AN EMPIRICAL ESTIMATION OF THE IMPORT DEMAND MODEL AND WELFARE EFFECTS: THE CASE OF RICE IMPORTING COUNTRIES

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An Empirical Examination of the Import Demand Model and Welfare Effects: The Case of Rice Importing Countries

This analysis presents the determination of an import demand function for the world rice market using annual data from 1994 to 2007. In the specification and analysis of a world rice market import demand function, Ordinary Least Square (OLS), Instrumental Variables (IV) with Generalized Method of Moments (GMM), and Seemingly Unrelated Regression (SUR) methods have been used. Social welfare effects have been obtained using consumer surplus and compensated variation for the top four rice importing countries (Indonesia, Philippines, Nigeria, and Saudi Arabia). Empirical results suggest that economic growth, Foreign Direct Investment (FDI), and importing countries' population positively affect national income, thus, positively affecting rice consumption. Oil price has a strong effect on the domestic rice prices in importing countries. This paper also estimates the social effects arising from increased rice export prices and examines how consumer surplus is affected in major rice importing countries.

Key Words: *rice export and import, consumer surplus, trade, import demand function*

1. Introduction

Since November 2007, international rice prices have been soaring exacerbated by the imposition of export restrains by a growing number of countries. In Figure 1, world rice price has gradually increased until 2007 when the rice price for April 2008 goes up 158% as compared to the same period in 2007. Although this phenomenon may signal a short term trend, international rice prices are expected to remain at relatively high levels due to increased fertilizer and fuel costs, especially as rice stocks held by those exporters are still allowing unrestrained sales (FAO rice market monitor, 2008). And the average variations of exporters for year to year are greater than those of importers (see Figure 2). That is, the world rice market is in an expanding situation which limits exporting countries while expanding rice consumption. For example, Thailand's rice exports have increased 10% annually while Indonesia's rice imports have increased 265% annually.

In this situation, we need to consider the rice import demand market structure in order to analyze the effects on price. Therefore, this paper presents econometric estimates of the world rice market for an import demand function using annual data from 1994 through 2007. We estimate the price and income elasticity for the world rice market and calculate the welfare effects in terms of consumer surplus for the top four rice importing countries (Indonesia, Philippines, Nigeria, and Saudi Arabia).

This paper is organized as follows: First, we review some previous literature. These papers estimated the import demand function with respect to price and income. Second, the methodology and data are discussed, which within the methodology employed, include the import demand function, Instrumental Variable (IV) and Seemingly Unrelated Regression (SUR). Third, we examine the unit root and cointegration test with respect to annual time series data. And we use the two-stage least squares (2SLS) to construct coefficient estimates for each of the endogenous variables and the SUR method in terms of simultaneous equations. Econometric results show how importing price and income affect rice import quantity in terms of the top four rice importing countries. Finally, a summary and concluding are presented along with suggestions for future study.

2. Review of Literature

An extensive literature has evolved in the past decades using economic theory to estimate the import demand function. This part outlines recent studies concerning developing countries, including econometric analyses, and structural economic analysis of import volumes and domestic price.

Houthakker and Magee (1969) analyzed demand elasticities for imports and exports in terms of income and price within the United Kingdom, Japan, and the U.S. using annual data from 1951 through 1966. They used the import and export equations including income, Gross Domestic Product (GDP), and a price index. They mentioned that the U.S. income elasticity of demand for total imports is about the same as that of other developed countries, but the income elasticity of other countries' demand for U.S. exports is relatively low and therefore, trends for the U.S. trade balance have worsened over time.

Murray and Ginman (1975) argued that imports depend upon the price of imports specified in domestic currency as well as the price of domestically produced substitutes. They estimated the relationships which constrain the influence of the two prices. They used a linearized logarithmically transformed model with respect to the import demand function. Their model especially included the import price index, domestic price index, and domestic price index with non-traded items. They mentioned that the traditional import demand model is inappropriate for estimating aggregate import demand parameters due to the aggregations of heterogeneous factors and the existence of differentiated commodity grouping.

Deyak et al. (1988 and 1993) analyzed the sensitivity of Canadian import demand in terms of changes in prices, incomes, and exchange rate from the 1970s to the 1980s. They include the exchange rate defined as foreign currency per unit of domestic currency in the import demand function. Also, they distinguished the models with respect to foreign prices, domestic prices, and exchange rates. They concluded that import demand

is relatively elastic in income and relatively inelastic in prices because Canadian import demand is not homogeneous and three types of prices tend to affect the quantity imported.

Carone (1996) introduced the new estimations of the aggregate demand for total and non-oil related merchandise imports for the U.S. over the two decades (1970−92). He extended the import demand function in terms of the quantity of non-petroleum merchandise imports. Carone discovered strong relationships between the level of imports to real income and relative prices. Also, he mentioned that income effects play a role in determining import demand with a very high elasticity while estimated price elasticities are very low. That is, strong domestic economic activity can provide the expansion impulse to the rest of industrialized countries and advance growth in developing countries.

3. Modeling and Data

Econometric estimations of an import demand model include that the demand for imports is the function of domestic price and real income (Murray and Ginman, 1975; Mayes, 1981; Deyak and Sawyer, 1988; and Carnoe, 1996). These papers suggest that in modeling the import demand function, the log-log linear model is preferable to the linear model. Therefore, the log-log import demand function is specified as follows;

$$(1) \quad \sum_{i=1}^{4} Log(IM_{it}) = a_0 + a_1 \sum_{i=1}^{4} Log(GNI_{it}) + a_2 Log(DRP_t) + \varepsilon_t$$

where IM_{it} is the import volume of rice in period t; GNI_{it} is the Gross National Income (GNI) for importing country[1] i in period t; DRP_t is domestic rice price in period t; and ε_{1t}

[1] Rice importing countries are Indonesia, Philippines, Nigeria, and Saudi Arabia with respect to top four importing volumes.

is the random error term. Coefficients a_1 and a_2 indicate the income and price elasticities of import demand, respectively. On the basis of demand theory, we can expect that $a_1 > 0$ and $a_2 < 0$.

Although this study can be estimated in terms of equation (1) by utilizing data on GNI and domestic rice prices for the top four rice importing counties, this process needs other determinants of the two explanatory variables (*GNI* and *DRP*) in terms of endogeneity problems. Therefore, we need to identify other factors associated with domestic price and GNI that are suitable for interaction with domestic consumption, oil price and substitute goods' prices.

The other variables that we need to enter into equation (1) are the effects of GDP, FDI, inflation, and population on GNI. These factors indicate the effects which can influence national income in terms of economic growth theory. Including all the variables in equation (1) yields the specified models as follows;

$$(2)\ Log(DRP_t) = b_0 + b_1 \sum_{i=1}^{4} Log(CON_{it}) + b_2 Log(OIL_t) + b_3 Log(DWP_t) + b_4 Log(DMP_t) + \varepsilon_{1t}$$

$$(3)\ \sum_{i=1}^{4} Log(GNI_{it}) = c_0 + c_1 \sum_{i=1}^{4} Log(GDP_{it}) + c_2 \sum_{i=1}^{4} Log(FDI_{it}) + c_3 \sum_{i=1}^{4} Log(IN_{it}) + c_4 \sum_{i=1}^{4} Log(POP_{it}) + \varepsilon_{2t}$$

where CON_{it} is the rice consumption for importing country *i* in period *t*, OIL_t is the annual average U.S. crude oil price in period *t*, and DWP_t and DMP_t [2]are the domestic price for wheat and maize in period *t*, respectively. And FDI_{it} is the average foreign direct investment of importing country *i* in period *t*, IN_{it} is the average inflation rate of importing country *i* in period *t*, and POP_{it} is the average population rate of importing

[2] Domestic wheat and maize price are calculated as the same method of domestic rice price. Exporting wheat price is Canadian No.1 Western Red Spring 13.5% and exporting maize price is the US No.2 yellow, fob Gulf ports.

country *i* in period *t*. Based on demand theory, we can expect the estimated coefficients' signs to be as follows; $b_1 < 0$, $b_2 > 0$, $b_3 > 0$, $b_4 > 0$, $c_1 > 0$, $c_2 > 0$, $c_3 < 0$, and $c_4 > 0$.

Data for this analysis were obtained from the USDA and the World Bank. The USDA database includes information such as importing volume and consumption. And the World Bank database contains information such as the real GDP, FDI, GNI, inflation ratio, population growth. Price databases were obtained from the International Rice Research Institute and the Bank of Indonesia. The annual data cover the top four rice importing countries from 1994 through 2007 (see Tables 1 and 2).

Given that this is annual time-series data, we need to pre-test for stationarity and the existence of a cointegration vector before we move on the specification of model. We estimate the system equation in terms of using the IV and three stage least square (TSLS) of the SUR. The IV procedure allows us to overcome endogeneity problems between GNI and domestic price. And the SUR method allows for different error variances in each equation and correlation of these errors across equations (see Greene).

4. Estimation and Results

4.1. Unit Root and Cointegration Tests

Given that this is annual time-series data, we need to pre-test for stationarity and the existence of a cointegration vector before we move on to the model specification. We estimate the system equation by OLS and Instrumental Variables (IV). The IV estimation procedure allows us to overcome endogeneity problems between national income and domestic rice price.

The unit root test is utilized in order to determine the order of integration for the variables under consideration. Another test employed for testing the order of integration is the Augmented Dikey-Fuller (ADF) test. This procedure statistics rejects the null hypothesis of non-stationary of all variables, when first difference variables are used. In Table 3, indicating variables are stationary of order 1. In Tables 4 and 5, we obtain the results of the Engle-Granger (EG)[3] test which estimate unit roots on the residuals from the regression model. The null hypothesis of this test is that the residuals are non-stationary. With respect to results of Tables 4 and 5, we conclude that the residuals are stationary which means that dependent variables and explanatory variables of each regression models are cointegrated. Also, we can call the estimated equation the static relationship function and interpret its parameter as long run parameters (Greene).

4.2. Endogeneity Problems and Empirical Results

We tested the effect of domestic price and income on total import quantity with respect to the import demand function. This analysis is covered in the framework of the top 4 rice importing counties from 1994 through 2007. Also, we constrained the model of two equations; includes the effects of consumption, oil price, domestic wheat and maize price on domestic rice price; and GDP, FDI, inflation, and population on the income.

We tested for over-identification using the *Hansen J-test*, and the test statistics show that over-identification is not a problem in the equation. And we also tested the validity of any instruments using the *Anderson* test. This test has a null hypothesis that the instruments are uncorrelated with the error term. In terms of the results, all cases can reject the null hypothesis and we conclude that at least one of the instrument variables is

[3] See Engle and Granger (1987)

not correlated with the errors. If the instrument variables are not exogenous, then the IV procedure is not consistent and we can not cast doubt as to the validity of the instrument. The *Breusch-Pagan* test indicates that this equation has heteroskedasicity (because the null hypothesis was rejected). Therefore, this equation is estimated with the IV/GMM procedure due to autocorrelation.

Table 4 shows the econometric results of OLS, IV/GMM, and SUR. In terms of the OLS results, the coefficient of GNI is positive but not statistically significant. The coefficient of domestic rice price is negative and statistically significant. However, both IV/GMM and SUR results indicate that the coefficient signs are correct and are statistically significant.

According to OLS results, we conclude that price elasticity and income elasticity of the world rice market are insensitive with −0.6346 and 0.5357, respectively, but income elasticity is not statistically significant. Also, the results of IV/GMM and SUR indicate that price elasticity is −0.9385 and −0.787, and income elasticity is 0.8799 and 0.5308 with statistically significance, respectively. In the next section, we estimate the welfare effects for using these price and income elasticities.

Table 5 shows the results of simultaneous equation in terms of equations (2) and (3). The coefficients of oil price and consumption are positive and statistically significant. But the effects of substitute goods are not statistically significant. That is, increasing consumption and oil price affect the increasing domestic rice price. And, the coefficients of GDP, FDI, and population are positive and statistically significant. These results imply that increasing economic growth, FDI, and population can advance income in rice importing countries.

4.3. Welfare Effects of Import Demand Function

In Figure 1, the world rice price was gradually increasing up until 2007 when in April 2008 rice price shot up 158 percent as compared to the same period in 2007. According to this variation, we need to consider the changes in social welfare, especially, consumer surplus because the increase of commodity price can positively or negatively affect the producer (due to a dependency on the supply elasticity) while the consumer can be negatively affected (no matter what the price elasticity is) in terms of social welfare theory.

This paper applies existing welfare estimation techniques to measure the consumer surplus and extends the work of Brynjolfsson and Smith (2003). They analyzed the empirical estimation that quantified the economic impact of increased product variety made available through electronic markets. Although Brynjolfsson and Smith (2003) divided the price factors in terms of existing and new products, this study used the only existing price factors.

Before looking at consumer surplus, we need to know the compensating variation because we cannot directly obtain the consumer surplus, and we don't know the import rice countries' utility function forms. The Compensation Variation (CV) as defined from increased quantity represents the amount of money which must be taken away from the consumer following the increase in quantity that leaves the consumer just as well off as before the change (see Just, Hueth, and Schmitz, 2004). That is, the maximum amount of money the consumer would be willing to pay rather than giving a higher quantity. The theoretical formation of CV is as follows:

(4) $CV = e(P_0, u_1) - e(P_1, u_1)$

where CV is the compensation variation, P_0 and P_1 are the vectors of pre and post prices of existing products, and u_1 is the post utility level. In terms of CV definition, equation (4) explains how much a pre-consumer would need to be compensated to be just as well off as he would be after the price change.

Equation (4) contains the expenditure function with respect to utility level. Again, it is hard to estimate the utility level in equation (4). Therefore, we need another expression of CV in terms of using the indirect utility function. To apply the indirect utility function, we specify the standard log-log linear demand function. This paper is based especially on the import demand function for estimating CV. The Hicksian demand function is specified as follows:

(5) $x(p, y) = Ap^{\alpha} y^{\delta}$

where P is the domestic rice price, y is income (also indicates the gross national income of rice importing countries), α is price elasticity, δ is income elasticity and A is the constant. Using Roy's identity, we obtain another expression of equation (5) and specify it as follows:

(6) $x(p, y) = -\dfrac{\partial v(p, y) / \partial p}{\partial v(p, y) / \partial y}$

where $v(p, y)$ is the indirect utility function. Using the partial difference of equation (5),

(7) $v(p, y) = -A\dfrac{p^{1+\alpha}}{1+\alpha} + \dfrac{y^{1-\delta}}{1-\delta}$

And the expenditure function

(8) $e(p, u) = \left[(1-\delta)(u + \dfrac{Ap^{1+\alpha}}{1+\alpha}) \right]^{1/(1-\delta)}$

Fortunately, we obtain the CV equation without utility level if we substitute equation (8) into equation (4)[4].

$$(9)\ CV = -y + \left[\frac{1-\delta}{1+\alpha} y^{-\delta}(p_0 x_0 - p_1 x_1) + y^{(1-\delta)}\right]^{1/(1-\delta)}$$

where x_0 and x_1 are pre and post-production of existing products, respectively.

To compare between CV and Consumer Surplus (CS), we need to look at the income elasticity due to the difference between Marshallian demand and Hicksian compensated demand. Figure 3 shows the effects of decreasing price with respect to utility level. If the price decrease from p_1 to p_2, the utility curve move upward from u_1 and u_2. Marshallian demand is $D(y_1)$ at initial income and Hicksian demand is $H(u_1)$ at the initial utility level. In this situation, CV and CS are the area of A+B and A+B+C, respectively. If there are no income effects, $D(y_1)$ and $H(u_1)$ are identical line, and therefore the area of C will disappear. Applying this situation to equation (9), we obtain the simple equation as follows:

$$(10)\ CV = -\frac{p_1 x_1}{1+\alpha}$$

In Table 4, the results of OLS indicate that price elasticity estimated to have a value of −0.6346 and is statistically significant while income elasticity estimated is 0.5357 but is statistically insignificant. In terms of these results, this paper calculates consumer surplus[5] using the value of $\alpha = -0.6346$ and $\delta = 0$ obtained from the OLS results. Also, we use the coefficients of the IV/GMM and SUR procedures, with $\alpha = -0.9385$ and $\delta = 0.8799$, and $\alpha = -0.787$ and $\delta = 0.5308$, respectively.

[4] See the specific procedures of Hausman (1981)
[5] The calculated CS is shown by Table 5.

This paper focuses on the percentage changes of export rice price on the percentage changes of CS. This procedure provides sensitivity analysis for export rice price's effect on consumer surplus for the four major rice importing countries. For estimation, we use the simple log-log model specified as follows:

(8) $Log(CS_t) = \alpha_0 + \alpha_1 Log(P_t)$

where CS_t is consumer surplus in period t and P_t is exporting rice price in period t. In conclusion, α_1 indicates the export price elasticity on consumer surplus. The OLS result[6] is as follows:

$$Log(CS_t) = -6.5297 - 0.527 Log(P_t)$$
(9) $$(-25.80)^{***} \quad (-2.91)^{**}$$ [7]
$$R^2 = 0.335 \quad Observations = 14 \quad \text{Engle - Granger test} = \text{-}1.0476^{*} (\text{-}2.15)$$

Equation (9) indicates that the price elasticity on CS is −0.527 and is statistically significant. That is, if export rice price increases by one percentage, importing countries' consumer surplus will decrease by 0.527%. Especially, Table 8 shows the changes of consumer surplus with respect to the variable changes of export rice price. Applying this to the recent situation where export rice price has increased approximately 150% since 2007 (see Figure1). In this case, importing countries' CS decreases by about 79% (see table 8). Although the elasticity of export price on CS is not sensitive, the reduction of CS seriously influences importing countries due to recent rice market trends.

[6] Again, I test the unit root (see Table 6). With respect to results of table 6, we conclude that the residuals are stationary which means that dependent variables and explanatory variables of each regression models are cointegrated. P_t indicates the FOB Thailand 25% price from 1994 through 2007 (Source: USDA world rice calendar 2008). t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level.

[7] The results of using the coefficients on IV/GMM and SUR are −0.8969 and −0.8697, respectively. The coefficient signs are correct but statistically insignificant.

5. Summary and Conclusions

This paper analyzes the effects of the domestic rice price and income on the import rice volumes for the top four rice importers using an import demand function. Using annual data from 1994 through 2007, we show the price elasticity and income elasticity in rice importing countries. We explain that consumption and oil price influence on the domestic rice price, and economic growth, FDI, and population contribute to the income of importing countries. Furthermore, we estimate the welfare effects on the increasing export rice price.

On the basis of results, the main findings are as follows. First, domestic rice price positively influences though not sensitive rice import volume. Also, incomes of importing countries affect the negative impacts on import volume while not sensitivity. That is, the price elasticity of demand and income elasticity are inelastic as regards import rice quantity.

Second, increasing both the rice consumption of importing countries and oil price positively affect domestic rice price. In terms of demand theory, increasing consumption can affect price which is coincident with the current situation. And oil price influences transport costs for rice which is adjusted by cost theory.

Third, increasing economic growth, FDI, and population can affect to increase the income of importing countries. This implies that economic growth and population are sources of national income in terms of economic growth theory, and FDI is the main channel through which advanced technology is transferred to rice importing countries.

Finally, although the elasticity of export price on consumer surplus is not sensitive, reductions of consumer surplus have a crucial effect on importing countries due to the recent trends of the world rice market.

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Table 1. Descriptive Data

Variables	Observations	Mean	Std	Min	Max
Log(Import Quantity)	14	3.7112	0.1636	3.3651	3.9974
Log(GDP)	14	11.7377	0.143	11.5296	12.0131
Log(GNI)	14	11.7219	0.1302	11.5889	11.9924
Log(Domestic Rice Price)	14	1.3083	0.1858	1.0495	1.6096
Log(Domestic Wheat Price)	14	1.5164	0.2224	1.1195	1.9051
Log(Domestic Maize Price)	14	1.7645	0.1999	1.4648	2.1298
Log(Oil Price)	14	1.4102	0.2254	1.0759	1.8075
Log(FDI)	14	9.584	0.5005	8.5558	10.147
Log(Inflation Rate)	14	1.6332	0.2013	1.2349	1.8979
Log(Consumption)	14	4.6736	0.0298	4.6167	4.7101
Log(Population)	14	8.6347	0.0336	8.581	8.6835

Table 2. The Definitions of Variables

Variables	Definitions
IM	**Total rice import quantity (1000 tons)** Source: FAOSTAT and USDA World Rice Calendar Years (2008)
GNI	**Gross national income (U.S. dollar)** Source: The World Bank Database
GDP	**Real gross domestic product (U.S. dollar)** Source: The World Bank Database
FDI	**Foreign direct investment (U.S. dollar)** Source: The World Bank Database
DRP	**Domestic rice price (U.S. dollar)** Source: this variable is calculated by using $DRP_t = E_t * EXP_t$ where E_t is the real exchange rate (U.S. dollar/Ruphia) in period t and EXP_t is the rice exporting price in period t. Also this is based on the real exchange rate of Indonesia and exporting rice price of Thailand FOB 5% broken and milled. Ruphia (Rp) is the currency of Indonesia.
CON	**Rice consumption (1000 ton)** Source: FAOSTAT and USDA World Rice Calendar Years (2008)
DWP	**Domestic wheat price (U.S. dollar)** Source: this variable is calculated by using $DWP_t = E_t * EXWP_t$ where E_t is the real exchange rate (U.S. dollar/Ruphia) in period t and $EXWP_t$ is the exporting wheat price in period t. Also this is based on the real exchange rate of Indonesia and exporting wheat price of Canadian No.1 Western Red Spring 13.5%. Ruphia (Rp) is the currency of Indonesia.
POP	**Population growth rate (annual %)** Source: The World Bank Database
IN	**Inflation rate (annual %)** Source: The World Bank Database

Table 3. Results of Unit Root Test

	ADF in Levels Lag(1)		ADF First Differences Lag(1)	
	Without Trend	**With Trend**	**Without Trend**	**With Trend**
Log(Import quantity)	−0.8188*	−0.9847*	−2.004***	−2.2044***
	(−2.21)	(−2.2)	(−4.32)	(−4.77)
Log(GNI)	−0.232	−0.244	−0.6041	−1.0974**
	(−0.14)	(−1.26)	(−1.67)	(−3.23)
Log(Domestic Rice Price)	−0.4866	−0.3364	−1.1109*	−1.8638***
	(−1.81)	(−1.10)	(−2.23)	(−3.92)
Log(Consumption)	−0.0587	−0.0289	−0.743*	−1.21***
	(−1.32)	(−0.08)	(−1.96)	(−5.57)
Log(Oil Price)	−0.0536	−0.7707*	−1.5415***	−1.917***
	(−0.25)	(−2.27)	(−3.96)	(−6.07)
Log(Domestic Wheat Price)	−0.3391	−0.2161	−0.6915*	−1.7614**
	(−1.13)	(−0.9)	(−1.98)	(−3.26)
Log(Domestic Maize Price)	−0.4125	−0.2887	−1.0537*	−1.949***
	(−1.33)	(−0.99)	(−1.99)	(−4.09)
Log(GDP)	−0.0543	−0.4088	−1.2632**	−1.8371***
	(−0.24)	(−1.29)	(−2.6)	(−4.27)
Log(FDI)	−0.4308	−0.4069	−0.9442*	−1.1732*
	(−1.43)	(−1.28)	(−1.97)	(−1.99)
Log(Inflation)	−1.2478**	−1.3354**	−1.7715**	−1.8242**
	(−2.95)	(−2.85)	(−3.11)	(−3.0)
Log(Population)	−0.0171	−1.395***	−1.3473*	−0.0264*
	(−1.21)	(−4.48)	(−2.08)	(−2.12)

Notes: t-values are in parentheses.
* indicates 90% confidence level
** indicates 95% confidence level
*** indicates 99% confidence level

Table 4. Model Results of Import Volume: Annual Observations from 1994 through 2007 (Dependent Variable: Log (Import Quantity))

Independence Variables	OLS	IV/GMM	SUR Estimates
Intercept	−3.399	−7.8537	−3.5415
	(−0.89)	(−1.76)	(−1.09)
Log (GNI)	0.5357	0.8799**	0.5308*
	(1.70)	(2.49)	(1.98)
Log (Domestic Rice Price)	−0.6346**	−0.9385**	−0.787***
	(−2.87)	(−2.98)	(−4.34)
R-square	0.4366	0.3043	0.406
Observations	14	14	14
Breusch-Pagan	0.69	–	–
	p-value: 0.4058		
Anderson	–	20.264**	–
		p-value: 0.00	
Hansen J	–	3.983	–
		p-value: 0.2634	
Engle-Granger	−1.4702***	−1.164***	−1.4246***
	(−3.57)	(−3.3)	(−3.55)

Notes: t-values are in parentheses.
* indicates 90% confidence level
** indicates 95% confidence level
*** indicates 99% confidence level

Table 5. Model Result of Simultaneous Equations Using Annual Observations from 1994 through 2007

Simultaneous Equation Estimates

$$Log(DRP_t) = 25.7149 + 1.86475Log(Consumption_t) + 0.6652Log(OIL_t) + 0.5339Log(DWP_t) - 0.1462Log(DMP_t)$$
$$(3.09)^{**} \quad (3.07)^{***} \qquad (2.48)^{**} \qquad (1.04) \qquad (-0.25)$$

$$Log(GNI_t) = -3.173 + 0.6507Log(GDP_t) + 0.0611Log(FDI_t) - 0.0119Log(Inflation_t) + 0.7748Log(POP_t)$$
$$(-1.51) \quad (7.84)^{***} \qquad (4.82)^{**} \qquad (-0.47) \qquad (2.36)^{**}$$

$R^2 = 0.9775$ Engle-Granger test= -1.4246^{***} (-3.55)

Notes: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

Table 6. The Estimation of Consumer Surplus (1000 US dollars)

Years	CS (a)	CS (b)	CS (c)
1994	377870.1	1162292.01	3355917.14
1995	1011197	3762635.21	1086398.09
1996	763977.5	1468752.9	1424076.07
1997	490862.5	1622602.78	16468497.44
1998	825387.2	1987436.77	19573838.4
1999	816750.1	513137.7	514815.92
2000	533672	1681795.51	1485588.11
2001	412455.4	720159.35	720793.32
2002	588362.8	1045080.72	1031748.9
2003	584169.6	2491230.85	2577192.98
2004	560849.9	1385443.27	1400022.29
2005	823526.4	1560582.92	14505911.8
2006	1313315	2909873.77	2840175.86
2007	1306285	4176528.68	1205898.87

Note: (a) is based on $\alpha = -0.6346$ and $\delta = 0$ of OLS using equation (7). (b) is based on $\alpha = -0.9385$ and $\delta = 0.8799$ of IV/GMM using equation (6). (c) is based on $\alpha = -0.787$ and $\delta = 0.5308$ of SUR using equation (6). The calculated values are absolute number. The consumer surplus is the aggregated value of importing countries. CS indicates the thousand U.S. dollars.

Table 7. Results of Unit Root Test using variables of CS and export price

	ADF in Levels Lag(1)		ADF First Differences Lag(1)	
	Without Trend	**With Trend**	**Without Trend**	**With Trend**
Log(OLS CS)	−0.665	−0.4866	−1.5655***	−1.8638***
	(−1.52)	(−1.81)	(−4.49)	(−3.92)
Log(IV/GMM CS)	−1.2924***	−1.6909***	−2.0189***	−2.0754***
	(−2.73)	(−3.4)	(−3.19)	(−2.91)
Log(SUR CS)	−1.2929***	−1.6906***	−2.0193***	−2.0762**
	(−2.73)	(−3.4)	(−3.2)	(−2.91)
Log(Export Rice Price)	−0.4866	−0.3364	−1.1109*	−1.8638**
	(−1.81)	(−1.10)	(−2.23)	(−3.92)

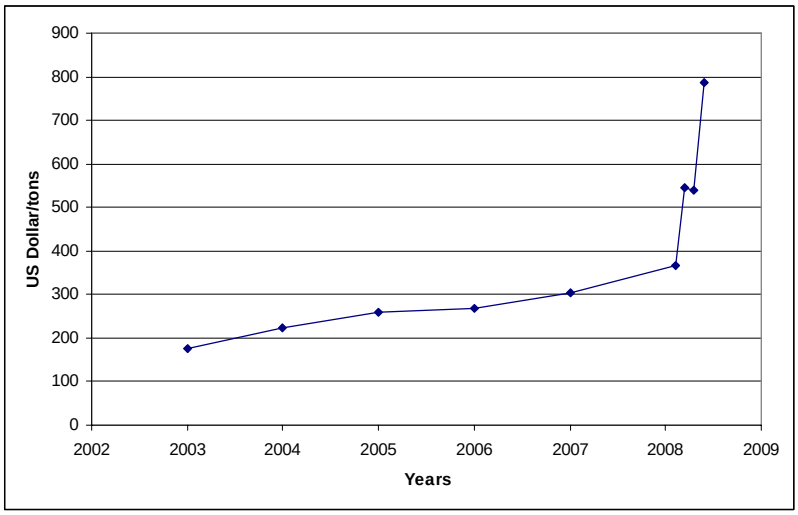
Notes: t-values are in parentheses. * indicates 90% confidence level. ** indicates 95% confidence level. *** indicates 99% confidence level

Table 8. The Changes of Consumer Surplus

% Changes of Rice Price	% Changes of Consumer Surplus
1	−0.527
5	−2.635
10	−5.270
15	−7.905
20	−10.541
25	−13.176
30	−15.811
35	−18.447
50	−26.35
100	−52.7
150	−79.05

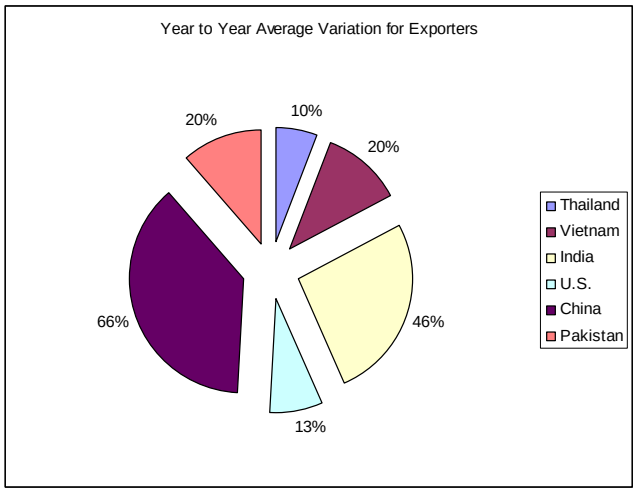
Note: rice price indicates the Thai 25% FOB price. Consumer surplus is calculated by using the price elasticity of −0.6346 and the income elasticity of zero.

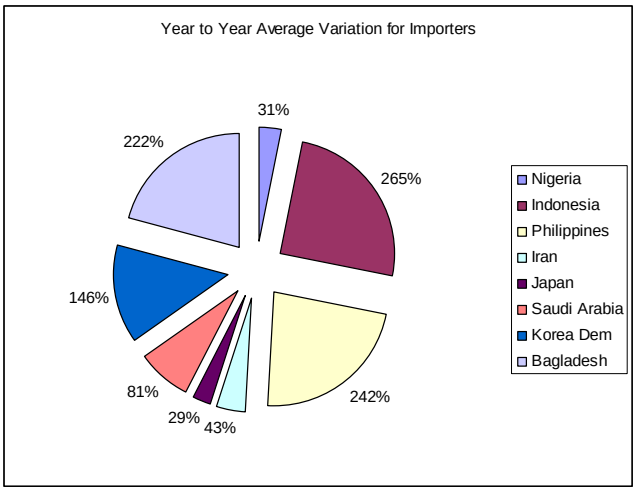
Figure 1. Trend of World Rice Price (From 2003 through April. 2008)



Note: World rice prices indicate the FOB Thailand 25% price. The year of 2008 includes the monthly data from January to April (Source: USDA world rice calendar 2008).

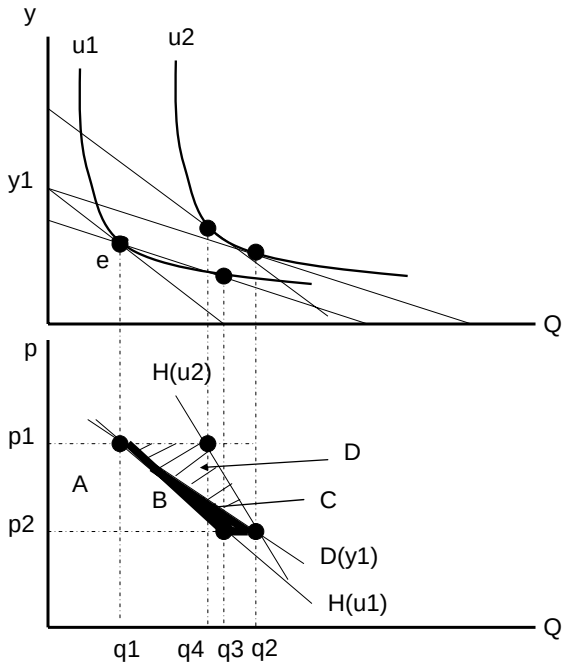
Figure 2. Variation of Export and Import Flows





Source: FAO STAT (Rice Market Monitor, 2008)

Figure 3. The Relationships between CV and CS



Note: The initial equilibrium is *e*. CV=A+B and CS=A+B+C if price decreases from *p1* to *p2*. *D(y1)* indicates Marshallian demand at income *y1*. *H(u1)* and *H(u2)* are Hicksian demands at *u1* and *u2*, respectively.