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Some Recent Empirical Developments regarding the Bio-industry: using the Granger-causality Test with Indonesia's palm oil data

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Abstract

Currently, aging population has been increased dramatically with development in medical technologies and dining experiences. And, incurable diseases can be healed more easily than before with this development. Many scientists strive to find ways regarding how to extend life. In this situation, the bio-industry has been to the fore to get solutions for prolongs human life at the moment of the economic crisis. Many developed countries attempt to kick-start the bio-industry and their attempts are also to promote their economy through the bio-investments. Additionally, energy crisis has emerged as an overriding concern in consequence of the diminishing fossil fuels. Many countries in the world try to find alternative energy sources to replace fossil fuels. Examples of alternative energy sources are clean energies such as solar power, wind power, and bio-energy. In the field of the bio-industry, palm oil is a very beneficial source that can be applied to many purposes: medical applications, new energy sources, and food applications. Official data shows that the bio-industry in the US is superior to the bio-industry in the EU. And, the European countries try to catch up the US which is a leading country over the world in the field of the bio-industry. This paper studies how bio-industry affects macroeconomic factors empirically. In other words, this paper studies recent empirical developments regarding the bio-industry using the Granger-causality test with Indonesia's palm oil data. This paper finds that GDP has a unidirectional causality and a reciprocal causality with macroeconomic factors. However, GDP has no causality with 'beginning stock' of palm oil. 'Ending stock' of palm oil has a unidirectional causality and a reciprocal causality with macroeconomic factors. Overall, our empirical test results show that economic growth affects development in the bio-industry. And, the most noteworthy feature of the bio-industry nowadays is that M&A has been spread over the world to acquire the most recent bio-technology economically.

Keywords: *Bio-industry, Bio-technology, the Granger-causality test, Macroeconomic factors, GDP, Palm oil, Indonesia*

1. Introduction

Development in medical technologies and organic foods makes aging phenomenon to be increased substantially. Technological improvements in medical devices help enhance possibility in detecting inextirpable disease easier than before. Many research scientists devote themselves to find solutions concerning how to extend human life. In this situation, the bio-industry has started to receive attention as a new industry to get solutions for prolongs human life and to overcome current economic crisis. Developed countries make an effort to improve the bio-industry by discovering new technologies and establishing new policies of

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government. Additionally, energy crisis has become a major global concern as fossil fuels are being diminished. Continually, many countries, all over the world, try to find alternative energy sources to overcome current energy crisis. These alternative energies are desired to be substantially suitable, renewable, and environmentally friendly ones. In the world of change, the bio-industry has become the most suitable solution for the energy shortage problem and the aging phenomenon. In the domain of the bio-industry, palm oil is a very beneficial source that can be applied to many purposes such as medical applications, new sources for energy, and food applications.

Empirically, this paper investigates how bio-industry affects macroeconomic factors and *vice versa*. This paper studies the relationship between bio-industry and macroeconomic variables by using the Granger-causality test with Indonesia's palm oil data from 1964 to 2005. This paper defines the bio-industry and explains why the bio-industry is important. This paper analyzes trends of the bio-industry and explains each country's policy to promote the bio-industry. And, this paper tests whether the bio-industry in Indonesia affects macroeconomic factors. To conduct the empirical test, this paper uses Indonesia's palm oil data from the World Bank, the UN database, the OECD, and the PWT 7.1.

Composition of this paper is like followings: Chapter 2 explains definition of the bio-industry and the range of this research. Chapter 3 studies current condition and trend of the bio-industry. Chapter 4 researches on the empirical tests. Chapter 5 explains about empirical test results. Chapter 6 concludes this paper with concluding remarks.

2. Definition of the Bio-industry and Range of this Research

2.1. Definition of the Bio-industry

The term "Bio" comes from the Greek word "Bios" which means "living things." Bio products refer to product family as a source of living things. The bio-industry stands for an industry that uses the bio-technology and the other life-science methods. The bio-technology means a technology that produces chemical products in the fields of a medical application and an eco-friendly application. The OECD defines the bio-technology as a technology that is applied to the principle of science and engineering in the process of material by using the mediums of biology to produce goods and services. Oliver's (2000) research investigates that the twenty-century is an era of physics and chemistry and the twenty-one century is an era of biology. Therefore, the bio-industry has taken a center stage here and now.

2.2. Previous Researches on the Bio-industry and Range of this Research

Research on the bio-industry has come a long way for many years domestically and internationally. Recently, speed of development in the bio-industry has become very fast. The acceleration of development in the bio-industry is derived from the synergy effect among industry, university, and research institute especially for the UK. Prevezer's research (2001) investigates that the US has gone on smoothly in financing toward the bio-industry when it compares to the EU. And, Prevezer (2001) studies that system of discovering new business is easier in the US than in the EU. And condition of the venture capital (VC) and stock market is better in the US than in the EU. Cooke (2001) studies that bio-industry in the UK gets left behind the bio-industry in the US. Cooke (2001) points out that the UK falls short of huge pharmaceutical firm's partnership when it compares to the EU. And, the UK's commercialization with the bio-enterprises is inferior to the US. Therefore, Cooke (2001) suggests that the bio cluster is the best solution to overcome a stagnant growth in the field of the bio-industry. Cooke (2001) insists that the bio cluster is especially important like

followings: the formation of a basic science, the foundation in the venture capital (VC), and the creation in social capital. With the rapid technological development in the bio-industry, industrial development of the bio-industry in the developed countries such as the US, the EU, and Japan has been accelerated. With broad range in the field of the bio-industry, this paper concentrates on current status and trend regarding the bio-industry using methodology of choice and concentration. And, this paper investigates empirically the relationship between the bio-industry and macroeconomic factors using Indonesia's palm oil data from 1964 to 2005. This paper uses the Granger-causality test's methodology. And, data for these empirical tests comes from the World Bank, the UN database, the OECD database, and the PWT 7.1 database.

3. Current Condition and Trend of the Bio-industry

3.1. Current Condition of the Bio-industry

Bio-industry has some characteristics that are different from the other industries like followings: the bio-industry is a knowledge-based industry based on the high-technology with potential and rapid growth; the bio-industry creates a lot of value-added; the bio-industry is an industry that is connected with various industries such as the IT and the ET; the bio-industry is a core industry that can solve many problems such as health problems, environmental problems, and energy problems; the bio-industry has issues of ethics and security; the bio-industry has high risk and high return. Regarding the bio-industry, total sales of the US consist of 76% of the world's sales amounts. And, employment of the bio-industry in the US is consists of 75% of the world's employment in the bio-industry. European countries try to catch up the US which is a leading country in the world in the field of the bio-industry. The US consists of 16% of the world's sales in the bio-industry. And, the US consists of 14% of the world's employment in the bio-industry. Total number of firms in the EU consists of 38.4% of the world's number of firm regarding the bio-industry. And total number of firms in the US in the field of the bio-industry consists of 33.7% of the world's number of firms regarding the bio-industry. Table 1 shows comparison of the US and the EU regarding revenue, R&D expense, net income, and number of employees in the field of the bio-technology. Table 1 shows that the US is superior than the EU in all the categories. Unit of the US is the US billion dollars and the unit of the EU is the US million dollars.

Table 1. Bio-technology of the US and the EU

	The US(US$b)		The EU(US$m)	
	2011	**2010**	**2011**	**2010**
Revenue	58.8	61.1	15,522	13,042
R&D Expense	17.2	17.2	2,641	2,100
Net Income	3.3	5.2	2,024	1,429
Number of Employees	98,560	113,010	33,570	30,970

Notes: We use the public company data for the US. We use data of the commercial leaders for the EU. Data: Ernst & Young and company financial statement, Ernst & Young (2012)

By the way, there are many obstacles to enter the market of the bio-industry in the case of South Korea. Here, obstacles are like followings: a severe completion over the world, a support of government, and procures of resources.

3.2. Trend of the Bio-industry

Nowadays, trend of the mergers and acquisitions (M&A) has been spread over the world in the case of the bio-industry. This phenomenon is happened especially in the field of the bio-pharmaceuticals. M&A in the bio-industry is intended to reorganize pattern of competition in the bio-industry. To put it concretely, firms which indulge in the bio-industry would like to expand their magnitude and area of business with the method of M&A. And, firms which are related to the bio-industry also seek to occupy the primary stage of technology through the corporate venture capital (VC) aside from M&A. Bio-firms use a method of M&A to acquire new products easily from the other company that has a core technology in the bio-industry. Here, new product means 'patented commercial articles.' Recently, many bio-firms prefer M&A rather than initial public offering (IPO) to acquire a new technology and a new business. In these circumstances, price of takeover in the bio-firms has been hiked recently. Therefore, many bio-firms highly regard strategic preoccupancy of technology as a matter of the highest priority in their business.

3.3. Policies to Promote the Bio-industry

Developed countries have accepted the bio-industry as a strategic business in the country level. And, developed countries promote the bio-industry as a government wide business. Each country concentrates on its commercialization of the technology. On the other hand, safety and ethicality have come to the fore caused by development in the bio-industry internationally. With this, countries over the world have accepted 'the Bio Safety Protocol' in January, 2000 at Montreal, Canada. With 'the Bio Safety Protocol,' the world can control movement of the bio-industry and establish guideline for bioethics internationally.

Government of the US fosters the bio-industry by the national Institute of health (NIH). Characteristics of the US' policy regarding the bio-industry are like followings: government of the US supports strongly for basic research regarding the bio-industry; the bio-industry is a knowledge based science; the bio-industry uses huge amount of the venture capital (VC); the US has an active academic-industrial connection; the US has a lot of high quality human resources. In these circumstances, the US leads the bio-industry over the world. Network activities in the US affect operating revenue of the bio-enterprise in the US. Here, examples of the network activities are joint researches, alliances on the production, marketing and selling, and M&A and financing. And, in the US, there is a positive relationship between bio-firms and pharmaceutical firms. And, there exists negative relationship between public research institutes and universities in the field of the bio-industry. Therefore, networking activities play an important role between bio-enterprises and pharmaceutical companies.

The EU pushes ahead the joint development projects to develop the bio-industry through the EUREKA and the European federation of bio-technology (EFB). One of the characteristics of the European bio-industry is the cluster policy to promote the bio-technology. The UK and Germany are the main countries in the world that use the cluster policy to enhance the bio-industry. Concrete examples of the bio-clusters that are undertaken in the EU are like followings: Oxford, Cambridge, Stockholm, and the bio-regions in Germany such as Munich, Rhine, Neckar, and Rhineland. European countries try to catch up the bio-industry of the US which is a leading country in the field of the bio-industry.

Development in the bio-industry in the EU is far behind development of the bio-industry in the US. This is supported by using data of earnings, R&D investment, and employment regarding the bio-industry for the EU and the US.

Japan supports the bio-industry to acquire advanced technologies through the government-led projects. Core strategic projects for Japanese bio-industry are derived from 'the Handbook of BT strategy' in 2002. Japan uses 'the Strategy of Catch Up' to keep up developed countries in the field of the bio-industry. Here, developed countries regarding the bio-industry are the US and the EU.

South Korea also insists that the bio-technology is needed for the future humanity through a policy of development regarding the bio-industry. South Korea enhances early stage of development in the bio-technology like followings: a plant molecular farming and a technology for bio-fuel with seaweed. South Korea conducts the R&D support with many government-led projects.

Indonesia has huge amounts of alternative energy resources that are desired to be sustainable, renewable, and environmentally friendly ones. And, government of Indonesia keeps in mind that the bio-energy is the best solution to overcome current and future energy crisis in the world. 'The National Energy Policy (No. 5)' in 2006 and 'the National Energy Mix 2025 (vision 2025)' in Indonesia have a plan to increase the usage of the bio-energy 5% and 8.9% respectively. Areas of the bio-energy that government of Indonesia pushes ahead are biofuels (such as bioethanol and biodiesel), biogas, biomass, hydrogen energy, fuel cell, and the improvement of a gas heater. Here, project for improvement of a gas heater means that government of Indonesia changes heating system from oil stove to gas stove or the HIVOS in association with the World Bank from 2012 to 2014. Government of Indonesia conducts the joint project of biogas for household (BIRU: Biogas Rumah) with the Netherlands. Indonesia has huge amounts of the bio-energy. And Indonesia has a great availability of land and a suitable climate for agriculture to get palm oil. Silitonga et al. (2011) studies that bio-fuel from vegetable oil is the most common type of the bio-fuels. They investigate that the bio-fuels from vegetable oil do not contain a fossil-based diesel. The most available feedstocks for biodiesel production are palm-oil and Jatropha curcas. From palm oil, we get the crude palm oil (CPO). From Jatropha curcas, we get the crude jatropha curcas oil (CJCO). Palm oil is a vegetable oil which is derived from the fruit of palm tree. Palm oil is used for both food and non-food consumption. Palm oil is the second consuming agricultural product in Indonesia after rice paddy. And, palm-oil is the largest agricultural export item in Indonesia. Production of palm oil is consists of more than 45 million tons globally. And, palm oil is produced in Indonesia and Malaysia around 80% of the world's production. Ebong et al. (1998) studies that fresh palm oil has rich source of the vitamin A, the vitamin E, and the beta-carotene that is good for human beings. Therefore, importance of palm oil as energy and food has been concentrated on nowadays.

Table 2. Indonesia's Plan for Development of Plantation (2007 – 2010 (in Ha))

	2007	2008	2009	2010	Total
Palm Oil	473,265	473,265	473,265	473,265	1,893,060
Jatropha Curcas	341,000	345,000	360,000	370,000	1,461,000

Note: 'Ha' means hectare(s). Data: Wirawan and Tambunan (2010).

4. Empirical Tests

Recently, the bio-energy consumption has changed from a direct consumption to an indirect modern consumption by shifting from the fossil fuels to renewable, abundant, and environmentally friendly energy sources. Here, a direct consumption means a process of combustion like cooking, space heating, and industrial process. An indirect modern consumption means more advanced processes of converting biomass into secondary energy. Currently, biofuels are widely used for biomass energy. The bioethanol and the biodiesel are common types of biofuels. 50% of the world's bioethanol is produced and used in the US and Brazil. And the European countries produce and use 15% of the world's production and usage of the bioethanol.

4.1. Previous Researches regarding Empirical Test of the Bio-industry

Per Bildirici's (2012) research, production of biomass which is a labor intensive product affects consumption and economic growth. Bildirici's (2012) research uses data of Argentina, Bolivia, Cuba, Costa Rica, El Salvador, Jamaica, Nicaragua, Panama, Paraguay, and Peru to do the research from 1980 to 2009. Liu (2008) investigates that there is a unidirectional Granger-causality in the bioethanol production and usage of bioethanol. Liu (2008) uses the US, Brazil, and the EU to conduct the Granger-causality test. Liu (2008) finds that the US is the most influential market in the world in the area of the bio-industry. Changes in the price of bioethanol in the US affect prices for the global ethanol market. Liu (2008) finds out that the EU produces more biodiesel than ethanol for seven years. Hadi *et al.'s* (2011) research studies that the relationship between price of the crude palm oil (CPO) and price of the crude oil using the Co-integration test. They find that there exists positive relationship between price of the CPO and price of the crude oil. These empirical results show that increase in price of the crude palm oil (CPO) affects increase in price of the crude oil.

Although production of palm oil for the biodiesel has been increased so far, most of the usage of palm oil is for food. Major vegetable oils over the world are palm oil and soybean oil. Alias and Othman (1998) conduct the Co-integration test to investigate the relation between the price of palm oil and the price of soybean oil. Alias and Othman's (1998) research points out that fluctuation in the palm oil's international price affects individual country's price of palm oil in Indonesia. In Indonesia, palm oil is used almost every household to use it as a frying oil. Harjanti (2012) studies that international price of the crude palm oil (CPO) affects export of the CPO in Indonesia. This makes increase producer's profit of palm oil in Indonesia. When exports of palm oil are increased in Indonesia, domestic supplies of palm oil are reduced in Indonesia. This affects the price of palm oil to be increased in Indonesia. By increasing the price of palm oil, inflation also becomes a crucial problem in Indonesia.

4.2. The Granger-causality Test

Granger's (1969) research uses methods of the econometrics to prove causality relation between the variables. Granger (1969) shows that results of one phenomenon cannot be preceded of a cause. We estimate certain variables by using the mean squared error (MSE). And, we estimate a time series data X under the information set I. When we add variable Y in the form of time series to the information set I and if there is no change in the estimation of X, we say that Y does not Granger-cause X. Actually, this is proven by Hamilton in 1994. To explain the Granger-causality test, let's assume that there are two variables, X and Y. Then, we set up two equations like following equation (1) and equation (2).

$$Y_t = a_0 + a_1 Y_{t-1} + a_2 Y_{t-2} + \cdots + a_m Y_{t-m} + U_t \quad (1)$$

$$Y_t = a_0 + a_1Y_{t-1} + a_2Y_{t-2} + \cdots + a_mY_{t-m} + b_1X_{t-1} + b_2X_{t-2} + b_3X_{t-3} + \cdots b_qX_{t-q} + U_t \quad (2)$$

We know that there is a possibility that U_1 and U_2 from U_t have a correlation between them. But, we assume that there is no correlation between U_1 and U_2 when we conduct the Granger-causality test. And, equation (1) and equation (2) are constructed as a linear combination. The Granger-causality test of the VAR model and the VECM model conduct the normality test. And, if error terms follow the normal distribution, we need to conduct the Wald test. If error terms do not follow the normal distribution, we need to conduct the Likelihood ratio test.

4.3. Data Descriptions

We use the following data of palm oil in Indonesia for this paper: 'beginning stock,' 'production,' 'total supply,' 'food use domestic consumption,' 'exports,' 'total distribution,' 'ending stock,' and 'total domestic consumption.' Additionally, we use data of GDP for Indonesia. We use above data from 1964 to 2005. For this empirical analysis, we use *the Eviews 7.0* program. We use the listed data from the World Bank, the UN database, the OECD database, and the PWT 7.1 database. Table 3 shows data descriptions that this paper uses. Here, skewedness measures a degree that a probability distribution of random variable leans to one side of the mean. Kurtosis measures the state of peak of the probability distribution of random variables. Test of the Jarque-bera measures a goodness of fit. And, the Jarque-bera test identifies whether sample data have the skewedness and the kurtosis making a normal distribution.

Table 3. Data Descriptions

	GDP	Dist.	Ending Stock	Dom. Cons.	Food use Dom. Cons.	Exports	Total Supply	Prod.	Beg. Stock
Mean	4.33E+14	3315.2	152.0	1322	1209.9	1841.1	3315.2	3134	133.5
Median	9.34E+13	1315.5	35	682	625.5	644.5	1315.5	1232.5	29.5
Max.	2.77E+15	15755	800	4455	3875	10500	15755	15000	750
Min.	7.53E+09	183	10	6	6	126	183	157	10
Std. Dev.	7.10E+14	4140.5	224.2	1405.6	1259.6	2618.7	4140.5	3957.9	200.2
Skewedness	1.8	1.5	1.7	0.7	0.6	2.0	1.5	1.5	1.9
Kurtosis	5.50	4.5	4.8	2.1	2.0	6.1	4.5	4.5	5.5
Jarque-Bera	35.9	21.3	27.9	5.2	5.0	45.2	21.3	21.6	37.2
Prob.	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0
Obs.	42	42	42	42	42	42	42	42	42

Notes: 'Max.' means maximum. 'Min.' stands for 'Minimum.' 'Std. Dev.' means standard deviation. 'Prob.' means probability. 'Obs.' means number of observation. 'Dist.' means distribution. 'Dom. Cons.' Means domestic consumption. 'Food use Dom. Cons.' means Food Use and Domestic Consumption. 'Prod.' means production. 'Beg. Stock' means Beginning Stock.

To avoid the heteroskedasticity, all of the data are changed to the natural logarithmic form. It is important to notify that the data for 'total supply' of palm oil in Indonesia and 'total distribution' of palm oil in Indonesia share similar value. Therefore, there might be problem between 'total supply' of palm oil in Indonesia and 'total distribution' of palm oil in Indonesia.

5. Test Results

Table 4 shows empirical test results of the 'the Unit root' test with level data. 'The unit root' test measures whether a time series variable is a non-stationary or not. This test uses an

autoregressive model. To conduct the Unit root test, we use the augmented Dickey-Fuller (ADF) test.

Table 4. Results of the Unit Root Tests (Level)

Variables	ADF	
	Constant No Trend	Constant Trend
Data Period: 1964-2005		
GDP	-3.00*	-8.76*
Total Distribution	1.06	-4.07*
Ending Stock	-0.69	-4.85*
Total Domestic Consumption	-1.81	-1.32
Food Use Domestic Consumption	-1.85	-1.33
Exports	1.04	-1.72
Total Supply	1.06	-4.07*
Production	0.85	-4.64*
Beginning Stock	-0.70	-4.76*

Notes: Table 4 shows a panel with level. The null hypothesis is that the series is a non-stationary. Or, it contains a unit root. Here, '*' indicates a rejection of the null hypothesis with the non-stationarity at 5% significance level.

Table 5 shows test results of the unit root test with the first differences.

Table 5. Results of the Unit Root Tests (The First Difference)

Variables	ADF	
	Constant No Trend	Constant Trend
Data Period: 1964-2005		
GDP	-13.45*	-11.51*
Total Distribution	-6.62*	-6.85*
Ending Stock	-10.02*	-10.38*
Total Domestic Consumption	-13.97*	-14.23*
Food Use Domestic Consumption	-13.90*	-14.18*
Exports	-7.23*	-7.67*
Total Supply	-6.62*	-6.85*
Production	-5.60*	-5.59*
Beginning Stock	-10.03*	-10.40*

Notes: Table 5 shows a panel with the first difference. The null hypothesis is that the series is a non-stationary. Or, it contains a unit root. Here, '*' indicates a rejection of the null hypothesis with the non-stationary at 5% significance level.

Table 5 shows that the series in the form of the first difference are easily rejected by the null hypothesis in testing the non-stationary. It means that all series are stationary in their first difference. Therefore, we accept that the series are integrated with the order one. And, higher order of differences is not required.

Table 6 shows results of the Granger-causality test.

Table 6. Results of the Granger-causality Test

Dependent Variable	Independent Variable								
	GDP	**Total Distribution**	**Ending Stock**	**Total Domestic Consumption**	**Food Use Domestic Consumption**	**Exports**	**Total Supply**	**Production**	**Beginning Stock**
GDP	-	9.51 (0.00)*	0.05 (0.00)*	2.78 (0.10)**	2.85 (0.1)**	2.20 (0.14)**	9.51 (0.00)*	6.36 (0.02)*	0.21 (0.64)
Total Distribution	0.06 (0.80)	-	0.92 (0.34)	0.92 (0.34)	0.92 (0.34)	1.34 (0.25)	NA (NA)	0.68 (0.41)	0.09 (0.75)
Ending Stock	0.09 (0.76)	0.35 (0.55)	-	0.24 (0.62)	0.24 (0.62)	2.92 (0.09)**	0.35 (0.55)	0.28 (0.59)	32095.1 (6E-56)*
Total Domestic Consumption	17.73 (0.00)*	0.14 (0.70)	0.09 (0.75)	-	0.00 (0.94)	0.18 (0.66)	0.14 (0.70)	0.48 (0.49)	0.99 (0.32)
Food Use Domestic Consumption	17.72 (0.00)*	0.15 (0.69)	0.07 (0.77)	0.00 (0.97)	-	0.23 (0.63)	0.15 (0.69)	0.48 (0.49)	1.05 (0.31)
Exports	0.64 (0.42)	0.22 (0.64)	0.96 (0.33)	1.54 (0.22)	1.64 (0.20)	-	0.22 (0.64)	2.30E-06 (0.99)	8.51 (0.00)*
Total Supply	0.06 (0.80)	NA (NA)	0.92 (0.34)	0.92 (0.34)	0.92 (0.34)	1.34 (0.25)	-	0.68 (0.41)	0.09 (0.75)
Production	0.19 (0.65)	0.00 (0.93)	0.13 (0.71)	0.13 (0.71)	0.14 (0.70)	0.97 (0.32)	0.00 (0.93)	-	0.15 (0.69)
Beginning Stock	0.00 (0.96)	0.06 (0.79)	17.65 (0.00)*	1.80 (0.18)**	1.88 (0.17)**	2.77 (0.10)**	0.06 (0.79)	0.00 (0.95)	-

Notes: This is the result of the Granger-causality test with the first differences. The null hypothesis is that the series is non-stationary. Or, it contains a unit root. Here, '*' and '**' indicate the rejection of the null hypothesis with the non-stationary at 5% and 10% significance level, respectively. 'NA' means that both 'total supply' of palm oil and 'total distribution' of palm oil share similar values within their series.

In summary, Table 6 shows a direction of the Granger-causality test for the series. It shows that GDP in Indonesia has a unidirectional causality with 'total distribution' of palm oil, 'ending stock' of palm oil, 'exports' of palm oil, 'total supply' of palm oil, and 'production' of palm oil, respectively. And, GDP in Indonesia has a reciprocal causality with 'total domestic consumption' and 'food use domestic consumption' of palm oil. GDP in Indonesia has no causality with 'beginning stock' of palm oil. 'Ending stock' of palm oil has a unidirectional causality to 'exports.' And, 'ending stock' of palm oil has a reciprocal causality with 'beginning stock' of palm oil. 'Exports' of palm oil in Indonesia have a reciprocal causality with 'beginning stock' of palm oil. Finally, 'beginning stock' of palm oil has a unidirectional Granger-cause to 'total domestic consumption' and 'food use domestic consumption' of palm oil. Figure 1 shows a diagram of the results regarding the Granger-causality test. In Figure 1, 'FUDC' means 'Food Use Domestic Consumption' of palm oil. 'TDC' means 'Total Domestic Consumption' of palm oil. 'GDP' stands for 'Gross Domestic Product.' 'TD' means 'Total Distribution' of palm oil. 'ES' means 'Ending Stock' of palm oil. 'EX' refers to 'Exports' of palm oil. 'TSU' means 'Total Supply' of palm oil. 'PR' means 'Production' of palm oil. 'BS' means 'Beginning Stock' of palm oil.

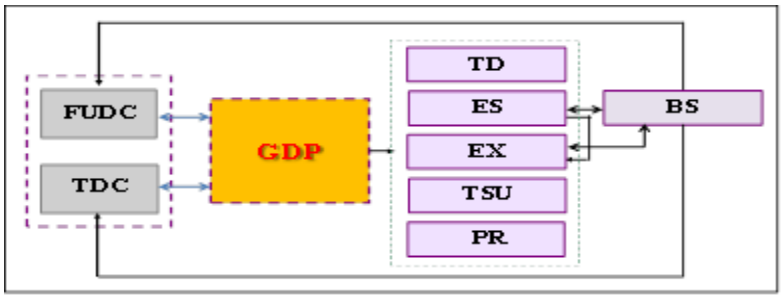

Figure 1. Diagram of Summary of the Granger-causality Test

6. Concluding Remarks

Currently, aging phenomenon has been increased with development in medical technologies and healthier foods. Development in medical science is able to detect inextirpable disease easily. Many scientists endeavor to find ways to extend human life. Under these circumstances, the bio-industry has begun to come into the spot light as a new industry to get solutions for extending human life and to overcome current economic crisis. Developed countries try to improve the bio-industry and get solutions for these issues. Energy crunch also has brought a world's attention as traditional fuels are being dwindled steadily. Many countries of the world try to search for alternative energy sources to get over current energy crisis. These alternative energy resources are desired to be sustainable, renewable, and environmentally friendly ones. With these changing circumstances, the bio-industry has become the most suitable solution for the energy shortage problem and an aging society. In the line of the bio-industry, palm oil is a very beneficial source that can be applied to many purposes: medical applications, new energy sources, and food applications.

Indonesia has many alternative energy resources and government of Indonesia especially keeps in mind that bio-energy is the best solution for the energy crisis. 'The National Energy Policy (No. 5)' in 2006 and 'the National Energy Mix 2025 (vision 2025)' in Indonesia make increase the usage of the bio-energy 5% and 8.9% respectively. Areas of the bio-energy that government of Indonesia pushes ahead are biofuels (such as bioethanol and biodiesel), biogas, biomass, hydrogen energy, fuel cell, and improvement of a gas heater. Here, a project for improvement of a gas heater means that government of Indonesia is changing from oil stove to gas stove or the HIVOS in company with the World Bank from 2012 to 2014. Government of Indonesia conducts the joint project of biogas for households with the Netherlands. Indonesia has huge amounts of the bio-energy. And, Indonesia has a great availability of land and a suitable climate for agriculture to get palm oil.

This paper investigates how bio-industry affects macroeconomic factors. To put it concretely, this paper investigates the relationship between the bio-industry and macroeconomic factors by using the Granger-causality test. This paper uses data of Indonesia's palm oil from 1964 to 2005. We use 'beginning stock,' 'production,' 'total supply,' 'food use domestic consumption,' 'exports,' 'total distribution,' 'ending stock,' 'total domestic consumption' of palm oil, and GDP for Indonesia. To conduct this empirical analysis, we use *the Eviews 7.0* program. And, we use data from the World Bank, the UN database, the OECD database, and the PWT 7.1 database.

With the Granger-causality test, this paper finds that GDP has a unidirectional causality with the following factors: 'distribution,' 'exports,' 'stocks,' 'supply,' and 'production' of palm oil. And, GDP has a reciprocal causality with 'total domestic consumption' and 'food use domestic consumption' in palm oil. However, GDP has no causality with 'beginning stock' of palm oil. 'Ending stock' of palm oil has a unidirectional causality to the 'exports' of palm oil and a reciprocal causality with 'beginning stock' of palm oil. Overall, our test results show that economic growth affects development in the bio-industry. Furthermore, we need a converging technology and an open-innovation for the bio-industry.

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