	1.19
6	2.88	73.8	8.65	7.32	1.82	4.11	1.41
8	2.5	73.44	8.87	7.71	1.84	4.12	1.52
10	2.26	73.22	8.99	7.96	1.86	4.13	1.59
Variance Decomposition of ΔK:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	4.43	1.75	93.83	0	0	0	0
2	3.71	1.04	93.5	1.7	0	0	0.04
4	3.17	0.53	93.74	2.32	0.01	0.14	0.08
6	3	0.36	93.72	2.6	0.02	0.2	0.1
8	2.92	0.28	93.71	2.73	0.02	0.23	0.11
10	2.88	0.24	93.71	2.81	0.02	0.24	0.11

Variance Decomposition of ΔL40:							
Period	ΔY	ΔN	ΔK	ΔL40	ΔL41	ΔF	ΔP
1	0.64	13.71	4.28	81.37	0	0	0
2	1.51	21.54	6.74	65.68	0.74	3.68	0.11
4	1.89	27.03	3.42	62.29	0.87	4.38	0.11
6	2.01	28.87	2.37	61.11	0.92	4.61	0.11
8	2.06	29.76	1.86	60.53	0.95	4.73	0.11
10	2.1	30.29	1.56	60.17	0.96	4.8	0.11
Variance Decomposition of ΔL41:							
Period	ΔY	ΔN	ΔK	ΔL40	ΔL41	ΔF	ΔP
1	0.65	13.59	4.25	81.51	0	0	0
2	1.5	21.46	6.7	65.82	0.78	3.63	0.11
4	1.88	26.99	3.4	62.4	0.92	4.3	0.11
6	1.99	28.83	2.35	61.21	0.98	4.53	0.11
8	2.05	29.72	1.84	60.63	1	4.64	0.11
10	2.09	30.25	1.54	60.27	1.02	4.72	0.11
Variance Decomposition of ΔF:							
Period	ΔY	ΔN	ΔK	ΔL40	ΔL41	ΔF	ΔP
1	3.29	16.84	2.75	5.38	1.04	70.7	0
2	9.64	20.53	1.6	8.08	0.73	58.72	0.7
4	7.36	19.92	1.74	7.84	1.15	61.35	0.64
6	7.12	19.3	1.17	7.89	1.27	62.61	0.64
8	7.01	19.02	0.88	7.92	1.32	63.2	0.64
10	6.95	18.86	0.71	7.95	1.36	63.55	0.64
Variance Decomposition of ΔP:							
Period	ΔY	ΔN	ΔK	ΔL40	ΔL41	ΔF	ΔP
1	4.66	0.15	13.08	14.9	1.25	15.95	50.01
2	9.36	0.07	25.39	12.26	1.46	10.37	41.09
4	10.76	1.47	21.08	12.86	2.27	11.7	39.87
6	11.24	1.63	18.87	13.8	2.48	11.83	40.15
8	11.48	1.73	17.68	14.24	2.59	11.91	40.38
10	11.63	1.8	16.95	14.5	2.65	11.96	40.52

Looking along the main diagonal, the results have also revealed that the own shock[27] is relatively high for land, capital, young farmers, old farmers, and fertiliser. Meanwhile, for the paddy price in VDCs, as after the 1-period after shock, the variance

[27] Shocks in the input of land, capital, young farmers, old farmers, and fertiliser are determined by its own variance. It is important especially to measure how big the difference is between the variance before and after the shock that comes from it. Furthermore, it is also important in constructing the forecast error variance of a variable.

appears to be less explained by its own innovations. Therefore, based on this evidence, we have concluded that paddy price is endogenous variable.

Table 5.12
VECM Variance Decomposition Paddy Yield in MADA Region 4

Variance Decomposition of ΔY:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2	80.71	0.00	0.01	11.83	7.04	0.38	0.02
4	81.81	0.25	0.10	9.89	7.39	0.44	0.12
6	81.97	0.19	0.13	9.57	7.52	0.53	0.09
8	82.20	0.16	0.16	9.29	7.56	0.56	0.07
10	82.29	0.14	0.17	9.13	7.63	0.58	0.06
Variance Decomposition of ΔN:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	3.47	96.53	0.00	0.00	0.00	0.00	0.00
2	1.70	93.23	0.15	3.18	0.08	1.63	0.03
4	3.01	89.12	1.87	3.21	1.03	1.49	0.26
6	2.82	88.56	2.26	3.64	1.22	1.28	0.23
8	2.62	88.64	2.33	3.76	1.27	1.16	0.21
10	2.48	88.77	2.36	3.82	1.29	1.09	0.20
Variance Decomposition of ΔK:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	12.99	11.55	75.46	0.00	0.00	0.00	0.00
2	4.84	4.98	88.56	0.70	0.07	0.67	0.18
4	2.61	1.84	89.40	4.08	1.13	0.51	0.43
6	1.92	1.40	89.07	5.23	1.31	0.42	0.65
8	1.63	1.20	89.04	5.69	1.33	0.36	0.76
10	1.46	1.04	89.12	5.91	1.33	0.34	0.81
Variance Decomposition of ΔL40:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	1.46	16.05	17.50	64.99	0.00	0.00	0.00
2	1.01	19.32	21.37	54.04	0.38	3.80	0.07
4	1.00	34.48	10.91	48.47	0.32	4.31	0.51
6	1.03	38.40	7.97	46.07	0.71	5.31	0.50
8	0.98	40.02	6.57	45.05	1.01	5.90	0.47
10	0.92	41.06	5.56	44.62	1.16	6.24	0.45
Variance Decomposition of ΔL41:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	1.58	15.60	19.15	63.49	0.18	0.00	0.00
2	1.04	18.82	23.56	52.36	0.20	3.96	0.07
4	1.03	33.94	12.22	47.36	0.48	4.45	0.52
6	1.08	37.94	8.71	45.12	1.18	5.46	0.52

8	1.03	39.58	7.00	44.16	1.68	6.05	0.49
10	0.96	40.63	5.83	43.75	1.94	6.41	0.47
Variance Decomposition of ΔF:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	11.87	4.88	0.96	13.97	28.86	39.45	0.00
2	9.19	14.45	0.47	22.49	18.43	34.20	0.77
4	7.84	21.02	0.63	19.17	14.75	35.34	1.25
6	7.32	21.79	0.58	19.76	13.42	35.89	1.25
8	7.09	22.21	0.54	19.85	12.87	36.20	1.24
10	6.95	22.51	0.50	19.89	12.54	36.37	1.24
Variance Decomposition of ΔP:							
Period	**ΔY**	ΔN	ΔK	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.26	4.72	13.55	8.40	2.80	16.92	53.34
2	0.21	4.53	24.15	8.80	4.40	10.51	47.40
4	0.20	2.54	32.70	8.42	4.77	8.41	42.97
6	0.19	1.79	34.62	7.94	5.17	8.11	42.17
8	0.18	1.41	35.15	7.85	5.29	8.03	42.09
10	0.17	1.18	35.45	7.84	5.34	7.96	42.05

Table 5.12 shows the variance decomposition of paddy yield in MADA Region 4. The VDCs show that the forecast error variance of paddy yield is 100 per cent explained by its own shocks in 1-period. None of the other explanatory variables plays a significant role affecting paddy yield in MADA Region 4 in 1-period. In the intermediate period, the contribution of land, capital, old farmers, fertiliser, and paddy price in explaining the variability of paddy yield is insignificant. This research has also discovered that young farmers are only significant at 2-period. However, for intermediate and long period, innovation in young farmers is not significant[28].

Looking along the main diagonal, the results have revealed that the own shock is relatively high for paddy yield, land, capital, and young farmers. The variance appears to be less explained by innovations in the other explanatory variables. This indicates the

[28] Insignificant innovation in young farmers refers to the variance of young farmers that was explained by more than 50 per cent by other variables such as paddy yield, land, capital, old farmers, fertiliser and paddy price. For example, in Period 4, 51.61 per cent of the variance in young farmers was explained by other variables. Meanwhile, in Period 10, 55.39 per cent of the variance of young farmers was explained by other variables.

presence of exogenous variables. Nevertheless, we have also discovered that old farmers, fertiliser, and paddy price are endogenous variables. This is because its variance is less explained by its own shock. Based on the results of impulse response function and variance decomposition analysis, we have found that each variable can explain shock for other variables. However, their explanation portion is still dominated by the variable itself.

5.11 Unstructured VAR Granger Analysis

For further analysis of non-co-integration variables, this research has employed the Vector Autoregressive (VAR) model at first difference. Thus, we have employed Equations 5.47 to 5.53 that excluded ECT for MADA Regions 1 and 3[29]. From Table 5.13, we have found that the null hypothesis that fertiliser does not Granger-cause paddy yield is rejected at 5 per cent significant level in MADA Region 2. This indicates that fertiliser is the important determinant of the paddy yield (Terano et al., 2013a). Furthermore, this research has also discovered that fertiliser and paddy yield have a unidirectional relationship in the short-run. Therefore, the use of fertiliser may assist farmers to produce better crops. This indicates that the use of fertilizer is very effective in increasing paddy production in MADA Region 2.

From the VAR result, this research has shown that fertiliser Granger cause land. This show that fertiliser is important to increase soil fertility in MADA Region 2. Further analysis has indicated that despite the land, fertiliser also has a two-way Granger cause with capital. In addition, the study has found that fertilizer Granger cause old farmers'

[29] Inverse roots of AR characteristic polynomial in Appendix 3 indicates that VAR model for MADA Regions 1 and 3 is stable.

participation in paddy-farming activities. Finally, in MADA Region 2, the research has also discovered that both young and old farmers Granger cause land. This shows that both old and young farmers are still dominant in influencing the size of the paddy fields in the MADA area. The involvement of young and old farmers in paddy cultivation can maintain soil function as a rice producer. This in turn can prevent the occurrence of land that is not exploited and abandoned.

Table 5.13
Probability of F-statistics from test of causality in MADA Region 2

Dependent variable (Probability of F statistics)							
	ΔLY	**ΔLN**	**ΔLK**	**ΔLL40**	**ΔLL41**	**ΔLF**	**ΔLP**
ΔLY		0.739 [0.389]	2.255 [0.133]	2.503 [0.113]	2.504 [0.113]	15.438* [0.0001]	0.673 [0.411]
ΔLN	1.386 [0.239]		0.781 [0.377]	1.021 [0.312]	0.997 [0.317]	3.87575* [0.049]	0.024 [0.876]
ΔLK	2.194 [0.138]	0.364 [0.546]		0.021 [0.882]	0.025 [0.872]	9.049* [0.002]	0.135 [0.713]
ΔLL40	2.211 [0.136]	4.676* [0.030]	0.3981 [0.528]		0.796 [0.372]	2.463 [0.116]	1.630 [0.201]
ΔLL41	2.246 [0.134]	4.698* [0.030]	0.4016 [0.526]	0.770 [0.380]		2.454 [0.117]	1.631 [0.201]
ΔLF	0.685 [0.407]	0.333 [0.563]	5.330* [0.021]	5.025 [0.025]	5.116* [0.023]		5.518* [0.018]
ΔLP	0.934 [0.333]	0.0643 [0.799]	1.4107 [0.234]	0.063 [0.801]	0.062 [0.802]	0.563 [0.452]	

Notes:
* denotes significance at 5 per cent level.

From Table 5.14, the null hypothesis that fertiliser does not Granger-cause paddy yield is rejected at 5 per cent significant level. This indicates that fertiliser is important in MADA Region 3. Subsequently, this research has also discovered that paddy yield does not Granger-cause capital, which is rejected at 5 per cent significant level. The analysis has also discovered that paddy yield does not Granger-cause paddy price, which is rejected at 5 per cent significant level. These imply that the past paddy yield is important in predicting the capital use and the paddy price level. The study has further indicated the presence of a bi-directional Granger causality between fertiliser and land in MADA Region 2. Nonetheless, there is also a presence of the unidirectional Granger causality between fertiliser and capital and between paddy price and fertiliser.

Table 5.14
Probability of F-statistics from test of causality in MADA Region 3

	Dependent variable (Probability of F statistics)						
	ΔLY	ΔLN	ΔLK	ΔLL40	ΔLL41	ΔLF	ΔLP
ΔLY		0.338 [0 .560]	0.556 [0.455]	1.052 [0.304]	1.145 [0 .284]	6.244* [0.012]	1.067 [0.301]
ΔLN	0.520 [0.470]		0.773 [0 .379]	0.148 [0 .700]	0.115 [0 .733]	4.868* [0.027]	0.039 [0 .843]
ΔLK	21.113* [0.000]	2.583 [0.108]		1.392 [0.23]	1.427 [0.232]	8.098* [0.004]	0.134 [0 .713]
ΔLL40	0.234 [0.628]	2.207 [0 .137]	0.450 [0. 502		0.357 [0.549]	1.236 [0 .266]	0.789 [0 .374]
ΔLL41	0.223 [0.636]	2.317 [0 .127]	0.511 [0. 474]	0.290 [0 .590]		1.095 [0.295]	0.771 [0 .379]
ΔLF	0.097 [0.754]	2.727* [0.098]	2.418 [0. 119]	0.337 [0.561]	0.453 [0.500]		4.966* [0.025]
ΔLP	3.781* [0 .051]	0.880 [0 .348]	1.231 [0. 267]	0.269 [0 .603]	0.282 [0.595]	0.191 [0.661]	

Notes:
* denotes significance at 5 per cent level.

5.12 VAR Impulse Response Function

Figure 5.3 shows the responses to one *standard deviation* (S.D) innovations in MADA Region 2 for VAR Model. Based on Figure 5.3, we have discovered that shocks in young farmers, old farmers, and fertiliser have a positive effect on paddy yield for a long period. Shock in old farmers gives a negative effect on paddy yield until the second

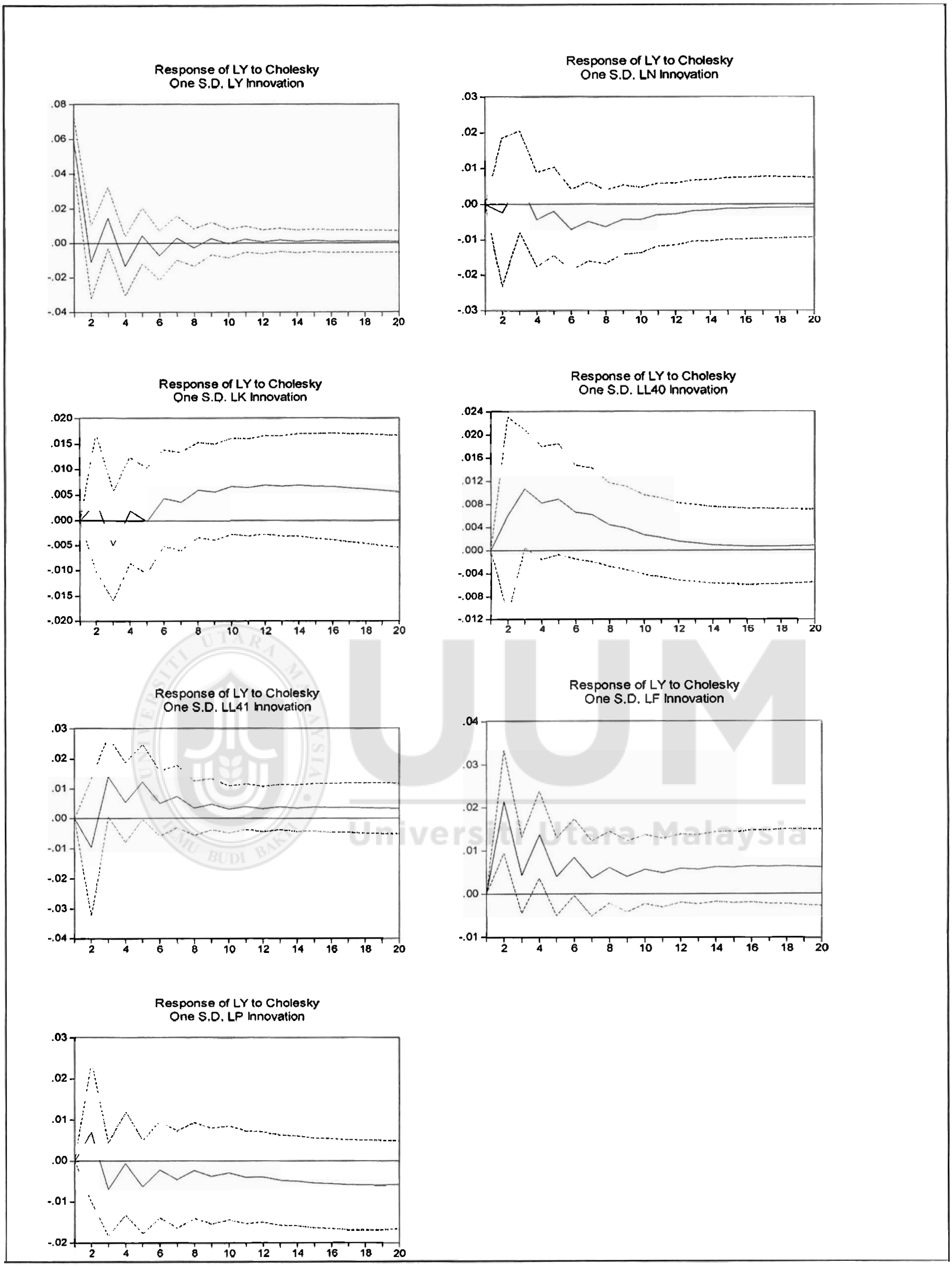

Figure 5.3
Responses to Clokesky One S.D. Innovations in MADA Region 2

period. After half of the second period, any shocks in old farmers give only a positive effect on paddy yield.

Shock in paddy yield itself has an obvious fluctuation. There is high positive effect on the first period, however, it becomes smooth fluctuation in period seven. We have also discovered that shock in capital gives a positive effect to paddy yield after five periods and onwards. Land and paddy price have a negative impact on paddy yield in the longer period. Thus, it can be concluded that the shocks in paddy yield, land, young farmers, old farmers, and fertiliser affect the changes in paddy yield. From this finding, we have found that land, young farmers, old farmers, and fertiliser are sources of change in paddy yield in the long-term. Meanwhile, paddy yields itself becomes the source of change for the short-period.

Based on Figure 5.4, we have discovered that only shock in young farmers gives a positive effect on paddy yield for the long period. Shock in old farmers gives a positive effect on paddy yield until five periods. After that, the variable of old farmers is not significant on paddy yield in MADA Region 3. Shock in paddy yield itself has an obvious fluctuation. It is the highest positive effect on the first period and it becomes smooth fluctuation in ninth period. Shock in fertiliser gives a small positive impact on paddy yield. Nonetheless, it provides a long-term effect to paddy yield in MADA Region 3.

Meanwhile, we have also discovered that shocks in old farmers and paddy price are only significant in the short-run. Thus, it can be concluded that the shocks in paddy yield itself, young farmers, old farmers, and paddy price are the sources of change in the

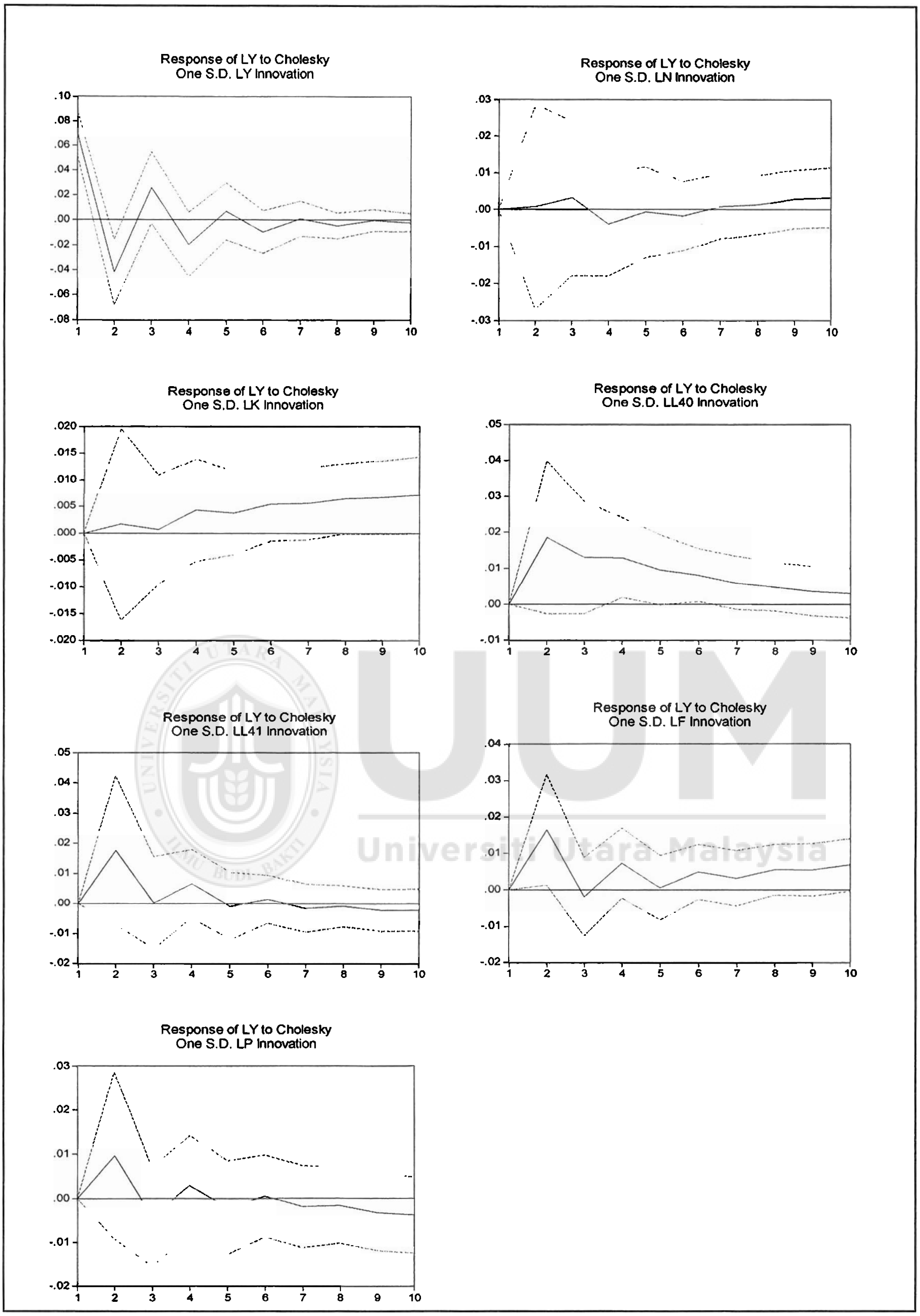

Figure 5.4
Responses to Clokesky One S.D. Innovations in MADA Region 3

paddy yield. From this finding, we have found that young farmers and fertiliser become the sources of change in paddy yield for the long-run. Meanwhile, paddy yield, old farmers, and paddy price become the sources of change for the short-run.

5.13 VAR Variance Decomposition

Table 5.15 presents the variance decompositions of paddy yield, land, young labour, old labour, fertiliser, and paddy price for the periods of 10 years. At 1-period, none of the explanatory variables plays a significant role in affecting paddy yield in MADA's paddy-production region 2. VDC showed that the variance in paddy yield is explained by its own innovation in 1-period.

In the intermediate and long-run, the contribution of own paddy yield shock is 73.42 per cent and 61.18 per cent respectively. It clearly shows that the own paddy yield is significant and has contributed more than 50 per cent in changing paddy yield until the 10-period. This research has also discovered that the shock in fertiliser is also significant in explaining the variations in paddy yield. This result is consistent with the previous Granger causality finding where fertiliser Granger cause paddy yield in one direction. The contribution of land, capital, young farmers, old farmers, and paddy price to the variations of paddy yield is consistently increasing in the intermediate and long-period. However, an innovation in land, capital, young farmers, old farmers, and paddy price are insignificant in explaining the shocks in paddy yield. This indicates that most of the variations in paddy yield are accounted mostly by its own variations.

Looking along the main diagonal, the results revealed that the own shock is relatively high for paddy yield and land. We have also discovered that capital, young farmers, old farmers, fertiliser, and paddy price are endogenous variables because the variance was less explained by their own shocks.

Table 5.15

VAR Variance Decomposition Paddy Yield in MADA Region 2

Variance Decomposition of ΔY:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2	84.25	0.12	0.29	0.89	2.20	11.08	1.16
4	73.42	1.20	0.78	4.15	5.99	12.62	1.83
6	67.40	2.04	1.02	5.84	8.42	12.88	2.41
8	64.04	2.98	1.74	6.47	9.04	13.01	2.71
10	61.68	3.47	2.84	6.57	9.20	13.27	2.97
Variance Decomposition of ΔN:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.12	99.88	0.00	0.00	0.00	0.00	0.00
2	2.25	83.61	2.58	4.38	3.98	3.16	0.04
4	1.70	65.02	7.17	7.65	7.74	6.65	4.07
6	1.45	54.39	9.69	7.86	7.62	9.59	9.41
8	1.32	48.44	10.40	7.32	7.32	11.73	13.47
10	1.24	45.24	10.41	6.85	7.19	13.06	16.01
Variance Decomposition of ΔK:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	18.87	3.71	77.42	0.00	0.00	0.00	0.00
2	10.99	2.64	78.73	2.18	0.20	5.13	0.13
4	8.53	1.34	66.45	3.42	2.39	12.81	5.06
6	6.03	1.31	54.97	3.00	4.26	18.65	11.78
8	4.53	1.14	47.13	2.34	5.41	22.22	17.24
10	3.68	0.93	42.13	1.86	6.06	24.34	21.01
Variance Decomposition of ΔL40:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.05	1.02	9.69	89.24	0.00	0.00	0.00
2	3.28	11.34	6.33	73.85	2.57	0.55	2.09
4	2.44	20.85	4.90	62.52	5.45	0.47	3.38
6	2.22	23.67	7.71	56.15	6.05	0.73	3.47
8	2.39	22.71	12.93	50.27	6.51	2.03	3.14
10	2.51	20.12	18.09	43.88	6.99	4.65	3.75
Variance Decomposition of ΔL41:							
Period	**ΔY**	ΔN	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.07	1.01	9.84	89.07	0.01	0.00	0.00
2	3.38	11.36	6.40	73.59	2.64	0.55	2.08
4	2.51	20.89	4.96	62.31	5.50	0.46	3.38
6	2.28	23.71	7.75	55.98	6.07	0.72	3.48

8	2.45	22.75	12.96	50.14	6.53	2.01	3.15
10	2.56	20.16	18.11	43.78	7.01	4.63	3.75
Variance Decomposition of ΔF:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	8.73	5.70	8.29	0.31	6.25	70.72	0.00
2	5.01	6.24	5.68	3.34	18.81	55.39	5.53
4	3.11	3.21	7.10	4.98	24.10	45.78	11.72
6	2.33	3.50	10.26	5.18	22.70	41.15	14.89
8	1.94	3.96	13.14	4.95	20.73	38.77	16.51
10	1.75	4.04	15.31	4.62	19.27	37.46	17.55
Variance Decomposition of ΔP:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	7.29	4.86	0.25	2.51	0.03	10.46	74.61
2	5.43	4.20	2.42	2.19	0.24	8.70	76.83
4	5.14	3.25	13.19	1.84	2.62	6.98	66.99
6	4.88	2.58	25.87	2.37	4.64	8.49	51.17
8	4.26	2.18	31.89	2.62	5.70	12.43	40.93
10	3.58	1.86	32.76	2.37	6.27	16.26	36.88

Table 5.16 presents the variance decompositions of paddy yield, land, young labour, old labour, fertiliser, and paddy price for the periods of 10 years. At 1-period, none of the explanatory variables plays a significant role is affecting paddy yield in MADA's paddy-production Region 3. VDC showed that the variance in paddy yield is explained by its own innovation in 1-period where 100 per cent of variation in paddy yield was explained by its own shocks.

In the intermediate and long-period, the contributions of land, capital, old farmers, and paddy price are less than 5 per cent of paddy yield variations in MADA Region 3. This indicates that land, capital, old farmers, and paddy price are insignificant in explaining the shocks in paddy yield. This indicates that most of the variations in paddy yield are accounted mostly by it owns variations.

Table 5.16
VAR Variance Decomposition Paddy Yield in MADA Region 3

Variance Decomposition of ΔY:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2	86.50	0.01	0.04	4.55	4.09	3.58	1.24
4	83.27	0.28	0.24	7.45	3.86	3.59	1.30
6	81.46	0.31	0.69	8.81	3.74	3.70	1.29
8	79.98	0.32	1.43	9.22	3.69	4.04	1.33
10	78.01	0.49	2.35	9.22	3.69	4.70	1.54
Variance Decomposition of ΔN:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	15.92	84.08	0.00	0.00	0.00	0.00	0.00
2	12.30	74.53	4.38	3.20	0.29	5.25	0.06
4	9.56	62.48	9.09	3.37	0.79	10.86	3.85
6	7.97	53.25	11.06	2.77	1.96	14.87	8.12
8	7.08	47.35	11.66	2.56	2.72	17.50	11.14
10	6.57	43.72	11.79	2.80	3.09	19.07	12.97
Variance Decomposition of ΔK:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	4.49	1.50	94.02	0.00	0.00	0.00	0.00
2	23.93	1.67	68.44	0.00	1.51	4.35	0.09
4	10.86	9.15	55.45	0.66	5.56	14.30	4.01
6	5.63	12.77	43.33	0.50	6.35	21.85	9.57
8	3.76	12.82	36.17	0.39	6.59	26.08	14.20
10	2.97	11.86	31.96	0.74	6.68	28.42	17.37
Variance Decomposition of ΔL40:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.45	0.27	3.90	95.38	0.00	0.00	0.00
2	2.07	4.42	2.48	88.06	1.58	0.47	0.92
4	3.51	5.54	2.20	84.31	2.38	0.44	1.63
6	4.78	5.21	3.97	81.27	2.26	0.76	1.75
8	5.19	5.03	7.37	76.33	2.14	2.25	1.69
10	4.85	5.56	11.13	68.43	2.31	5.31	2.42
Variance Decomposition of ΔL41:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.50	0.13	3.80	95.46	0.10	0.00	0.00
2	2.10	4.42	2.41	87.94	1.84	0.40	0.89
4	3.63	5.74	2.13	83.92	2.58	0.34	1.66
6	4.94	5.42	3.86	80.89	2.45	0.62	1.82
8	5.36	5.23	7.24	76.06	2.31	2.06	1.74
10	5.00	5.76	11.00	68.25	2.46	5.09	2.44
Variance Decomposition of ΔF:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	0.14	3.56	14.76	1.91	0.29	79.36	0.00

2	1.36	13.18	11.52	11.35	0.15	58.18	4.26
4	0.84	10.08	13.51	16.91	0.28	48.53	9.85
6	0.65	7.82	15.18	18.64	0.92	44.29	12.49
8	0.57	6.74	16.41	18.74	1.51	42.22	13.81
10	0.51	6.21	17.31	18.23	1.96	41.09	14.69
Variance Decomposition of ΔP:							
Period	**ΔY**	**ΔN**	**ΔK**	**ΔL40**	**ΔL41**	**ΔF**	**ΔP**
1	1.82	2.98	0.22	3.29	12.39	8.16	71.14
2	7.81	2.29	0.54	4.01	14.50	6.34	64.51
4	7.64	3.15	2.73	3.77	14.47	5.79	62.46
6	9.03	4.31	6.71	3.39	13.38	5.39	57.79
8	8.06	8.00	15.92	2.84	10.99	7.65	46.54
10	6.02	10.84	21.24	2.20	9.52	12.90	37.29

Looking along the main diagonal, the results revealed that the own shock is relatively high for paddy yield, young farmers, old farmers, fertiliser, and paddy price. This implies the exogeneity of paddy yield, land, capital, young farmers, fertiliser, and paddy price in VDCs, as after the 1-period after the shock. The variance appears to be less explained by innovations in other explanatory variables. Nevertheless, we also discover that the variable of old farmers is an endogenous variable because its variance is explained more by other explanatory variables.

5.14 Total Factor Productivity (TFP)

The results of real TFP growth for MADA Regions 1, 2, 3, and 4 during 1996H1 to 2011H1 are shown in Figure 5.5. This research has discovered that the real TFP growth is less than 5 per cent for every harvest. In all MADA regions, the present research has found that the real TFP trend is fluctuating over time. This finding isconsistent with Tobias et al., (2012) and Bahiah, Haris, Hamzah, Krauss, & Ismail (2013) which indicates that the average yield in the granary areas was 4.1 metric tons per hectare. The fluctuation of the real TFP growth is uncertain. There are times where TFP growth was recorded greater than one in the main season and less than one in the off season and vice versa. Basically, the observation from the Figure 5.5 has discovered that the progress of real TFP growth was recorded in the main season, and the regress of real TFP growth often exits in off-season.

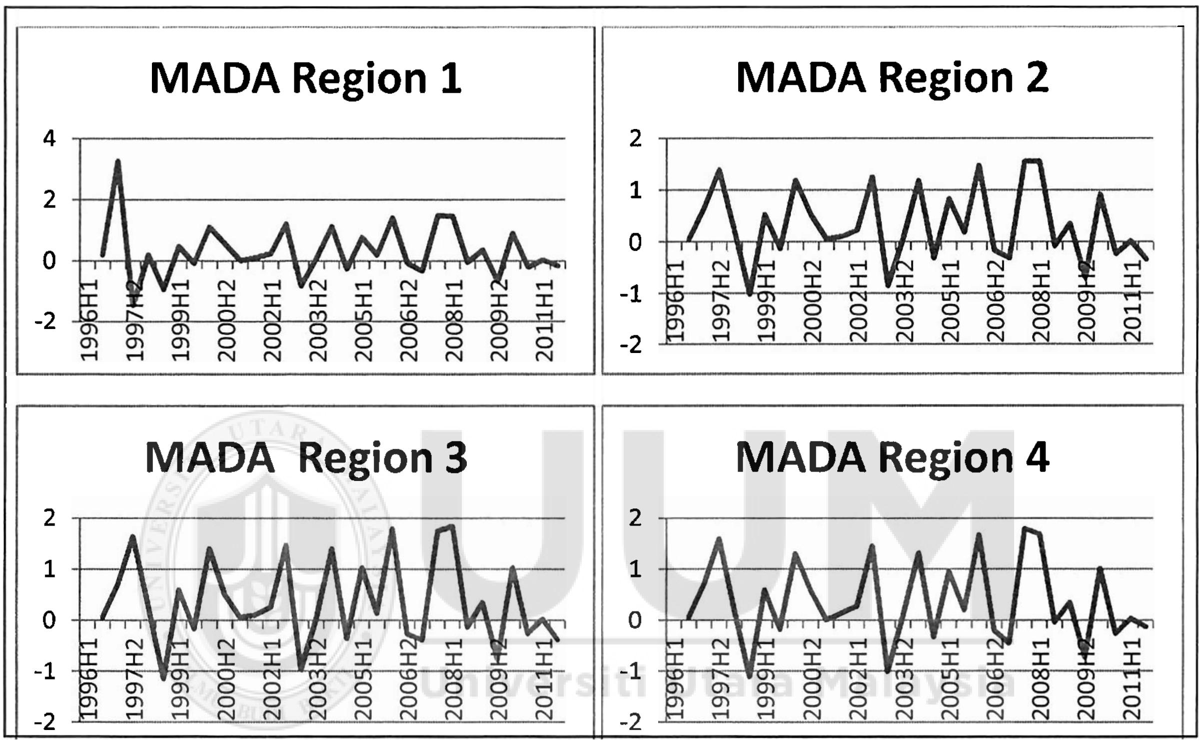

Figure 5.5
Real Total Factor Productivity (TFP) Growth of Paddy Production in MADA (%)

Table 5.17 shows the real Total Factor Productivity (TFP) of paddy production in MADA areas. In MADA Region 1, on the average, the real TFP growth is 0.34 per cent per season over the entire period of 1996H1 to 2011H1. For the short-run periods, the real TFP average growth was 0.27 per cent per-season over 1996H2 to 2003H1 and 0.38

Table 5.17

Real Total Factor Productivity (TFP) of Paddy Production in MADA (%)

Years	MADA 1	MADA 2	MADA 3	MADA 4
1996H1	-	-	-	-
1996H2	0.20	0.05	0.06	0.06
1997H1	3.25	0.65	0.69	0.70
1997H2	-1.47	1.38	1.64	1.59
1998H1	0.19	0.20	0.27	0.19
1998H2	-0.94	-1.02	-1.15	-1.11
1999H1	0.47	0.53	0.59	0.59
1999H2	-0.09	-0.14	-0.17	-0.18
2000H1	1.10	1.19	1.40	1.30
2000H2	0.56	0.52	0.51	0.58
2001H1	0.01	0.05	0.06	0.01
2001H2	0.10	0.10	0.11	0.14
2002H1	0.24	0.22	0.25	0.27
2002H2	1.21	1.25	1.48	1.46
2003H1	-0.82	-0.85	-0.97	-1.01
2003H2	0.07	0.06	0.02	0.07
2004H1	1.12	1.18	1.40	1.32
2004H2	-0.27	-0.32	-0.36	-0.33
2005H1	0.76	0.83	1.03	0.95
2005H2	0.19	0.18	0.14	0.20
2006H1	1.41	1.47	1.79	1.68
2006H2	-0.08	-0.17	-0.27	-0.20
2007H1	-0.33	-0.32	-0.39	-0.46
2007H2	1.48	1.55	1.75	1.80
2008H1	1.46	1.55	1.84	1.69
2008H2	-0.05	-0.09	-0.13	-0.04
2009H1	0.35	0.35	0.34	0.34
2009H2	-0.68	-0.70	-0.78	-0.74
2010H1	0.90	0.92	1.03	1.01
2010H2	-0.21	-0.23	-0.26	-0.26
2011H1	0.03	0.01	0.02	0.03
Average TFP 1996H1 -2003H1	0.27	0.28	0.32	0.31
Average TFP 2003H2 -2011H1	0.38	0.39	0.45	0.44
Average TFP 1996H1 -2011H1	0.34	0.35	0.40	0.39

Note:

All the values are computed by researcher.

per cent over 2003H2 to 2011H1. Meanwhile, in MADA Region 2, the average real TFP growth is 0.35 per cent. For short run periods, the real TFP average growth is 0.28 per cent per season over 1996H2 to 2003H1 and 0.39 per cent over 2003H2 to 2011 H1.

Furthermore, in MADA Region 3, on the average, the real TFP growth is 0.40 per cent per season over the entire period of 1996H1 to 2011H1. For the short-run periods, the real TFP average growth is 0.32 per cent per season over 1996H2 to 2003H1 and 0.45 per cent over 2003H2 to 2011H1. Meanwhile, in MADA Region 4, the average real TFP growth is 0.39 per cent. For the short-run periods, the real TFP average growth is 0.31 per cent per season over 1996H2 to 2003H1 and 0.44 per cent over 2003H2 to 2011H1.

The statistic discussed above is meaningless if we do not know what the significant causes are that influence the behaviour of the real TFP growth. Therefore, to investigate what causes the real TFP growth trend to fluctuate, we have employed the Fabricant's Law (1942). Under the Fabricant's Law in every short or long-run, there is a significant and positive correlation between labour's productivity growth and output growth and there is also a significant and positive correlation between the TFP growth and the output growth. Basically, the TFP growth tends to be high when the output growth is high.

Table 5.18 shows the correlation coefficients and t ratios between the growth of TFP, the growth of output, the growth of capital, the growth of labour, and others growth factors such as land, fertiliser, and paddy price. The long-run TFP growth in MADA Region 2 and MADA Region 4 is significant and positively correlated with the output growth. It suggests that TFP growth tends to move closely with the growth of the output. Thus, the cyclical behaviour of the TFP growth was due to the growth of paddy yield, which is greatly affected by the volume of paddy production. However, for the other MADA regions such as MADA Region 1 and MADA Region 3, this study has shown that the TFP is having insignificant relationship with paddy yield in the long-run.

Another important finding from the correlation study is that there is a significant and positive correlation between TFP and fertiliser in MADA Regions 2, 3, and 4 in the long-run. This finding is consistent with the findings of Khali & Anthony (2012). However, in MADA Region 1, the long-run correlation study has indicated that there is no significant correlation between TFP and fertiliser. This study has discovered that most of the TFP and fertiliser in MADA regions have a positive and significant relationship in the short-run for the period of 1996H1 to 2003H1 and 2003H2 to 2011H1. Only MADA Regions 1 and 2 for the period of 2003H2 to 2011H1 have shown that TFP and fertiliser have no correlation. Based on the finding, it was found that fertiliser is significant in most of short- and long-run in all MADA regions. Therefore, we can conclude that fertiliser plays an important role in the TFP growth of the paddy production. We have also discovered that TFP and land have a neutral relationship in MADA Regions 1, 2, 3, and 4.

Additionally, on the average, the young and old farmers have a significant correlation with TFP in the long-run in MADA Region 1. The significant correlation between TFP and young farmers, TFP and old farmers can be traced in MADA Region 1 in the short-run. This finding supports the Feyrer's (2002) and Kunimitsu, (2012) works. In his works, Feryer has indicated that the age structure has a significance impact on TFP. The insignificant correlation between TFP and farmers, either in short- or long-run indicates that the paddy sub-sector employs unskilled farmers.

Table 5.18
Total Factors Productivity (TFP) Correlation Coefficients

MADA	Period	Δly	Δln	Δlk	Δll40	Δll41	Δlf	Δlp
1	**Long-run**							
	1996H1 - 2011H1	-0.22 (-1.18)	0.16 (0.84)	0.38* (2.20)	0.44* (2.59)	0.49* (3.01)	0.24 (1.32)	0.20 (1.08)
	Short-run							
	1996H1 - 2003H1	-0.31 (-1.17)	0.27 (1.01)	-0.05 (-0.17)	0.73* (3.81)	0.72* (3.78)	0.70* (3.54)	-0.11 (-0.39)
	2003H2- 2011H1	0.51* (2.12)	-0.07 (-0.26)	0.73* (3.84)	0.12 (0.42)	0.11 (0.40)	0.23 (0.86)	0.41 (1.61)
2	**Long-run**							
	1996H1 - 2011H1	0.34** (1.94)	0.20 (1.08)	0.51** (3.17)	0.19 (1.05)	0.19 (1.03)	0.73** (5.63)	0.28 (1.52)
	Short-run							
	1996H1 - 2003H1	0.005 (0.27)	0.0002 (1.29)	-0.001 (-0.32)	0.002 (1.16)	0.002 (1.16)	0.05* (5.61)	-0.003 (-0.57)
	2003H2- 2011H1	0.51* (2.12)	-0.07 (-0.26)	0.73* (3.84)	0.12 (0.42)	0.11 (0.40)	0.23 (0.86)	0.41 (1.61)
3	**Long-run**							
	1996H1 - 2011H1	0.29 (1.63)	0.03 (0.18)	0.53* (3.32)	0.17 (0.93)	0.18 (0.95)	0.72* (5.53)	0.29 (1.57)
	Short-run							
	1996H1 - 2003H1	0.11 (0.38)	0.07 (0.26)	-0.09 (-0.31)	0.28 (1.07)	0.30 (1.11)	0.85* (5.71)	-0.14 (-0.49)
	2003H2- 2011H1	0.41 (1.640	-0.06 (-0.20)	0.75* (4.10)	0.09 (0.33)	0.09 (0.32)	0.67* (3.25)	0.42 (1.65)
4	**Long-run**							
	1996H1 - 2011H1	0.41* (2.37)	0.02 (0.13)	0.52* (3.18)	0.18 (0.95)	0.17 (0.93)	0.74* (5.83)	0.26 (1.42)
	Short-run							
	1996H1 - 2003H1	0.27 (1.01)	0.07 (0.24)	-0.10 (-0.37)	0.28 (1.07)	0.29 (1.08)	0.85* (5.75)	-0.16 (-0.60)
	2003H2- 2011H1	0.55* (2.39)	-0.08 (-0.30)	0.74* (3.96)	0.10 (0.35)	0.09 (0.31)	0.70* (3.58)	0.39 (1.54)

Note:

* 5 per cent significant level, values in parentheses is t-statistic

This study has also found that the relationship between TFP growth and capital input growth is significant in the long-run. Furthermore, TFP and capital input growth are also significant in the short-run especially for the period of 2003H2 to 2011H1 for all

MADA regions. It is undeniable that capital and TFP have an interdependent relationship. Therefore, these reinforce the view that the technology incorporated in machinery and equipment utilised in MADA paddy-cultivation areas is generally high.

5.15 Elasticity of Substitution between Capital and Labour

We begin by assuming that the aggregate production in the all MADA regions can be represented by constant returns to scale production function characterised by a constant elasticity of substitution between the two factors. Arrow et al., (1961) showed that the assumption of a constant elasticity of substitution implies the following functional form for the production function in Equation 4.21. The advantage of this function is that it has one less restrictive assumption by allowing the elasticity to take values other than zero or one. The assumption of constant returns to scale is, however, still made.

The estimates of the elasticities of substitution are presented in Table 5.19[30]. The ordinary least squares (OLS) estimation technique was employed to the data covering the time period from 1996H1 to 2011H1. As in most time-series analysis, this study has also confronted the time-series properties. The unit roots test has indicated that the series are stationary at first difference or I(1). This study has also confronted the problem of serially correlated residuals. The presence of serial correlation implies that the regression coefficients by using the least squares estimation method are not efficient and the estimated variances are biased. Based on the OLS regression output, we have discovered that Durbin-Watson value and LM Test have indicated that OLS estimation for MADA Regions 1, 2, and 4 are free from the first and second-order serial correlations. However,

[30] Refer Appendix 5 for capital-labour elasticity of substitution.

Durbin-Watson value on the OLS estimation shows that MADA Region 3 has suffered a negative first-order serial correlation.

Table 5.19
The Estimation Results for Elasticity of Substitution between Capital and Labour

Variables	MADA Region			
	1	**2**	**3**	**4**
$\ln K_t$	-3.308 (-1.661)	-3.022 (-1.484)	0.679 (0.563)	7.161 (3.655)**
$\ln L_t$	6.403 (-2.994)**	5.990 (2.571)**	2.898 (2.052)**	-3.584 (-2.074)**
$(\ln K_t - \ln l_t)^2$	-0.623 (-1.724)***	-0.472 (-1.432)	0.122 (0.532)	-0.662 (-2.144)**
Constant	-24.352 (2.829)**	-25.305 (-3.127)**	-35.155 (-4.345)**	-29.377 (-4.188)**
R^2	0.66	0.68	0.80	0.76
F-statistic	17.526**	19.690**	36.911*	28.837*
D.W	1.590	2.042	2.010	2.021
σ_{KL}	0.817	0.845	0.554	0.815
v	3.09	2.97	3.57	3.58
N	31	31	31	31

Notes: all the values are computed by researcher.
σ_{KL} is capital-labour elasticity of substitution
v is return to scale parameter
with t-values in parentheses
** and *** donate 5% and 10% significant level

We have further investigated the second-order serial correlation by employing the LM test. We have found that the OLS estimation is free from the second-order serial correlation. Therefore, to address the problems of first-order serial correlation in MADA Region 3, we have employed the Cochrane-Orcutt iteration method.

The elasticity of substitution result is presented in Table 5.19. Equation 4.21 used to estimate the elasticity of substitution for all MADA's paddy-production areas. All the result reported are free from the first and second-order of serial correlation. The result revealed that the elasticity of substitution between capital and labour

(σ_{KL}) in all MADA's paddy-production regions are ranging from 0.554 to 0.845. This shows that the elasticity of substitution between capital and labour is inelastic because the value is less than one. This finding is accordance with Lebrun & Perez Ruiz (2011). Furthermore, empirical estimate has also indicated that the elasticity of substitution value is positive for all areas. In this case, changing relative proportions of each input does not change much in the face of changing relative input prices. A one per cent change in relative factor prices results in less than one per cent of change in the capital-labour ratio.

The elasticity of substitution in MADA Region 1 is 0.82, which means that a one per cent changes in relative factor prices results in 0.82 per cent of change in capital-labour ratio. In MADA Region 2, the elasticity of substitution is 0.85, indicating that a change of one per cent in factor price may increase capital-labour ratio by 0.85 per cent. The response of capital-labour ratio to the changing in factor price in MADA Region 3 is 0.55. This shows that the increasing one per cent in factor price may lead to capital-labour increase by 0.55 per cent. Furthermore, a one per cent change in factor price may cause capital-labour ratio in MADA Region 4 changes by about 0.82 per cent. The value elasticity of substitution is less than one, which means that the substitution between capital and labour in the MADA paddy-production region is relatively difficult. The study has also found that the CES regression result showed that return to scale (v) parameter for MADA Regions 1, 2, 3, and 4 is 3.09, 2.97, 3.57, and 3.58 respectively. On the average, parameters return to scale (v) for the entire MADA regions is 3.15. This shows that overall MADA regions have also experienced the increasing return to scale.

5.16 Young-Old Farmers Elasticity of Substitution

Before we proceed with the constant elasticity of substitution between young and old farmers, we first had to check the time-series properties. The ADF and PP tests have confirmed that all series are stationary at order one or I(1). Equation 4.21 was then estimated by using the OLS technique. To suit with the analysis of young-old farmers' elasticity of substitution, we have changed the notation of labour and capital in Equation 4.21 to young and old farmers.

OLS result has indicated that MADA Regions 2 and 4 are free from the first- and second-order serial correlation. However, for MADA Regions 1 and 3, this study has found the presence of the first- and second-order serial correlation. Therefore, to address the problems of the first-order and second-order serial correlation in MADA Regions 1 and 3, the researcher has employed the Cochrane-Orcutt iteration method.

The result in Table 5.20 shows the elasticity of substitution between young and old farmers (σ_{YO}) in all MADA regions[31]. Specifically, the empirical results show that the elasticity of substitution for MADA Region 1, 2, and 4 is approximately 0.99 and near to Cobb-Douglas. Meanwhile, for MADA Region 3, the elasticity of substitution equals to 1. Generally, these show that the elasticity of substitution between young and old farmers is approximately unitary elastic. This shows that young and old farmers are perfectly substituted. The existence of perfect substitution between young and old farmers is due to the homogeneity of technology employed by both different groups of farmers.

[31] Refer to Appendix 6 for young-old farmers' elasticity of substitution

Table 5.20

The Estimation Results for Elasticity of Substitution between Young and Old Farmers

Variables	MADA Region			
	1 (PB)	**2**	**3 (PB)**	**4**
$lnL40_t$	-110.783 (-1.661)	268.612 (-1.432021	69.127 1.529	-87.145 -1.153
$lnL41_t$	114.693 (2.829)**	-265.515 2.571**	-65.412 -1.440	91.702 1.209
$(lnL40_t - lnL41_t)^2$	-22.169 (-1.724)***	-39.619 -1.484	4.806 1.535	-6.822 -1.219
Constant	-117.246 (-2.994)**	398.322 1.144	167.910 1.135	-197.058 -1.219
R^2	0.43	0.69	0.82	0.69
F-statistic	6.721**	20.721*	41.043*	20.695*
D.W	2.218	2.339	2.232	1.670
σ_{YO}	0.986	0.996	1.007	0.99
N	31	31	31	31

Notes: all the values are computed by the researcher.
σ_{YO} is young-old farmers elasticity of substitution
with t-values in parentheses
** and *** donate 5% and 10% significant level

5.17 Concluding Remarks

This study has succeeded in determining the production function factors in Muda Agricultural Development Authority (MADA). The finding shows that each MADA region has a separate set of factors that influences the paddy production. Generally, all the factors have their own capacity in influencing paddy production. Based on this study, all the factors have successfully measured the productivity trends in MADA regions. The determinants are also useful for the measurement of elasticity of substitution between capital and labour, and between young and old farmers.

CHAPTER 6

SUMMARY, POLICY IMPLICATION AND RECOMENDETIONS

6.0 Introduction

This chapter deals with the summary and concluding remarks for the study. It is divided into four sections. Section 6.1 focuses on the research contributions to the body of knowledge. Section 6.2 discusses the policy recommendations while Section 6.3 outlines potential area for future research.

6.1 Summary of Finding

The aim of this study was to investigate the important factors that influence the paddy production in Malaysia. In addition, this study has also examined the level of Total Factor Productivity (TFP) paddy sub-sector in Malaysia. Moreover, this study has also investigated the substitutability rates between farmers at different age groups. Besides, this study has also measured the substitution between capital and labour for paddy sub-sector in Malaysia. In total, four main paddy-production regions in MADA areas have been examined in this study and the results were presented in Chapter 5. This study has examined whether the production function in the different locations (four MADA paddy-production regions) would show different outcomes. Specifically, this study has examined whether land, capital, age of farmers, fertiliser, and price have influenced the paddy production. The result for the whole study is shown in Table 6.0.

Table 6.0

Summary of findings and hypothesis testing on the sub-sector Paddy Production in the Selected MADA Areas

MADA Regions	Hypothesis Testing (H_a)	VECM Long-run Relationship	VAR Short-run Relationship	TFP Growth Value	Substitution Value	Results
1	Capital ⟶ Paddy Yield	(+) 10.59*				Fail to reject
	Land ⟶ Paddy Yield	(+) 9.83*				Fail to reject
	Young Farmers ⟶ Paddy Yield	(+) 9.84*				Fail to reject
	Old Farmers ⟶ Paddy Yield	(+) 9.84*				Fail to reject
	Fertiliser ⟶ Paddy Yield	(+) 10.62*				Fail to reject
	Price ⟶ Paddy Yield	(+) 10.32*				Fail to reject
	TFP main season > 5%			< 5%		Rejected
	TFP off season > 5%			< 5%		Rejected
	Capital-Labour Substitution > 1				0.817	Rejected
	Young-Old Substitution = 1				$(0.986 \approx 1)$	Fail to reject
2	Capital ⟶ Paddy Yield		(+) 2.25			Rejected
	Land ⟶ Paddy Yield		(+) 0.73			Rejected
	Young Farmers ⟶ Paddy Yield		(+) 2.50			Rejected
	Old Farmers ⟶ Paddy Yield		(+) 2.50			Rejected
	Fertiliser ⟶ Paddy Yield		(+) 15.43*			Fail to reject
	Price ⟶ Paddy Yield		(+) 0.67			Rejected
	TFP main season > 5%			< 5%		Rejected
	TFP off season > 5%			< 5%		Rejected
	Capital-Labour Substitution > 1				0.845	Rejected
	Young-Old Substitution = 1				$(0.996 \approx 1)$	Fail to reject

3	Capital → Paddy Yield		(+) 0.33			Rejected
	Land → Paddy Yield		(+) 0.55			Rejected
	Young Farmers → Paddy Yield		(+) 1.05			Rejected
	Old Farmers → Paddy Yield		(+) 1.14			Rejected
	Fertiliser → Paddy Yield		(+) 6.24*			Fail to reject
	Price → Paddy Yield		(+) 1.067			Rejected
	TFP main season > 5%			< 5%		Rejected
	TFP off season > 5%			< 5%		Rejected
	Capital-Labour Substitution > 1				0.554	Rejected
	Young-Old Substitution = 1				(1.007 ≈ 1)	Fail to reject
4	Capital → Paddy Yield	(+) 12.64*				Fail to reject
	Land → Paddy Yield	(+) 13.13*				Fail to reject
	Young Farmers → Paddy Yield	(+) 12.49*				Fail to reject
	Old Farmers → Paddy Yield	(+) 12.49*				Fail to reject
	Fertiliser → Paddy Yield	(+) 15.96*				Fail to reject
	Price → Paddy Yield	(+) 12.49*				Fail to reject
	TFP main season > 5%			< 5%		Rejected
	TFP off season > 5%			< 5%		Rejected
	Capital-Labour Substitution > 1				0.815	Rejected
	Young-Old Substitution = 1				(0.99 ≈ 1)	Fail to reject

Notes:

The sign in the ( ) parentheses indicates the direction of the relationship between paddy yield and its determinant. The value in the [ ] parentheses reflects the percentage change in paddy-yield protection following a 1 per cent change in the respective determinant. * denotes significance at 1 per cent level.

From Table 6.0 above, it can be concluded that this research has discovered that each MADA region has different paddy-production function. In addition, this research has discovered that the real TFP growth is less than 5 per cent for every season. The findings of this study have supported what was explained by Tobin and his fellow colleagues who stated that the productivity of paddy in Malaysia is low, which is around 3 per cent per hectare (Tobias et al., 2012). This research has also revealed that the substitution between capital and labour is inelastic and the value is less than one. This shows that capital and labour are difficult to substitute. This research also has shown that the elasticity of substitution between young and old farmers for MADA Regions 1, 2, 3, and 4 is almost unitary. This indicates that young and old farmers are almost perfectly substituted. These mean that young farmers can easily replace the old farmers.

6.2 Implications of the Study

From the previous empirical analysis in Chapter 5, the current research has found that land, capital, young farmers, old farmers, fertiliser, and paddy price are the important inputs in paddy production. All these inputs can influence the volume of production either in the short-run or long-run. Apart from being the determining factors in paddy production, all these factors are also important in the paddy sub-sector productivity growth. By using all of these production factors, the study has found that the level of the productivity growth for all four MADA regions is lower than 5 per cent. This situation is not favorable to the growth of the paddy sub-sector as a whole. In the long-term, if the productivity growth is low, then this will create a dependency on rice import. Even if the level of paddy production is still low, this situation will create problems of inadequate food supply to meet the demand of the people. To ensure the increase in revenue, the level of productivity of paddy should be increased. It can be done in many ways such as the use of high quality seeds, technology, high investment in capital, and research and development (R&D). In addition, cultivation techniques that helps the germination of rice breed rules like transplanting and System of Rice Intensification (SRI) that should also be introduced.

Meanwhile, the substitution between capital and labour is inelastic and the value is near to one. These show that the substitution between capital and labor is not so difficult, which indirectly shows that the farmers in the MADA areas are willing to accept the inclusion of technology in the farming activities. Gradually, the use of machinery and technology has replaced the role of labours in farming activities. This may help this sector towards the labour-saving technologies. Being concurrent with the above findings, the present study has found that young farmers and old farmers are a perfect substitute. These indicate that the difference in farming experience does not give a significant impact to the paddy yield. This is because young and old farmers in MADA regions basically use a homogeneous level of technology or machinery. The question of whether young or old farmers are not a major concern in the paddy cultivation in the MADA areas is because machines can replace labours in a lot of ways.

All the findings above have a direct impact on the amount of paddy produced. The most important things are the timeliness factor for next planting and harvesting. By using machines, farmers can ensure that planting and harvesting can be carried out in a timely manner. The use of the machine can also facilitate the process of harvesting twice a year. In addition, machine can also ensure that harvesting crops is done more efficiently. This indirectly leads to the increase in paddy production and TFP level. The increase in TFP level and the improvement of the degree of capital-labour elasticity of substitution of paddy production are crucial. These require immediate attention in any development policies for increasing the domestic paddy output. Several policy options can be used to improve the productivity and paddy output such as cooperative (coop) machinery and the paddy estate. Through the coop, machinery used by farmers may not over charge and this may help to develop paddy-estate project planned by the government. The efforts to increase paddy production should be comprehensive in order to provide the maximum impact on paddy output. The higher paddy yield may directly help to improve national foods security. This would be a feasible strategy to increase the targeted SSL of 90 per cent in the RMK10 (2011-2015) from the current level of 72 per cent.

6.3 Contribution to the Body Knowledge

Table 6.3 shows the summary of the research contributions. Essentially, this study has made a various contributions in the paddy production study in Malaysia. In general, the theoretical frameworks of this study have been based on several existing theories. The current study has indicated that the developed research framework is satisfactory and can fit to the existing actual data. The estimates of the core findings have found that each variable has its own characteristics in influencing paddy production in each of the MADA regions. From the theoretical aspect, this study has used six explanatory variables such as land, capital, young farmers, old farmers, fertilizer, and paddy price. Some of these variables also have a causal relationship. These were incorporated in the present theoretical model for each MADA region. Previous studies such as Rakotoarisoa (2011);

Terano, Mohamed, Shamsudin & Abd. Latif (2013b); Mailena, Shamsudin, Mohamed, & Radam, (2013) and Shamsudin (2014) employed only one production function for Malaysia.

It seems that one production function for all MADA regions with different characteristics may not be precise. Therefore, data from four MADA regions needed to be isolated in the analysis. The results were then compared in terms of counts. From the empirical evidence, this research has shown that every region has different significant factors that influence the paddy production. These indicate that different MADA region requires a different approach to increase the paddy production. Accordingly, these are the solid contributions to the body of knowledge.

Table 6.1
A Summary of Research Contributions

Contribution to the Body of Knowledge		
To	Findings	Comments
Production Functions	Each MADA paddy production region has different factors that influence the paddy production	It requires different approaches and policies to increase the paddy production
Elasticity of substitutions	The elasticity of substitutions of young farmers and old famers is unitary	These imply that young and old farmers are perfect substations. Therefore, in order to increase productivity, other options in technologies are important
Total Factor Productivity (TFP)	1. Successfully measured the TFP for the main and off-season 2. Successfully identified the production factors that affected the TFP in the long-run and short-run	The researcher has found that TFP growth differs in all MADA paddy-production areas. These imply that same input gives different effects on TFP growth in MADA areas.

The extended current research is that this study has divided the paddy farmers into two groups, namely young and old farmers. The elasticity of substitutions between young farmers and old farmers is unitary. These imply that young and old farmers are perfect substitutes. However, Nordiana & Mook (2009) discovered that old farmers between the ages of 51-70 have produced significantly greater yields than those between 36-45 years old. From the current finding, in order to increase productivity, the applications of technologies via appropriate capital items are important. Most significantly, this study has contributed to the understanding of the effects of generations of farmers in paddy-productions system in Malaysia.

This study has made several major contributions to the body of knowledge in the measurement of TFP. Firstly, this study has been able to measure the TFP for MADA Production Areas 1, 2, 3, and 4 separately. Moreover, this research has also successfully measured the TFP for the main season and off season for each MADA production area. This study has also successfully identified the production factors that affect the TFP in the long-run and short-run. The study has also discovered that, in the long-run, all the variables have a positive relationship with TFP growth. Moreover, we have found that the size of the influence of each factor varies from one production area to another.

6.4 Policy Recommendations of the Study

The low TFP effects observed in the MADA areas have implications for national and regional rice-policy development in Malaysia. This is because MADA area is one of the major paddy producers in Malaysia. Low TFP growth indicates that Malaysia has to import more rice in order to meet the local demand. The decreasing paddy production may also affect the rice Self-Sufficiency Level (SSL) and food security in Malaysia.

Therefore, to increase the SSL and food security level, the government should encourage farmers to increase the paddy production. This can be achieved through the improvement in technologies. If the government wants to reverse the low effects of productivity growth, they should develop the new paddy-production technologies or variety that can offset the effect of weather and dryness. They also have to make sure the existing technologies dissemination is done quickly.

The government also needs to ensure that paddy researchers and development (R&D) fund are increased and properly directed. The research and development (R&D) should focus on developing new methods, identifying techniques to prevent post-harvest losses, and developing stress-resistant varieties. In addition, the non-granary and dry-land paddy areas should also be given a priority by the government through increasing irrigation schemes and developing relevant infrastructures.

Preliminary studies have found that the average number of paddy farmers in the MADA area is 48,000 people. From this amount, farmers are divided into the land owners and tenants of land. The average size of farms cultivated by each farmer in the MADA area is approximately 2 hectares. The average farm size has been found to be uneconomical. However, the current research has found that the land in MADA paddy-production areas is elastic. Therefore, the one per cent increase in land size may increase the output by more than one per cent.

Therefore, the authorities should take steps to improve the efficiency of land management. The increase in land management should be comprehensive and should be started at the farm level and involve the entire value chain. Since the average farm size is small, the government should encourage farmers to do a collective effort such as a consortium or centralised management. Through the consortium or centralised management, the size of farms may increase. Therefore, this will increase the size of agricultural land and this makes farmers more competitive. This action is very important for the sustainability of small farmers, the reduction of poverty and income inequalities. These efforts may also improve the overall productivity to achieve self-sufficiency in paddy production to ensure the food security of the country.

In addition, the land authorities should ensure that paddy field status is not easily converted to commercial status. This is because the conversion of paddy field status may reduce the size paddy field. This may influence the amount of paddy yield for every season. Strict action should be taken on landlords who convert the land status without the permission from the government.

Fertiliser is considered the most important non-traditional input in paddy production. The granger causality analysis has shown that fertiliser plays an important role in raising the paddy output in MADA regions. The TFP analysis has also indicated that fertiliser influences TFP in both short- and long-run in MADA areas. For the overall analysis, the current research shows that fertiliser has a positive relationship with paddy production.

Therefore, the government should provide information and knowledge related to the fertiliser use to paddy farmers. The government should also reduce the price of fertiliser by increasing the amount of subsidies. In addition, paddy farmers themselves should have a better understanding on how to use fertiliser efficiently. Besides, farmers should also follow the fertilising schedule provided by the government in order to increase the paddy output.

Support services need to be enhanced to provide continuing education to farmers on new paddy technology. In addition, support services provide the latest agricultural information to farmers. In addition, support services can educate farmers in handling new equipment. This in turn can reduce the risk of injury and damage to crops.

The elasticity of substitution between young and old farmers equals to unity. This means that young and old farmers are perfectly substituted. Basically, old farmers have reached more than 50 years old and their healthy conditions are even falling. Therefore, reliance on old farmers may result in declining productivity. This in turn may reduce the volume of paddy production. For long-term paddy sub-sector development, the government should encourage more young people to become paddy farmers. The physical condition of young people who are energetic as well as their willingness and openness in accepting new ideas may increase the paddy sub-sector productivity. The government should also initiate policies that aim to help farmers to increase their productivity. This can be done through special trainings or education programmes, awareness creation programmes, additional incentive programmes, starting a new paddy-production area, opting organic fertiliser, paddy estate, and introducing the System of Rice Intensification (SRI).

6.5 Limitation of the Study

This study has offered a perspective on the paddy-production function in the MADA areas only. The information for the production is important for the study of productivity growth and the elasticity of substitution between the selected variables. It was conducted in four major traditional paddy-production areas of MADA. The semiannual time-series data were employed. As a direct consequence of this research, several limitations were detected and should be considered in future research, such as:

a) The studied areas are limited to the MADA areas only. Therefore, the results could be generalised to the granary areas which have the same features with the MADA areas.

b) Aggregate data were limited to the series of data from 1996 main season to 2011 main season of paddy production.

c) Econometric measurements have also suffered from the difficulties of incorporating some information related to demography, the level of education, working capital change, and man hours. Therefore, estimation may be biased or under specification.

e) The complete survey of farmers was not undertaken. Therefore, data related to demographic, education, capital assets, transportation, labour, and the allocation of resources were not included.

f) This study has not considered the physical micro-climatic data such as soil type and irrigation water efficiency and tillering of paddy plants.

6.6 Area of Further Research

This research has drawn an extensive reading on multi-level of paddy production. To strengthen the paddy sub-sector, a number of strategies and growth target should be created. Therefore, case studies at local level have to been reviewed in order to allow further assessment of local dimensions of the subject. The following research strategy can facilitate further understanding of paddy production. Among the strategies are:

a) Future research should extend the areas of study to include others granary areas and non-granary areas. Basically, all these areas are important in contributing to the rice supply in Malaysia. By studying all the paddy-production areas in the granary and non-granary areas, we may get an extensive overview of paddy-production function for Malaysia.

b) Further research should also capture the farmers' skill level and education attainment level. The farmers' skill and their level of education are important in order to capture the labours' productivity level.

c) To estimate the elasticity of substitution, the next research should take into consideration factors such as the quality of management, the existence of different qualities of labours, and the different types of capital equipment for mechanisation.

d) Further research should also consider the tillering planting of paddy varieties, the System of Rice Intensification (SRI) and transplanting. According to Terano at al., (2013a), transplanting would increase the gross return by about 30 to 40 per cent.

e) Further research should consider the new production function that inserts the System of Rice Intensification (SRI) as one of the new elements in paddy production in Malaysia. The SRI method is able to produce paddy plants that are more resistant to abiotic stress. SRI method has been successful in increasing rice yields. In some countries, the average yield increase is 47 per cent (Africare, 2010).

f) For better quality of data, the next researcher should reinforce by estimates based on better quality firm level data based on empirical surveys, field investigations, and interviews with farmers.

g) Further research needs to study the physical attribute of the main rice-growing areas such as the use of organic fertiliser, soil, water, irrigation, and machinery use.

h) For better result, the true experimental plot data need to be used. The advantages of experimental plot data are that they can control the independent variables. At the same time, it can also eliminate the unwanted external variables. Experiments involving the manipulation of the independent variables to observe the effect on the dependent variable. This makes it possible to determine the cause-and-effect relationship.

i) Further research should study on pricing, price support, and subsidies mechanisms to encourage higher productivity and reduce rice import.

6.7 Conclusion

This study was able to increase the level of understanding of the importance of rice as a main source of food in Malaysia. The total supply of local paddy is very important in ensuring the adequacy of rice supply. High local rice supply means less flow of money to foreign countries. However, the results of this study indicated that the level of the existing rice production cannot meet the growing demand. Through this study, several proposals have been made to enable us to increase the paddy production such as SRI method and transplanting.

Furthermore, this study has also enhanced a better understanding of the importance of the production functions knowledge. From the production function, the cost of a paddy yield can be determined. Through the production function, we can also identify that the farmers' productivity levels. Therefore, it can dispel the notion that the production-function analysis is the neglected and unimportant study. Hence, the production-function knowledge is useful to derive the efficient policies to increase the paddy production.

In addition, through the production function, we have discovered that the paddy sub-sectors in Malaysia is labour-intensive. This study has also proven that the substitution rate between different ages of farmers is perfectly elastic. This indicates that the old and young farmers have equal impact on paddy production. Therefore, to increase the paddy yield, the technology should be introduced into this sector.

The increasing level of productivity may lead to the increase in the amount of production. To improve the level of productivity, the government and the farmers should ensure that all the inputs of production are efficiently utilised. The increase in productivity also has a direct impact on farmers' income. The increase in farmers' income may enable them to escape from poverty. In addition, the increase in paddy production may help Malaysia to achieve 90 SSL for rice in the 10th Malaysia Plan (MOA, 2011a). This in turn may reduce the amount of rice import.

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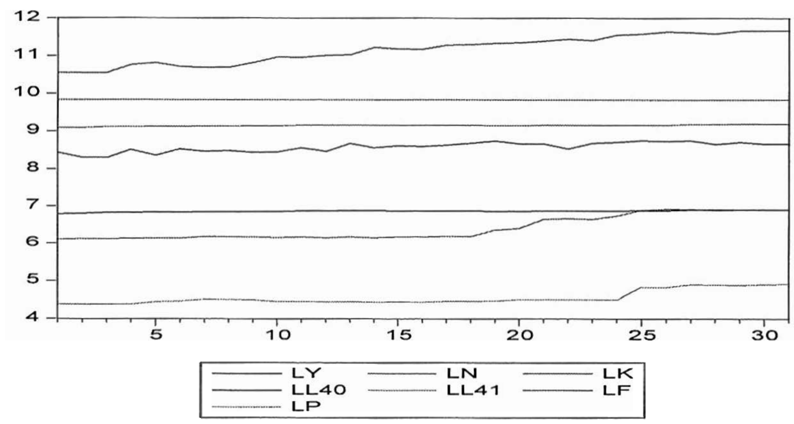
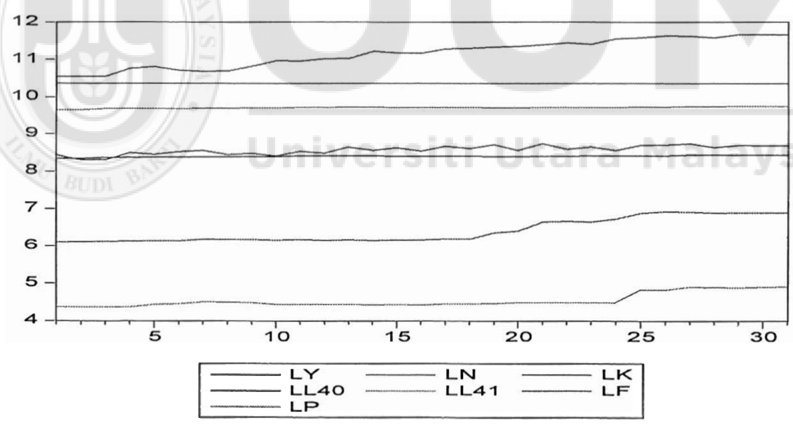
Appendix 1

Descriptive Statistics For MADA Region

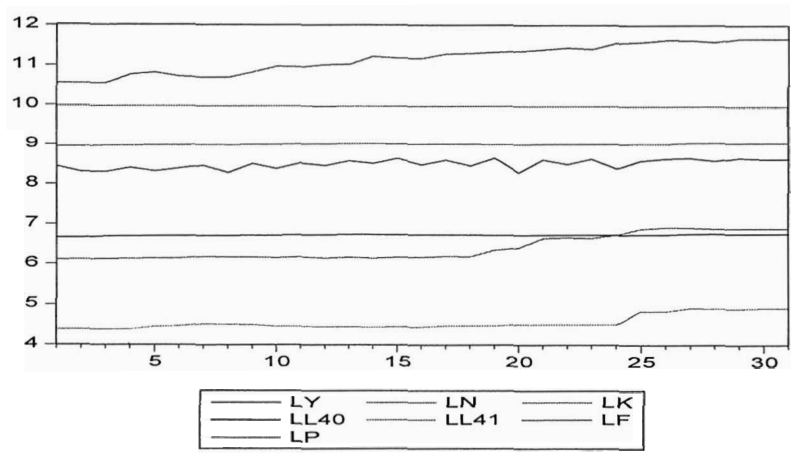
MADA Region 1



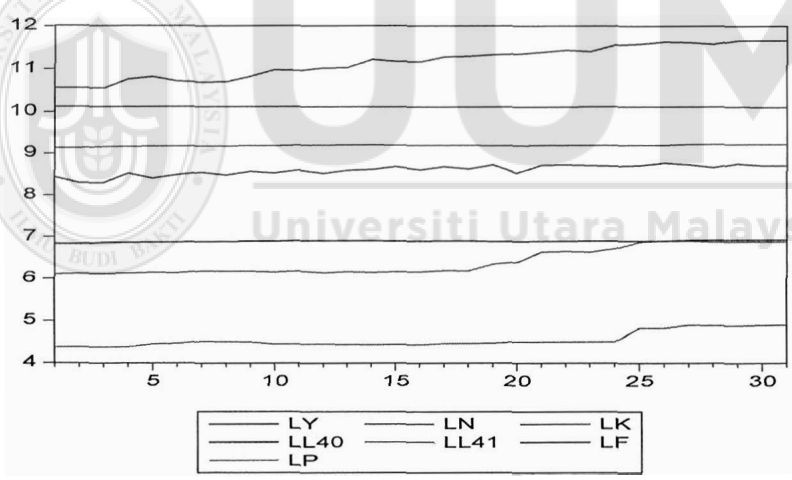
MADA Region 2



MADA Region 3



MADA Region 4



Appendix 2

Correlation Matrix

MADA Region 1

	LY	LN	LK	LL40	LL41	LF	LP
LY	1.000000	0.587045	0.689842	0.733433	0.758118	0.865068	0.583700
LN	0.587045	1.000000	0.789143	0.356806	0.397698	0.677374	0.630561
LK	0.689842	0.789143	1.000000	0.677905	0.703142	0.865266	0.886467
LL40	0.733433	0.356806	0.677905	1.000000	0.992036	0.856003	0.702778
LL41	0.758118	0.397698	0.703142	0.992036	1.000000	0.874945	0.729891
LF	0.865068	0.677374	0.865266	0.856003	0.874945	1.000000	0.743692
LP	0.583700	0.630561	0.886467	0.702778	0.729891	0.743692	1.000000

MADA Region 2

	LY	LN	LK	LL40	LL41	LF	LP
LY	1.000000	0.218607	0.701649	0.785914	0.785209	0.843411	0.635923
LN	0.218607	1.000000	0.567014	0.061293	0.060973	0.373099	0.427611
LK	0.701649	0.567014	1.000000	0.703805	0.703219	0.865266	0.886467
LL40	0.785914	0.061293	0.703805	1.000000	0.999997	0.875380	0.730330
LL41	0.785209	0.060973	0.703219	0.999997	1.000000	0.875005	0.730001
LF	0.843411	0.373099	0.865266	0.875380	0.875005	1.000000	0.743692
LP	0.635923	0.427611	0.886467	0.730330	0.730001	0.743692	1.000000

MADA Region 3

	LY	LN	LK	LL40	LL41	LF	LP
LY	1.000000	0.516171	0.597632	0.719486	0.718689	0.705109	0.586748
LN	0.516171	1.000000	0.789148	0.400706	0.397587	0.677370	0.630593
LK	0.597632	0.789148	1.000000	0.706491	0.703172	0.865266	0.886467
LL40	0.719486	0.400706	0.706491	1.000000	0.999935	0.877601	0.731016
LL41	0.718689	0.397587	0.703172	0.999935	1.000000	0.874829	0.730153
LF	0.705109	0.677370	0.865266	0.877601	0.874829	1.000000	0.743692
LP	0.586748	0.630593	0.886467	0.731016	0.730153	0.743692	1.000000

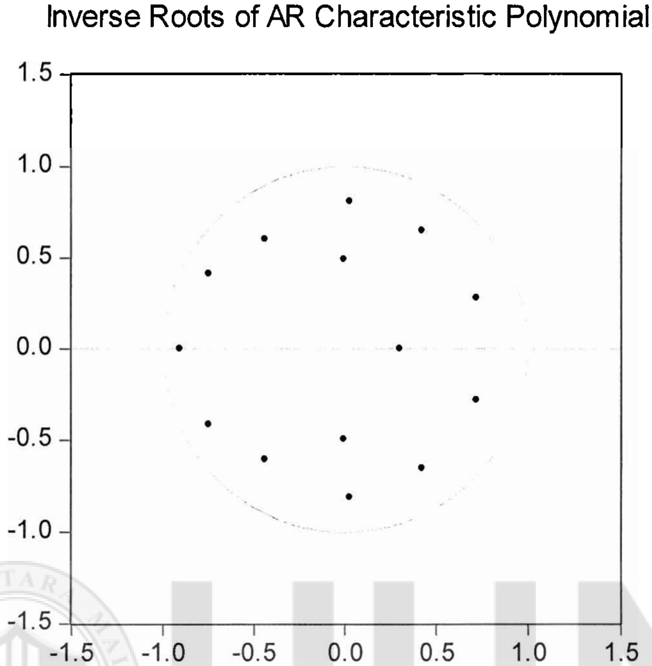
MADA Region 4

	LY	LN	LK	LL40	LL41	LF	LP
LY	1.000000	0.528394	0.726249	0.823592	0.824044	0.893354	0.599838
LN	0.528394	1.000000	0.789145	0.394619	0.397415	0.677391	0.630554
LK	0.726249	0.789145	1.000000	0.702057	0.703117	0.865266	0.886467
LL40	0.823592	0.394619	0.702057	1.000000	0.999932	0.872855	0.728669
LL41	0.824044	0.397415	0.703117	0.999932	1.000000	0.874928	0.729772
LF	0.893354	0.677391	0.865266	0.872855	0.874928	1.000000	0.743692
LP	0.599838	0.630554	0.886467	0.728669	0.729772	0.743692	1.000000

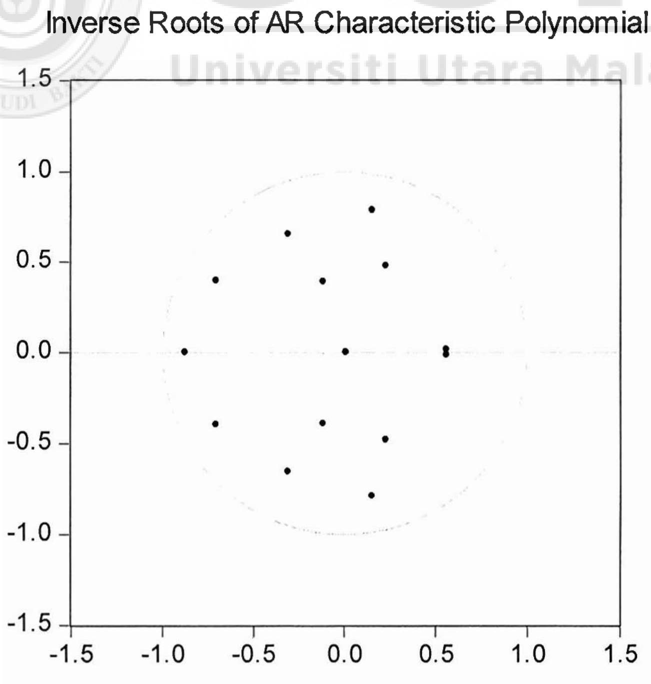
Appendix 3

Inverse Roots of AR Characteristic Polynomial

MADA Region 2



MADA Region 3



Appendix 4

Capital and Labour Elasticity of Substitution Result using OLS

MADA Region 1 (No serial correlations)

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 12:35				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LK	-3.308823	1.991957	-1.661092	0.1083
LL	6.403609	2.263205	2.829443	0.0087
KL2	-0.623497	0.361520	-1.724657	0.0960
C	-24.35287	8.131389	-2.994921	0.0058
R-squared	0.660714	Mean dependent var		8.579883
Adjusted R-squared	0.623016	S.D. dependent var		0.129877
S.E. of regression	0.079743	Akaike info criterion		-2.100101
Sum squared resid	0.171692	Schwarz criterion		-1.915070
Log likelihood	36.55156	Hannan-Quinn criter.		-2.039785
F-statistic	17.52633	Durbin-Watson stat		1.590227
Prob(F-statistic)	0.000002			

MADA Region 2 (No serial correlations)

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 12:39				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LK	-3.022251	2.110480	-1.432021	0.1636
LL	5.990105	2.329710	2.571181	0.0160
KL2	-0.472589	0.318396	-1.484280	0.1493
C	-25.30520	8.091469	-3.127392	0.0042
R-squared	0.686311	Mean dependent var		8.572221
Adjusted R-squared	0.651457	S.D. dependent var		0.118947
S.E. of regression	0.070223	Akaike info criterion		-2.354364
Sum squared resid	0.133145	Schwarz criterion		-2.169333
Log likelihood	40.49264	Hannan-Quinn criter.		-2.294048
F-statistic	19.69085	Durbin-Watson stat		2.042243
Prob(F-statistic)	0.000001			

MADA Region 3 (Presence serial correlation)

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 12:51				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL	2.136059	2.470196	0.864732	0.3948
LK	0.820740	2.153328	0.381150	0.7061
KL2	0.143393	0.411861	0.348160	0.7304
C	-17.26664	8.998853	-1.918760	0.0656
R-squared	0.535521	Mean dependent var		8.503904
Adjusted R-squared	0.483912	S.D. dependent var		0.126449
S.E. of regression	0.090840	Akaike info criterion		-1.839518
Sum squared resid	0.222802	Schwarz criterion		-1.654487
Log likelihood	32.51253	Hannan-Quinn criter.		-1.779203
F-statistic	10.37655	Durbin-Watson stat		2.959635
Prob(F-statistic)	0.000102			

For remedy we employed Cochrane-Orcutt. The result as follows:

Dependent Variable: NEWLY				
Method: Least Squares				
Date: 08/02/12 Time: 13:17				
Sample (adjusted): 2 31				
Included observations: 30 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEWLK	0.679363	1.205100	0.563740	0.5778
NEWLL	2.898467	1.412289	2.052318	0.0503
NEWKL2	0.122589	0.230266	0.532381	0.5990
C	-35.15785	8.090940	-4.345336	0.0002
R-squared	0.809851	Mean dependent var		12.91254
Adjusted R-squared	0.787911	S.D. dependent var		0.158148
S.E. of regression	0.072832	Akaike info criterion		-2.277758
Sum squared resid	0.137917	Schwarz criterion		-2.090931
Log likelihood	38.16637	Hannan-Quinn criter.		-2.217990
F-statistic	36.91159	Durbin-Watson stat		2.010954
Prob(F-statistic)	0.000000			

Region 4

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 14:50				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL	7.161634	1.959073	3.655625	0.0011
LK	-3.584724	1.728350	-2.074072	0.0477
KL2	-0.662840	0.309117	-2.144303	0.0412
C	-29.37702	7.013465	-4.188659	0.0003
R-squared	0.762142	Mean dependent var		8.614063
Adjusted R-squared	0.735714	S.D. dependent var		0.132600
S.E. of regression	0.068168	Akaike info criterion		-2.413770
Sum squared resid	0.125465	Schwarz criterion		-2.228740
Log likelihood	41.41344	Hannan-Quinn criter.		-2.353455
F-statistic	28.83774	Durbin-Watson stat		2.021512
Prob(F-statistic)	0.000000			

Appendix 5

Young and Old Farmers Elasticity of Substitution Result using OLS

MADA Region 1

Serial correlations present. For remedy we employed the Cochrane-Orcutt and the result as follow:-

Dependent Variable: NEWLY				
Method: Least Squares				
Date: 08/02/12 Time: 12:28				
Sample (adjusted): 2 31				
Included observations: 30 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEWLL40	-110.7830	210.7982	-0.525541	0.6037
NEWLL41	114.6936	211.3196	0.542749	0.5919
NEWLYO2	-22.16904	47.59649	-0.465770	0.6453
C	-117.2462	170.3205	-0.688386	0.4973
R-squared	0.436800	Mean dependent var		6.122205
Adjusted R-squared	0.371815	S.D. dependent var		0.104835
S.E. of regression	0.083090	Akaike info criterion		-2.014208
Sum squared resid	0.179505	Schwarz criterion		-1.827382
Log likelihood	34.21313	Hannan-Quinn criter.		-1.954441
F-statistic	6.721582	Durbin-Watson stat		2.218477
Prob(F-statistic)	0.001657			

Region 2

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 12:46				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL40	268.6128	312.0782	0.860723	0.3970
LL41	-265.5150	312.0381	-0.850906	0.4023
LYO2	-39.61918	46.80554	-0.846463	0.4047
C	398.3228	348.1574	1.144088	0.2626
R-squared	0.697186	Mean dependent var		8.572221
Adjusted R-squared	0.663540	S.D. dependent var		0.118947
S.E. of regression	0.068995	Akaike info criterion		-2.389646
Sum squared resid	0.128529	Schwarz criterion		-2.204615
Log likelihood	41.03951	Hannan-Quinn criter.		-2.329330
F-statistic	20.72118	Durbin-Watson stat		2.339124
Prob(F-statistic)	0.000000			

Region 3

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 13:01				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL40	68.15097	78.97378	0.862957	0.3958
LL41	-64.84958	79.31091	-0.817663	0.4207
LYO	3.566719	5.392931	0.661369	0.5140
C	116.0996	165.9988	0.699400	0.4903
R-squared	0.529640	Mean dependent var		8.503904
Adjusted R-squared	0.477377	S.D. dependent var		0.126449
S.E. of regression	0.091413	Akaike info criterion		-1.826935
Sum squared resid	0.225623	Schwarz criterion		-1.641905
Log likelihood	32.31750	Hannan-Quinn criter.		-1.766620
F-statistic	10.13427	Durbin-Watson stat		3.020166
Prob(F-statistic)	0.000121			

Serial correlations present –For remedy we employed Cochrane-Orcutt.
The result as follows:

Dependent Variable: NEWLY				
Method: Least Squares				
Date: 08/02/12 Time: 17:42				
Sample (adjusted): 2 31				
Included observations: 30 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
NEWLL40	69.12767	45.20757	1.529117	0.1383
NEWLL41	-65.41276	45.42007	-1.440173	0.1618
NEWLYO	4.806084	3.129151	1.535907	0.1366
C	167.9102	147.8140	1.135956	0.2663
R-squared	0.825656	Mean dependent var		13.20682
Adjusted R-squared	0.805539	S.D. dependent var		0.160907
S.E. of regression	0.070956	Akaike info criterion		-2.329939
Sum squared resid	0.130905	Schwarz criterion		-2.143113
Log likelihood	38.94909	Hannan-Quinn criter.		-2.270172
F-statistic	41.04343	Durbin-Watson stat		2.232011
Prob(F-statistic)	0.000000			

Region 4

Dependent Variable: LY				
Method: Least Squares				
Date: 08/02/12 Time: 14:50				
Sample: 1 31				
Included observations: 31				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LL40	-87.14597	75.57226	-1.153148	0.2590
LL41	91.70288	75.80083	1.209787	0.2368
LYO2	-6.822310	5.592085	-1.219994	0.2330
C	-197.0588	153.4322	-1.284338	0.2099
R-squared	0.696920	Mean dependent var		8.614063
Adjusted R-squared	0.663245	S.D. dependent var		0.132600
S.E. of regression	0.076948	Akaike info criterion		-2.171447
Sum squared resid	0.159869	Schwarz criterion		-1.986416
Log likelihood	37.65743	Hannan-Quinn criter.		-2.111132
F-statistic	20.69515	Durbin-Watson stat		1.670008
Prob(F-statistic)	0.000000			