YANGON UNIVERSITY OF ECONOMICS

DEPARTMENT OF STATISTICS

CAUSAL ANALYSIS AND STRUCTURAL BREAK OF RUBBER EXPORT IN MYANMAR

(1966-2016)

BY

HUN SHWE YEE THIN

M.Econ (Statistics)

Roll No. 1

DECEMBER, 2018

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This is to certify that thesis entitled **"CAUSAL ANALYSIS AND STRUCTURAL BREAK OF RUBBER EXPORT IN MYANMAR (1966-2016)"**, submitted as a partial fulfillment towards the requirements of the Degree of Master of Economics (Statistics) has been accepted by the Board of Examiners.

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ABSTRACT

This study investigates causal relationships between rubber export and its price as well as production and also the structural breaking of Rubber Export in Myanmar by using annual time series data for the period 1966-2016. The data used in this study is collected from food and agriculture organization (FAO). It uses the Granger causality test to confirm affecting between variables. It also uses co-integration analysis and error correction model (ECM) test to determine the short and long run causality between variables. The results conclude that there is long term causality but there is no short run causation according to Wald test. And the test for structural breaking of Rubber Export in Myanmar is conducted by using Chow test at the break point 1988. This study confirms that there is structural breaking in Myanmar's Rubber Export. From the results and findings of the study, Myanmar's Rubber Export is hoped to provide some implications and suggestions in adopting more effective and well organized planning and policy for the rubber export of the country in future.

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LIST OF ABBREVIATIONS

ADF	=	Augmented Dickey-Fuller
AIC	=	Akaike information criterion
CUSUM	=	Cumulative Sum of Residual
DOA	=	Department of Agriculture
EXP	=	Export Value of Rubber
FAO	=	Food and Agriculture Organization
FPE	=	Final prediction error
HQ	=	Hannan-Quinn information criterion
LR	=	Likelihood Ratio
MOAI	=	Ministry of Agriculture and Irrigation
MOC	=	Ministry of Commerce
MOFR	=	Ministry of Finance and Revenue
MOST	=	Ministry of Science and Technology
MRPPA	=	Myanmar Rubber Planters and Producers Association
PRI	=	Price of Rubber
PRO	=	Production of Rubber
RSS	=	Residual Sum of Squares
SC	=	Schwarz information criterion
SLORC	=	State Law and Order Restoration Council
VAR	=	Vector Autoregression
VEC	=	Vector Error Correction

CHAPTER I

INTRODUCTION

1.1 Rationale of the Study

Myanmar central government and military authorities had long supported rubber production as a strategic for export to earn foreign exchange. Rubber had been cultivated in Myanmar since the British colonial period in the early 20th century, mostly in Mon State.

There are more than 90 rubber exporting countries around the globe, with Asian countries accounting for 80 percent of the world rubber export, while African countries export 8.5 percent. Myanmar is currently ranked seventh in rubber production in Southeast Asia, behind Thailand, Laos, Cambodia, Indonesia, Bangladesh and the Philippines.

Throughout the country some 1,430,000 acres are devoted to rubber only, according to a report by the Ministry of Agriculture. Rubber is mainly grown in Myanmar's southern Mon and southeastern Kayin states as well as Tanintharyi, Yangon and Bago regions. More than 90 percent of rubber production goes to export market but export accounts for only 1.6 percent of that in the global market. Over 80 percent of rubber production in Myanmar is exported to China. Local rubber consumption is below 10 percent. However, the rubber demand in the domestic market has risen because of increase in tyre production. In the past, the country exported 80,000-90,000 tonnes of rubber.

Around 85 percent of rubber globally is, in fact, produced by smallholders, with farmers typically owing plots of land ranging anywhere between 5 and 100 acres. Myanmar rubber sector has the potential to become greater source of export earnings and rural household incomes, but there are major challenges related to low rubber productivity and poor rubber quality. In export market, the price of Myanmar's rubber is low due to lack of better technology and quality, traders said. Rubber producer are now hoping to harness international expertise to improve the quality of their rubber so that they can charge more for their product.

The rubber export volumes and earnings are changing over time. This study investigates the causal linkage between rubber export and its price as well as production during 1966-2016. The study uses a dynamic time series procedure to test the hypothesis of exports and variables in Myanmar rubber export.

Myanmar has changed its economy course from a Socialist Economy into a Market-Oriented Economy in 1988.Thus, it is also interesting to study structural breaking in Myanmar's Rubber Export because export structure is one of the sources of the structural break in Myanmar economy which reflects the economic development. Study on structural break is important for at least two reasons. Firstly, different structures produce different behavioral relations and secondly, observations generated by an unstable structure give unreliable estimates of the relationships. Structural instability of economic variables may occur by a policy change such as a new tax law, a new government program or a major disturbance of the economy. Therefore, structural break is now being recognized as essential when examining world trade and capital flows between countries as well as production and employment within countries.

1.2 Objectives of the Study

The main objectives of the study are as follows:

i. To investigate the causality analysis between Rubber Export and its price as well as production in Myanmar.

ii. To examine the structural break in Myanmar' Rubber Export.

1.3 Scope and Limitations of the Study

This study examines the Rubber Export in Myanmar over the period covering from 1966 to 2016. The secondary data were obtained from Food and Agriculture Organization (**FAO**). The econometric methods were employed to forecast the Export of Rubber in Myanmar.

1.4 Method of Study

In this study, the unit root test for stationary and the Johansen Co-integration test for long run relationship among variables were used as pre-tests. Then, the Granger causality test by using the vector error correction model (VECM) and the structural break of Myanmar's Rubber Export by using Chow test were conducted.

1.5 Organization of the Study

This study is organized into five chapters. Chapter I is introduction consists of the rationale of the study, objectives of the study, scope and limitations, method of the study, and organization of the study. Chapter II presents the overview of the rubber export structure in Myanmar. Chapter III is the review on theoretical concepts of the unit root test, Johansen Co-integration test, Granger causality test and Chow test of structural break. Chapter IV is concerned with the test for causality analysis and structural break of rubber export in Myanmar. Finally, the findings and conclusions are summarized in Chapter V.

CHAPTER II

RUBBER EXPORT IN MYANMAR

2.1 Myanmar Rubber Planters and Producers Association (MRPPA)

Myanmar Rubber Planters and Producers Association (MRPPA) is formed by rubber firm owners, farmers, traders, exporters and some stakeholders. Due to a decline in the rubber price in the global market, the current local rubber price is declining. The association has suggested that rubber planters should grow high-yield rubber strains only and produce high-quality raw materials. Most of the rubber farm owners sell the latex once it is produced. Only some of them store the rubber while waiting for the price goes up. Rubber producers are willing to improve the quality of their rubber because they can charge more for their products. And they expect to increase the rubber exports by promoting the industries to the international community.

2.2 Types and uses of Rubber in Myanmar

Rubbers include natural rubber and synthetic rubber. Natural Rubber is a naturally occurring substance obtained from the exudations of certain tropical plants. Synthetic Rubber is an artificially derived from petrochemical products. Natural Rubber is the raw material for a wide range of rubber products. Synthetic Rubber which can substitute possess the same properties of Natural Rubber had been used industries in making some rubber products. Although Natural Rubber cannot substitute almost all vehicles, including motor cars, bicycles, buses and airplanes are used natural tyres. Therefore Natural Rubber is used for every industry. Now, Natural Rubber becomes a very important cash crop in the economy of Myanmar. Rubber is enough for not only local consumption but also for foreign export. It is a foreign exchange earner and can serve the long term interest with a considerable amount of capital. Rubber is very important as accessory raw materials in some industry such as various tyre production, gloves production for medical, rubber shoes, rubber balls, rubber based rain coats and other uses some household appliances. Today rubber is very useful raw material and popular in the world market.

2.3 The Political Ecology of Rubber Production in Myanmar

In 1989, the State Law and Order Restoration Council (SLORC) government introduced an open door policy and the production of perennial crops was partially liberalized from state control in theory, although more limited in practice. The government still retained control over the export of rubber, while allowing domestic producers to sell freely to local buyers after they fulfilled their procurement quota to the government agency. As the country opened up its economy for private sector and foreign investment, the price of rubber rose rapidly. By the mid-1990s smallholders had reengaged in the market sector.

The Ministry of Agriculture and Irrigation's (MOAI) 30-year Master Plan for the Agriculture Sector (2000-01 to 2030-31) aims to convert 10 million acres of 'wasteland' for private industrial agricultural production. The ministry specifically encourages rubber, oil palm, paddy, pulses, and sugarcane for export. The government has transformed its forced crop campaigns that originally targeted farmers to enlisting its preferred domestic businessmen to realize its agricultural commodity export goals.

2.4 Rubber Producers in Myanmar

According to MRPPA, in terms of rubber cultivation, two thirds of the total rubber cultivated is in Mon State. Rubber farmers in Myanmar are predominately smallholders. An MOAI table from 2005–2006 shows that 40.2 percent of rubber producers were smallholders with less than 2.02 hectares in that year, 50.3 percent were medium holders with between 2.0 and 8.1 hectares, and 9.5 percent were large plantation owners with more than 8.1 sown hectares. In the same year, large holders produced 58.1 percent of output, medium holders 33.3 percent, and smallholders 8.6 percent (Myint 2013). The literature indicates that today, large holders own more rubber land that they ever have (Kenney-Lazar 2016; Global Witness 2014; Woods 2012). This is primarily a result of a new policy preference to give concessions to large holders to bring about significant increases in production and meet agriculture production targets (Woods 2012). The expansion of large-holder production is taking place primarily in northern Myanmar, though our data indicate that there is also increased large-holder production in the south. Estimates based on data from the 2015 MSRHS indicate that smallholders and medium holders have a combined 126,370 hectares of rubber land in Mon State, equivalent to 63 percent of the total MOAI estimate for sown acres in Mon in that year. Using the latest MOAI estimate for government ownership of rubber land, 2.3 percent, we find that 34.7 percent of plantation owners in Mon owned more than 8.09 hectares in 2015, a considerable increase from the 2005–2006 data. Further research is needed to understand the true extent of large-holder expansion, the implications of large-holder expansion on smallholders, and the likely role of large plantations in Myanmar's future rubber sector.

2.5 Trade of Rubber in Myanmar

Myanmar currently exports rubber to Asia and Europe. Myanmar's rubber export destinations are very concentrated, with two countries, China and Malaysia, importing nearly all of Myanmar's rubber. In 2005, China imported just 21.4 percent of Myanmar's rubber. Malaysia was by far Myanmar's largest trading partner, importing 67.0 percent of Myanmar's rubber. India, Myanmar's third-largest trading partner, imported 7.4 percent of the country's rubber. In 2014, China imported 72.7 percent of Myanmar's rubber, Malaysia 20.3 percent, and South Korea 3.4 percent (UN 2016). China imports almost all grades of Myanmar's block and sheet rubber. Malaysia imports inferior grades of Myanmar's block and sheet rubber to process into value-added higher grades for tire production or re-export. The Republic of Korea imports higher-grade Myanmar sheet rubber for tire production (Myanmar, MOC and ITC 2015). Myanmar has struggled to tap into new markets such as the United States, Japan, and Germany, all of which are major rubber importers.

2.6 Quality of Rubber in Myanmar

As a result of poor planting techniques, cultivation management, tapping practices, field-level processing, and factory-level processing, Myanmar rubber is of an extremely low quality. Traders interviewed in Mon felt that the quality of Myanmar's rubber raw material was among the best in the world, but the quality of the country's processed rubber was the worst in the world. There are limited incentives across the value chain for rubber actors to produce higher-quality rubber. At the producer level, traders buy all rubber sheets regardless of quality. There is no formal grading system. Whereas in most countries rubber sheets are generally visually graded based on their characteristics, such as texture, color, and amount of resinous matter, in Myanmar the grade is determined almost entirely by the thickness of the rubber sheet. Therefore, prices are paid simply based on weight and not on the true quality of the rubber. Traders also have limited incentive to improve the quality of the rubber they sell to processers. Processors buy almost all rubber from traders, even though they often need to reprocess it due to its poor quality. The traders' rubber is also graded by weight and not physical quality. At the processor level, there is no certification scheme or public lab to test rubber quality. Therefore, processors will always receive a discounted price on the world market for their rubber, as they cannot guarantee its quality.

2.7 Marketing of Rubber in Myanmar

Farmers sell their rubber sheets to traders. If the farmer's plot size is large enough, the trader will travel to the plantation to buy the rubber. Sometimes, however, the farmer will go to the trader to sell the rubber. In this case, the farmer is responsible for paying for transport. Farmers will sell to the trader who can offer the most money, but the price varies little between traders. There are three levels of traders in Myanmar's rubber value chain. Because Mudon is the center of rubber trading in Myanmar, the distance of a smallholder's plot from Mudon City determines the number of traders the rubber will pass through before arriving at a processor. Traders who collect rubber from rural villages are first-level rubber traders. They are often rubber farmers as well as traders. They sell the rubber they buy to second-level traders, or those located in township city centers. These traders are usually traders only, and not farmers. Further, many of them trade multiple commodities in addition to rubber, such as limes or betel nut. Rubber farmers located close to cities bring their rubber directly to these traders, skipping the first-level traders. Second-level traders sell their rubber to third-level traders, or traders located in Mudon City. The traders sell their rubber to the processing company in Mudon that can offer the highest price. In Mudon there are around 70 rubber traders—50 collecting from rural villages and 20 in Mudon City.

There is currently no rubber-marketing infrastructure in Myanmar. The government has recognized the need for such infrastructure, and newspapers indicate that Myanmar's first central rubber market will be set up in Mawlamyine.

2.8 Policy Support of Rubber in Myanmar

Several different state actors manage the various levels of the value chain in the Myanmar rubber sector. The forest department, under the Ministry of Environmental Conservation and Forestry, manages current and future land under rubber cultivation. MOAI manages land use through its Settlement and Land Records Department. MOAI also manages training and education and research and development in both upstream and downstream rubber industries. MOI issues business licenses, promotes small and medium-size enterprises, and manages the last components of the state-owned rubber industry. The Ministry of Commerce (MOC) also governs aspects of the rubber industry, as it manages trade policy, import and export licenses, border control, and trade promotion. The Ministry of Science and Technology (MOST) provides research on rubber products, including rubber polymers. Finally, the Ministry of Finance and Revenue (MOFR), through the Myanmar Foreign Trade Bank, the Myanmar Investment and Commercial Bank, and the Myanmar Economic Bank, provides commercial banking and foreign exchange services for the sector (Myanmar, MOC and ITC 2015). The Department of Agriculture (DOA) runs rubber extension programs under the umbrella of MOAI. There is a DOA extension office in each township. There are no laws governing rubber trading. Traders do not need to be registered, which makes rubber quality control nearly impossible. Processors do need to register with the Directorate of Industrial Supervision and Inspection under MOI; however, this has very little impact on sector governance, as there are no laws regulating processing or the type and quality of processed rubber. Finally, exporters are required to obtain permits from the Department of Commerce and Consumer Affairs under MOC. But, like processors, exporters face no regulations related to the types and grades of rubber exported, and there is no certification system for the quality of rubber exported. Increasing rubber production, rubber quality, and farmers' incomes will require immense focus and coordination on the part of the government institutions that regulate rubber production.

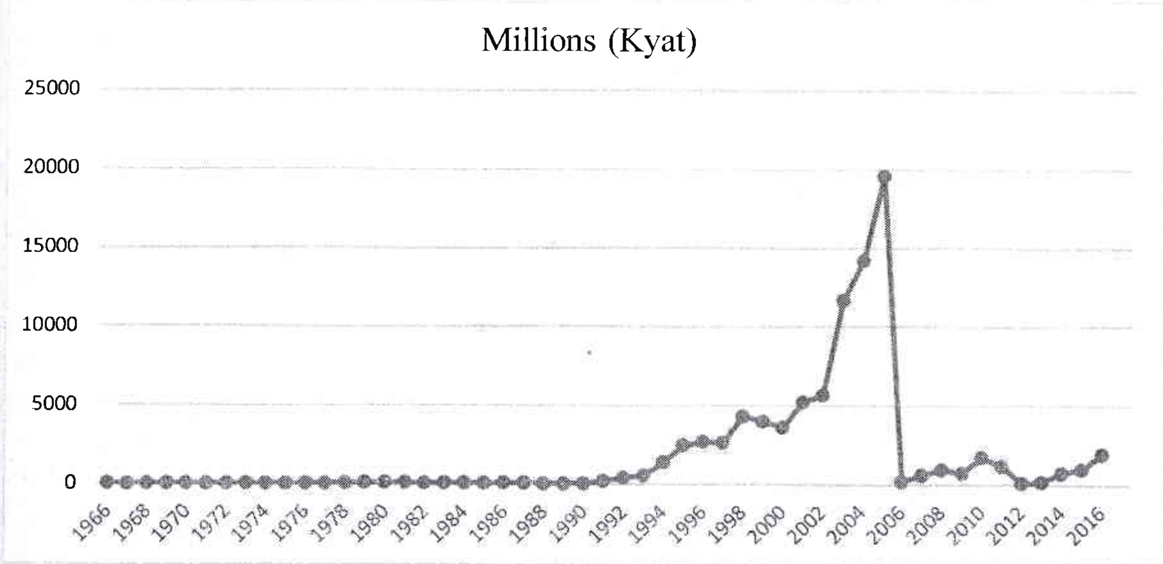
2.9 Rubber Export Structure of Myanmar

Myanmar's economy can be divided into two parts: socialist economic system from 1966 to 1988 and market-oriented economic system from 1989 to 2016. The rubber export of Myanmar from 1966 to 2016 is presented in Figure (2.1) and the data are given in Appendix-A. During the period from 1966 to 1988 Myanmar's rubber export has increased from 16.315425 (millions of kyat) to 32.961952 (millions of kyat). During this period, Myanmar's rubber export is lowest at 8.9908 (millions of kyat) in 1967 and this is highest at 77.449008 (millions of kyat) in 1979.

During the period from 1989 to 2016, Myanmar's rubber export has increased from 40.8339762 (millions of kyat) to 1900.464161 (millions of kyat). During this period, Myanmar's rubber export is lowest at 17.1306135 (millions of kyat) in 1990 and this is highest at 19566.8327 (millions of kyat) in 2005.

Figure (2.1)

Export of Rubber in Myanmar (1966-2016)



Source: Food and Agriculture Organization (FAO)

From the result of above Figure (2.1), the rubber export is significantly highest in 2005 because the high demand of rubber in Japan for tyre production. The lowest and other instable values of rubber export are due to the quality of rubber and changes of exchange rate. Myanmar always receive a discounted price on the world market because there is no guarantee for quality.

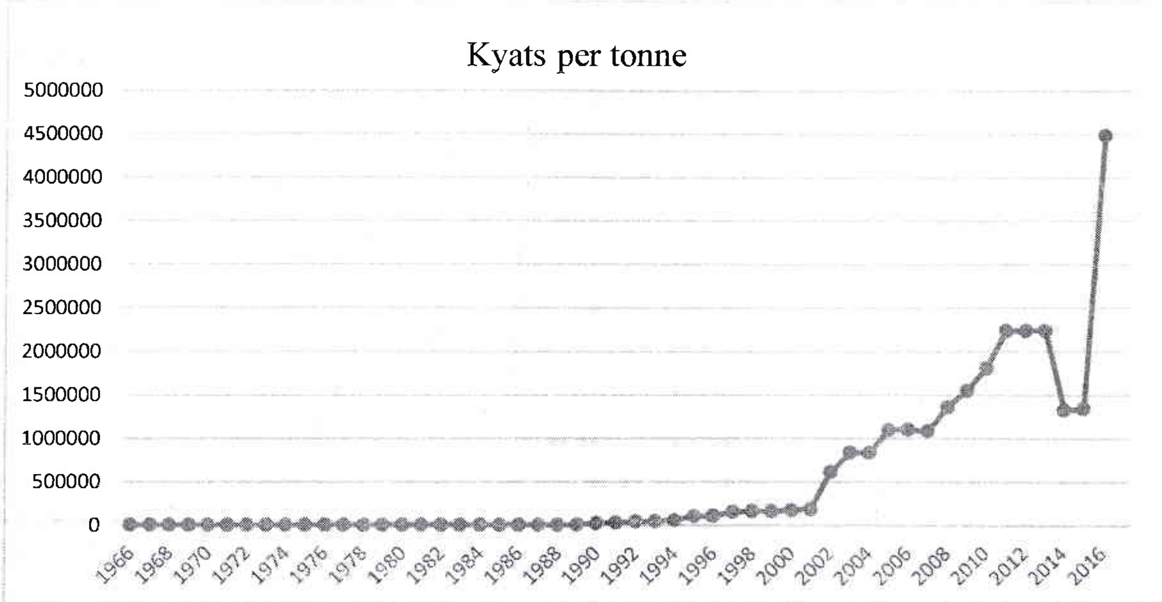
2.10 Changes of Rubber Price in Myanmar

The rubber price of Myanmar from 1966 to 2016 is presented in Figure (2.2) and the data are given in Appendix-A. During the period from 1966 to 1988 Myanmar's rubber price has increased from 1819 (kyats per tonne) to 3754 (kyats per tonne). During this period, Myanmar's rubber price is lowest at 1735 (kyats per tonne) in 1967 and this is highest at 3814 (kyats per tonne) in 1977, 1978 and 1979.

During the period from 1989 to 2016, Myanmar's rubber price has increased from 7717 (kyats per tonne) to 4488361 (kyats per tonne). During this period, Myanmar's rubber price is lowest at 7717 (kyats per tonne) in 1989 and this is highest at 4488361 (kyats per tonne) in 2016.

Figure (2.2)

Price of Rubber in Myanmar (1966-2016)



Source: Food and Agriculture Organization (FAO)

As the country opened up its economy for private sector and foreign investment in 1989, the price of rubber rose rapidly in later. Therefore, the result of above Figure (2.2) shows the price of rubber rises in the beginning of 2001. The price of rubber suddenly drops in 2014 and 2015 because low quality of rubber and less demand of rubber in exporting countries. The price of rubber is highest in 2016 because Japan helps laboratory testing for the quality of rubber which has been set up in Yangon. Therefore, the quality of rubber can high and the farmer can receive the highest price from the exporting of rubber in later.

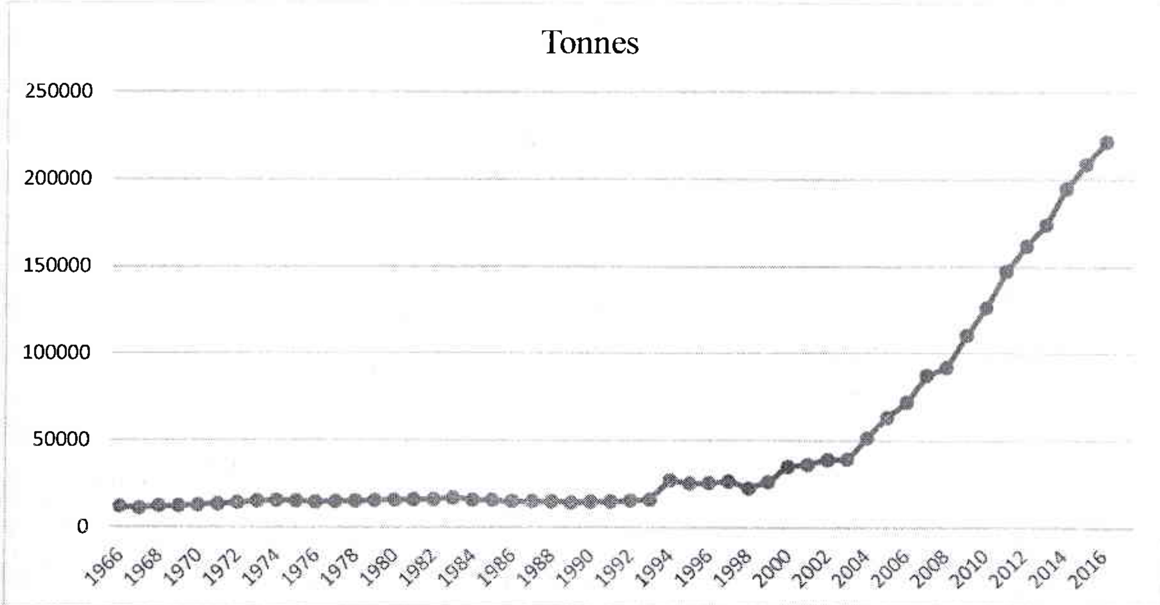
2.11 Rubber Production of Myanmar

The rubber production of Myanmar from 1966 to 2016 is presented in Figure (2.3) and the data are given in Appendix-A. During the period from 1966 to 1988 Myanmar's rubber production has increased from 11847 (tonnes) to 14885 (tonnes). During this period, Myanmar's rubber production is lowest at 11248 (tonnes) in 1967 and this is highest at 17108 (tonnes) in 1983.

During the period from 1989 to 2016, Myanmar's rubber production has increased from 14377 (tonnes) to 221670 (tonnes). During this period, Myanmar's rubber production is lowest at 14377 (tonnes) in 1989 and this is highest at 221670 (tonnes) in 2016.

Figure (2.3)

Production of Rubber in Myanmar (1966-2016)



Source: Food and Agriculture Organization (FAO)

From the result of above Figure (2.3), rubber production are increased from the beginning of 2005 because sown area and yield are higher than the previous years.

In summarizing, the framers should try to upgrade the quality of rubber for more price and also try to increase the sown area for more production before exporting.

2.12 Direction of Myanmar's Rubber Export

Earnings from exports of over 75,000 tons of rubber amounted to US$ 218 million in 2012-2013 FY, 84,000 tons of rubber, US$ 196 million in 2013-2014 FY, 77,500 tons of rubber, US$ 112 million in 2014-2015 FY, over 88,500 tons of rubber, US$ 101 million in 2015-2016 FY, according to the Commerce Ministry. Due to a decline in the rubber price in the global market, the current local rubber price is declining. The association has suggested that planters should grow high-yield rubber strains only and produce high-quality raw materials.

The country's annual rubber production amounts to around 200,000 tons in total. The country exports more than 90 percent of rubber and consumes around 8 per cent with China as the major importer. Myanmar exports rubber to Malaysia, Singapore, Indonesia, South Korea, Japan, Taiwan and India.

Rubber is mostly grown in Mon and Kayin States, Yangon, Bago and Tanintharyi Regions. There are nearly 500,000 acres of rubber plantations in Mon State and nearly 270,000 acres in Kayin State. There are around 1,600,000 acres of rubber plantations nationwide. The main purchaser countries are China, Singapore, Malaysia, Indonesia, Korea, Vietnam and India. Due to lack of technology, the exporters only trade rubber as a raw material. China, Singapore and Malaysia are the largest importers of Myanmar's rubber, according to rubber exporters in Myanmar.

2.13 Data and Variable Description

The data are annual time series data from 1966 to 2016 collected from the Food and Agriculture Organization (FAO). The data set consists of observations on export, price and production of rubber in Myanmar. All of the variables have been transformed into natural logarithmic forms and the resulting variables are denoted as Ln (EXP), Ln (PRI) and Ln (PRO). As indicated in majority of economic literature, logarithms a much more useful way to measure economic data due to minimize multicollinearity and to satisfy one of assumptions of the classical linear regression model. According to Gelman and Hill (2007), coefficients on natural log (logarithms base e) scale are directly interpretable as approximate proportional differences. Since the logarithm is applied for both the dependent and the independent variables, the coefficients will be interpreted as expected proportional change in Y per proportional change in X. The descriptive statistics for the three variables are illustrated in Table (2.1) below:

Table (2.1)

Descriptive Statistics (1966-2016)

	Ln(EXP)	Ln(PRI)	Ln(PRO)
Units	Kyats (million)	Kyats per tonne	Tonnes
Observations	51	51	51
Standard Deviation	2.233902	2.740280	0.923581
Mean	5.399992	10.59364	10.26215
Median	4.496938	10.33754	9.680344
Maximum	9.881591	15.31700	12.30895
Minimum	2.196202	7.458763	9.327946

Source: Food and Agriculture Organization (FAO)

CHAPTER III

METHODOLOGY

3.1 Introduction

In this chapter, the statistical methodologies used in this study are presented. Before illustrate the Granger causality test, the variables are stationary and hence are co-integrated together. If all variables are non- stationary in levels and are stationary in first differences, then a co-integration test is carried out to determine if a long-term relationship exists. Once co-integration is detected, causality test have to be performed using an error correction model (ECM). If the variables are not co-integrated, the unrestricted VAR model would be run (Engle and Granger, 1987 in Alam, 2010).Therefore, the Unit Root Test and the Johansen Co-integration Test are used as the pre-test, and then the Granger Causality Test is designed. Then the structural change in regression model, test for structural change in regression models, Chow test such as Chow forecast test, Chow breakpoint test and instability test such as CUSUM test and CUSUM square test are presented.

3.2 Test of Stationary

The term stationary time series is used to denote a time series whose statistical properties are independent of time. In particular this means that

1. The process generating the data has a constant mean.
2. The variability of the time series is constant over time.

The graphical analysis, the correlogram test and the unit root test can be used for stationary. In this study, ADF test of unit root test is employed for stationary.

3.2.1 The Unit Root Test

A test of stationary (or non-stationary) that has become widely popular over the past several years is the unit root test.

The unit root (stochastic) process is

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \leq \rho \leq 1 \qquad (3.1)$$

where u_t is a white noise error term.

If ρ=1, that is, in the case of the unit root, equation (3.1) becomes a random walk model without drift, which is nonstationary stochastic process. If it is, then Y_t is non-stationary. This is the general idea behind the unit root test of stationary.

However, we cannot estimate equation (3.1) by OLS and test the hypothesis that $\rho = 1$ by the usual t test because that test is severely biased in the case of a unit root. Therefore, we manipulate equation (3.1) as follows: Subtract Y_{t-1} from both sides of equation (3.1) to obtain:

$$\boldsymbol{Y_t - Y_{t-1} = \rho Y_{t-1} - Y_{t-1} + u_t}$$

$$\boldsymbol{= (\rho - 1)\, Y_{t-1} + u_t} \qquad (3.2)$$

Which can be alternatively written as:

$$\Delta \boldsymbol{Y_t = \delta Y_{t-1} + u_t} \qquad (3.3)$$

Where δ= (ρ-1) and Δ, as usual, is the first-difference operator.

In practice, therefore, instead of estimating equation (3.1), equation (3.3) is estimated and test the (null) hypothesis that δ=0, the alternative hypothesis being that δ<0. If δ=0, then ρ=0, i.e., there is a unit root, meaning the time series under consideration is non-stationary.

If δ=0, equation (3.3) will become

$$\Delta \boldsymbol{Y_t = (Y_t - Y_{t-1}) = u_t} \qquad (3.4)$$

Since u_t is a white noise error term, it is stationary, which means that the first differences of a random walk time series are stationary.

Takes the first differences of Y_t and regress them on Y_{t-1} and see if the estimated slope coefficient in this regression ($\hat{\delta}$) is zero or not. If it is zero, it can be concluded that Y_t is non-stationary. But if it is negative, it can be concluded that Y_t is stationary. Dickey and Fuller have shown that under the null hypothesis that δ=0, the estimated t value of the coefficient of Y in equation (3.3) follows the τ(tau) statistic. In the literature, the tau statistic or test is known as the Dickey-Fuller (DF) test.

The actual procedure of implementing the DF test involves several decisions. The Dickey-Fuller test is estimated in three different forms, under three different null hypotheses.

Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$ (3.5)

Y_t is a random walk with drift: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$ (3.6)

Y_t is a random walk with drift
around a stochastic trend: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$ (3.7)

Where t is the time or trend variable. In each case, the hypotheses are:

Null hypothesis: H_0: δ=0 (i.e., there is a unit root or the time series is non-stationary).

Alternative hypothesis: H_1: δ<0 (i.e., the time series is stationary).

If the null hypothesis is rejected, it means that Y_t is stationary with zero mean in the case of equation (3.5), that Y_t is stationary with nonzero mean [$=\beta_1/(1-\rho)$] in the case of equation (3.6), and that $Y_t$is stationary around a deterministic trend in equation (3.7).

It is extremely important to note that the critical values of the tau test to test the hypothesis that δ =0, are different for each of the preceding three specifications of the Dickey-Fuller test.

3.2.2 Augmented Dickey-Fuller (ADF) Test

In conducting the Dickey-Fuller test as in equations (3.5, 3.6, and 3.7), it was assumed that the error term u_t was uncorrelated. But in case the u_t are correlated, Dickey and Fuller have developed another test, known as the Augmented Dickey-Fuller (ADF) test. This test is conducted by "augmenting" the preceding three equations by adding the lagged values of the dependent variable ΔY_t. To be specific, the Augmented Dickey-Fuller test consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (3.8)$$

Where ε_t is a pure white noise error term and where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$; $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The number of lagged difference terms to include is often determined empirically, based on that the error term in equation (3.8) is serially uncorrelated, so that we can obtain an unbiased estimate of δ, the coefficient of lagged Y_{t-1}.In Augmented Dickey-Fuller it is needed to test whether $\delta=0$ and the Augmented Dickey-Fuller test follows the same asymptotic distribution as the Dickey-Fuller statistic, so the same critical values can be used.

3.3 Lag Length Selection

An important aspect of empirical research is the selection of the appropriate number of lags which need to be included in the empirical model. The lag length (k) has to be properly selected to ensure that the residuals empirically follow a white noise process. It has been observed that the power properties of the unit roots tests are sensitive to the number of lagged terms (k) used (Maddala et al. 1998). Moreover, as referred by Maddala et al. (1998), specification of too few lags in the Johansen procedure causes specification distortions, and over specification of lags leads to loss of power. In such chances, it is more efficient to decide on a smaller lag (Maddala et al., 1998, pp. 334).

The adequate lag length can be determined using model selection criteria which provide results of the following test statistics: the sequential modified LR test statistic (LR), Final Predictor Error test (FPE), Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC) and the Hannan-Quinn Information Criterion (HQC). As optimum lag selection criteria for this model is chosen the value which minimizes the Akaike (1974) and the Schwartz Information Criterion. As in most empirical research, the paper follows a sequential general-to-specific strategy selection. That is, starting with a maximum lag length k (max) and reduce the number of lags until reaching significance. Results from the optimum lag length selection criterion often might support different lag lengths, however, in the case of the current model the LR, FPE, AIC, SC and HQ tests show congruent test statistics results on the inclusion of 1 lag.

3.4 Johansen Co-integration Test

In statistics, the Johansen test, named after Søren Johansen, is a procedure for testing co-integration of several, say k, I(1) time series. This test permits more than one co-integrating relationship so is more generally applicable than the Engle–Granger test which is based on the Dickey–Fuller (or the augmented) test for unit roots in the residuals from a single (estimated) co-integrating relationship.

The Johansen tests are called the maximum eigenvalue test and the trace test.

Let r be the rank of Π, this is the same as the number of co-integrating vectors. The Johansen tests are likelihood-ratio tests. There are two tests: (1) the maximum eigenvalue test, and (2) the trace test. For both test statistics, the initial Johansen test is a test of the null hypothesis of no co-integration against the alternative of co-integration. The tests differ in terms of the alternative hypothesis.

3.4.1 Maximum Eigenvalue Test

The maximum eigenvalue test examines whether the largest eigenvalue is zero relative to the alternative that the next largest eigenvalue is zero. The first test is a test whether the rank of the matrix Π is zero. The null hypothesis is that rank (Π) = 0 and the alternative hypothesis is that rank (Π) = 1. For further tests, the null hypothesis is that rank (Π) = 1, 2, ..., and the alternative hypothesis is that rank (Π) = 2, 3, ...

In more detail, the first test is the test of rank (Π) = 0 and the alternative hypothesis is that rank (Π) = 1. This is a test using the largest eigenvalue. If the rank of the matrix is zero, the largest eigenvalue is zero, there is no co-integration and tests are done. If the largest eigenvalue λ_1 is nonzero, the rank of the matrix is at least one and there might be more co-integrating vectors. Now test whether the second largest eigenvalue λ_2 is zero. If this eigenvalue is zero, the tests are done and there is exactly one co-integrating vector. If the second largest eigenvalue $\lambda_2 \neq 0$ and there are more than two variables, there might be more co-integrating vectors. Now test whether the third largest eigenvalue λ_3 is zero. And so on until the null hypothesis of an eigenvalue equal to zero cannot be rejected.

The test of the maximum (remaining) eigenvalue is a likelihood ratio test. The test statistic is

$$\mathbf{LR}\,(\gamma_0, \gamma_0 + 1) = -\mathbf{T}\,\mathbf{ln}\,(1 - \lambda_{\gamma_0+1}) \qquad (3.9)$$

Where LR $(\gamma_0, \gamma_0 + 1)$ is the likelihood ratio test statistic for testing whether rank (Π) = γ_0 versus the alternative hypothesis that rank (Π) =$\gamma_0 + 1$. For example, the hypothesis that rank (Π) = 0 versus the alternative that rank (Π) = 1 is tested by the likelihood ratio test statistic LR (0, 1) = -T ln (1- λ_1).This likelihood ratio statistic does not have the usual asymptoticχ^2 distribution.

3.4.2 Trace Test

The trace test is a test whether the rank of the matrix is γ_0. The null hypothesis is that rank (Π) =γ_0. The alternative hypothesis is that γ_0 < rank (Π) ≤ n, where n is the maximum number of possible co-integrating vectors. For the succeeding test if this null hypothesis is rejected, the next null hypothesis is that rank (Π) = γ_0+1 and the alternative hypothesis is that γ_0+ 1 < rank (Π) ≤n.

Testing proceeds as for the maximum eigenvalue test.

The likelihood ratio test statistic is

$$\mathbf{LR}\ (\gamma_0, \mathbf{n}) = \text{-}\mathbf{T} \sum_{i=\gamma_0+1}^{n} \ln(1 - \lambda_i) \tag{3.10}$$

Where LR (γ_0, n) is the likelihood ratio statistic for testing whether rank (Π) = r versus the alternative hypothesis that rank (Π) ≤ n. For example, the hypothesis that rank (Π) = 0 versus the alternative that rank (Π) ≤ n is tested by the likelihood ratio test statistic LR (γ_0, n) = -T $\sum_{i=1}^{n} \ln(1 - \lambda_i)$.

Why the trace test is called the "trace test"? It is called the trace test because the test statistic's asymptotic distribution is the trace of a matrix based on functions of Brownian motion or standard Wiener processes (Johansen Econometrics 1995, p. 1555).

3.5 Vector Error Correction Model

Vector error correction (VEC) model is a restricted VAR (vector autoregression) designed for use with non-stationary series that are known to be co-integrated. The VEC has co-integration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge their co-integrating relationships while allowing for short-run adjustment dynamics (Engle and Granger, 1987).The co-integration term is known as the error correction term since the deviation from long run equilibrium is corrected gradually through a series of partial short-run adjustments. If the variables are co-integrated of the same order, then valid error correction model exists between the two variables. The determination of co-integration relationship (co-integrated vector) that shows the presence of long-term relationship between variables, causality relationships must be analyzed with error correction model.

The corresponding VEC model is:

$$\Delta y_{1,t} = \alpha_1 (y_{2,t-1} - \beta_{y1,t-1}) + \varepsilon_{1,t} \tag{3.11}$$

$$\Delta y_{2,t} = \alpha_2 (y_{2,t-1} - \beta_{y1,t-1}) + \varepsilon_{2,t} \tag{3.12}$$

In this (simple) model, the only right-hand side variable is the error correction term. In long-run equilibrium, this term is equal to zero. However, if $y_1$and y_2 deviate from the long-run equilibrium, the error correction term will not be equal to zero and each variable adjusts to partially restore the equilibrium relation. The coefficient measures the speed of adjustment of the i^{th}endogenous variable towards the equilibrium.

3.6 Wald Test for Short Run Causality

The short-run causality is tested using Wald test. The Wald test computes a test statistic based on the unrestricted regression. The Wald statistic measures how close the unrestricted estimates come to satisfy the restrictions under the null hypothesis. If the restrictions are in fact true, then the unrestricted estimates should come close to satisfy the restrictions.

3.7 The Granger Causality Test

To explain the Granger test, we should consider the question: Is it Y that "causes" X (Y→ X)? Or is it X that causes Y (X→Y)? (Where the arrow points to the direction of causality). The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another, first proposed in 1969. More specifically, tests for Granger causality are based on the following vector auto-regression (VAR) model:

$$Y_t = \sum_{i=1}^{n} \alpha_i X_{t-i} + \sum_{j=1}^{n} \beta_j Y_{t-j} + u_{1t} \tag{3.13}$$

$$X_t = \sum_{i=1}^{n} \gamma_i X_{t-i} + \sum_{j=i}^{n} \delta_j Y_{t-j} + u_{2t} \tag{3.14}$$

Where u_{1t} and $u_{2t}$are mutually uncorrelated white noise series. The null hypotheses to be tested are $\alpha_i = 0$ and$\gamma_i = 0$, which means that X does not Granger cause Y and Y also does not Granger cause X for all i (i=0, 1,..., n). The alternative hypotheses that are $\alpha_i \neq 0$ and$\gamma_i \neq 0$, which means that X Granger causes Y and Y also Granger causes X for at least some i.

If none of the hypothesis is rejected, it means that X does not Granger cause Y and Y does not Granger cause X. If the first hypothesis is rejected, it shows that X Granger causes Y. Rejection of the second hypothesis means that the causality runs from Y to X. If all hypotheses are rejected, there is bi-directional causality between X and Y.

3.8 Structural Change in Regression Model

The model of classical linear regression has often been widely applied to the measurement of economic relationships. When a regression model involving time series data is used, it may happen that there is a structural change in the relationship between regressand (Y) and the regressors (Xs). By structural change, it means that the values of the parameters of the model do not remain the same through the entire period. Sometimes the structural change may be due to external forces (for example, the oil embargoes imposed by the OPEC oil cartel in 1973 and 1979 or the GULF War of 1990-1991), or due to policy changes, (for example, the switch from a fixed exchange-rate system to a flexible exchange-rate system around 1973) or action taken by the US congress (for example, the tax changes initialed by President Reagan in his two terms in office or changes in the minimum wage rate) or to a variety of other causes. Therefore, when a linear regression is used to represent an economic relationship, the question often arises as to whether the relationship remains stable in two or more periods of time or whether the same relationship holds for two or more different groups of economic units. Statistically this question can be answered by listing whether two sets observations can be regarded as belonging to the same regression model. It can be statistically examine whether subsets of coefficients in two regressions are equal. Often there is no economic rationale in assuming that two relationships are completely the same. It may be more reasonable to suppose that only parts of the relationships are identical in different periods, or for different groups.

To state this problem more formally, suppose Y be the dependent variable, and $X_1, X_2, \ldots, X_k$ be the explanatory variables. Assume that there is a random sample of n observations. The classical linear regression of Y on X is:

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_k X_{ki} + \varepsilon_i \qquad (3.15)$$

Where the X's are k fixed variables. The β's are the regression coefficients. β_1 is the intercept if X_1 is set identically equal to one. The unknown parameters$\beta_1, \beta_2, \ldots, \beta_k$ and σ^2 can be estimated under the classical assumptions such as: the ε's are independent and normally distributed, each with mean zero and constant standard deviation. The number of observations n is greater than the number of parameters k and no singularity of the X matrix.

$$\begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_{11} & \cdots & x_{k1} \\ \vdots & \ddots & \vdots \\ x_{1n} & \cdots & x_{kn} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_k \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

In matrix notations, the model is:

$$y = X\beta + \varepsilon$$

To investigate whether the relationship remains stable in two periods of time, the suggested procedure is to divide the data set of n sample observations into n_1 and $n_2$observations. A structural change or structural break occurs if the parameters underlying a relationship, differ from one subset of the data to another. There may be several relevant subsets of the data, with the possibility of several structural breaks. In this study, the whole sample is divided into two regions at the suspected time point 1988-1989. The whole period 1966 to 2016 will be considered two subsets of n_1 and n_2 observations making up the total sample of $n = n_1 + n_2$ observations.

3.9 Tests for Structural Change in Regression Models

In applied econometric work, researchers are often interested in testing equality between sets of coefficients in two linear regressions. Tests for changes in the coefficients of linear regression models are frequently used by econometricians. The well-known test is Chow test proposed by G.C. Chow (1960), based on residual analysis and is a kind of standard analysis of covariance test. Chow test can be applied under the assumption of homogeneity of variances.

3.10 Chow Test

One of the most important criteria for an estimated equation is that it should have relevance for data outside the sample data used in the estimation. This criterion is embodied in the notation of parameter constancy; that is, that the β vector should apply both outside and within the sample data. Parameter constancy; may be examined in various ways. One of the most useful is a test of predictive accuracy, widely referred to as the Chow test proposed by G.C. Chow (1960).

Chow forecast test leads to more general tests of structural change. A structural change or structural break occurs of the parameters underlying in the relationship differ from one subset of the data to another. The test of structural change may be carried out as follows.

Let Y_i and X_i (i=1, 2) indicate the appropriate partitioning of the data. The unrestricted model may be written

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \quad (3.16)$$

Where β_1 and β_{21} are the k-vectors of two sample groups, respectively and the error term ε is assumed to be independently and normally distributed with mean 0 and constant variances σ^2 .

The OLS coefficients may be written as:

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} X_1'X_1 & 0 \\ 0 & X_2'X_2 \end{bmatrix}^{-1} \begin{bmatrix} X_1'Y_1 \\ X_2'Y_2 \end{bmatrix} = \begin{bmatrix} (X_1'X_1)^{-1} & X_1'Y_1 \\ (X_2'X_2)^{-1} & X_2'Y_2 \end{bmatrix}$$

Thus the unrestricted model may be estimated by setting up the data in equation (3.17) and by fitting the equation to the data of n_1 and n_2 observations separately. The two RSSs must be summed to give the unrestricted RSS (RSS_{UR}).

Under the null hypothesis Ho: $\beta_1 = \beta_2$, equation (3.17) gives the restricted model as:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} \beta + \varepsilon \quad (3.17)$$

Denoting residual sum of squares from fitting equation (3.18) as RSS_R, the test statistic of the null hypothesis no structural change, Ho: $\beta_1 = \beta_2$ is

$$F = \left(\frac{(RSS_R - RSS_{UR})/k}{RSS_{UR}/(n-2k)} \right) \quad (3.18)$$

Which follows F distribution with k and n-2k d.f.

Where RSS_R is restricted RSS obtained from equation (3.17);

RSS_{UR} is unrestricted RSS that is RSS_1+RSS_2. RSS_1 is RSS obtained from the regression equation of Y_1 on X_1. RSS_2 is RSS obtained from the regression equation of Y_2 on X_2.

The Chow test will tell only if the two regressions are different, without telling that whether the difference is on account of the intercepts, or the slopes, or both. Johnston and Dinlardo (1997) extended the test for difference which is caused by intercepts, or slopes, or both.

3.10.1 Chow Forecast Test

The Chow forecast test estimates two models, that is, one using the full set of data T, and the other using a long sub-period T_1. A long difference between the two models casts doubt on the stability of the estimated relation over the sample period. The Chow forecast test can be used with least squares and two stage least squares regressions.

The F-statistic is computed as:

$$F = \frac{(\tilde{u}'\tilde{u} - u'u)/T_2}{u'u/(T_1 - k)} \tag{3.19}$$

Where $\tilde{u}'\tilde{u}$ is the residual sum of squares when the equation is fitted to all T sample observations, is the residual sum of squares when the equation is fitted to T_1 observations, and k is the number of estimated coefficients. This F-statistic follows an exact finite sample F-distribution if the errors are independent, and identically, normally distributed.

3.10.2 Chow Breakpoint Test

The idea of the breakpoint Chow test is to fit the equation separately for each subsample and to see whether there are significant differences in the estimated equations. A significant difference indicates a structural change in the relationship. For example, can use this test to examine whether the demand function for energy was the same before and after the oil shock. The test may be used with least squares and two-stage least squares regressions.

To carry out the test, we partition the data into two or more subsamples. Each subsample must contain more observations than the number of coefficients in the equation so that the equation can be estimated. The Chow breakpoint test compares the sum of squared residuals obtained by fitting a single equation to the entire sample with the sum of squared residuals obtained when separate equations are fit to each subsample of the data.

The F-statistic is based on the comparison of the restricted and unrestricted sum of squared residuals and in the simples case involving a single breakpoint, is computed as:

$$F = \frac{(\tilde{u}'\tilde{u}-(u_1{'}u_1+u_2{'}u_2))/k}{(u_1{'}u_1+u_2{'}u_2)/(T-k)} \quad (3.20)$$

Where $\tilde{u}'\tilde{u}$ is the restricted sum of squared residuals, $u_i{'}u_i$ is the sum of squared residuals from subsample i, T is the total number of observations and k is the number of parameters in the equation. This formula can be generalized naturally to more than one breakpoint. The F-statistic has an exact finite sample F-distribution if errors are independent and identically distributed normal random variables.

The log likelihood ratio statistic is based on the comparison of the restricted and unrestricted maximum of the (Gaussian) log likelihood function. The log likelihood ratio test statistic has an asymptotic χ^2 distribution with degrees of freedom equal to (m-1) k under the null hypothesis of no structural change, where m is the number of subsamples. One major drawback of the breakpoint test is that each subsample requires at least as many observations as the number of estimated parameters.

3.11 CUSUM Test

The CUSUM test (Brown, Durbin, and Evans, 1975) is based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. The test finds parameter instability if the cumulative sum goes outside the area between the two critical lines.

The CUSUM test is based on the statistic:

$$W_t = \sum_{r=k+1}^{t}\left(\frac{W_r}{s}\right) \quad (3.21)$$

For t=k+1, ..., T, where w is the recursive residual defined above, and s is the standard error of the regression fitted to all T sample points. If the β vector remains constant from period to period E (W_t) = 0, but if β changes, W_t will tend to diverge from the zero mean value line. The significance of any departure from the zero line is assessed by reference to a pair of 5% significance lines, the distance between which decreases with t.

The 5% significance lines are found by connecting the points:

$$\left[k, \pm - 0.948\,(T-k)^{1/2}\right] \text{ and } \left[T, \pm 3 \times 0.948\,(T-k)^{1/2}\right] \quad (3.22)$$

3.12 CUSUM of Squares Test

The CUSUM of squares test (Brown, Durbin, and Evans, 1975) is based on the test statistic:

$$W_t = \left(\sum_{r=k+1}^{t} W_r^2\right) / \left(\sum_{r=k+1}^{T} W_r^2\right) \quad (3.23)$$

The expected value of under the hypothesis of parameter constancy is:

$$E(s_t) = (t-k)/(T-k) \quad (3.24)$$

Which goes from zero at t= k to unity at t = T. The significance of the departure of S from its expected value is assessed by reference to a pair of parallel straight lines around the expected value.

CHAPTER IV

TESTING FOR CAUSAL ANALYSIS AND STRUCTURAL BREAK OF RUBBER EXPORT

4.1 Testing for Stationary

In time series, before running the causality test the variables must be tested for stationarity by using unit root test. For unit roots in order to investigate the stationary properties of the data, Augmented Dickey-Fuller (ADF) test is used to each of the three time series Rubber Export, Price and Production testing for the presence of a unit root and the data are given in Appendix-A. It is also to check the order of integration of these variables. The results of the Augmented Dickey Fuller (ADF) test with and without trend as recommended by Engle and Granger (1987) .The tests are performed on both the levels and first differences of the Rubber Export, Price and Production. The results of the stationarity tests show that all variables are non-stationary at level. These results are given in the following Tables. The ADF test at the first difference of the data series reject the null hypothesis of nonstationarity for all the variables used in this study.

Table (4.1a)

Stationary Tests of Export using ADF

Export				
t-statistic	Level		First Difference	
	Without Trend	With Trend	Without Trend	With Trend
ADF	-1.623394	-2.460127	-7.788788*	-8.028152*

Source: Food and Agriculture Organization (FAO)

Note: * denotes highly significance at the 1 percent.

Hypotheses (For Export),

H_0: Export has a unit root (i.e. Export is non-stationary).

H_1: Export has no a unit root (i.e. Export is stationary).

From Table (4.1a), the ADF test confirms the presence of unit root in Export and therefore nonstationarity in the level. But the first difference of the Export is considered, the null hypothesis is rejected in favor of alternative hypothesis, which states that Export is stationary.

Table (4.1b)

Stationary Tests of Price using ADF

Price				
t-statistic	**Level**		**First Difference**	
	Without Trend	**With Trend**	**Without Trend**	**With Trend**
ADF	0.618394	-2.186514	-5.079279*	-5.147584*

Source: Food and Agriculture Organization (FAO)

Note: * denotes highly significance at the 1 percent.

Hypotheses (For Price),

H_0: Price has a unit root (i.e. Price is non-stationary).

H_1: Price has no a unit root (i.e. Price is stationary).

From Table (4.1b), the ADF test states that the presence of unit root in Price, that is, nonstationrity in the level of Price. But the first difference of the Price is considered, the null hypothesis of Price has a unit root is rejected. Therefore, Price is stationary in the case of first difference.

Table (4.1c)

Stationary Tests of Production using ADF

Production				
t-statistic	**Level**		**First Difference**	
	Without Trend	**With Trend**	**Without Trend**	**With Trend**
ADF	2.238768	-0.538171	-6.291998*	-7.123117*

Source: Food and Agriculture Organization (FAO)

Note: * denotes highly significance at the 1percent.

Hypotheses (For Production),

H_0: Production has a unit root (i.e. Production is non-stationary).

H_1: Production has no a unit root (i.e. Production is stationary).

From Table (4.1c), the ADF test shows that there is unit root in Production, that is, nonstationarity in the level of Production. The first difference of the Production is considered, the null hypothesis of there is unit root in Production is rejected. Thus, in the case of first difference, Production is stationary.

More specifically, the null hypothesis about non-stationary cannot be rejected at the levels of all variables under ADF test. But in the first differences, the null hypothesis of non-stationary is rejected under the test of ADF. That allows this study to do the Johansen Co-integration test. It also recommends for taking the causal relationship between the variables.

4.2 Testing for Co-integration of Long-run Relationship

4.2.1 VAR Lag Length Selection

In order to apply co-integration test, lag length in the VAR model needs to be determined. Lag lengths are decided by evaluating sequential modified LR test statistic (LR), Final prediction error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn information criterion (HQ).

Table (4.2)

VAR Lag Order Selection Criteria

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.386670	8.840517	8.958612	8.884957
1	319.8614*	0.001197*	1.784859*	2.257237*	1.962618*
2	9.122835	0.001406	1.939767	2.766429	2.250846
3	4.076260	0.001871	2.212577	3.393522	2.656974
4	9.312425	0.002139	2.321661	3.856889	2.899378

Source: Food and Agriculture Organization (FAO)

Note: * indicates lag order selected by the criterion

Where; 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

From Table (4.2), the optimal number of lags to be included in the model is found to be one. Therefore, there is chance for more efficient on a small lag one and also no loss of power because the minimum lags that eliminates VAR residual autocorrelation. Different lag length selection criteria often lead to a different conclusion and regard the optimal lag order that should be used. The choice of lag length can drastically affect the results of the co-integration analysis.

4.2.2 Johansen Co-integration Test

The Johansen Co-integration test is performed to find out whether there is a long-run relationship among the variables. Other preconditions for performing this test is that the variables had to be non-stationary at level but when convert into first difference they had to become stationary. The ADF test allows running the co-integration test. The results of Johansen Co-integration tests (trace test and maximum eigenvalue test) are stated in the following Tables.

Table (4.3a)

Johansen Co-integration of Trace Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	p-value**
None *	0.378832	36.36708	29.79707	0.0076
At most 1	0.233063	13.03552	15.49471	0.1135
At most 2	0.000680	0.033314	3.841466	0.8551

Source: Food and Agriculture Organization (FAO)

Note: Trace test indicates 1 co-integrating equation at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level.

**MacKinnon-Haug-Michelis (1999) p-values.

Table (4.3a) shows that the null hypothesis of no co-integration is rejected because the trace statistic is greater than its critical value at 5% significance level. Therefore, there is co-integration among variables. And, the null hypothesis of there is at most one co-integration among variables is not rejected, because the trace statistic is less than the critical value at 5% significance level. Thus, there is at most one co-integration.

Table (4.3b)

Johansen Co-integration of Maximum Eigenvalue Test

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	p-value**
None *	0.378832	23.33157	21.13162	0.0241
At most 1	0.233063	13.00220	14.26460	0.0784
At most 2	0.000680	0.033314	3.841466	0.8551

Source: Food and Agriculture Organization (FAO)

Note: Trace test indicates 1 co-integrating equation at the 0.05 level.

* denotes rejection of the hypothesis at the 0.05 level.

**MacKinnon-Haug-Michelis (1999) p-values.

In addition, Table (4.3b) also states that the null hypothesis of no co-integration among variables is rejected because the maximum eigenvalue statistic is greater than the critical value at 5% significance level. Therefore, there is co-integration among variables. And the null hypothesis of at most one co-integration among variables is not rejected because the maximum eigenvalue statistic is less than its critical value at 5% significance level. Thus, there is also at most one co-integration.

The null hypothesis in the Johansen co-integration test is that there is no co-integration equation against the alternative hypothesis is that there is at most one co-integration equation. Both the trace and maximum eigenvalue tests of Johansen Co-integration test show that the same results, that is, there is one co-integration equation. Therefore, co-integration relationships reflect the long term relationship between the relevant variables (they will move together in the long run). Consequently, a restricted VAR (Vector Error Correction) model is run to test for the short-run relationship. If the variables are not co-integrated, the unrestricted VAR model would been run (Engle and Granger, 1987 in Alam, 2010).

4.2.3 Long-Run Elasticities in the Co-integration Equation (VECM)

Three steps are involved in VECM: Lag order selection, the Johansen test of co-integration and VECM. The optimal number of lags to be included in the model is found to be one. The results of co-integration equation in vector error correction model (VECM) are shown in Table (4.4).

Table (4.4)

Long-Run Elasticities in the Co-integrating Equation

Variables	Coefficients	Standard Error	t-statistic
Ln(EXP)	1.00		
Ln(PRI)	-2.360306	0.26195	-9.01061
Ln(PRO)	4.704943	0.78874	5.96512
Constant	-28.56266		

Source: Food and Agriculture Organization (FAO)

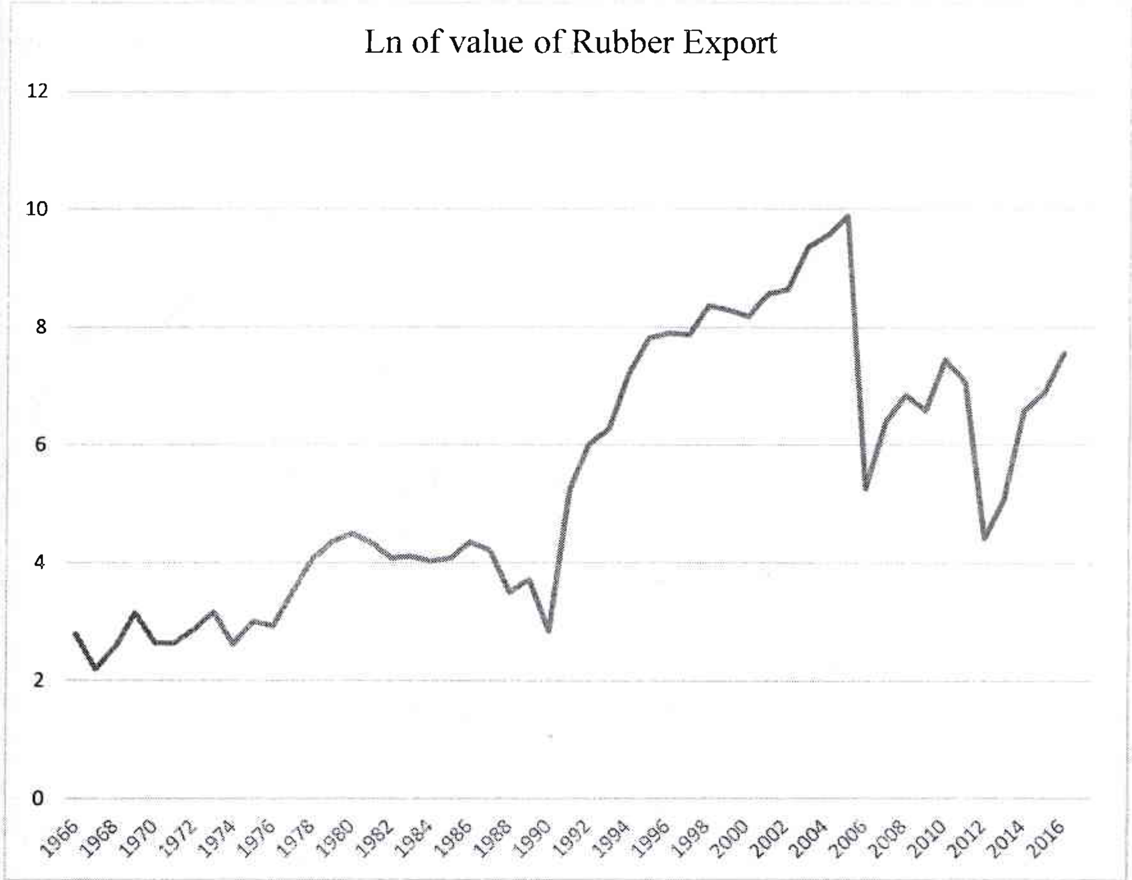
Table (4.4) confirms that if the production of rubber increase by 1 percent in the long run, then the value of rubber export goes up by 4.704943 percent. In the case of there is a 1 percent increase in the price of rubber, the long-run response is that the value of rubber export decrease by 2.360306 percent.

4.3 The Value of Rubber Export in Myanmar (1966-2016)

The following Figure (4.1) gives the value of Rubber Export in Myanmar and the data are given in Appendix-A. Its shows that the movements of Rubber Export in Myanmar during from 1966 to 1988 are obviously less than the movements of Rubber Export in Myanmar during from 1989 to 2016. Because Myanmar Economy has changed from a centrally planned economy into a market- oriented economy. Then, a series of structural reforms have been implemented in the economy. It is well-known that the effectiveness of international trade policy is highly dependent on the sizes of imports and exports price and income elasticities.

Figure (4.1)

Value of Rubber Export in Myanmar (1966-2016)



Source: Food and Agriculture Organization (FAO)

Therefore, before the running of causality the interesting explanatory variables are price of rubber, production of rubber, and dummy variables to capture structural change variables with 1 standing for the presence of structural change and 0 otherwise.

The above Figure (4.1) also shows that the instable pattern of rubber export in Myanmar because the quality of rubber and exchange rate change over time. The value of rubber export is significantly highest in 2005 due to more demand of rubber in Japan for tyre production.

4.4 OLS Model: Econometric Estimation Results and Discussion

The following OLS model uses the FAO data for the period (1966-2016) and they are given in Appendix-A.

Table (4.5)

OLS Model Estimation

Variables	Coefficient	Standard Error	t-statistic	p-value
Constant	-6.889745	1.705641	-4.039388	0.0002
Price	1.259191	0.334432	3.765158	0.0005
Production	-1.934087	0.662498	-2.919387	0.00054
Dummy for 1966-1988	23.08566	4.882708	4.728043	0.0000
Dummy for 1989-2016	22.85266	4.673942	4.889376	0.0000
F-statistic	22.72636			
Probability > F	0.00000			
R-squared	0.664002			
Adjusted R-squared	0.634784			
Root MSE	1.598537			
Durbin-Watson stat	1.665485			

Source: Food and Agriculture Organization (FAO)

From the results of Table (4.5), the variables are all significant and F value shows that the entire model is highly significant at 1 percent. The F statistic tests the hypothesis that all the slope coefficients are simultaneously zero, that is, all the explanatory values jointly have no impact on the regressand (Gujarati 2004). Therefore, all independent variables in the model jointly influence the dependent variable. The Durbin-Watson d statistic for this regression is 1.665485. The critical values of Durbin-Watson d test are d_L =1.206 and d_U =1.537 at 1 percent significance level. If $d_U < d < 4-d_U$, accept H_0: there is no serial correlation. The statistic 1.665485 is within 1.537 and 2.463, thus there is no serial correlation. If R^2 is less than d, the estimated regression is not incorrect (Gujarati 2004).

4.5 Wald Test Results for Short-run Causation

The results of short-run causality between rubber export and its price as well as production are given in the following Tables.

Table (4.6a)

Short Run Causality between Rubber Export and Price

Test Statistic	Value	Df	p-value
t-statistic	-0.643601	44	0.5232
F-statistic	0.414223	(1, 44)	0.5232
Chi-square	0.414223	1	0.5198

Source: Food and Agriculture Organization (FAO)

From Table (4.6a), the probability of test statistics are greater than 1 percent significance level. Thus, it can be said that lag 1 of price of rubber does not jointly affect the value of rubber export in the short run.

Table (4.6b)

Short Run Causality between Rubber Export and Production

Test Statistic	Value	Df	p-value
t-statistic	-0.683805	44	0.4977
F-statistic	0.467589	(1, 44)	0.4977
Chi-square	0.467589	1	0.4977

Source: Food and Agriculture Organization (FAO)

From Table (4.6b), the probability of test statistics are greater than 1 percent significance level. Thus, it can be said that lag 1 of production of rubber does not jointly affect the value of rubber export in the short run.

4.6 Testing for Causality

4.6.1 Granger Causality Test

The results of the Granger Causality test are given in the following Table (4.7).

Table (4.7)

Granger Causality Test Results for Variables Lagged Once

Null Hypothesis: Not Granger Cause	Observations	F-statistic	p-value
PRI → EXP	50	2.95651	0.0921
EXP → PRI	50	1.42513	0.2386
PRO → EXP	50	0.33581	0.5650
EXP → PRO	50	4.03683	0.0503
Dummy66-88 → EXP	50	8.49915	0.0054
EXP → Dummy66-88	50	0.00061	0.9804
Dummy89-16 → EXP	50	8.49915	0.0054
EXP → Dummy89-16	50	0.00061	0.9804
PRO → PRI	50	0.13920	0.7108
PRI → PRO	50	8.98580	0.0043
Dummy66-88 → PRI	50	9.39339	0.0036
PRI → Dummy66-88	50	0.05830	0.8103
Dummy89-16 → PRI	50	9.39339	0.0036
PRI → Dummy89-16	50	0.05830	0.8103
Dummy66-88 → PRO	50	5.25022	0.0265
PRO → Dummy66-88	50	0.00196	0.9649
Dummy89-16 → PRO	50	5.25022	0.0265
PRO → Dummy89-16	50	0.00196	0.9649

Source: Food and Agriculture Organization (FAO)

Table (4.7) shows that, although the price of rubber "Granger Causes" the value of rubber export at 10 percent significance level, the value of rubber export does not "Granger Cause" the price of rubber. The production of rubber does not "Granger Cause" the value of rubber export but the value of rubber export "Granger Causes" the production of rubber at 10 percent significance level.

And the dummy for the period 1966-1988 "Granger Causes" the value of rubber export at highly 1 percent significance level. But the value of rubber export does not "Granger Cause" the dummy for the period 1966-1988. A centrally planned economy and the structural movement of rubber export in Myanmar is substituted by the dummy contained information that is useful for forecasting changes in the value of rubber export and vice versa.

Although The dummy for the period 1989-2016 "Granger Causes" the value of rubber export at highly 1 percent significance level, the value of rubber export does not "Granger Cause" the dummy for the period 1989-2016. Market- oriented economy and the structural movement of rubber export in Myanmar is substituted by the dummy contained information that is useful for forecasting changes in the value of rubber export and vice versa.

The production of rubber does not "Granger effect" the price of rubber, but the price of rubber "Granger effects" the production of rubber at highly 1 percent significance level. The dummy for the period 1966-1988 "Granger Causes" the price of rubber at highly 1 percent significance level, but the price of rubber export does not "Granger Cause" the dummy for the period 1966-1988.

Although the dummy for period 1989-2016 "Granger Causes" the price of rubber at highly 1 percent significance level, the price of rubber does not "Granger Cause" the dummy for the period 1989-2016. The dummy for the period 1966-1988 "Granger Causes" the production of rubber at 5 percent significance level, but the production of rubber does not "Granger Cause" the dummy for the period 1966-1988.

Although the dummy for the period 1989-2016 "Granger Causes" the production of rubber at 5 percent significance level, the production of rubber does not "Granger Cause" the dummy for the period 1989-2016.

4.7 Testing for Structural Break

4.7.1 Breusch-Pagan-Godfrey test of Heteroskedasticity

The following Table (4.8) is the pre-test for homoscedasticity to test the hypothesis of structural break in Myanmar's Rubber Export.

Table (4.8)

Result of Pre- test (Heteroskedasticity Test)

	F-statistic	p-value
Breusch-Pagan-Godfrey test	2.473224	0.0950

From the pre-test of F-value of homoscedasticity, the null hypothesis of no heteroskedasticity is not rejected at highly 1 percent significance level. Therefore the Chow test of structural break can be conducted.

4.7.2 Chow Test for Rubber Export

The Chow forecast test and Chow breakpoint test are used to examine significant structural break in data for the period of a centrally planned economy (1966-1988) and a market-oriented economy (1989-2016). The F-statistic and the log likelihood ratio results are given in Table (4.9).

Table (4.9)

Statistical Output for Structural Change Tests

	F-statistic	p-value	Log likelihood ratio	p-value
Chow Forecast Test	18.58028	0.0000	172.3602	0.0000
Chow Breakpoint Test	1.740236	0.1723	5.598013	0.1329

Source: Food and Agriculture Organization (FAO)

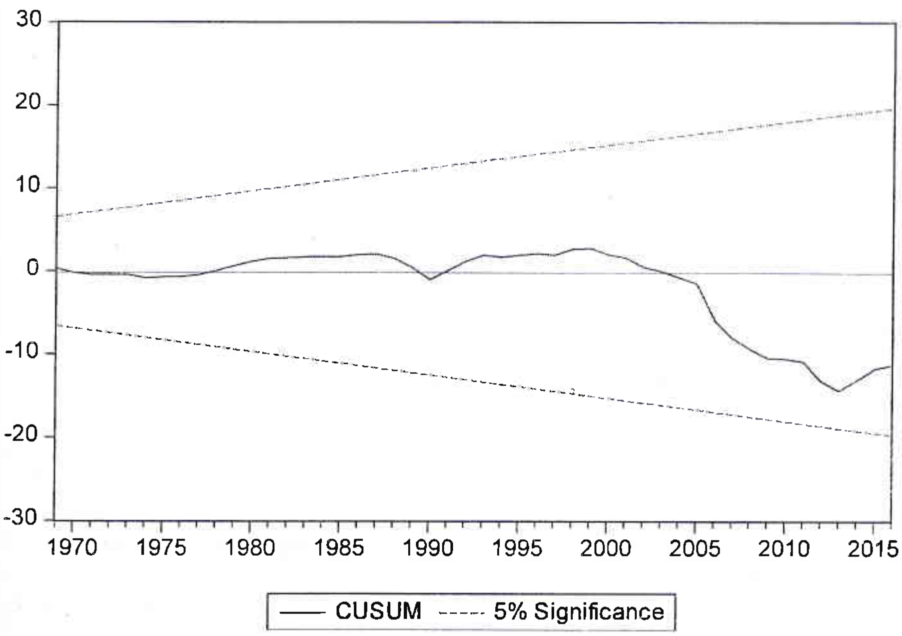
From the results of Table (4.9), although both of the Chow breakpoint test statistics cannot reject the null hypothesis of no structural change in rubber export model, both of the Chow forecast test statistics reject the null hypothesis of no structural change in the model. Therefore, there is structural break in Myanmar's Rubber Export.

4.7.3 CUSUM Test for Rubber Export

The movement of W_t fall inside the critical of the 5% confidence interval of parameter stability. A sample CUSUM (cumulative sum of recursive residuals) test is given below Figure (4.2):

Figure (4.2)

CUSUM Test for Rubber Export



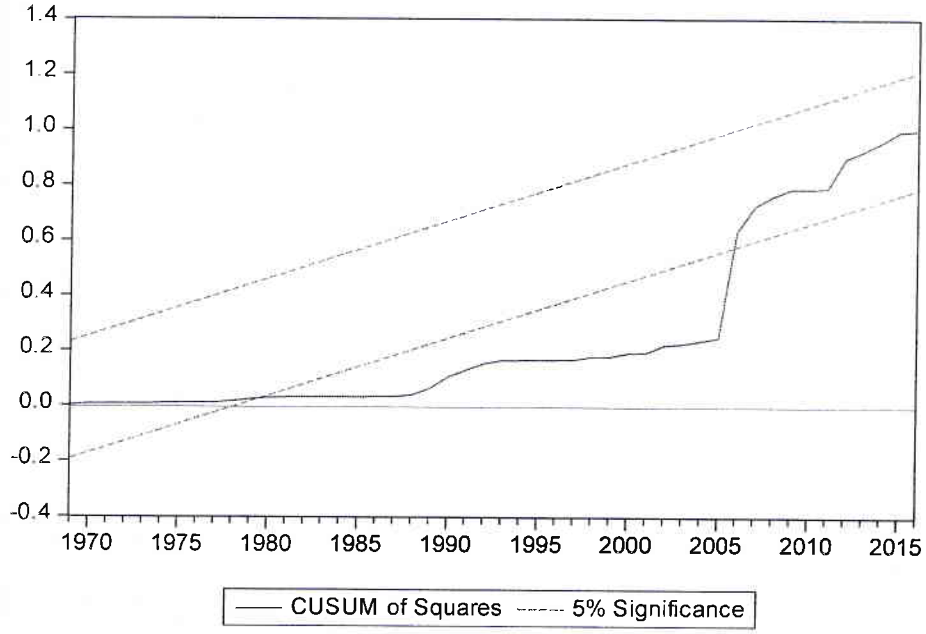
The test clearly indicates the absence of instability in Myanmar's Rubber Export.

4.7.4 CUSUM of Squares Test for Rubber Export

In the following Figure (4.3), the cumulative sum of squares is not within the 5% significant lines, suggesting that the residual variance is instable.

FIGURE (4.3)

CUSUM of Squares Test for Rubber Export



Therefore, CUSUM of squares test confirms that there is instability in Myanmar's Rubber Export.

4.8 Testing for Forecast of Rubber Export in Myanmar

4.8.1 Multiple Linear Regression Model in Rubber Export

The fitting of linear regression model, the price of rubber and the production of rubber are used as the independent variables and the rubber export is used as dependent variable. For the necessary assumptions, the rubber export model is determined by the exponential relationship which can be transformed into a log-linear form. The log-linear model for the rubber export is as follows:

$$Ln(EXP_t) = \beta_0 + \beta_1 Ln(PRI_t) + \beta_2 Ln(PRO_t) + u_i$$

Where u_i is disturbance term and the unknown parameters $\beta_0, \beta_1 and\ \beta_2$ in the rubber export model are estimated by using the ordinary least squares.

In constructing the model, the variables are noted as:

EXP_t is the rubber export of Myanmar (Kyat in millions)

PRI_t is the price of rubber (Kyats per tonne)

PRO_t is the production of rubber (tonnes)

The estimated rubber export model for the entire period 1966-2016 and two sub-periods, 1966-1988 and 1989-2016 are presented as follows. The p-values are shown below corresponding coefficients.

For the entire period 1966-2016:

$$Ln(\widehat{EXP}_t) = 14.4009 + 1.3443\ Ln(PRI_t) - 2.2650\ Ln(PRO_t) \quad (4.1)$$

(0.0000) (0.0000)

R-squared=0.7746, Adjusted R-squared=0.7652, DW=1.0305

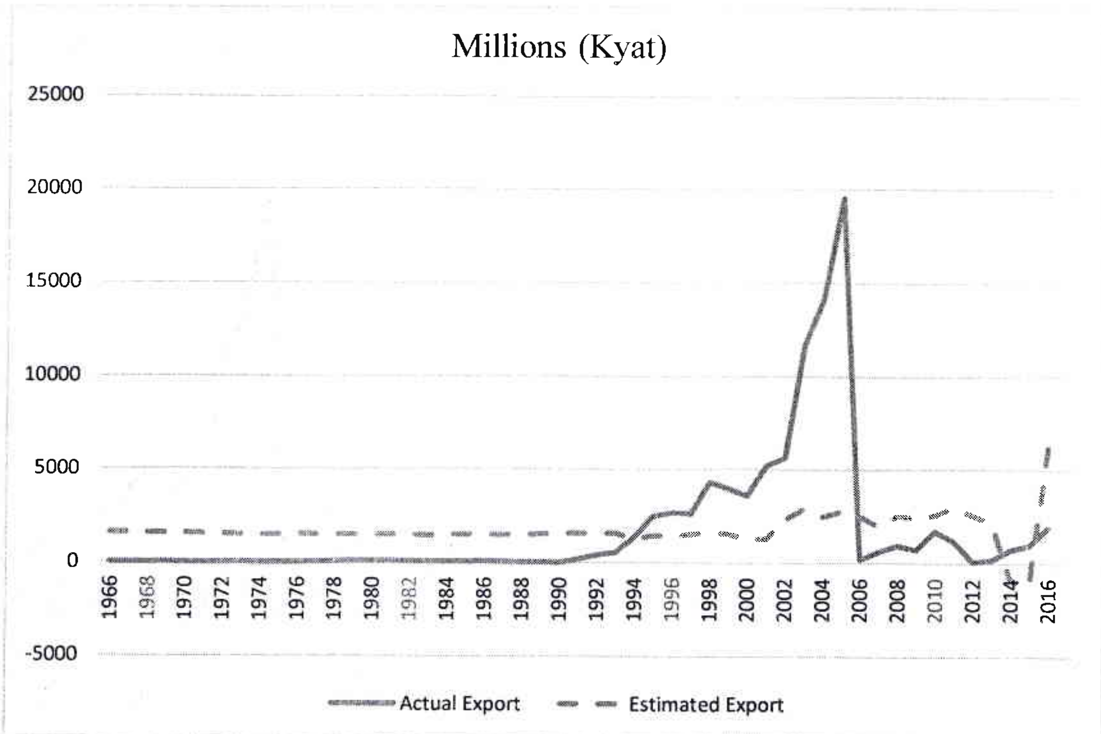
F-statistic=82.4603, Probability (F-statistic) =0.000000

From the results of estimated model, the elasticity of price coefficient is 1.3443. Thus if 1 percent of price is increased, the rubber export on average will increase about 1.3443 percent.

And the elasticity of production is -2.2650, thus if 1 percent of production is increased, the rubber export on average will decrease about 2.2650 percent.

Figure (4.4)

Actual Values and Estimated Values of Rubber Export in Myanmar (1966-2016)



Source: Food and Agriculture Organization (FAO)

In summarizing the results of estimated model, the diagnostic statistic such as F ratio and p-value indicate that the estimated rubber export model is found to be significant. By using the estimated model, the fitted values of Rubber Export in Myanmar are portrayed in above Figure (4.4) compare with the actual values.

For the sub-period 1966-1988:

$$Ln(EXP_t) = -9.1493 + 2.0386\ Ln(PRI_t) - 0.3726\ Ln(PRO_t) \quad (4.2)$$

(0.0000) (0.7600)

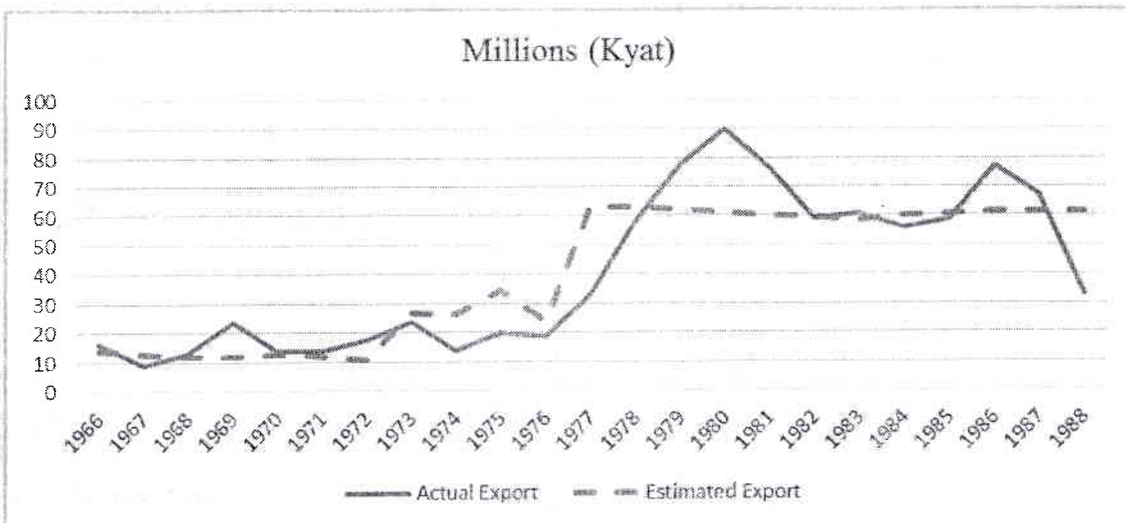
R-squared=0.8083, Adjusted R-squared=0.7892, DW=1.3091

F-statistic=42.1746, Probability (F-statistic) =0.0000

From the results of estimated model, the elasticity of price coefficient is 2.0386. Thus if 1 percent of price is increased, the rubber export on average will increase about 2.0386 percent. And the elasticity of production is -0.3726, thus if 1 percent of production is increased, the rubber export on average will decrease about 0.3726 percent.

Figure (4.5)

Actual Values and Estimated Values of Rubber Export in Myanmar (1966-1988)



Source: Food and Agriculture Organization (FAO)

In summarizing the results of estimated model, the diagnostic statistic such as F ratio and p-value indicate that the estimated rubber export model is found to be significant. By using the estimated model, the fitted values of Rubber Export in Myanmar are portrayed in above Figure (4.5) compare with the actual values.

For the sub-period 1989-2016

$$Ln(\widehat{EXP_t}) = 15.7394 + 1.7200\ Ln(PRI_t) - 2.8386\ Ln(PRO_t) \quad (4.3)$$

$$(0.0000) \qquad (0.0011)$$

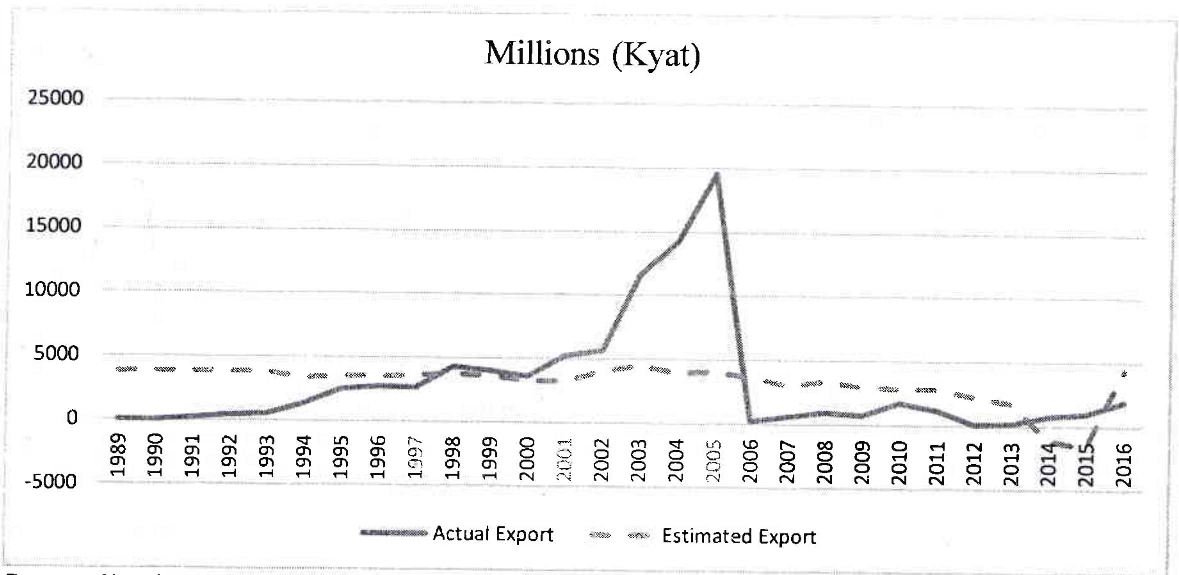
R-squared=0.4019, Adjusted R-squared=0.3541, DW=1.2727

F-statistic=8.4010, Probability (F-statistic) =0.0016

From the results of estimated model, the elasticity of price coefficient is 1.7200. Thus if 1 percent of price is increased, the rubber export on average will increase about 1.7200 percent. And the elasticity of production is -2.8386, thus if 1 percent of production is increased, the rubber export on average will decrease about 2.8386 percent.

Figure (4.6)

Actual Values and Estimated Values of Rubber Export in Myanmar (1989-2016)



Source: Food and Agriculture Organization (FAO)

In summarizing the results of estimated model, the diagnostic statistic such as F ratio and p-value indicate that the estimated rubber export model is found to be significant. By using the estimated model, the fitted values of Rubber Export in Myanmar are portrayed in above Figure (4.6) compare with the actual values.

CHAPTER V

CONCLUSION

This study investigates the export values of rubber in Myanmar using annual time series data for the period 1966-2016. Many econometrics methods are used not only for export values but also price and production of rubber.

Firstly, the ADF test of unit root test is used for the stationarity of the variables. Because, it is very important to find out if the relationship between economic variables are true or spurious. To avoid the spurious regression problem, it is needed to test the time series data are stationary or not. From the results of the ADF tests for EXP, PRI and PRO of rubber are non-stationary in levels. But at the first differencing, the ADF tests for three variables of rubber are stationary at highly 1 percent significance level. Therefore, ADF tests for three variables are stationary in first difference.

Furthermore, the trace test and maximum eigenvalues test of Johansen Co-integration test are used to investigate the co-integration, which show the long-run relationship between the export values, price and production of rubber in Myanmar. The result of trace test shows that there is one co-integration relationship between variables and the maximum eigenvalues test also confirms there is one co-integration relationship between the three variables. Thus, both trace and maximum eigenvalue tests of Johansen Co-integration test find out there is long-run relationship between the export values, price and production of rubber in Myanmar.

Following the detection of the co-integration relationship, an error correction modeling technique is used to investigate there is short run or long run causality between variables. The error correction model shows that there is long run causality effect between the export values, price and production of rubber in Myanmar. The Wald test is employed to know there is short run causality effect between variables.

From the results of Wald test, there is no short run causality linkage between the rubber export values and the price of rubber. And again, the production of rubber does not effect on the values of rubber export in Myanmar. Therefore, there is no short run causation effects between the variables.

After showing the stationary and long run relationship conditions, Granger Causality test is used to investigate the direction of causality between the variables. In this study, the structural change of policy change is also employed to know the direction of causation effect. The dummy variables are used for the structural change variables: denotes 1 for there is structural change and 0 for not. In this study the two dummy variables are used, first is the structural change for the period of socialist economy (1966-1988) and second for the structural change during the period of market-oriented economy (1989-2016).

From the result of Granger Causality, price of rubber causes the production of rubber but production does not cause the price of rubber. And the price of rubber effects the export values of rubber but the export values of rubber does not affect the price of rubber. Again, although the export values of rubber Granger causes the production of rubber, the production of rubber does not Granger cause the export values of rubber.

By considering the structural change dummies, structural change for the period of socialist economy causes the export values of rubber but the export values of rubber does not cause the structural change. Again, although the structural change for the period of socialist economy effects the price of rubber, the price of rubber does not cause the structural change of socialist economy. And the structural change for the period of socialist economy Granger causes the production of rubber but the production of rubber does not Granger causes the structural change of socialist economy.

In addition, the structural change for the period of market-oriented economy Granger causes the export values of rubber but the export values of rubber does not Granger causes the structural change dummies variables. Although the structural change for the period of market-oriented economy effects the price of rubber, the price of rubber does not affect the structural change of market-oriented economy. And the structural change for the period of market-oriented economy causes the production of rubber but the production of rubber does not cause the structural change dummy variables. Shortly, although the structural changes for the period of socialist economy and market-oriented economy Granger cause the export values, price and production of rubber, the three variables don't Granger cause the two structural changes for the period of socialist economy and market-oriented economy.

There are structural change in an economy because of (i) change in final demand, (ii) change in export structure, (iii) change in import structural and (iv) change in technology. It is interesting to analyze structural change in Myanmar's Rubber Exports since it is hoped that the change in export structure is one of the sources of structural change in Myanmar economy which reflects its economic development. Therefore, the structural break in Myanmar's Rubber Export is mainly investigated by Chow test, CUSUM test and CUSUM square test.

The structural break in Myanmar's Rubber Export is also conducted by using Chow test at the break time point 1988. Based on the results of Chow test, it is found that there is structural break in Myanmar's Rubber Export at the breakpoint 1988. There is common intercepts but differential slopes on Rubber Export Model for two sub periods are detected. The CUSUM test clearly indicates structural stability in Myanmar's Rubber Export but the CUSUM square test is not within the 5% significance lines thus there is instability in Myanmar's Rubber Export.

In addition, the rubber export, price and production are computed by a log-linear model for the sub-periods: 1966-1988, 1989-2016 and the whole period 1966-2016. On the average, annual rubber export values, price and production are higher in the market-oriented economy during the period 1989-2016 than in the socialist economy during the period 1966-1988. The Rubber Export Model is also estimated for the two sub periods and the whole period.

The study of structural breaking in Myanmar's Rubber Export is hoped to provide policy implications and suggestions in adopting more effective and well-organized planning and policy for the promotion of export of the country.

REFERENCES

1. Asselt, J.V., Htoo, K. and Dorosh, P.A. (2017), *"Prospects for the Myanmar Rubber Sector: An Analysis of the Viability of Smallholder Production in Mon State"*, IFPRI Discussion Paper 01610, February 2017.

2. Centre for Economic and Social Development, International Food Policy Research Institute and Michigan State University (2016). *"Mon State Livelihoods and Rural Development Report"*, Yangon, Mynmar: CESD, IFPRI and MSU.

3. Chritiann.H. (2004). *"Econometric Methods with Application in Business and Economics"*, (First Edision). Oxford University Press.

4. Ciuiu, D., Badileanu, M. and Georgescu, L.I. (2014). *"Granger Causality Test and Chow Breakpoint Test on the Romanian Day head Electricity Market: Theoretical, Empirical and Practical Approaches"*, 2nd International Conference. Bucharest, Romania. Retrieved November 13-14, 2014.

5. Dufuor, J.M. (1982). *"Generalized Chow Tests for Structural Change:A coordinate-free Approch"*, International Economic Review,23:564-574.

6. *Eleven Media Group newspaper website, a member of Asia News Network.*

7. Emerson, J. (2007). *"Cointegration analysis and the choice of lag length"*. Pages 881-885/ Published online: September 28, 2007.

8. Granger, C.W.J., Lin, J.L. (1995). *"Causality in Long run."* Economic Theory 11, 530-536.

9. Gujarati, D.N. and Sangeetha (2004). *"Basic Econometrics"*, (Fourth Edision). McGraw. Hill Companies.

10. Johansen, S. (1991). *"Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models"*, Econometrica 59, 1551-1580.

11. Mangs, J. (2009). *"Identifying Change Points in Linear Regression"*, Helsinki University of Technology.

12. Mitra, S. (2015). *"Trapping the White Gold Rubber"*, Myanmar Insider, July. Retrieved from www. myanmarinsider.com/tapping-the-white-gold-rubber.

13. Myanmar Rubber Planters and Producers Association (2015). *"Myanmar Rubber Planted Area and Production"*, Yangon, Myanmar: MRPPA.

14. Myint, H. (2008). *"Development of Rubber Planting Industry in Myanmar: Review and Major Constraints"*, IRRDB International Natural Rubber Conference, Kuala Lumpur, Malaysia. Retrieved October 13, 2008.

15. Myint, H. (2013). *"Rubber Planting Industry in Myanmar: Current Situation and Potentials"*, ASEAN Plus 2013 Rubber conference. Phuket, Thailand, April 10-12.

16. P.UWIMANA, C. M. (2018). *"An Analysis of Causality between Tea Exports and its Determinants in Rwanda"*, East Africa Research Papers in Economics and Finance, Ph.D Programme, Retrieved from http://www.ju.se/earp, E-mail: EARP@ju.se

17. Tha Ya Phe (2013). *"A Study on Structural Instability in Myanmar's Paddy Export"*, M.Econ(Stats) Thesis,Department of Statistics, Yangon University of Economics.

18. Verbeck, M. (2008). *"A Guide To Modern Econometrics"*, (Third Edition). John Wiley & Sons,Ltd.

19. Woods, K. (December, 2012). *"The Political Ecology of Rubber Production in Myanmar"*.

20. Wah Wah Shwe Sin (2011). *"A Study on Structural Change in Myanmar's Export", M.Econ(Stats) Thesis, Department of Statistics* Yangon University of Economics.

APPENDIX

APPENDIX-A

The Values of Rubber Export, Price of Rubber and Production of Rubber in Myanmar (1966-2016)

Year	Export (Millions of kyat)	Price (Kyat per tonne)	Production (Tonnes)
1966	16.315425	1819	11847
1967	8.9908	1735	11248
1968	13.10322	1749	12113
1969	23.42396	1759	12215
1970	13.9380813	1828	12904
1971	13.9084512	1826	13417
1972	17.535914	1808	14114
1973	23.584973	2469	15205
1974	13.6490375	2469	15421
1975	20.0504542	2756	15154
1976	18.5239054	2317	14515
1977	32.9562188	3814	14940
1978	58.0642803	3814	15021
1979	77.449008	3814	15443
1980	89.7419606	3783	15686
1981	76.462977	3753	15835
1982	59.0362878	3754	16027
1983	60.9050204	3754	17108
1984	56.0555783	3754	15760
1985	58.89986	3754	15550
1986	77.164745	3754	15069
1987	67.25346	3754	15031
1988	32.9619528	3754	14885
1989	40.8339762	7717	14377

1990	17.1306135	27077	14805
1991	189.102832	30870	14900
1992	405.97596	40417	15300
1993	527.782	48003	16000
1994	1373.736574	60792	27100
1995	2467.453824	104892	25300
1996	2697.341166	110250	25600
1997	2622.764659	155227	26600
1998	4304.894599	163482	22600
1999	3982.840829	160386	26200
2000	3598.574	174165	35100
2001	5221.43202	187393	36200
2002	5642.000	617294	39100
2003	11662.500	837757	39200
2004	14166.6672	837757	51500
2005	19566.8327	1102312	63200
2006	192.2333386	1106721	72000
2007	593.8813488	1089084	87200
2008	936.97725	1360103.5	91800
2009	718.32925	1552199.3	110300
2010	1716.033	1804581.7	126200
2011	1165527.15	2237354.1	147300
2012	82.3323872	2240000	161800
2013	156.839844	2240000	174100
2014	724.4784352	1327774	194900
2015	975.4342367	1344820	208741
2016	1900.464161	4488361	221670

Source: Food and Agriculture Organization (FAO)

APPENDIX-B

Null Hypothesis: LN_EXP_ has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.623394	0.4634
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_EXP_)
Method: Least Squares
Date: 10/04/18 Time: 21:47
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_EXP_(-1)	-0.099336	0.061190	-1.623394	0.1111
C	0.627299	0.354659	1.768738	0.0833

R-squared	0.052047	Mean dependent var	0.095155
Adjusted R-squared	0.032298	S.D. dependent var	0.973240
S.E. of regression	0.957394	Akaike info criterion	2.789976
Sum squared resid	43.99700	Schwarz criterion	2.866456
Log likelihood	-67.74939	Hannan-Quinn criter.	2.819100
F-statistic	2.635409	Durbin-Watson stat	2.131001
Prob(F-statistic)	0.111055		

Null Hypothesis: D(LN_EXP_) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.788788	0.0000
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_EXP_,2)
Method: Least Squares
Date: 10/04/18 Time: 21:49
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_EXP_(-1))	-1.125253	0.144471	-7.788788	0.0000
C	0.119715	0.140617	0.851356	0.3989

R-squared	0.563462	Mean dependent var	0.025773
Adjusted R-squared	0.554174	S.D. dependent var	1.468754
S.E. of regression	0.980690	Akaike info criterion	2.838840
Sum squared resid	45.20241	Schwarz criterion	2.916057
Log likelihood	-67.55157	Hannan-Quinn criter.	2.868136
F-statistic	60.66522	Durbin-Watson stat	2.024622
Prob(F-statistic)	0.000000		

Null Hypothesis: LN_EXP_ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.460127	0.3458
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_EXP_)
Method: Least Squares
Date: 10/04/18 Time: 21:50
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_EXP_(-1)	-0.230770	0.093804	-2.460127	0.0176
C	0.664593	0.347044	1.915009	0.0616
@TREND("1966")	0.026149	0.014383	1.818028	0.0754

R-squared	0.114331	Mean dependent var	0.095155
Adjusted R-squared	0.076642	S.D. dependent var	0.973240
S.E. of regression	0.935201	Akaike info criterion	2.762014
Sum squared resid	41.10625	Schwarz criterion	2.876736
Log likelihood	-66.05035	Hannan-Quinn criter.	2.805701
F-statistic	3.033601	Durbin-Watson stat	1.996964
Prob(F-statistic)	0.057661		

Null Hypothesis: D(LN_EXP_) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.721482	0.0000
Test critical values:	1% level	-4.156734	
	5% level	-3.504330	
	10% level	-3.181826	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_EXP_,2)
Method: Least Squares
Date: 10/04/18 Time: 21:51
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_EXP_(-1))	-1.127109	0.145971	-7.721482	0.0000
C	0.205452	0.296861	0.692079	0.4924
@TREND("1966")	-0.003292	0.010009	-0.328855	0.7438

R-squared	0.564486	Mean dependent var	0.025773
Adjusted R-squared	0.545550	S.D. dependent var	1.468754
S.E. of regression	0.990129	Akaike info criterion	2.877308
Sum squared resid	45.09639	Schwarz criterion	2.993134
Log likelihood	-67.49404	Hannan-Quinn criter.	2.921252
F-statistic	29.81110	Durbin-Watson stat	2.026342
Prob(F-statistic)	0.000000		

Null Hypothesis: LN_PRI_ has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.618394	0.9889
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRI_)
Method: Least Squares
Date: 10/04/18 Time: 22:05
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_PRI_(-1)	0.010925	0.017667	0.618394	0.5392
C	0.041517	0.191327	0.216994	0.8291

R-squared	0.007904	Mean dependent var	0.156219
Adjusted R-squared	-0.012765	S.D. dependent var	0.329686
S.E. of regression	0.331783	Akaike info criterion	0.670508
Sum squared resid	5.283845	Schwarz criterion	0.746989
Log likelihood	-14.76270	Hannan-Quinn criter.	0.699633
F-statistic	0.382411	Durbin-Watson stat	1.528632
Prob(F-statistic)	0.539239		

Null Hypothesis: D(LN_PRI_) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.079279	0.0001
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRI_,2)
Method: Least Squares
Date: 10/04/18 Time: 22:06
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_PRI_(-1))	-0.819902	0.161421	-5.079279	0.0000
C	0.136093	0.052044	2.614941	0.0120

R-squared	0.354387	Mean dependent var	0.025561
Adjusted R-squared	0.340651	S.D. dependent var	0.407554
S.E. of regression	0.330935	Akaike info criterion	0.666173
Sum squared resid	5.147358	Schwarz criterion	0.743390
Log likelihood	-14.32124	Hannan-Quinn criter.	0.695469
F-statistic	25.79907	Durbin-Watson stat	1.736117
Prob(F-statistic)	0.000006		

Null Hypothesis: LN_PRI_ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.186514	0.4864
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRI_)
Method: Least Squares
Date: 10/04/18 Time: 22:07
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_PRI_(-1)	-0.134818	0.061659	-2.186514	0.0338
C	0.860783	0.379919	2.265699	0.0281
@TREND("1966")	0.027879	0.011348	2.456724	0.0178

R-squared	0.120805	Mean dependent var	0.156219
Adjusted R-squared	0.083393	S.D. dependent var	0.329686
S.E. of regression	0.315640	Akaike info criterion	0.589694
Sum squared resid	4.682539	Schwarz criterion	0.704416
Log likelihood	-11.74236	Hannan-Quinn criter.	0.633381
F-statistic	3.229010	Durbin-Watson stat	1.523180
Prob(F-statistic)	0.048529		

Null Hypothesis: D(LN_PRI_) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.147589	0.0006
Test critical values:	1% level	-4.156734	
	5% level	-3.504330	
	10% level	-3.181826	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRI_,2)
Method: Least Squares
Date: 10/04/18 Time: 22:08
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.

D(LN_PRI_(-1))	-0.832698	0.161765	-5.147589	0.0000
C	0.047525	0.100020	0.475160	0.6369
@TREND("1966")	0.003473	0.003350	1.036634	0.3053

R-squared	0.369125	Mean dependent var	0.025561
Adjusted R-squared	0.341696	S.D. dependent var	0.407554
S.E. of regression	0.330673	Akaike info criterion	0.683897
Sum squared resid	5.029855	Schwarz criterion	0.799723
Log likelihood	-13.75547	Hannan-Quinn criter.	0.727841
F-statistic	13.45732	Durbin-Watson stat	1.759147
Prob(F-statistic)	0.000025		

Null Hypothesis: LN_PRO_ has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.238768	0.9999
Test critical values:	1% level	-3.568308	
	5% level	-2.921175	
	10% level	-2.598551	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRO_)
Method: Least Squares
Date: 10/04/18 Time: 22:15
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_PRO_(-1)	0.037780	0.016875	2.238768	0.0298
C	-0.327574	0.173118	-1.892194	0.0645

R-squared	0.094546	Mean dependent var	0.058582
Adjusted R-squared	0.075682	S.D. dependent var	0.108737
S.E. of regression	0.104541	Akaike info criterion	-1.639297
Sum squared resid	0.524583	Schwarz criterion	-1.562816
Log likelihood	42.98242	Hannan-Quinn criter.	-1.610172
F-statistic	5.012080	Durbin-Watson stat	2.049011
Prob(F-statistic)	0.029843		

Null Hypothesis: D(LN_PRO_) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.291998	0.0000
Test critical values:	1% level	-3.571310	

	5% level	-2.922449
	10% level	-2.599224

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRO_,2)
Method: Least Squares
Date: 10/04/18 Time: 22:16
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_PRO_(-1))	-0.903541	0.143602	-6.291998	0.0000
C	0.055189	0.017735	3.111937	0.0032

R-squared	0.457207	Mean dependent var	0.002285
Adjusted R-squared	0.445659	S.D. dependent var	0.146806
S.E. of regression	0.109303	Akaike info criterion	-1.549424
Sum squared resid	0.561517	Schwarz criterion	-1.472206
Log likelihood	39.96088	Hannan-Quinn criter.	-1.520128
F-statistic	39.58924	Durbin-Watson stat	2.007930
Prob(F-statistic)	0.000000		

Null Hypothesis: LN_PRO_ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.538171	0.9783
Test critical values:	1% level	-4.152511	
	5% level	-3.502373	
	10% level	-3.180699	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRO_)
Method: Least Squares
Date: 10/04/18 Time: 22:17
Sample (adjusted): 1967 2016
Included observations: 50 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN_PRO_(-1)	-0.019518	0.036267	-0.538171	0.5930
C	0.158455	0.322046	0.492027	0.6250
@TREND("1966")	0.003907	0.002202	1.774399	0.0825

R-squared	0.151393	Mean dependent var	0.058582
Adjusted R-squared	0.115283	S.D. dependent var	0.108737

S.E. of regression	0.102277	Akaike info criterion	-1.664138
Sum squared resid	0.491648	Schwarz criterion	-1.549416
Log likelihood	44.60344	Hannan-Quinn criter.	-1.620451
F-statistic	4.192457	Durbin-Watson stat	2.063049
Prob(F-statistic)	0.021115		

Null Hypothesis: D(LN_PRO_) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.123117	0.0000
Test critical values:	1% level	-4.156734	
	5% level	-3.504330	
	10% level	-3.181826	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LN_PRO_,2)
Method: Least Squares
Date: 10/04/18 Time: 22:18
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LN_PRO_(-1))	-1.052323	0.147734	-7.123117	0.0000
C	-0.011670	0.031049	-0.375866	0.7087
@TREND("1966")	0.002907	0.001136	2.558821	0.0139

R-squared	0.524841	Mean dependent var	0.002285
Adjusted R-squared	0.504182	S.D. dependent var	0.146806
S.E. of regression	0.103373	Akaike info criterion	-1.641685
Sum squared resid	0.491551	Schwarz criterion	-1.525859
Log likelihood	43.22127	Hannan-Quinn criter.	-1.597740
F-statistic	25.40483	Durbin-Watson stat	1.970249
Prob(F-statistic)	0.000000		

VAR Lag Order Selection Criteria
Endogenous variables: LN_EXP_ LN_PRO_
Exogenous variables: C
Date: 10/04/18 Time: 22:33
Sample: 1966 2016
Included observations: 47

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-157.5384	NA	3.043862	6.788868	6.867598	6.818495
1	-22.96506	251.9671*	0.011762*	1.232556*	1.468745*	1.321435*
2	-22.20687	1.355070	0.013519	1.370505	1.764153	1.518637
3	-20.50023	2.904910	0.014948	1.468095	2.019203	1.675480

4	-20.05279	0.723519	0.017476	1.619268	2.327835	1.885906

* 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

Date: 10/04/18 Time: 22:36
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments
Trend assumption: Linear deterministic trend
Series: LN_EXP_ LN_PRI_ LN_PRO_
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.378832	36.36708	29.79707	0.0076
At most 1	0.233063	13.03552	15.49471	0.1135
At most 2	0.000680	0.033314	3.841466	0.8551

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.378832	23.33157	21.13162	0.0241
At most 1	0.233063	13.00220	14.26460	0.0784
At most 2	0.000680	0.033314	3.841466	0.8551

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LN_EXP_	LN_PRI_	LN_PRO_
-0.771832	1.821761	-3.631427
0.796884	-0.586719	1.128698
0.139358	0.327024	-2.174130

Unrestricted Adjustment Coefficients (alpha):

D(LN_EXP_)	0.305391	-0.342556	-0.010432
D(LN_PRI_)	-0.045761	0.051206	-0.007681
D(LN_PRO_)	0.053321	0.029764	3.63E-05

1 Cointegrating Equation(s):	Log likelihood	-29.22158

Normalized cointegrating coefficients (standard error in parentheses)

LN_EXP_	LN_PRI_	LN_PRO_
1.000000	-2.360306	4.704943
	(0.26195)	(0.78874)

Adjustment coefficients (standard error in parentheses)

D(LN_EXP_)	-0.235710
	(0.10514)
D(LN_PRI_)	0.035320
	(0.03707)
D(LN_PRO_)	-0.041155
	(0.01071)

2 Cointegrating Equation(s):	Log likelihood	-22.72048

Normalized cointegrating coefficients (standard error in parentheses)

LN_EXP_	LN_PRI_	LN_PRO_
1.000000	0.000000	-0.074492
		(0.65512)
0.000000	1.000000	-2.024922
		(0.33490)

Adjustment coefficients (standard error in parentheses)

D(LN_EXP_)	-0.508688	0.757333
	(0.13985)	(0.24126)
D(LN_PRI_)	0.076125	-0.113409
	(0.05259)	(0.09072)
D(LN_PRO_)	-0.017436	0.079675
	(0.01456)	(0.02512)

Vector Error Correction Estimates
Date: 10/04/18 Time: 23:45
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LN_EXP_(-1)	1.000000
LN_PRI_(-1)	-2.360306
	(0.26195)
	[-9.01061]
LN_PRO_(-1)	4.704943
	(0.78874)
	[5.96512]
C	-28.65491

Error Correction:	D(LN_EXP_)	D(LN_PRI_)	D(LN_PRO_)
CointEq1	-0.235710	0.035320	-0.041155

	(0.10514)	(0.03707)	(0.01071)
	[-2.24179]	[0.95282]	[-3.84427]
D(LN_EXP_(-1))	-0.027136	0.016745	0.008678
	(0.14700)	(0.05183)	(0.01497)
	[-0.18459]	[0.32309]	[0.57977]
D(LN_PRI_(-1))	-0.353985	0.281143	-0.147190
	(0.55001)	(0.19391)	(0.05600)
	[-0.64360]	[1.44989]	[-2.62837]
D(LN_PRO_(-1))	-0.859685	0.250550	0.054507
	(1.25721)	(0.44323)	(0.12801)
	[-0.68381]	[0.56528]	[0.42582]
C	0.209580	0.106403	0.076764
	(0.17296)	(0.06098)	(0.01761)
	[1.21176]	[1.74500]	[4.35911]
R-squared	0.128800	0.058803	0.268353
Adj. R-squared	0.049600	-0.026761	0.201840
Sum sq. resids	40.01014	4.972989	0.414776
S.E. equation	0.953583	0.336188	0.097091
F-statistic	1.626261	0.687243	4.034573
Log likelihood	-64.56215	-13.47691	47.38200
Akaike AIC	2.839271	0.754159	-1.729878
Schwarz SC	3.032314	0.947202	-1.536835
Mean dependent	0.109258	0.160372	0.060837
S.D. dependent	0.978150	0.331778	0.108676

Determinant resid covariance (dof adj.)	0.000914
Determinant resid covariance	0.000662
Log likelihood	-29.22158
Akaike information criterion	1.927412
Schwarz criterion	2.622366

Dependent Variable: A
Method: Least Squares
Date: 11/12/18 Time: 23:01
Sample: 1966 2016
Included observations: 51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.889745	1.705641	-4.039388	0.0002
B	1.259191	0.334432	3.765158	0.0005
D01	-1.934087	0.662498	-2.919387	0.0054
E	23.08566	4.882708	4.728043	0.0000
F	22.85266	4.673942	4.889376	0.0000

R-squared	0.664002	Mean dependent var	3.521529
Adjusted R-squared	0.634784	S.D. dependent var	1.598537
S.E. of regression	0.966045	Akaike info criterion	2.861681
Sum squared resid	42.92915	Schwarz criterion	3.051076
Log likelihood	-67.97286	Hannan-Quinn criter.	2.934054
F-statistic	22.72636	Durbin-Watson stat	1.665485

Prob(F-statistic)	0.000000

Dependent Variable: D(LN_EXP_)
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 10/04/18 Time: 23:40
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments
D(LN_EXP_) = C(1)*(LN_EXP_(-1) - 2.36030642655*LN_PRI_(-1) + 4.70494345099*LN_PRO_(-1) - 28.6549055126) + C(2)*D(LN_EXP_(-1)) + C(3)*D(LN_PRI_(-1)) + C(4)*D(LN_PRO_(-1)) + C(5)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.235710	0.105144	-2.241792	0.0301
C(2)	-0.027136	0.147005	-0.184594	0.8544
C(3)	-0.353985	0.550007	-0.643601	0.5232
C(4)	-0.859685	1.257208	-0.683805	0.4977
C(5)	0.209580	0.172956	1.211757	0.2321

R-squared	0.128800	Mean dependent var	0.109258
Adjusted R-squared	0.049600	S.D. dependent var	0.978150
S.E. of regression	0.953583	Akaike info criterion	2.839271
Sum squared resid	40.01014	Schwarz criterion	3.032314
Log likelihood	-64.56215	Hannan-Quinn criter.	2.912511
F-statistic	1.626261	Durbin-Watson stat	2.031028
Prob(F-statistic)	0.184587		

Wald Test:

Test Statistic	Value	df	Probability
t-statistic	-0.643601	44	0.5232
F-statistic	0.414223	(1, 44)	0.5232
Chi-square	0.414223	1	0.5198

Null Hypothesis: C(3)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-0.353985	0.550007

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.683805	44	0.4977
F-statistic	0.467589	(1, 44)	0.4977
Chi-square	0.467589	1	0.4941

Null Hypothesis: C(4)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.859685	1.257208

Restrictions are linear in coefficients.

Pairwise Granger Causality Tests
Date: 10/04/18 Time: 23:57
Sample: 1966 2016
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
LN_PRI_ does not Granger Cause LN_EXP_	50	2.95651	0.0921
LN_EXP_ does not Granger Cause LN_PRI_		1.42513	0.2386
LN_PRO_ does not Granger Cause LN_EXP_	50	0.33581	0.5650
LN_EXP_ does not Granger Cause LN_PRO_		4.03683	0.0503
D66_88 does not Granger Cause LN_EXP_	50	8.49915	0.0054
LN_EXP_ does not Granger Cause D66_88		0.00061	0.9804
D89_16 does not Granger Cause LN_EXP_	50	8.49915	0.0054
LN_EXP_ does not Granger Cause D89_16		0.00061	0.9804
LN_PRO_ does not Granger Cause LN_PRI_	50	0.13920	0.7108
LN_PRI_ does not Granger Cause LN_PRO_		8.98580	0.0043
D66_88 does not Granger Cause LN_PRI_	50	9.39339	0.0036
LN_PRI_ does not Granger Cause D66_88		0.05830	0.8103
D89_16 does not Granger Cause LN_PRI_	50	9.39339	0.0036
LN_PRI_ does not Granger Cause D89_16		0.05830	0.8103
D66_88 does not Granger Cause LN_PRO_	50	5.25022	0.0265
LN_PRO_ does not Granger Cause D66_88		0.00196	0.9649
D89_16 does not Granger Cause LN_PRO_	50	5.25022	0.0265
LN_PRO_ does not Granger Cause D89_16		0.00196	0.9649
D89_16 does not Granger Cause D66_88	50	NA	NA
D66_88 does not Granger Cause D89_16		NA	NA

regress LnEXP LnPRI LnPRO

```
      Source |       SS           df       MS           Number of obs   =     51
-------------+----------------------------------       F(2, 48)        =  82.46
       Model |  193.266012         2  96.6330059        Prob > F        = 0.0000
    Residual |  56.2498974        48  1.17187286        R-squared       = 0.7746
-------------+----------------------------------       Adj R-squared   = 0.7652
       Total |  249.515909        50  4.99031818        Root MSE        = 1.0825
```

LnEXP	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
LnPRI	1.344436	.1374803	9.78	0.000	1.068013	1.620859
LnPRO	-2.264959	.4079062	-5.55	0.000	-3.08511	-1.444809
_cons	14.40087	2.919883	4.93	0.000	8.530048	20.27168

. regress ln1y ln1x1 ln1x2

Source	SS	df	MS		
				Number of obs =	23
				F(2, 20) =	42.17
Model	9.54264119	2	4.77132059	Prob > F =	0.0000
Residual	2.26265289	20	.113132644	R-squared =	0.8083
				Adj R-squared =	0.7892
Total	11.8052941	22	.536604276	Root MSE =	.33635

ln1y	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
ln1x1	2.038638	.3906603	5.22	0.000	1.223735	2.853541
ln1x2	-.3725514	1.202906	-0.31	0.760	-2.88177	2.136667
_cons	-9.149255	9.069897	-1.01	0.325	-28.06873	9.770218

. regress ln2y ln2x1 ln2x2

Source	SS	df	MS		
				Number of obs =	28
				F(2, 25) =	8.40
Model	32.2792298	2	16.1396149	Prob > F =	0.0016
Residual	48.0289714	25	1.92115886	R-squared =	0.4019
				Adj R-squared =	0.3541
Total	80.3082013	27	2.97437782	Root MSE =	1.3861

ln2y	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
ln2x1	1.719999	.4208509	4.09	0.000	.8532405	2.586758
ln2x2	-2.838604	.7732761	-3.67	0.001	-4.431196	-1.246012
_cons	15.7394	3.948436	3.99	0.001	7.607448	23.87136

.Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	2.473224	Prob. F(2,48)	0.0950
Obs*R-squared	4.764603	Prob. Chi-Square(2)	0.0923
Scaled explained SS	7.471401	Prob. Chi-Square(2)	0.0239

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 10/08/18 Time: 22:48
Sample: 1966 2016
Included observations: 51

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.747019	5.493827	0.864064	0.3919
LN_PRI_	0.459841	0.258672	1.777698	0.0818
LN_PRO_	-0.829794	0.767485	-1.081187	0.2850

R-squared	0.093424	Mean dependent var	1.102939
Adjusted R-squared	0.055650	S.D. dependent var	2.095961
S.E. of regression	2.036807	Akaike info criterion	4.317666
Sum squared resid	199.1319	Schwarz criterion	4.431303
Log likelihood	-107.1005	Hannan-Quinn criter.	4.361090
F-statistic	2.473224	Durbin-Watson stat	1.784724
Prob(F-statistic)	0.094996		

Chow Forecast Test
Equation: UNTITLED
Specification: LN_EXP_ C LN_PRI_ LN_PRO_
Test predictions for observations from 1988 to 2016

	Value	df	Probability
F-statistic	18.58028	(29, 19)	0.0000
Likelihood ratio	172.3602	29	0.0000

F-test summary:

	Sum of Sq.	df	Mean

			Squares
Test SSR	54.33399	29	1.873586
Restricted SSR	56.24990	48	1.171873
Unrestricted SSR	1.915909	19	0.100837

LR test summary:

	Value	df
Restricted LogL	-74.86432	48
Unrestricted LogL	11.31578	19

Unrestricted log likelihood adjusts test equation results to account for observations in forecast sample

Unrestricted Test Equation:
Dependent Variable: LN_EXP_
Method: Least Squares
Date: 10/08/18 Time: 22:50
Sample: 1966 1987
Included observations: 22

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.643279	8.668848	-0.766339	0.4529
LN_PRI_	2.223531	0.382061	5.819832	0.0000
LN_PRO_	-0.784504	1.157185	-0.677942	0.5060

R-squared	0.837691	Mean dependent var	3.460093
Adjusted R-squared	0.820606	S.D. dependent var	0.749733
S.E. of regression	0.317549	Akaike info criterion	0.669754
Sum squared resid	1.915909	Schwarz criterion	0.818533
Log likelihood	-4.367297	Hannan-Quinn criter.	0.704802
F-statistic	49.03043	Durbin-Watson stat	1.348772
Prob(F-statistic)	0.000000		

Chow Breakpoint Test: 1988
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1966 2016

F-statistic	1.740236	Prob. F(3,45)	0.1723
Log likelihood ratio	5.598013	Prob. Chi-Square(3)	0.1329
Wald Statistic	5.220708	Prob. Chi-Square(3)	0.1563