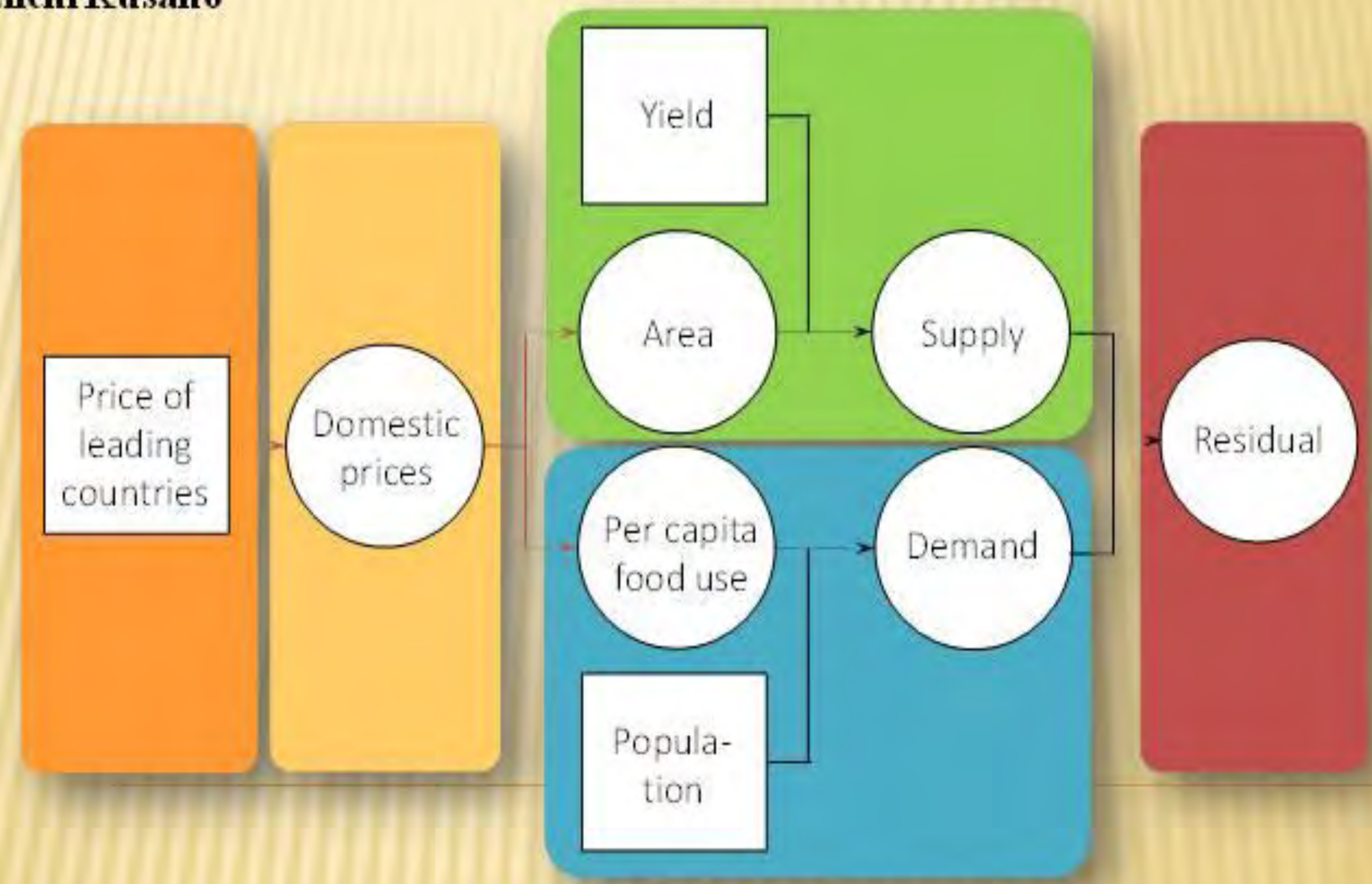
ASEAN FOOD SECURITY INFORMATION SYSTEM (AFSIS)

Medium-long-term non-equilibrium projection model for the AFSIS project

Eiichi Kusano



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Contents

1 Preface

This paper summarizes the knowledge on the food supply–demand model for the medium-long-term projection transferred from the Research Strategy Office at the Japan International Research Center for Agricultural Sciences (JIRCAS) to the government officials of ASEAN countries under the project of the ASEAN Food Security Information System (AFSIS), conducted in collaboration with the Statistics Department, Minister’s Secretariat of the Ministry of Agriculture, Forestry and Fishery (MAFF), Japan. The project is also supported by the Office of Agricultural Economics (OAE), the Ministry of Agriculture and Cooperative, Thailand, each government of the ASEAN countries, Kasetsart University, Chiang Mai University, and the Policy Research Institute of MAFF, Japan. This work is intended for readers interested in the food supply–demand model or regression analyses.

AFSIS and JIRCAS aimed to convey the methodology of the projection model and knowledge of basic econometrics to participants through six workshops at OAE, Bangkok, with a 17-day exercise using Microsoft Excel, extensive homework, and question and answers using an e-learning system during 2013–2015. Involved in the project are presenters from AFSIS, JIRCAS, MAFF Japan, Kasetsart University, and Chiang Mai University.

JIRCAS took on the responsibility of building and providing a model framework for the project and transferring know-how on model building using basic econometrics. The framework was developed by drawing on Cambodia and Laos’ models, built through the collaborative efforts of FAO-RAP and JIRCAS (TCP/RAS/3403) from 2011 to 2013. A number of partial equilibrium food supply–demand models for medium-long-term projections, in particular, ASEAN model (Ohga et al. 2008) and REMEW-Mekong (Furuya et al. 2010) were referenced to create the model’s framework. Presentation files and contents on the web board for participants used in the project were revised and compiled for the purpose of this paper.

Section 2 describes the basic econometrics ideas, mainly the regression analysis, necessary for the model building. Section 3 provides the structure of the food supply–demand model for the AFSIS project. Finally, section 4 explains how to interpret the projection results and utilize the model. The supplementary data and tutorials on the functions in the model and those for using Excel file for regression analyses, which were administered to the project participants, are presented in the appendices.

2 Basic econometrics for model building

The principles underlying the projections of the food supply–demand model are essentially the same as those of a regression model, which captures the future behavior of a target variable *Y* when the future behavior of variable *X* is given using clues of the past relationship between *X* and *Y*. The past relationship, a parameter in the food supply–demand model, is estimated using a regression analysis. Basic knowledge of econometrics is necessary to avoid providing biased results of the regression analysis and select appropriate parameters for the model. In this section, several econometrics concepts required for the parameter estimation are briefly introduced.

2.1 Nominal and real prices

Nominal price or current price, shown in common data sources, is affected by inflation in many countries. Nominal price can be deflated to cancel out the effect of inflation using a deflator. Deflated prices, a real or constant price, are an indicator of the real value of prices (Table 2.1). There are two major deflators, the GDP deflator and consumer price index (CPI). The GDP deflator is generally used to deflate values close to production, such as a farmgate price and GDP. The CPI is preferred to deflate values close to consumption, including wholesale price, retail price, import price, export price, and income. The behaviors of a GDP deflator and CPI are similar, allowing us to use the CPI as a proxy for the GDP deflator, and vice versa.

Table 2.1 shows us an example of the deflation of the rice price in Malaysia. First, each GDP deflator value is divided by the 2010 value. Then, the nominal price of rice is divided by the GDP deflator for 2010 to calculate the real price.

Table 2.1 Example of rice price deflation for Malaysia

		2008	2009	2010	2011
GDP deflator	Raw data	120	113	118	124
	2010 level	=120/118 1.02	=113/118 0.96	=118/118 1.00	=124/118 1.06
Producer price (Farmgate price) LCU/kg	Nominal price	1.21	1.47	1.44	1.40
	Real price	=1.21/1.02 1.19	=1.47/0.96 1.53	=1.44/1.00 1.44	=1.40/1.06 1.33

Note: LCU denotes local currency unit.
Source: Data on the GDP deflator are taken from the World Economic Outlook Database (IMF; April 2015)

2.2 Natural log and exponential conversion

Values for the regression analysis are often converted to a natural logarithmic (log) form. Symbols such as "log" or "ln" before a variable represent the natural log series. The base of the natural log is Napier's constant $e \approx 2.718$. The log series can be reconverted to the original series using exponential (exp) conversion. Thus, exp (log X) equals X. Table 2.2 provides us with examples of the log and exp conversion.

The difference of the log-converted series denotes the rate of change. This is used to cancel out the effects of the unit in the original data series.

Table 2.2 Example of log and exp conversion

Equation	Value	Expression in Excel
$\log 9$	=2.197	=LN(9)
$e^4 = \exp 4$	=54.898	=EXP(4)
$e^{\log 9} = \exp(\log 9)$	=9	=EXP(LN(9))

2.3 Regression analysis (ordinary least squares (OLS))

Regression analysis, or ordinary least squares (OLS), can be used to establish a relationship between two or more data series. Table 2.3 lists the rice-harvested areas and producer prices in Thailand. To establish a relationship between the area and price, first, the price series is deflated using the GDP deflator. Then, it is assumed that the area is affected by the price in the previous year ($t - 1$). The relationship between the area, ARA_t, and producer price, PPR_{t-1}, can be drawn using Excel. Figure 2.1(a) is a scatter plot of the two series with an approximate curve. In Excel, the following equation represents the curve, which is also the result of the regression analysis:

$$ARA = 0.33PPR + 7478. \qquad (2.1)$$

The value 0.33 indicates that the area increases by 0.33 (1000 ha) when price rises to 1 baht/t. When the linear approximated in Figure 2.1(a) changes to a power approximation, you will see another line, as shown in Figure 2.2(b). The equation in the figure is

$$ARA = 936PPR^{0.26}. \qquad (2.2)$$

Equation (2.2) can be rewritten as

$$\log ARA = 6.84 + 0.26 \cdot \log PPR \qquad (2.3)$$

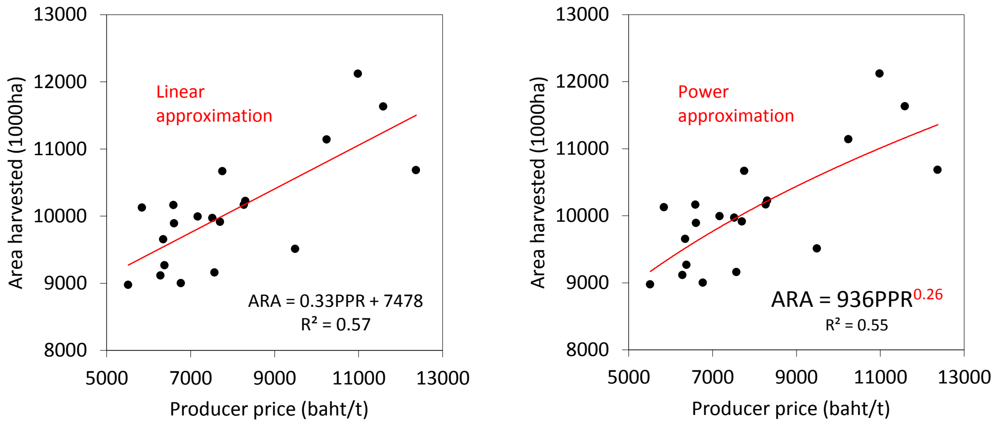
using a double-log form. The value 0.26, or the power of *PPR*, indicates that the area increases by 0.26% when price rises by 1%. This value, which is the percentage change of the explained variable against a 1% change in the explanatory variable, denotes elasticity. The relationship expressed using power approximation or a double-log form is often used for a regression analysis because it is easy to handle in the model.

Table 2.3 Rice harvested area and producer price in Thailand (1)

	Macro-economic data		Commodity data			
	IMF		FAO	FAO		
	GDP Deflator	GDP Deflator	Area harvested	Producer price	Producer price	Producer price
Commodity	—	—	rice	rice	rice	rice
Unit	Index	2010=1	1000ha	THB/t	THB/t	THB/t
Time	t	t	t	t	t	t–1
Note				nominal	real	real
	GDPD	GDPD	ARA	PPR	PPR	PPR
1990	112	0.51	8792			
1991	119	0.54	9053	4089	7568	
1992	124	0.56	9160	3822	6770	7568
1993	128	0.58	9000	3215	5514	6770
1994	135	0.61	8975	3854	6282	5514
1995	142	0.65	9113	4132	6379	6282
1996	148	0.67	9267	5189	7702	6379
1997	154	0.70	9913	6654	9491	7702
1998	168	0.77	9512	5759	7520	9491
1999	161	0.73	9970	4856	6607	7520
2000	164	0.74	9891	4351	5842	6607
2001	167	0.76	10125	4825	6347	5842
2002	168	0.77	9654	5051	6590	6347
2003	171	0.78	10164	5569	7170	6590
2004	176	0.80	9993	6653	8304	7170
2005	184	0.84	10225	6922	8268	8304
2006	193	0.88	10165	6832	7758	8268
2007	200	0.91	10669	11271	12372	7758
2008	208	0.95	10684	9689	10242	12372
2009	212	0.96	11141	10595	10987	10242
2010	220	1.00	12120	11590	11590	10987
2011	229	1.04	11630			11590

Figure 2.1 Relationship between producer price (*PPR*) and area (*ARA*)

(a) Linear approximation (b) Power approximation



Note: To draw the figure, select two target series and click on “Insert” and then “Scatter” from the “Charts” section in the Excel tool bar. To draw the approximate line, right click on any dot in the scatter plot and select “Add approximate curve.”

To obtain more detailed results and extend the analysis from two to three or more variables, use the “Data analysis” option in Excel. Table 2.4 presents the data for Thailand converted to a log series. The regression analysis can be conducted by clicking on “Data → Data analysis → Regression analysis” in the toolbar. Select log*ARA* data for the range of Y (explained variable) and log*PPR* for the range of X (explanatory variable). To display the residuals of the regression, check the residual box and click on the OK button. The regression analysis result will appear as shown in Table 2.5.

Table 2.4 Rice harvested area and producer price in Thailand (2)

	Commodity data FAO		Log conversion	
	Area harvested	Producer price	Area harvested	Producer price
Commodity	rice	rice	rice	rice
Unit	1000ha	THB/t		
Time	t	t–1	t	t–1
Note		real		real
	ARA	PPR	logARA	logPPR
1990	8792			
1991	9053			
1992	9160	7568	9.12	8.93
1993	9000	6770	9.10	8.82
1994	8975	5514	9.10	8.62
1995	9113	6282	9.12	8.75
1996	9267	6379	9.13	8.76
1997	9913	7702	9.20	8.95
1998	9512	9491	9.16	9.16
1999	9970	7520	9.21	8.93
2000	9891	6607	9.20	8.80
2001	10125	5842	9.22	8.67
2002	9654	6347	9.18	8.76
2003	10164	6590	9.23	8.79
2004	9993	7170	9.21	8.88
2005	10225	8304	9.23	9.02
2006	10165	8268	9.23	9.02
2007	10669	7758	9.28	8.96
2008	10684	12372	9.28	9.42
2009	11141	10242	9.32	9.23
2010	12120	10987	9.40	9.30
2011	11630	11590	9.36	9.36

Log conversion

The following five variables (Table 2.5), at least, need to be confirmed to obtain better parameters for the projection:

1. Adjusted R-square (Adj. R^2) indicates the accuracy of the regression model. In other words, it shows how the values predicted by the explanatory variables fit the explained variable. We can say that the fit of the model is high if the Adj. R^2, which can take from a negative value to 1, is close to 1.

2. Observations (*n*) represent the number of observed data. If *n* is small, the reliability of the coefficients decreases.

Table 2.5 Regression analysis output in Excel

SUMMARY OUTPUT

Regression Statistics		
Multiple R	0.74	
R Square	0.55	
Adjusted R Square	0.53	
Standard Error	0.06	B7
Observations	20	B8

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0.07	0.07	22.39	0.00
Residual	18	0.06	0.00		
Total	19	0.13			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	6.84	0.50	13.64	0.00000	5.79	7.89	5.79	7.89
logPPR	0.26	0.06	4.73	0.00017	0.15	0.38	0.15	0.38

RESIDUAL OUTPUT

Observation	Predicted: logARA	Residuals
1	9.21	-0.08
2	9.18	-0.07
3	9.12	-0.02
4	9.16	-0.04
5	9.16	-0.03
6	9.21	-0.01
7	9.27	-0.11
8	9.21	0.00
9	9.17	0.03
10	9.14	0.08
11	9.16	0.01
12	9.17	0.06
13	9.19	0.02
14	9.23	0.00
15	9.23	0.00
16	9.21	0.06
17	9.34	-0.06
18	9.29	0.03
19	9.31	0.10
20	9.32	0.04

C25 (first residual), C44 (last residual); a = residuals 2–20, b = residuals 1–19, c = residuals 1–20

DW 1.25 (F25)
=SUMXMY2(**a**,**b**)/SUMSQ(**c**)
=SUMXMY2(C26:C44,C25:C43)/SUMSQ(C25:C44)

DH 1.74
=(1–DW/2)*SQRT(n/(1–n*SE^2))
=(1–F25/2)*SQRT(B8/(1–B8*B7^2))

3. The coefficients of the model denote the relationships between explanatory and explained variables. In particular, the coefficients of a double-log model (equation (2.3)) are interpreted as elasticity, or the percentage change of the explained variable against a 1% change in the explanatory variable. The coefficient 0.26 in Table 2.5 suggests that the explained variable (harvested area) increases by 0.26% when the explanatory variable (producer price) rises by 1%. The value of 0.26 is the same as that shown in Figure 2.2 and equations (2.2) and (2.3). When the coefficient from the double-log model takes a significantly high or low value, a failure in estimation should be suspected.

4. P-value, or the probability value of the t-test, represents the reliability of the coefficient. The p-value of 0.00017 in Table 2.5 denotes that the probability that the true value of the coefficient equals zero is 0.017%. In this case, we can say that the true value of the coefficient 2.6 is not zero and it is statistically significant. If the p-value is large, we can

interpret the true value of the coefficient to be zero. Criteria 0.05 (5%) and 0.01 (1%) are often used to judge the significance of the coefficient. A looser criterion 0.1 (10%) is also used in the field of social sciences.

5. The Durbin–Watson statistic (DW) represents the reliability of the p-value. When DW is far from 2, the p-value is underestimated. DW is calculated using the SUMXMY2 and SUMSQ functions in Excel (Table 2.5). The DW value of 1.25 in Table 2.5 suggests that the true value of p-value 0.00017 will be larger. Durbin's h-statistic (DH) is used instead of DW when the previous year's explained variable is used as an explanatory variable. A DH value far from zero suggests that the p-value is underestimated.

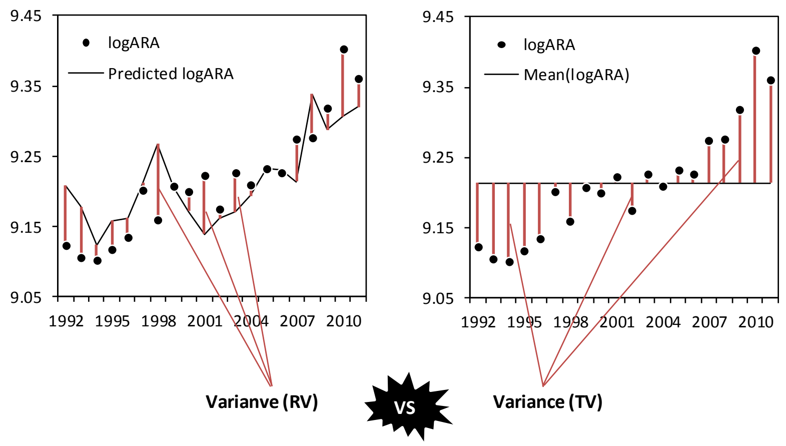
2.3.1 Measuring model performance using Adj. R^2

The Adj. R^2 indicates the fit of the predicted value to the observed values against the mean of the observed values. Unbiased variances, or estimators of population variances, are used for the comparison (Figure 2.2). The variances in the gaps between the predicted and observed values (RV) and mean and observed values (TV) are compared using

$$\mathrm{Adj.R}^2 = 1 - \mathrm{RV}/\mathrm{TV}$$

(Table 2.6). When the predicted values are closer to the observed values than the mean series, RV becomes smaller than TV. Thus, a larger Adj. R^2, or a smaller RV/TV, indicates higher predictability of the regression model. On the other hand, if the performance of the prediction is similar to the mean of the observed values, RV is closer to TV. In this case, Adj. R^2 shows a small value near 0; for example, an Adj. R^2 of 0.8 suggests that RV/TV = 0.2 and the variance

Figure 2.2 Concept of Adj.R^2 (comparison of variances)



Notes: RV and TS denote estimators of the residual variance and total variance, respectively.

Table 2.6 Rice harvested area and producer price in Thailand (3) (calculation of Adj.R^2)

Note			=6.84 + 0.26*logPPR		(a)	(b)
	logARA	logPPR	Predicted logARA	Mean(logARA)	logARA −Predicted logARA	logARA −Mean(logARA)
1992	9.12	8.93	9.21	9.21	-0.08	-0.09
1993	9.10	8.82	9.18	9.21	-0.07	-0.11
1994	9.10	8.62	9.12	9.21	-0.02	-0.11
1995	9.12	8.75	9.16	9.21	-0.04	-0.10
1996	9.13	8.76	9.16	9.21	-0.03	-0.08
1997	9.20	8.95	9.21	9.21	-0.01	-0.01
1998	9.16	9.16	9.27	9.21	-0.11	-0.05
1999	9.21	8.93	9.21	9.21	0.00	-0.01
2000	9.20	8.80	9.17	9.21	0.03	-0.01
2001	9.22	8.67	9.14	9.21	0.08	0.01
2002	9.18	8.76	9.16	9.21	0.01	-0.04
2003	9.23	8.79	9.17	9.21	0.06	0.01
2004	9.21	8.88	9.19	9.21	0.02	0.00
2005	9.23	9.02	9.23	9.21	0.00	0.02
2006	9.23	9.02	9.23	9.21	0.00	0.01
2007	9.28	8.96	9.21	9.21	0.06	0.06
2008	9.28	9.42	9.34	9.21	-0.06	0.06
2009	9.32	9.23	9.29	9.21	0.03	0.10
2010	9.40	9.30	9.31	9.21	0.10	0.19
2011	9.36	9.36	9.32	9.21	0.04	0.15

	RSS	TSS		
Sum of Squares	0.06	0.13	=SUMSQ(a)	=SUMSQ(b)
df	18	19	=n-1–k	=n–1
	RV	TV		
Variance	0.0032	0.0068	=Sum of squares/df	
RV/TV	0.47		=RV/TV	
Adj.R^2	0.53		=1–RV/TV	

Notes: "n" and "k" denote numbers of observations and explanatory variables without the constant. "df" denotes degree of freedom.

of gaps between the predicted and observed values is 20% of the variance of those between the mean and observed values. When Adj. R^2 is greater than 0.8, we can say that the performance of the regression model is significantly high. An Adj. R^2 value of around 0.5 can be interpreted as a certain degree of performance of the regression model. A low Adj. R^2 does not necessarily suggest the impossibility of projection using the regression model's results because the mean value can suffice in some cases.

The Adj. R^2 is not affected by the number of observations; in contrast, R^2 calculated by the sum of squares instead of variance increases with larger observations. The estimator of population variances, calculated by dividing the sum of squares by the degree of freedom, requires the assumption that the distribution of the gaps composing RV and TV follows normal distribution. Therefore, Adj. R^2 can be biased when the assumption is not appropriate.

2.3.2 Obtaining coefficients in the regression model

The coefficient of the OLS is derived by minimizing the gaps between the predicted variables in the model and the observed data series. A regression model can be describe as

$$Y = \mathrm{a} + \mathrm{b} \cdot X,$$

where Y and X denote the explained and explanatory variable, and a and b are parameters. The

observed values are used for both Y and X. The gaps or residuals between the predicted and observed variables are aggregated to an indicator, namely the residual sum of squares (RSS):

$$\mathrm{RSS} = Sum\ of\ residual^2 = \sum residual^2 = \sum(Y - \hat{Y})^2 = \sum[Y - (\mathrm{a} + \mathrm{b} \cdot X)]^2 \qquad (2.4)$$

where $\hat{Y}$ represents the predicted value of Y using the regression model. The residuals are squared; otherwise, they cannot be summed up because of the negative residual values. To minimize the RSS, the partial differential of equation (2.4), which is zero, is expanded. Finally, we get the following normal equations:

$$\sum Y = n \cdot \mathrm{a} + \mathrm{b} \cdot \sum X,$$
$$\sum YX = \mathrm{a} \cdot \sum X + \mathrm{b} \cdot \sum X^2,$$

where *n* is the number of observation. The normal equations can be simplified to

$$\mathrm{a} = \bar{Y} - \mathrm{b} \cdot \bar{X},$$
$$\mathrm{b} = \sum[(X - \bar{X})(Y - \bar{Y})] \,/\, \sum(X - \bar{X})^2,$$

where $\bar{X}$ and $\bar{Y}$ represent the means of *X* and *Y*.

2.3.3 Interpreting coefficients of a double-log model

The coefficient obtained from a double-log model, such as equation (2.3), equals elasticity. This is briefly demonstrated as follows: first, a double-log model is denoted by $\log Y = \mathrm{a} + \mathrm{b} \cdot \log X$. The exponential form of this equation is $Y = \mathrm{a} \cdot X^{\mathrm{b}}$. The partial differentiation can be delivered as $dY/dX = \mathrm{b} \cdot \mathrm{a} \cdot X^{b-1}$. Thus, the elasticity ε, which is the percentage change against a 1% change of an explanatory variable, can be written as

$$\varepsilon = \frac{dY}{dX}\frac{X}{Y} = \mathrm{b} \cdot \mathrm{a} \cdot X^{\mathrm{b}-1} \cdot \frac{X}{Y} = \mathrm{b} \cdot \frac{\mathrm{a} \cdot X^{\mathrm{b}}}{Y} = \mathrm{b}.$$

As shown in Table 2.7, elasticity from the double-log form is constant against both the explained and explanatory variables and is the most easy to handle in a large model.

When the coefficient obtained from the double-log model takes a significantly large value, a failure in estimation should be suspected. For example, if the coefficient of the log*PPR* in equation (2.3) is 7.2, then the area increases by 7.2% against a 1% increase in rice price. Such a sensitive adjustment of area is considered impossible when the area is

Table 2.7 Elasticity obtained from major forms

Form	Equation	Elasticity
Linear	$Y = \mathrm{a} + \mathrm{b} \cdot X$	$\mathrm{b} \cdot X/Y$
Semi-log (log-lin)	$\log Y = \mathrm{a} + \mathrm{b} \cdot X$	$\mathrm{b} \cdot X$
Semi-log (lin-log)	$Y = \mathrm{a} + \mathrm{b} \cdot \log X$	b/Y
Double-log	$\log Y = \mathrm{a} + \mathrm{b} \cdot \log X$	b

Note: Elasticity is the percentage change of Y against a 1% change of X.

sufficiently large. The medium-long-term projection value takes an unrealistic exponential trend if these large values are used as a projection parameter.

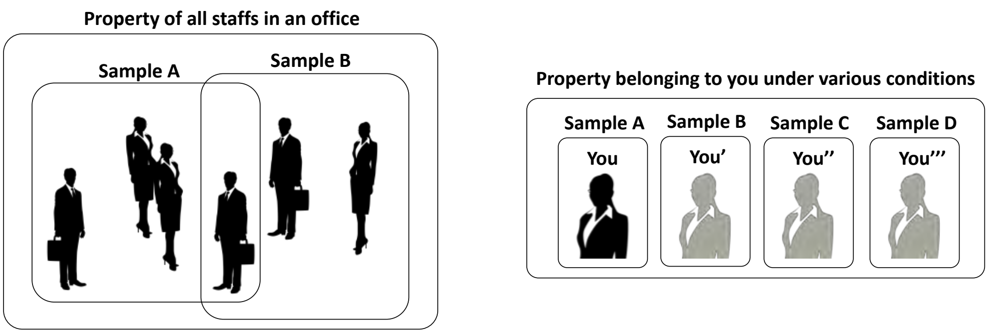
2.3.4 Using p-value of a t-test to measure coefficients' reliability

Coefficients calculated using the regression model do not necessarily represent a true relationship. For example, you may want to estimate the total amount of property owned by the staff in an office (Figure 2.3(a)). The amounts that appear in sample A or B can differ from their true value. Similarly, if you want to estimate the true value of the property belonging to you, which is observed with a time lapse, observed property alone cannot be used to do so (Figure 2.3(b)). The observed property of sample A can differ from the properties of unobserved samples B, C, and D or the true value. The property of sample A in Figure 2.3(b) corresponds to the coefficients of the regression model against time series data, 6.84 and 0.26, in Table 2.5. Although these values are obtained from observed data, the true value can differ.

Figure 2.4 shows the distribution of coefficients including an estimated value of 1.3. If samples B, C, D, etc. in Figure 2.3(b) are observable, then the coefficients estimated from those samples can draw a distribution chart similar to Figure 2.4(b). The mean of coefficients

Figure 2.3 Example of sampling

(a) Cross-section sampling (b) Time series sampling



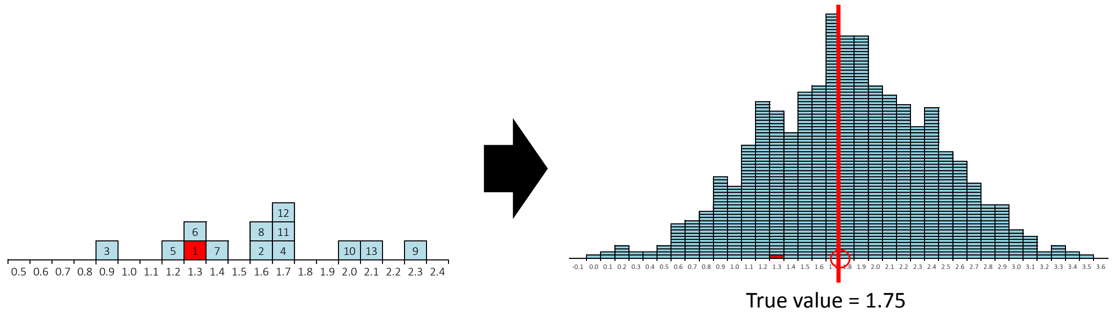
Note: (a) Samples are observed during a particular period. (b) Each sample contains information with a time sampling. Samples B, C, D, etc., which must be simultaneously observed with sample A, do not hold in reality.

from many samples indicates the true parameter value; however, in the real world, we cannot draw such a distribution because samples B, C, and D are unobservable. Instead, we can draw the distribution shown in Figure 2.5 when normal distribution is assumed. The mean of the distribution is the coefficient estimated from observed data and the width of the distribution is denoted by standard error (SE), which is estimated using RSS and *n*.

Figure 2.5 does not provide information on the relationship between the estimated value 1.3 and unobservable true parameter. To approximate the true value, statistic *t* is

Figure 2.4 Distribution of coefficients

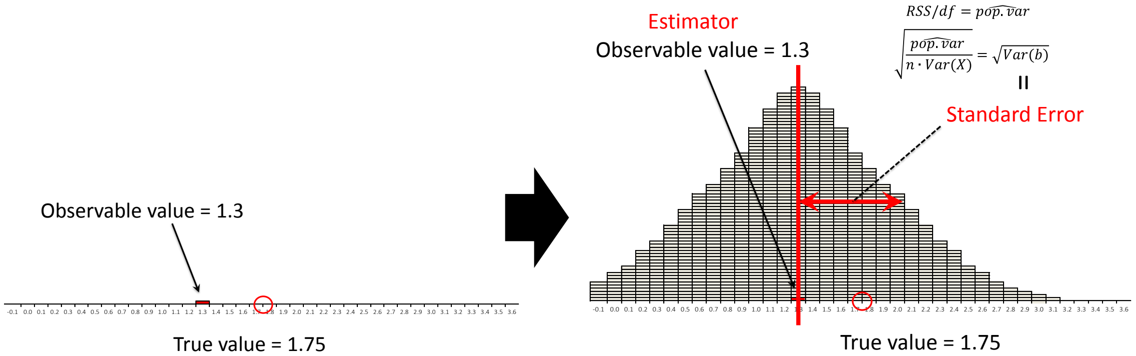
(a) Coefficients from 13 samples (b) Coefficients from many samples



Notes: The number in each box indicates the sample from which the coefficient was estimated (a). Box 1 with a value of 1.3 denotes that the coefficient estimated from the first sample (Sample A in Figure 2.3(b)) equals 1.3. The figure (b) suggests an accumulated box that approximates normal distribution. The mean of the distribution, which is 1.75, is the true value.

Figure 2.5 Estimated distribution of coefficients

(a) Observed value (b) Estimated distribution



Notes: In reality, only one coefficient is observable (a). Normal distribution is assumed to draw the distribution of coefficients (b). The coefficient 1.3 is assumed to be an estimator of the true value and mean of the distribution. SE is the width of the distribution, *RSS* is the residual sum of squares, *df* is the degree of freedom of the residuals (*n*–2 here), $\widehat{pop.var}$ is the estimator of population variance, *n* is the number of observation, *Var(X)* is the variance of the explanatory variable *X*, and *Var*(b*)* is the variance of the coefficient b or estimated parameter of *X*.

calculated as follows:

$$t = \frac{\text{Coefficient} - \text{True value}}{\text{SE}},$$

The statistic *t* follows the *t*-distribution and changes its shape according to the number of observations (*n*) rather than normal distribution. An interval in which *t* falls under a certain probability is already known; therefore, the occurrence probability of *t* when we assume a certain value for the true parameter can be calculated. Simply put, we can test how much a certain true value holds. The test of the true value = 0 is called *t*-test, where *t* denotes the *t*-statistic (*t*-stat), described as follows:

$$t\text{– stat} = \frac{\text{Coefficient}}{\text{SE}}. \qquad (2.5)$$

The p-value in the result of the regression analysis using Excel indicates that the probability of the true parameter is zero. The p-value becomes smaller with a larger absolute *t*-stat value ($|t\text{– stat}|$). A small p-value (or large $|t\text{– stat}|$) means that the true value of the observed coefficient cannot be zero or is statistically significant. A large p-value (or small $|t\text{– stat}|$), on the other hand, means that the true value of the observed coefficient can be zero. To judge significance, 0.05 (5%; corresponding to $|t\text{– stat}| \approx 2.0$) or a more rigorous 0.01 (1%) is commonly used as the criterion for p-value. A less rigid criterion of 0.1 (10%) is also occasionally used in the field of social sciences. A p-value of 0.00017 for logPPR (Table 2.5) indicates that the probability of the true value being zero is 0.017%. Thus, we can say that the true value of the coefficient 0.26 cannot be zero.

Following is an easier interpretation of the p-value using statistical inference. In the case of the result indicated in Table 2.5, an interval in which *t* (not *t*-value) falls with a 95% probability can be described as

$$-2.10 < t < 2.10.$$

The interval can be rewritten using the definition of *t* as

$$-2.10 < \frac{\text{Coefficient} - \text{True value}}{\text{SE}} < 2.10.$$

Therefore, the interval of the true value can be calculated using

$$\text{Coefficient} - 2.10 \cdot \text{SE} < \text{True value} < \text{Coefficient} + 2.10 \cdot \text{SE}.$$

According to Table 2.5, the coefficient and SE are 0.26 and 0.056. Thus, we can infer the true value of the parameter or the true relationship between log*PPR* and log*ARA* in equation (2.3) falls in the interval of $0.15 < \text{True value} < 0.38$ with a 95% probability. A small p-value calculated using a small SE suggests a narrow interval for the true value surrounding the estimated coefficient. On the other hand, a large p-value from a large SE suggests a wide interval for the true value and the inability of the estimated coefficient to grasp the true relationship among other variables.

2.3.5 Ascertaining if a *t*-test's p-value is reliable using DW or DH

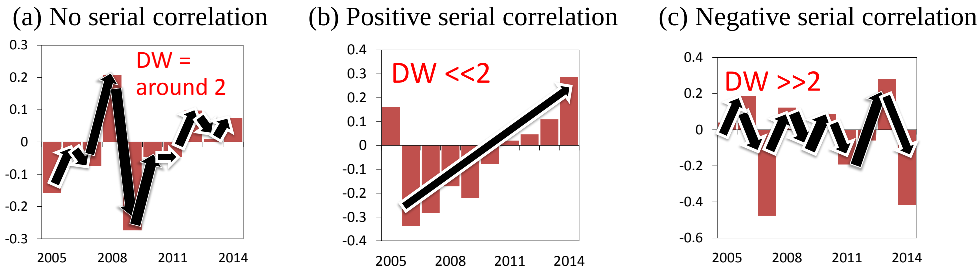
The p-value of a *t*-test cannot be relayed when the residual of the regression is not randomly distributed. The p-value depends on the *t*-stat, which is affected by SE and the number of observations. SE is estimated using RSS (see Figure 2.5 and equation (2.4)); therefore, the p-value is affected by the residuals.

The randomness of the residual can be measured using DW as follows:

$$\text{DW} = \frac{\sum(e_t - e_{t-1})^2}{\sum e_t^2},$$

where *e* denotes residual and subscript *t* denotes time (see Table 2.5). DW can take a value between 0 and 4. When DW is around 2 (almost 1.7 < DW < 2.3 for a small *n*), we can say that the residual is randomly distributed or does not have a serial correlation (Figure 2.6(a)). If DW significantly greater or less that 2, the residuals are serially correlated (Figure 2.6(b,c)). The serial correlation decreases SE or narrows the coefficients' distribution (Figure 2.7), and finally, decreases the p-value.

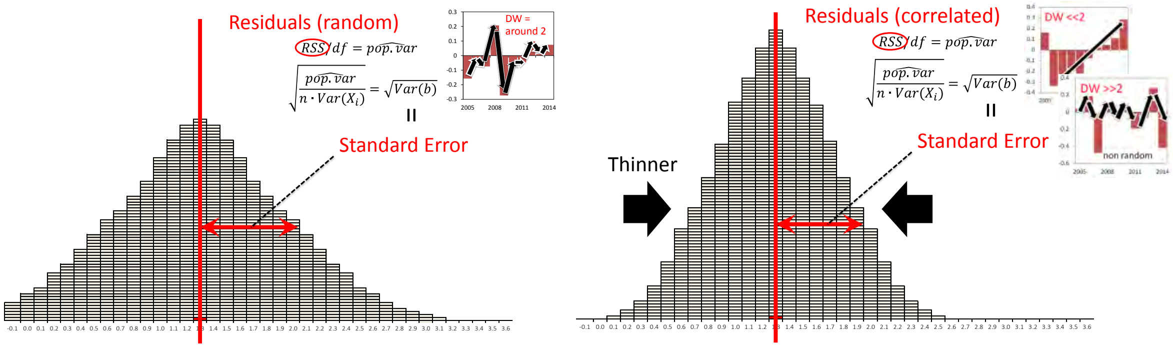
Figure 2.6 Distribution of residuals



Note: A small DW suggests a smooth pattern of the residuals and a large one forms a zigzag pattern.

Figure 2.7 Underestimation of SE under correlated residuals

(a) DW is around 2 (b) DW is far from 2



Note: When DW is far from 2, SE is underestimated.

When a lagged explained variable is used for an explanatory variable (e.g., $\boldsymbol{Y_t} = \mathrm{a} + \mathrm{b} \cdot X + \mathrm{c} \cdot \boldsymbol{Y_{t-1}}$), DW is biased. In this case, DH is estimated instead of DW. DH can be calculated as follows:

$$\mathrm{DH} = (1 - \mathrm{DW}/2)\sqrt{\frac{n}{1-n*SE^2}},$$

where *n* is the number of observations and *SE* is the standard error of the residuals (see Table 2.5). We test the hypothesis that there is no serial correlation using standard normal distribution. When DH is around zero (–1.65 < DH < 1.65), the hypothesis is not rejected at the 10% significance level; thus, we can say that there is no serial correlation and the *t*-test is reliable. When DH > 1.65, there is a positive serial correlation and when DH < –1.65, there is a negative serial correlation.

The serial correlation of the residuals is related to the issue of “spurious regression.” The regression analysis result is unreliable when there is a strong positive serial correlation (i.e., if DW close to zero or DH is large) and high Adj. R^2 are observed. The spurious regression can be more strictly judged using the cointegration test (see Briand and Carter 2011; pp. 294–309).

2.4 Obtaining more reasonable OLS results

There are various methods used to derive a better Adj. R^2, coefficient, p-value, and DW or DH. For example, to improve the model $\log Y = \mathrm{a} + \mathrm{b} \cdot \log X_1$, an explanatory variable can be added as $\log Y = \mathrm{a} + \mathrm{b} \cdot \log X_1 + \mathrm{c} \cdot \log X_2$ or changed to $\log Y = \mathrm{a} + \mathrm{b} \cdot \log X_1 + \mathrm{d} \cdot \log X_3$. Dummy variable and/or time trend representing qualitative information

can also be used as an explanatory variable. The observed data period can be trimmed if it is not appropriate for the parameter estimation. The model form can be changed from a double-log to a linear form such as $Y = \mathrm{a} + \mathrm{b} \cdot X_1$, semi-log form $\log Y = \mathrm{a} + \mathrm{b} \cdot X_1$ or $Y = \mathrm{a} + \mathrm{b} \cdot \log X_1$, inverse form $1/Y = \mathrm{a} + \mathrm{b} \cdot 1/X_1$, log-inverse form, difference form, and log-difference form, although the double-log form is the easiest in terms of handling and result interpretation. In addition to OLS, several methods can be used for the regression analysis. The use of dummy variables and countermeasures against serial correlation are explained in the following sections.

2.4.1 Dummy variable

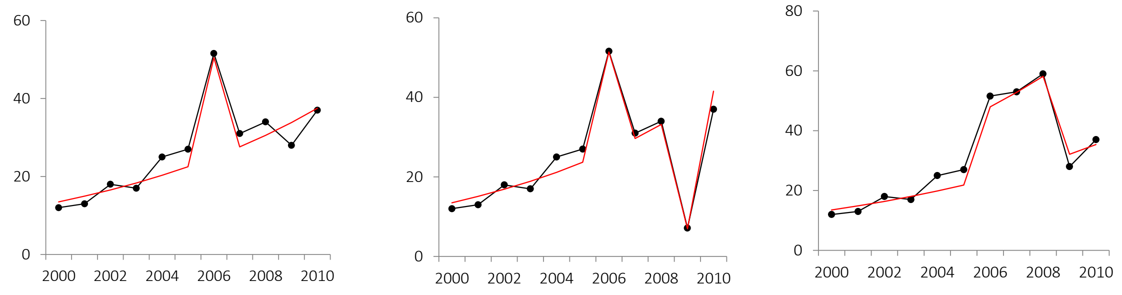
A dummy variable represents qualitative information or a proxy variable of unobservable shocks or structural changes, such as the 1997–1998 Asian financial crisis, the 2007–2008 food crisis, alterations in policies or systems, natural disasters, turmoil, changes in data collection methods, and data input errors. A dummy variable can be incorporated into the model as follows:

$$\log Y = \mathrm{a} + \mathrm{b} \cdot \log X + \mathrm{c} \cdot DM,$$

where DM denotes the dummy variable. As explained in Figure 2.8, a dummy variable takes the value of zero for ordinal periods and one when a certain shock is assumed (Figure 2.8(a)). A plural number of dummy variables are used for shocks in dispersed periods (Figure 2.8(b)). A dummy variable containing serial value of one is used for a shock that continues for a certain period (Figure 2.8(c); see Appendix E.2).

Figure 2.8 Adjustment of the predicted value using dummy variables

(a) Pulse dummy DM_1 (b) Two pulse dummies DM_1 and DM_2 (c) Step dummy DM_3



$\log Y = 8.5 + 0.7 \cdot \log X + 0.7 \cdot DM_1$

$\log Y = 8.5 + 0.7 \cdot \log X + 0.7 \cdot DM_1 - 1.7 \cdot DM_2$

$\log Y = 8.5 + 0.7 \cdot \log X + 0.7 \cdot DM_3$

Notes: The red line denotes the predicted value of each regression model. DM_1, DM_2, and DM_3 are dummy variables. The values for each dummy variable are as follows: DM_1 equals one for 2006 and zero for other years, DM_2 equals one for 2009 and zero for other years, and DM_3 equals one for 2006–2009 and zero for other years.

A bias in the coefficient by an outlier in the observations can be adjusted with a dummy variable. As shown in Figure 2.8, the variance in residual becomes smaller and Adj. R^2 can be higher. A smaller standard error affected by smaller residuals can improve the p-value and DW of coefficient b. Coefficient c of a dummy variable suggests a percentage change of Y in a certain period affected by the unobserved factor. The equation in Figure 2.8(b) suggests that Y increases by 0.7% in 2006 and decreases by 1.7% in 2009 owing to implicit factors.

2.4.2 Countermeasures when DW is far from 2 or DH is far from zero

In addition to the abovementioned measures, there are several countermeasures when DW or DH does not take a good value. First is the correction of the p-value by a heteroscedasticity and autocorrelation consistent (HAC) standard error, such as Newey-West standard errors, and second is the regression using a log-difference form, which can be written as

$$\log Y_t - \log Y_{t-1} = \mathrm{a} + \mathrm{b} \cdot (\log X_t - \log X_{t-1}).$$

The log-difference model can cancel out the serial correlation in the residuals and often allows DW to take a value around two. The third measure is the Cochrane–Orcutt estimation, which is a difference model with weight described as

$$\log Y_t - \mathrm{c} \cdot \log Y_{t-1} = \mathrm{a} + \mathrm{b} \cdot (\log X_t - \mathrm{c} \cdot \log X_{t-1} + u_t) + u_t,$$
$$e_t = u_t + \mathrm{c} \cdot e_{t-1},$$

where e denotes residuals; u is a part of e that is not serially correlated, subscript t is time; and a, b, and c are parameters. The model does not contain the original correlated residual e and can avoid a biased p-value. The procedure of the Cochrane–Orcutt estimation using Excel is explained in Briand and Carter (2011; pp. 245–251).

2.5 Incorporating coefficients in the food supply–demand model

Elasticity or coefficient estimated using a regression analysis is used as a parameter in the food supply–demand model. Although various type of equations can incorporate elasticity into the projection model, the model for the AFSIS project followed the method of partial-equilibrium models such as ASEAN model (Ohga et al. 2008) and REMEW-Mekong (Furuya et al. 2010).

Following is an example of how to induce an equation into the project's per capita consumption using the food supply–demand model with elasticity estimated using a regression analysis. First, the equation for the regression analysis is assumed as

$$\log QFP_t = \mathrm{a} + \mathrm{b} \cdot \log PCS_t + \mathrm{c} \cdot \log GPP_{t,} \qquad (2.6)$$

where *QFP* denotes per capita food consumption; *PCS* is the consumer price (retail price); *GPP* is per capita *GDP*, subscript *t* denotes the year; and a, b, and c are parameters of the regression model. *PCS* and *GPP* are deflated by the CPI and GDP deflator. Parameters a, b, and c are estimated using a regression analysis. Equation (2.6) can be exponentially converted and rewritten as

$$QFP_t = e^{\mathrm{a}} \cdot PCS_t^b \cdot GPP_t^c, \qquad (2.7)$$

where e is a Napierian logarithm ($\approx$ 2.718). It is assumed that parameters a, b, and c are constant even if the period of the observed data for the regression shifts one year. The equation of the regression for a series shifted by a year can be described as

$$\log QFP_{t-1} = \mathrm{a} + \mathrm{b} \cdot \log PCS_{t-1} + \mathrm{c} \cdot \log GPP_{t-1}$$

and the exponential converted form is

$$QFP_{t-1} = e^{\mathrm{a}} \cdot PCS_{t-1}^b \cdot GPP_{t-1}^c. \qquad (2.8)$$

The rate of QFP_t–QFP_{t-1} is expressed as

$$\frac{QFP_t}{QFP_{t-1}} = \frac{e^{\mathrm{a}}}{e^{\mathrm{a}}} \cdot \frac{PCS_t^{\mathrm{b}}}{PCS_{t-1}^{\mathrm{b}}} \cdot \frac{GPP_t^{\mathrm{c}}}{GPP_{t-1}^{\mathrm{c}}} = \left(\frac{PCS_t}{PCS_{t-1}}\right)^{\mathrm{b}} \cdot \left(\frac{GPP_t}{GPP_{t-1}}\right)^{\mathrm{c}}. \qquad (2.9)$$

Thus, QFP_t can be estimated using

$$QFP_t = QFP_{t-1} \cdot \left(\frac{PCS_t}{PCS_{t-1}}\right)^{\mathrm{b}} \cdot \left(\frac{GPP_t}{GPP_{t-1}}\right)^{\mathrm{c}}.$$

The pros of this form is the omission of the constant a, which often causes an exponential increase in the projected value. Furthermore, the decrease in efficiency (larger SE and p-value) and lower Adj. R^2 obtained by the regression analysis using a log-difference model

can be avoided. On the other hand, a projection obtained using this form does not minimize the residual of the projected value.

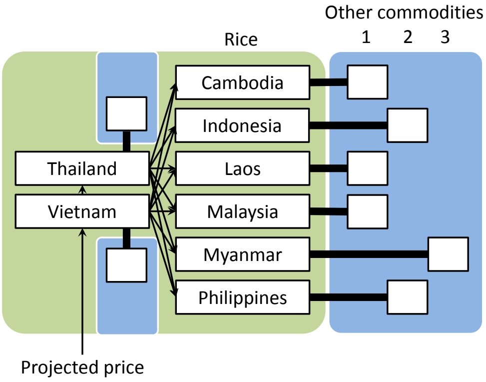
3 Model structure

3.1 Basic structure

The food supply–demand model for the AFSIS project is a medium-long-term non-equilibrium model. The structure of the model is similar to that of partial-equilibrium models, widely used to project future trends in the agricultural market. Target commodities in the AFSIS project are rice and those determined by its participants. Country-level data for 1980–2014 were collected to create the food balance sheet (FBS) and estimate the model parameters for the projection from around 2012 to 2019. The projection means the creation of FBS in the future using parameters representing past relationships between variables in the FBS. The data period was adjusted to reflect its availability in each country. We used Microsoft Excel for the model building and parameter estimation.

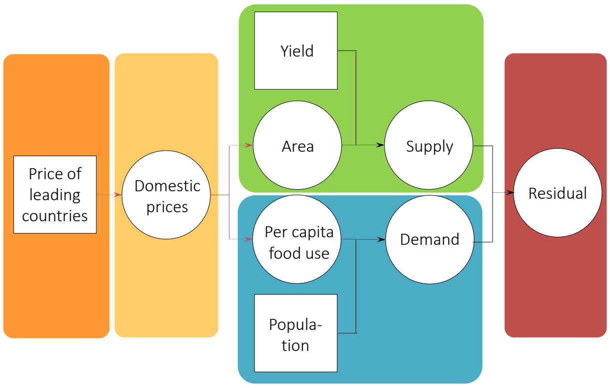
Figures 3.1 and 3.2 show the basic concept of the model. The model is driven by the

Figure 3.1 Flow of price transmission



Notes: The arrows denote the flow of price information and the bold lines represent the linkage of the models.

Figure 3.2 Conceptual chart of the model (simplified)

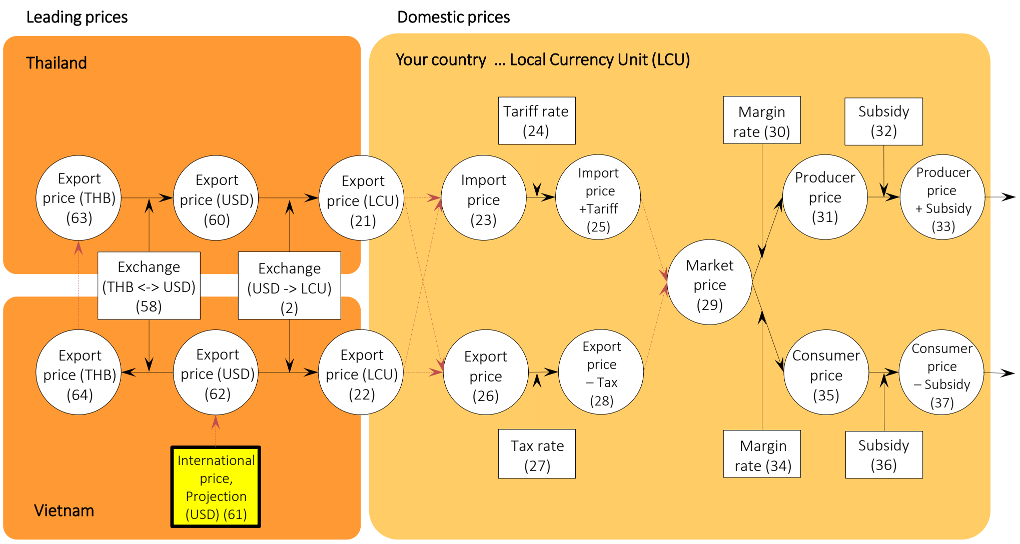


Notes: The squares indicate exogenous variables and the circles are endogenous variables. The red arrows are the links mainly connected by elasticity.

international price and scenarios. The export price of Vietnam projected by OECD-FAO (2015) was used as the international price for the rice model. The international price is transmitted to domestic prices and mainly affects the area and per capita consumption of rice in each country (Figure 3.2). The endogenous variables calculated in the model and exogenous variables from outside of the model, such as yield and population, determine the supply and demand quantities of rice. Finally, the gap between supply and demand, interpreted as the potential of export or import, is estimated.

Figure 3.3 illustrates a more detailed flow of price transmission. Here, the international price given in nominal USD is converted to real local currency unit (LCU) import and export prices. In the case of rice, the export price of Vietnam, used as the international price by OECD-FAO (2015), affects the export price in Thailand. The export prices in the two countries affect trade prices in each country and influence domestic market prices. In the figure, the import tariff and export tax are incorporated into the model. The market price is converted to producer and consumer prices and consequently, affects supply and demand quantities.

Figure 3.3 Conceptual chart of price transmission



Notes: The numbers in parentheses correspond to equation numbers in Table 3.1. The red arrow indicates linkages connected by elasticity. Export price = FOB price. Import price = CIF price. All prices are deflated by the GDP deflator or CPI (see Table 3.1).

As indicated in Figure 3.3 and Appendix A, the margin rates connect producer, market, and consumer prices. The concept of estimating past and future prices are illustrated in Figures 3.4 and 3.5. The past market price can be estimated using the producer price and assumed margin rate. Similarly, producer and consumer prices in the future are estimated using market price and margin rates.

Figure 3.4 Estimating past market price using producer price

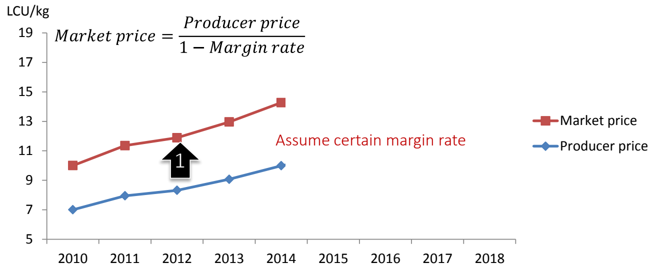
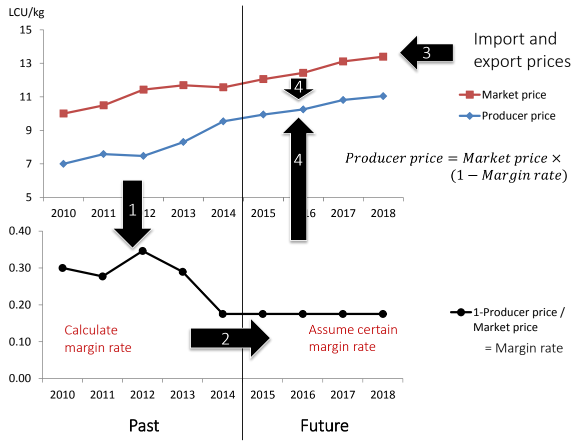


Figure 3.5 Estimating future producer and consumer prices using market price

(a) Future producer price



(b) Future consumer price

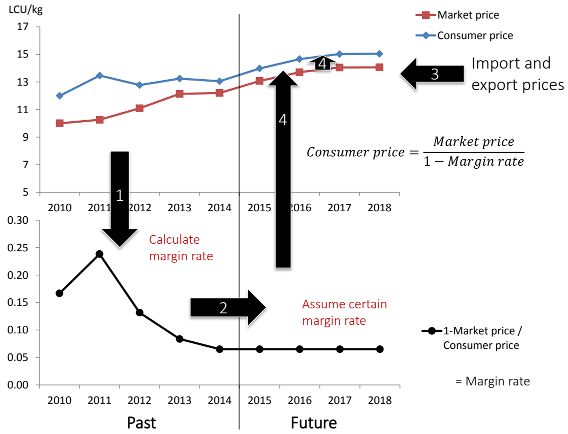


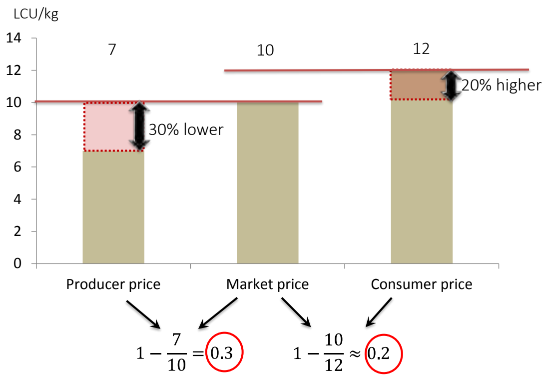
Figure 3.6 shows the concept of margin rates in the model. The margin rates are defined as price gaps in comparison to other prices. In the figure, the margin rate between producer and market prices is 30% and that between market and consumer prices is 20%. The margin between producer and market prices is generalized as

$$1 - \frac{Producer\ price}{Market\ price} = Margin.$$

On the other hand, the margin between market and consumer prices can be written as

$$1 - \frac{Market\ price}{Consumer\ price} = Margin.$$

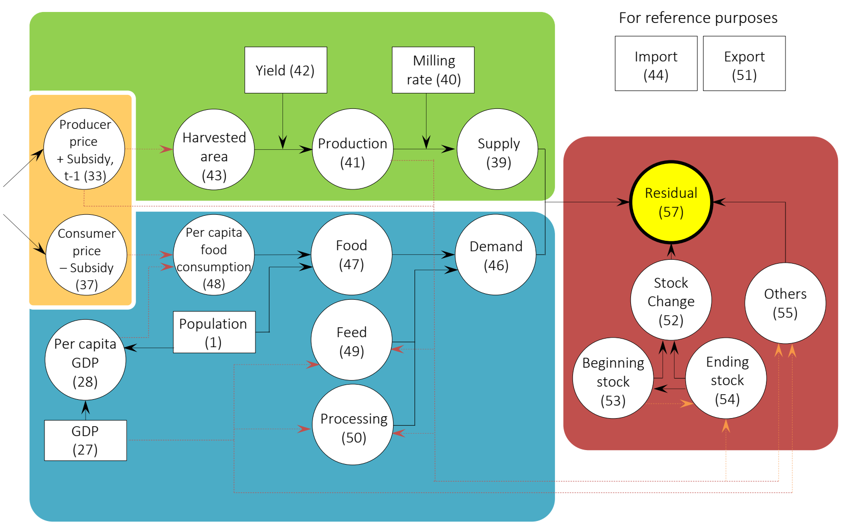
Figure 3.6 Concept of margin rates



Note: The values in the red circles, 0.3 (30%) and 0.2 (20%), are margin rates.

Figure 3.7 shows the FBS in the model. We assumed that the producer price affects the harvested area, consumptions as feed, processing, stock, and other utilizations with a one-year time lag. On the other hand, per capita food consumption is influenced by consumer price and per capita GDP in the same period. Production quantity is calculated by multiplying area by yield. Domestic supply quantity is then the product of production and the milling rate. Rice consumption as food is estimated from the per capita food consumption multiplied by population. Consumption as food, feed, and processing are aggregated to total demand. Stock change and others, including waste, loss, and discrepancy, as demand, which are comparatively unclear, are prepared outside of the demand. These items are influenced by production, beginning stock, and GDP. The residual or potential of export or import is estimated using supply, demand, and stock change and others as demand. Data for import and export quantities are also collected for the expansion of the model in the future.

Figure 3.7 Conceptual chart for the FBS



Notes: All prices and GDP in LCU are deflated by the GDP deflator or CPI. *t – 1* indicates a one-year lag or the previous year's value.

Microsoft Excel is used for the model building. As indicated in Figure 3.8, there are 13 spreadsheets, of which eight (ID, KH, LA, MM, MY, PH, TH, and VN) are the price transmission and FBS in each country. Refer to Appendix B for the expanded forms of the abbreviations used in the model. The sheet named LD represents price relationships in terms of rice in leading countries, Vietnam and Thailand. The equations in each country sheet are similar.

Figure 3.8 Example of spread sheet for the model

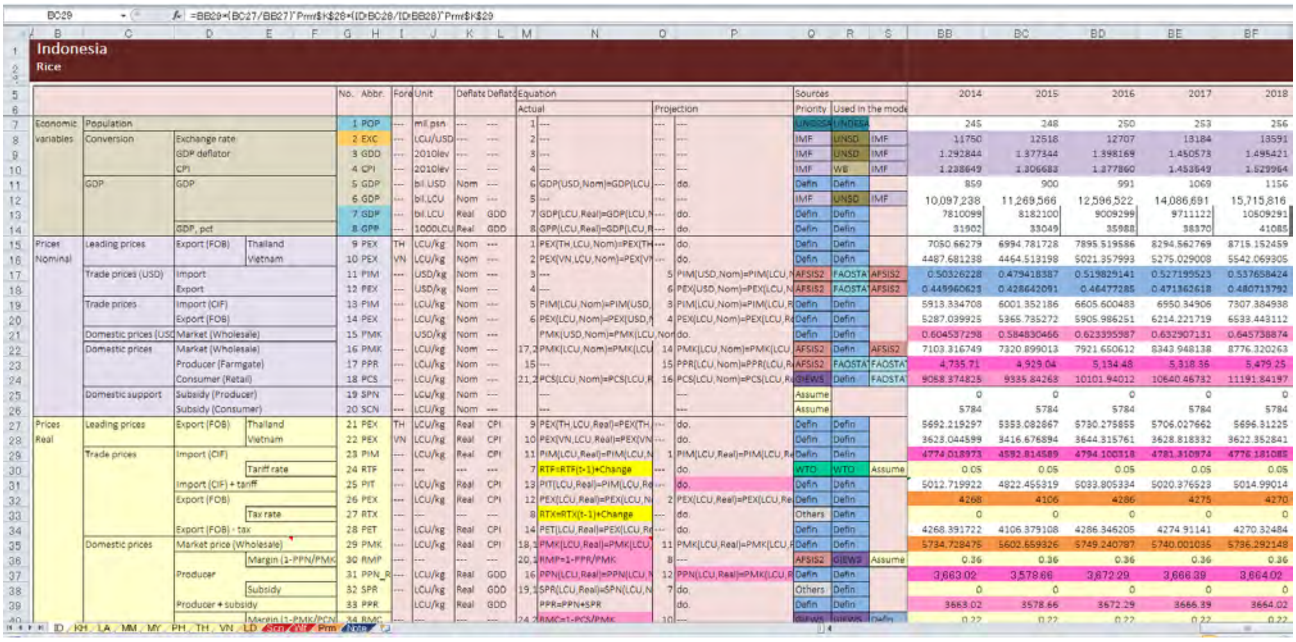


Table 3.1 lists the items and equations in the country and LD sheets. In the table, the items are mainly classified into five categories: economic variables, prices (nominal), prices (real), FBS, and leading prices. The column Foreign in Table 3.1 indicates that the data belong to a specific country in a given cell. The column Deflate indicates whether the values are nominal (Nom) or real (Real). The deflator (3GDD or 4CPI) is also displayed in this column. Each item has two equations, actual and projected, for its values. An actual equation is used to compile the FBS using actual or observed data from the past and projected is used for the future estimation of variables. For example, the actual value of 41QPP, paddy production, is expressed as

QPP = YLD*ARA,

where YLD and ARA are yield and area. The equation indicates that production is the product

Table 3.1 Excel spread sheet for the model (country sheet and leading prices)

					No.	Abbr.	Foreign	Unit	Deflate		Equation Actual
Economic variables	Population				1	POP	---	mil.psn	---	---	---
	Conversion	Exchange rate			2	EXC	---	LCU/USD	---	---	---
		GDP deflator			3	GDD	---	2010lev	---	---	---
		CPI			4	CPI	---	2010lev	---	---	---
	GDP	GDP			5	GDP	---	bil.USD	Nom	---	GDP(USD,Nom)=GDP(LCU,Nom)/EXC(LCU/USD)
					6	GDP	---	bil.LCU	Nom	---	---
					7	GDP	---	bil.LCU	Real	GDD	GDP(LCU,Real)=GDP(LCU,Nom)/GDD
		GDP, pct			8	GPP	---	1000LCU	Real	GDD	GPP(LCU,Real)=GDP(LCU,Real)/POP
Prices Nominal	Leading prices	Export (FOB)	Thailand		9	PEX	TH	LCU/kg	Nom	---	PEX(TH,LCU,Nom)=PEX(TH,USD,Nom)*EXC(LCU/USD)
			Vietnam		10	PEX	VN	LCU/kg	Nom	---	PEX(VN,LCU,Nom)=PEX(VN,USD,Nom)*EXC(LCU/USD)
	Trade prices (USD)	Import			11	PIM	---	USD/kg	Nom	---	---
		Export			12	PEX	---	USD/kg	Nom	---	---
	Trade prices	Import (CIF)			13	PIM	---	LCU/kg	Nom	---	PIM(LCU,Nom)=PIM(USD,Nom)*EXC(LCU/USD)
		Export (FOB)			14	PEX	---	LCU/kg	Nom	---	PEX(LCU,Nom)=PEX(USD,Nom)*EXC(LCU/USD)
	Domestic prices (USD)	Market (Wholesale)			15	PMK		USD/kg	Nom	---	PMK(USD,Nom)=PMK(LCU,Nom)/EXC
	Domestic prices	Market (Wholesale)			16	PMK	---	LCU/kg	Nom	---	PMK(LCU,Nom)=PMK(LCU,Real)*CPI
		Producer (Farmgate)			17	PPN	---	LCU/kg	Nom	---	---
		Consumer (Retail)			18	PCN	---	LCU/kg	Nom	---	PCN(LCU,Nom)=PCN(LCU,Real)*CPI
	Domestic support	Producer Subsidy			19	SPR	---	LCU/kg	Nom	---	---
		Consumer Subsidy			20	SCS	---	LCU/kg	Nom	---	---
Prices Real	Leading prices	Export (FOB)	Thailand		21	PEX	TH	LCU/kg	Real	CPI	PEX(TH,LCU,Real)=PEX(TH,LCU,Nom)/CPI
			Vietnam		22	PEX	VN	LCU/kg	Real	CPI	PEX(VN,LCU,Real)=PEX(VN,LCU,Nom)/CPI
	Trade prices	Import (CIF)			23	PIM	---	LCU/kg	Real	CPI	PIM(LCU,Real)=PIM(LCU,Nom)/CPI
			Tariff rate		24	RTF	---	---	---	---	RTF=RTF(t-1)+Change
		Import (CIF) + tariff			25	PIT	---	LCU/kg	Real	CPI	PIT(LCU,Real)=PIM(LCU,Real)*(1+RTF)
		Export (FOB)			26	PEX	---	LCU/kg	Real	CPI	PEX(LCU,Real)=PEX(LCU,Nom)/CPI
			Tax rate		27	RTX	---	---	---	---	RTX=RTX(t-1)+Change
		Export (FOB) - tax			28	PET	---	LCU/kg	Real	CPI	PET(LCU,Real)=PEX(LCU,Real)/(1+RTX)
	Domestic prices	Market price (Wholesale)			29	PMK	---	LCU/kg	Real	CPI	PMK(LCU,Real)=PPR(LCU,Real)/(1-RMP)
			Margin (1-PPN/PMK)		30	RMP	---	---	---	---	RMP=1-PPR/PMK
		Producer			31	PPN	---	LCU/kg	Real	GDD	PPN(LCU,Real)=PPN(LCU,Nom)/GDD
			Subsidy		32	SPR	---	LCU/kg	Real	GDD	SPR(LCU,Real)=SPR(LCU,Nom)/GDD
		Producer + subsidy			33	PPR		LCU/kg	Real	GDD	PPR=PPN+SPR
			Margin (1-PMK/PCN)		34	RMC	---	---	---	---	RMC=1-PCS/PMK
		Consumer			35	PCN	---	LCU/kg	Real	CPI	PCN(LCU,Real)=PMK(LCU,Real)/(1-RMC)
			Subsidy		36	SCS	---	LCU/kg	Real	CPI	SCS(LCU,Real)=SCS(LCU,Nom)/CPI
		Consumer - subsidy			37	PCS		LCU/kg	Real	CPI	PCS=PCN-SCN
FBS	Supply				38	QSS	---	1000t	---	---	QSS=QPM+IMP
		Production	Milled		39	QPM	---	1000t	---	---	QPM=QPP*RML
			Milling rate		40	RML	---	---	---	---	RML=RML(t-1)+Change
			Paddy		41	QPP	---	1000t	---	---	QPP=YLD*ARA
				Yield	42	YLD	---	t/ha	---	---	---
				Area	43	ARA	---	1000ha	---	---	---
		Imports			44	IMP	---	1000t	---	---	---
	Demand				45	QDD	---	1000t	---	---	QDD=QDU+EXP
		Domestic use			46	QDU	---	1000t	---	---	QDU=QFO+QFE+QPC
			Food		47	QFO	---	1000t	---	---	QFO=QFP*POP
				Food, pct	48	QFP	---	kg/psn/year	---	---	---
			Feed		49	QFE	---	1000t	---	---	---
			Processing		50	QPC	---	1000t	---	---	---
		Exports			51	EXP	---	1000t	---	---	---
	Stock	Stock change			52	SKC	---	1000t	---	---	SKC=SKE-SKB
		(as demand)	Beginning stock		53	SKB	---	1000t	---	---	---
			Ending stock		54	SKE	---	1000t	---	---	---
	Others	(as demand)			55	QOT	---	1000t	---	---	QOT=QSS-QDD-SKC
	SD-gap	Net export (estimated by prices)			56	NEP	---	1000t	---	---	NEP=EXP-IMP
		Export availability (as residual)			57	NER	---	1000t	---	---	NER=QPM-QDU-SKC-QOT
Leading prices	Conversion	Exchange rate	Thailand		58	EXC	TH	THB/USD	---	---	---
		CPI	Thailand		59	CPI	TH	2010lev	---	---	---
	Export prices	Thailand			60	PEX	TH	USD/kg	Nom	---	---
		International, Projection			61	PWD	VN	USD/kg	Nom	---	---
		Vietnam			62	PEX	VN	USD/kg	Nom	---	PEX(VN,USD,Nom)=PWD(VN,USD,Nom)
		Thailand			63	PEX	TH	THB/kg	Real	CPI	PEX(TH,THB,Real)=PEX(TH,USD,Nom)*EXC(THB/USD)/CPI(TH)
		Vietnam			64	PEX	VN	THB/kg	Real	CPI	PEX(VN,THB,Real)=PEX(VN,USD,Nom)*EXC(THB/USD)/CPI(TH)

Table 3.1 (contd.) Excel spread sheet for the model (country sheet and leading prices)

No.	Abbr.		Sources		
		Projected	Priority	Used in the model	
1	POP	---	UNDESA	UNDESA	
2	EXC	---	IMF	IMF	
3	GDD	---	IMF	IMF	
4	CPI	---	IMF	IMF	
5	GDP	do.	Defin	Defin	
6	GDP	---	IMF	IMF	
7	GDP	do.	Defin	Defin	
8	GPP	do.	Defin	Defin	
9	PEX	do.	Defin	Defin	
10	PEX	do.	Defin	Defin	
11	PIM	PIM(USD,Nom)=PIM(LCU,Nom)/EXC(LCU/USD)	AFSIS2	AFSIS Excel	
12	PEX	PEX(USD,Nom)=PEX(LCU,Nom)/EXC(LCU/USD)	AFSIS2	AFSIS Excel	
13	PIM	PIM(LCU,Nom)=PIM(LCU,Real)*CPI	Defin	Defin	
14	PEX	PEX(LCU,Nom)=PEX(LCU,Real)*CPI	Defin	Defin	
15	PMK	do.	Defin	Defin	
16	PMK	do.	AFSIS2	AFSIS Excel	
17	PPN	PPN (LCU,Nom)=[PPR(LCU,Real)-SPR(LCU,Real)]*GDD	AFSIS2	FAOSTAT	
18	PCN	do.	GIEWS	Defin	
19	SPR	---	Assume		
20	SCS	---	Assume		
21	PEX	do.	Defin	Defin	
22	PEX	do.	Defin	Defin	
23	PIM	PIM(LCU,Real)=PIM(LCU,Real,t-1)* [PEX(TH,LCU,Real)/PEX(TH,LCU,Real,t-1)]^Elast * [PEX(VN,LCU,Real)/PEX(VN,LCU,Real,t-1)]^Elast	Defin	Assume	
24	RTF	do.	WTO	WTO	
25	PIT	do.	Defin	Defin	
26	PEX	PEX(LCU,Real)=PEX(LCU,Real,t-1)* [PEX(TH,LCU,Real)/PEX(TH,LCU,Real,t-1)]^Elast * [PEX(VN,LCU,Real)/PEX(VN,LCU,Real,t-1)]^Elast	Defin	Defin	
27	RTX	do.	Others	Assume	
28	PET	do.	Defin	Defin	
29	PMK	PMK(LCU,Real)=PMK(LCU,Real,t-1) * [PIT(LCU,Real)/PIT(LCU,Real,t-1)]^Elast * [PET(LCU,Real)/PET(LCU,Real,t-1)]^Elast	Defin	Defin	
30	RMP	---	AFSIS2	Defin	
31	PPN	PPN(LCU,Real)=PMK(LCU,Real)*(1-RMP)	Defin	Defin	
32	SPR	do.	Others	Defin	
33	PPR	do.	Defin	Defin	
34	RMC	---	GIEWS	Assume	
35	PCN	PCN(LCU,Real)=PMK(LCU,Real)/(1-RMC)	Defin	Defin	
36	SCS	do.	Others	Defin	
37	PCS	do.	Defin	Defin	
38	QSS	do.	Defin	Defin	
39	QPM	do.	AFSIS1	Defin	
40	RML	do.	Defin	AFSIS	Assume
41	QPP	do.	Defin	Defin	
42	YLD	YLD=YLD(t-1)+Change	AFSIS2	AFSIS Excel	
43	ARA	ARA=ARA(t-1) * [PPR(LCU,Real,t-1)/PPR(LCU,Real,t-2)]^Elast * [ARA(t-1)/ARA(t-2)]^Elast	AFSIS2	AFSIS Excel	
44	IMP	IMP=IMP(t-1)	AFSIS1	USDA	
45	QDD	do.	Defin	Defin	
46	QDU	do.	Defin	Defin	
47	QFO	do.	AFSIS1	Defin	
48	QFP	QFP=QFP(t-1)* [PCS(LCU,Real)/PCS(LCU,Real,t-1)]^Elast * [GPP(LCU/Real)/GPP(LCU,Real,t-1)]^Elast * [QFP(t-1)/QFP(t-2)]^Elast	Defin	SO KH	
49	QFE	QFE=QFE(t-1)* [QPP/QPP(t-1)]^Elast * [GDP(LCU,Real)/GDP(LCU,Real,t-1)]^Elast * [PMK(LCU,Real)/PMK(LCU,Real,t-1)]^Elast * [QFE(t-1)/QFE(t-2)]^Elast	AFSIS1	FAOSTAT	
50	QPC	QPC=QPC(t-1)*(QPP/QPP(t-1))^elst* [GDP(LCU,Real)/GDP(LCU,Real,t-1)]^Elast * [PMK(LCU,Real)/PMK(LCU,Real,t-1)]^Elast	FAOSTAT	Assume	
51	EXP	EXP=EXP(t-1)	AFSIS1	USDA	
52	SKC	do.	Defin	Defin	
53	SKB	SKB=SKE(t-1)	AFSIS1	AFSIS Excel	
54	SKE	SKE=SKE(t-1)* [QPR/QPR(t-1)]^Elast * [SKB/SKB(t-1)]^Elast * [SKE(t-1)/SKE(t-2)]^Elast * Exp(1)^Elast	AFSIS1	AFSIS Excel	
55	QOT	QOT=QOT(t-1)* [QPR/QPR(t-1)]^Elast * [GDP(LCU,Real)/GDP(LCU,Real,t-1)]^Elast * [QOB(t-1)/QOB(t-2)]^Elast	Defin	Defin	
56	NEP	do.	Defin	Defin	
57	NER	do.	Defin	Defin	
58	EXC	---	IMF	UNSD	IMF
59	CPI	---	IMF	IMF	
60	PEX	PEX(TH,USD,Nom)=PEX(TH,USD,Real)*CPI(TH)/EXC(THB/USD)	AFSIS2	AFSIS2	Defin
61	PWD	---	AFSIS2	AFSIS2	OECD-FAO
62	PEX	PEX(VN,USD,Nom)=PWD(VN,USD,Nom)*(1+Discrepancy*t)	Assume	Defin	Assume
63	PEX	PEX(TH,THB,Real)=PEX(TH,Real,t-1)* [PEX(VN,Real)/PEX(VN,Real,t-1)]^Elast *(1+Discrepancy*t)	Defin	Defin	Project
64	PEX	do.	Defin	Defin	

Notes: "pct" denotes per capita. The symbol "do." in the projected column indicates that the equation is the same as that written in the actual column. The bar (---) in the equation column denotes that the values are from outside of the model. Data sources for the model are given in the sources column. The symbol "Defin" denotes defined values by equations and "Assume" is assumed values.

Table 3.2 Model parameters

	Explained variable				Unit	Deflator	Explanatory variable	ID	KH	LA	MM	MY	PH	VN	TH
Prices Real	Trade prices	Import price			LCU/kg	CPI	Thailand export price	0.63	0.13	-0.38	2.29	0.74	0.00	-0.08	1.00
							Vietnam export price	0.00	-0.07	0.88	0.00	0.00	1.06	1.99	0.00
		Export price			LCU/kg	CPI	Thailand export price	0.63	0.14		1.41	1.50	6.64	0.17	0.78
							Vietnam export price	0.00	-0.10		0.00	0.00	0.00	1.72	0.00
	Domestic prices	Market price	Farmgate price		LCU/kg	GDD	Export price	0.00	0.44	0.00	0.72	0.00	0.04	0.60	1.58
							Import price	0.60	0.49	0.07	0.00	0.60	0.21	0.00	
		Famgate price					Market price								0.91
FBS	Supply	Production	Paddy	Area	1000t	---	Producer price,t-1	0.04	0.23	0.19	0.12	0.14	0.26	0.26	0.17
	Demand	Domestic use	Food	Food, pct	kg/person/year	---	Consumer price	-0.07	0.02	-0.10	-0.10	-0.38	-0.30	-0.10	
							Wholesale price								0.21
							GDP,pct	-0.04	-0.08	0.05	-0.19	-0.24	0.05		0.09
							Food,pct,t-1	-0.04					0.00		0.00
			Feed		1000t	---	Production (QPP)	0.72	1.32	0.88	0.75	0.19	-0.47	0.50	0.88
							GDP	0.11	-0.26	0.31	0.25	0.16	0.64	0.30	-0.07
							Market price	-0.04	0.39	-0.01	0.20	0.00	0.00	0.00	
							Wholesale price								0.00
							Feed,t-1	1.00		0.00					0.00
			Processing		1000t	---	Production	0.52	4.47	0.18	0.00	1.00	-0.35		1.34
							GDP	0.10	-3.99	0.11	0.00	0.00	1.46	1.00	0.00
							Market price	0.00	-0.43	-0.04		0.00			0.00
			Others		1000t	---	Production	1.89	-0.50	1.00	2.25	0.50	1.46	-0.50	-0.50
							GDP	0.09	0.00	0.00	-0.07	0.00	0.00	0.00	0.00
							Others,t-1						0.00		0.00
	Stock	Ending stock			1000t	---	Production	0.98	0.62	9.05	0.16	0.00	0.00		1.11
							BegStock	0.50	1.08	-0.40	0.57	0.81	0.01		0.00
							Time trend		0.00						0.00
							Yield							5.24	
Leading prices	Export price	Thailand			USD/kg	---	Vietnam export price								1.05

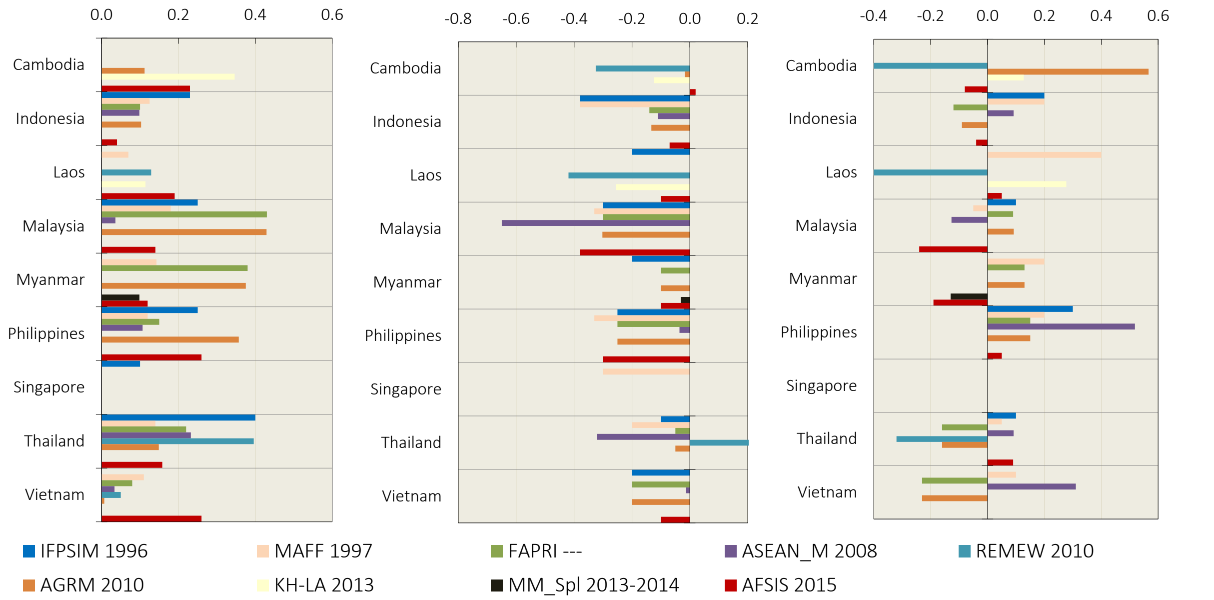
Notes: “pct” denotes per capita. Several parameters indicated by the gray cells, which could cause extreme results in the simulation, were substituted by presumed parameters.

Figure 3.9 Elasticity of rice in selected models

(a) Price (t − 1) elasticity of harvested area

(b) Price (t − 1) elasticity of per capita food use

(c) Income or per capita GDP elasticity of per capita food use



Notes: Several parameters were adjusted or arranged for comparison.

Sources: IFPSIM 1996 (Oga and Yanagishima 1996), ASEAN_M 2008 (Ohga et al. 2008), REMEW-Mekong 2010 (Furuya et al. 2010), MAFF 1997 (Inoue et al. 1997), AGRM 2010 (Wailes and Chavez 2011), KH-LA 2013 (estimated by the author in 2013), MM_Spl 2013-2014 (estimated by author in 2014), FAPRI (FAPRI), and AFSIS 2015 (estimated by the AFSIS project trainees)

of yield and area. The cell for production in 2000 is populated by

=AN48*AN49.

Another example is the projected value of 43ARA, area. The following equation is in the projected column:

ARA=ARA(t-1)*[PPR(LCU,Real,t-1)/PPR(LCU,REAL,t-2)]^Elast,

where PPR denotes producer price and Elast represents the elasticity or parameter for the projection estimated using a regression analysis. LCU represents the value expressed in local currency unit, real is the real or deflated value, and t-1 and t-2 denote one- and two-year lagged data. The meaning of the equation is the same as

$$ARA_t = ARA_{t-1} \cdot \left(\frac{PPR_{t-1}}{PPR_{t-2}}\right)^{Elast}.$$

The area cell for 2019 is populated by

=BF49*(BF39/BE39)^Prm!K7.

Table B.3 in Appendix B shows the major data sources used in the model corresponding to the symbols in Figure 3.1. The data provided by AFSIS were prioritized in the project.

Table 3.2 indicates the parameters (Elast) for the projection equations, all of which were estimated using double-log form regression models. The red arrows in Figures 3.3 and 3.7 represent linkages connected by parameters. For example, 0.63 in the first row of the ID column indicates that a 1% rise in the export price of rice from Thailand leads to a 0.63% rise in the import price in Indonesia. The parameters were mainly estimated by the project participants as an exercise. Although Adj. R^2, p-value, and DW obtained in this project were not necessarily good, the parameters were a result of trial and error to find appropriate explanatory variables, including dummy variables, and the data period for the estimation. Figure 3.9 shows that an extremely high or low parameter is not used in the model for AFSIS. To utilize the model, further validation of the parameter is necessary.

3.2 Expanding the rice model to other commodity models

The rice model can be expanded to other commodity models using a simple procedure. Fundamentally, another commodity model can be created by copying and pasting the sheets for rice in Excel. The linked cells are then replaced using Excel's replacement function.

Several other modifications to the structure are also required. First, the leading price of rice is replaced by that of another commodity. The projected international price of the other commodity can be obtained from sources such as OECD-FAO (2015) or the World Bank (2015). Second, the FBS for the rice is adjusted. The milling rate and paddy production rows for rice are omitted and instead, the FBS for processed goods are added (Figure 3.10). The production quantity of the processed goods are mainly estimated using the consumption quantity for processing multiplied by fixed processing rates (Figure 3.11):

$$QPR_{Sec} = QPC_{Prm} \cdot Processing\,rate,$$

where *QPR* denotes production, *QPC* is consumption for processing, subscript *Sec* denotes secondary product, and *Prm* is primary products. Tertiary products, such as refined sugar from raw sugar, can be estimated using

$$QPR_{Ter} = QPC_{Sec} \cdot Processing\,rate,$$

where subscript *Ter* denotes a tertiary product. Byproducts such as soymeal from soyoil can be estimated using

$$QPR_{Sec} = QPC_{Prm} \cdot (1 - Processing\,rate).$$

Figure 3.12 indicates the major flows of processing for secondary and tertiary products of rice and candidates for another commodity, for example, soybean, maize, sugarcane, and cassava.

Figure 3.10 FBS for rice and other commodity models

FBS for rice FBS for another commodity Additional FBS for processed goods

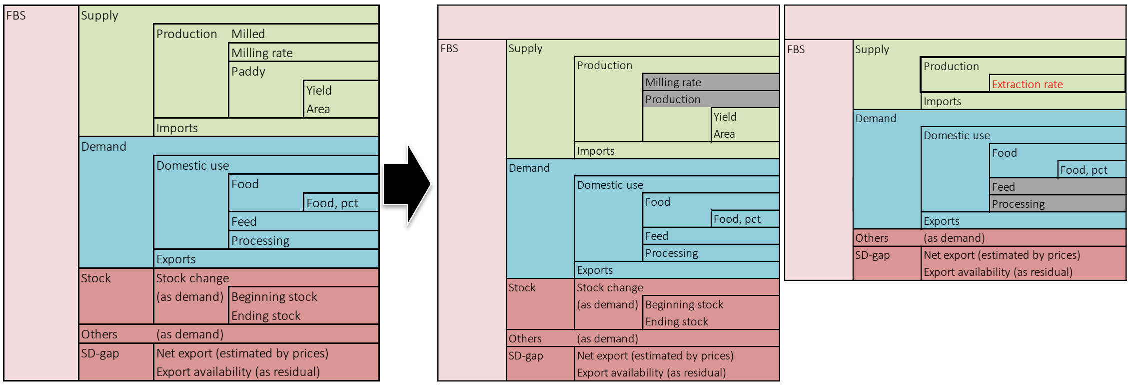


Figure 3.11 Conceptual chart of FBS for another commodity

Primary products Processed goods

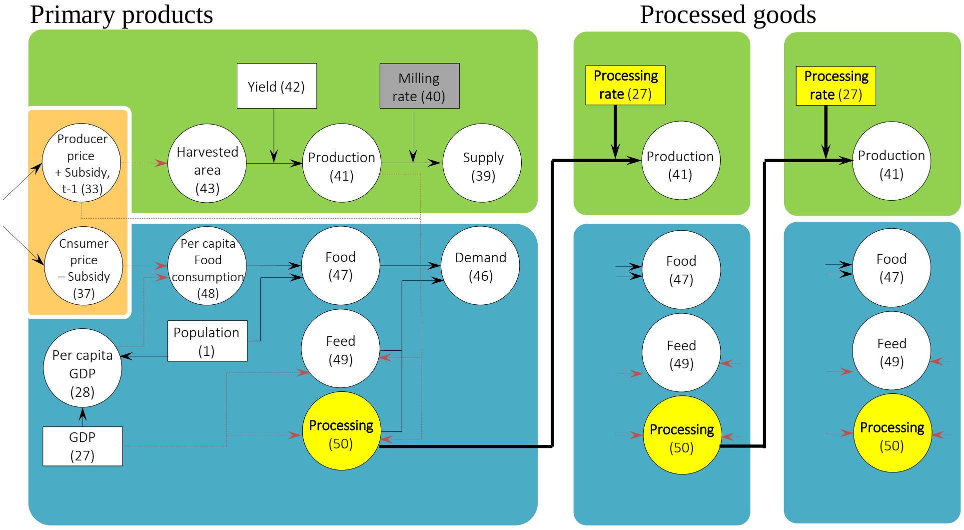
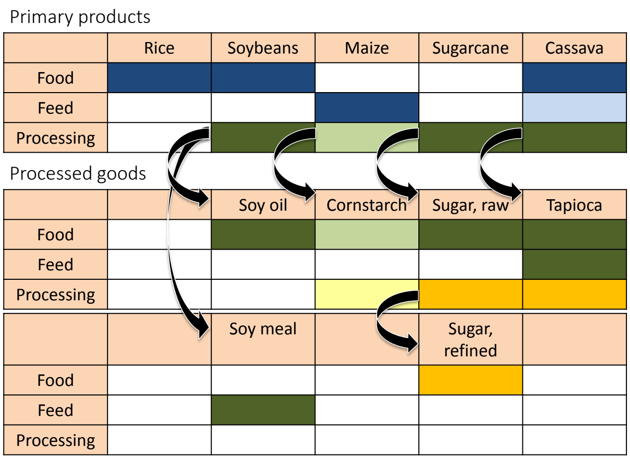


Figure 3.12 Consumption of processed goods



Note: The colored cells indicate major consumption channels.

The mutual interaction of multiple commodities can be incorporated into the model using cross elasticity. The competitive commodities against a major commodity should be attentively selected. The parameter for maize area in the projection model is estimated using a double-log model:

$$\log ARA_{m,t} = \mathrm{a} + \mathrm{b} \cdot \log PPR_{m,t-1},$$

where *ARA* denotes harvested area, *PPR* is the producer price, subscript *m* denotes maize, and *t* is year. The parameter b is the own-price elasticity of the maize area. Here, we assume that the maize production competes with sugarcane production and the maize area is also affected by sugarcane price. Thus, another parameter representing the mutual interaction is estimated using

$$\log ARA_{m,t} = \mathrm{a} + \mathrm{b} \cdot \log PPR_{m,t-1} + \mathrm{c} \cdot \log PPR_{s,t-1},$$

where subscript *s* denotes sugarcane. The parameter c is called the cross-price elasticity of the maize area. The sign condition of c is negative because we assumed that the sugarcane is a competitive maize crop. In other words, if the sugarcane price increases by 1%, maize area by decreases c%. The equation for the projection of maize area in the Excel sheet can be written as

ARAm=ARAm(t-1)*[PPRm(LCU,Real,t-1)/PPRm(LCU,REAL,t-2)]^Elast*[PPRs(LCU,Real,t-1)/PPRs(LCU,REAL,t-2)]^Elast,

where Elast represents the parameters for the projection, namely b and c in the previous equation. LCU is the value expressed in a local currency unit and Real is the real or deflated value. The equation is the same as

$$ARA_{m,t} = ARA_{m,t-1} \cdot \left(\frac{PPR_{m,t-1}}{PPR_{m,t-2}}\right)^{\mathrm{b}} \cdot \left(\frac{PPR_{s,t-1}}{PPR_{s,t-2}}\right)^{\mathrm{c}}.$$

In addition to area, per capita consumption can be projected using the prices of multiple commodities.

3.3 Incorporating scenarios into the model

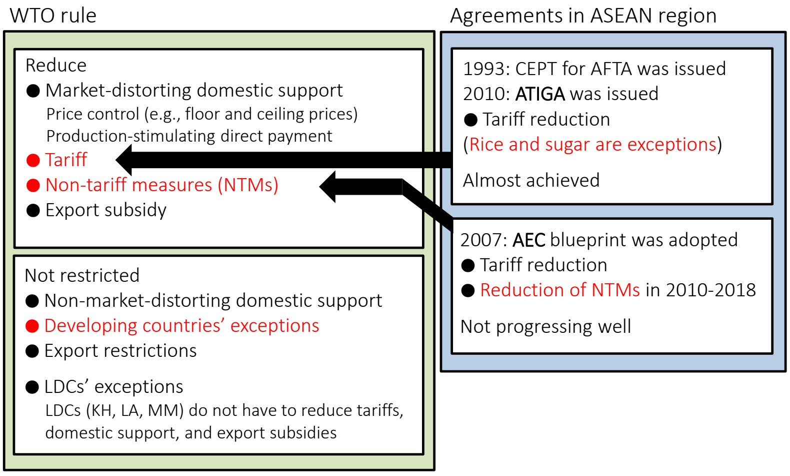
A model comprises policy variables used for a simulation analysis, such as tariff rate,

export tax rate, and producer and consumer subsidies. These variables are added to related prices such as import, export, producer, and consumer prices. A more realistic simulation can be performed when the model structure is modified for a specific purpose. Basic information on the actual policies and several ideas to amend the model structure are described in the following sections.

3.3.1 Basic information

First, information on possible interventions in a market was collected. Tariff and non-tariff measures (NTMs) are suppressed under the WTO rule (Figure 3.13). In the ASEAN Free Trade Area (AFTA), the tariff rate was reduced with the issuance of the Common Effective Preferential Tariff (CEPT) in 1993 and the ASEAN Trade in Goods and Agreement (ATIGA) in 2010. The tariff rates on many commodities have been reduced on the basis of these agreements. However, rice and sugar are exceptions to the hasty tariff reductions. Table 3.3 shows the tariff rates of ATIGA and MFN under the WTO rule on milled rice. In addition to the tariff, there have been attempts to reduce NTMs since 2007, when the ASEAN economic community (AEC) blueprint was adopted. Although ASEAN summarized NTMs as a non-tariff measures database, following the classification of UNCTAD, the entire picture of NTMs remains difficult to grasp (Table 3.4). One of the major NTMs is the control of trade quantity. According to WTO's secretariat reports, a certain quantity of rice trade, stock, and circulation in the domestic market is controlled by state-owned enterprises or governmental institutions; such as Perusahaan Umum Badan Urusan Logistik (Perum BULOG) in Indonesia, the National Rice Reserves Supervisory Committee (NRRSC) in Myanmar, the

Figure 3.13 Trade agreements in the ASEAN region



Notes: CEPT: Common Effective Preferential Tariff; AFTA: ASEAN Free Trade Area; ATIGA: ASEAN Trade in Goods Agreement; AEC: ASEAN Economic Community.

Table 3.3 ATIGA and MFN tariffs on milled rice (%)

	ATIGA	MFN tariff
Brunei	0	0
Cambodia	5	7
Indonesia	25	30
Laos	5	5
Malaysia	20	40
Myanmar	5	5
Philippines (In-Quota)	35	35
Philippines (Out-Quota)	35	50
Singapore	0	0
Thailand	0	52
Viet Nam	5	40

Notes: The figures denote tariff under ATIGA in 2015, and the average of accessible data of most favored nation (MFN) tariff for 2009–2013.
Sources: ATIGA (ASEANa, 2012), MFN (WTOa)

Table 3.4 NTMs on rice applied in ASEAN countries

	Type of NTM
1400	Tariff quota duties
5100	Automatic licensing
6100	Non-automatic licensing
6300	Prohibitions
6700	Enterprise-specific restrictions
7100	Single channel for imports
8100	Technical regulations
6370	Prohibition for sensitive product categories
7110	State trading administration
8110	Product characteristics requirements
8150	Testing, inspection, and quarantine requirements

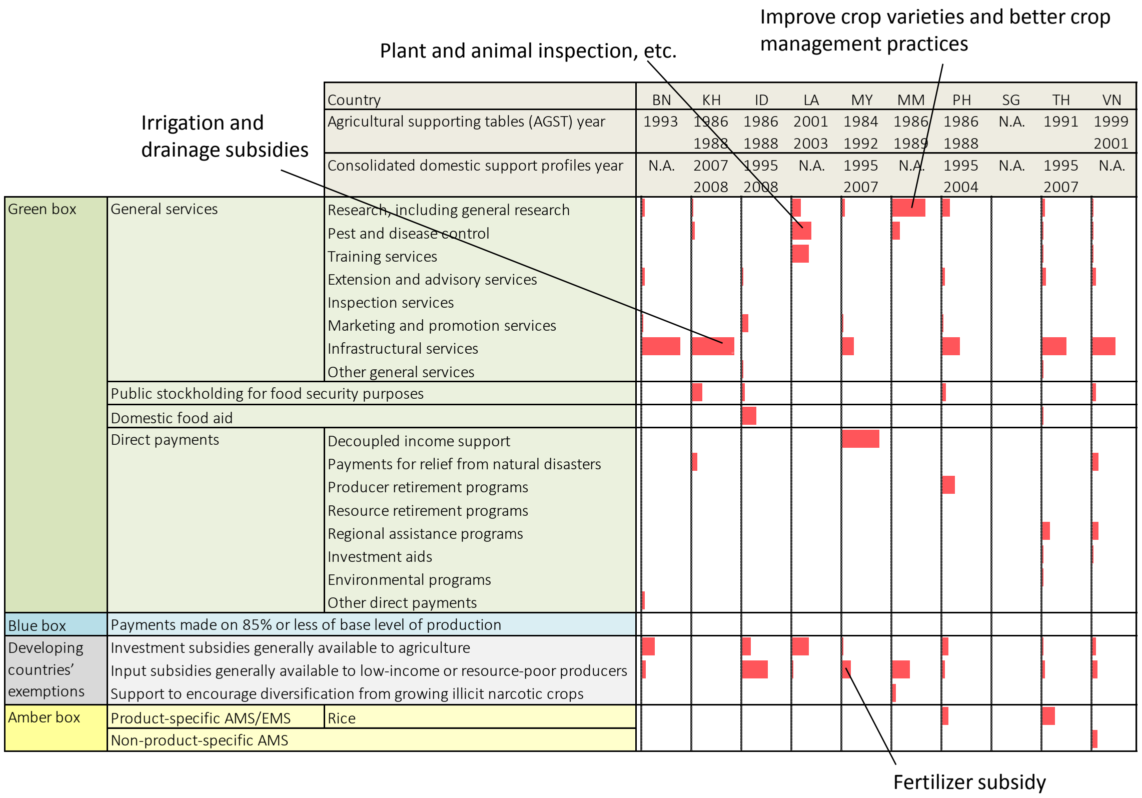
Source: ASEANb

Green Trade Company (GTC) in Cambodia, Padiberas Nasional Berhad (BERNAS) in Malaysia, the National Food Authority (NFA) in the Philippines, the Vietnam Northern Food Corporation (Vinafood 1) and the Vietnam Southern Food Corporation (Vinafood 2) in Vietnam, and the Supply and State Stores Department (SSSD) in Brunei. On the other hand, export restrictions such as the export ban of rice by Vietnam, Cambodia, and Indonesia around 2008 are not clearly limited.

WTO restricts trade-distorting domestic support such as price control and production-stimulating direct payments, except in least developed countries such as Cambodia, Laos, and Myanmar in the ASEAN region (Figure 3.14). These domestic supports fall in the amber box. A typical non-exempt direct payment that can distort trade is the rice mortgage scheme in Thailand. On the other hand, subsidies in the green and blue box and developing countries' exemptions are not limited. Although subsidies in the green box are defined as non-trade-distorting or non-production-stimulating policies, some of them including irrigation and drainage subsidies as an infrastructural service, public stockholding, and domestic food aid seem to affect the market. Developing countries' exemptions used in many ASEAN countries such as fertilizer subsidies for low-income farmers in Malaysia also

stimulate production. In addition to direct payment, price control including the floor and ceiling price for rice were confirmed in the WTO's secretariat reports (WTOd). For the purpose of the project, these policies were summarized for each country to prepare simulation scenarios (Table 3.5).

Figure 3.14 Proportion of domestic support amount (value) in each country



Notes: The red bar indicates the proportion of domestic support in each column. The green box includes subsidies that do not distort the trade (allowed without limits). The blue box comprises subsidies with a limitation on production (allowed without limits). The amber box consists of trade-distorting subsidies, including price support and direct payments stimulating production (limited).

Sources: WTOb, WTOc

Table 3.5 Price control on rice

	Floor for farmgate price	Ceiling for consumer price
Cambodia		
Indonesia	✓	15.7 trillion IDR to subsidize 3.41 million t of rice to 17.5 million households (2012)
Laos		
Malaysia	0.75MYR/kg (2014)	✓
Myanmar	✓	
Philippines	17PHP/kg (2012)	25PHP/kg (wholesale), 27PHP/kg (retail) (2012)
Thailand		
Vietnam	✓	

Notes: The checks in the cell indicate the confirmed existence of a scheme, although concrete prices are not indicated in data sources. The rice mortgage scheme of Thailand was abolished in 2014.
Sources: WTOd, Indonesia (ILO)

Table 3.6 Example of rice policies in Indonesia

Policy	Type	Description	Mechanism	Legality Number
Market price support	Domestic price support : intervention purcases	Government purchases of farmgate paddy (HPP)	Government sets the price of government purchases of farmgate paddy (HPP)	Presidential instruction No. 3/2012
			If the market price of paddy is below goverment price purchase (HPP), the government through logistics institution (BULOG) should purchase from farmers	
	Import measure	Import tariff	Import tarrif of rice is Rp 450/kg is imposed to protect the high rice imports as a result of import prices lower than domestic prices	Tariff, ATIGA dan Tariff, MFN Revision of PMK-1993/PMK-011/2007
		Import control	If domestic price is 10% higher than normal price, Perum BULOG import rice	-
Direct payments	Payments based on variable input use	Seed subsidy	Seed and fertilizer subsidies given directly to farmers through the distric/city agriculture department	Regulation No. 23 Year 2013 Regulation of the Ministry of Agriculture No. 122/Ministry of Agriculture Regulation/SR.130/11/2013
		Fertilizer subsidy		
Consumer subsidy	Domestic food aid	Government distribute cheap rice to the poor household	Provision and distribution of cheap rice by logistics institution (BULOG)	Regulation of the Ministry of Finance No.125/PMK.02/2010

Source: The framework of the table is provided by N. Kuga. The table is created by workshop participants, T. H. Astuti and B. Waryanto.

3.3.2 Trade measures

Certain tariff or export tax rates can be inserted into the corresponding Excel sheet cells to estimate the effects on the domestic market. The effects of trading partners within and outside of the ASEAN region, where ATIGA is applied instead of the MFN tariff rate, can be also understood in a simple manner; the value of the average tariff rate for the model is given by

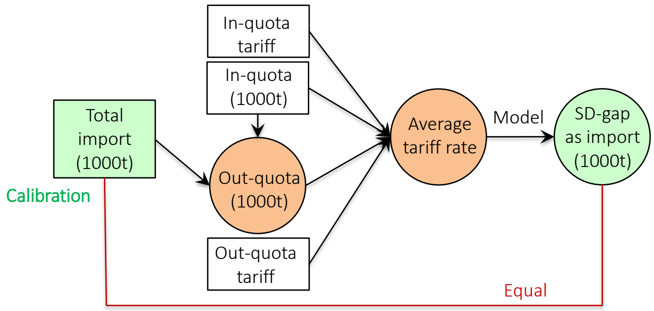
$$RTF_{ave} = \frac{IMP_{in} \cdot RTF_{in} + IMP_{out} \cdot RTF_{out}}{IMP_{in} + IMP_{out}}, \qquad (3.1)$$

where *RTF* is the tariff rate, *IMP* is import quantity, subscript *ave* is an average, *in* is inside of ASEAN, and *out* is outside of ASEAN. RTF_{in} indicates the tariff rate under ATIGA and RTF_{out} denotes the MFN tariff rate.

A typical NTM in ASEAN countries is import quantity control by state-owned enterprises, although the rule differs by country. In Indonesia, the state-owned enterprise imports rice when its consumer price is 10% higher than the normal price. The import quantity triggered by the prices can be estimated using the consumer and normal price substituted by the average of the past prices. Another well-known NTM is the import quota of rice, which has been applied in the Philippines. The quantity of the out-quota can be estimated by calibration (Figure 3.15). First, total import, in-quota, and in- and out-quota tariffs are exogenously given. Then, out-quota is calculated by subtracting in-quota from total import. These values are used to estimate the average tariff rate given by equation (3.1); subscripts *in* and *out* are reinterpreted as in- and out-quota. Under the given average tariff rate, the model

returns the supply–demand gap that can be interpreted as net import. To equate the supply–demand gap and total import initially given, the latter value is calibrated or gradually changed.

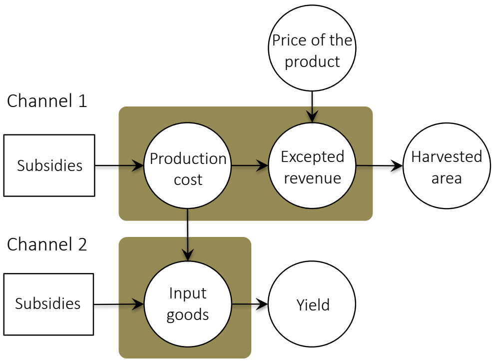
Figure 3.15 Calibration of project out-quota



3.3.3 Direct payment

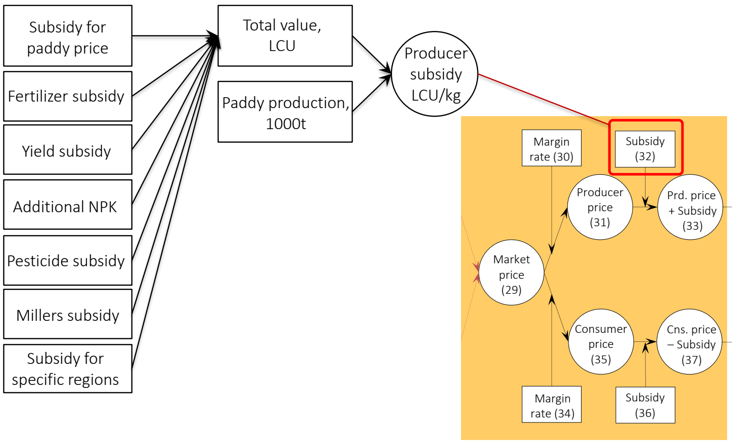
A major direct payment including subsidies for fertilizer, pesticides, seeds, high yielding seeds, and millers influences production through various channels; two of them are illustrated in Figure 3.16. The subsidy expands the harvested area through a decrease in the production cost and increase in expected revenue. The expected revenue per unit production can be estimated by subtracting cost from the producer price. The relationship between the expected revenue and area estimated using the regression analysis can be useful in estimating the effect of subsidies on the area. Another channel of subsidies to production is an increase or improvement in input goods. If certain parameters between the subsidies and yield are obtained through the regression analysis, the future yield, given as an exogenous trend in the model, can be substituted by the projected value on the basis of exogenous subsidies. However, the time series data of subsidies, which could possibly affect the production cost

Figure 3.16 Channels of direct payments to area and yield



Note: Data for the variables in the beige squares were not collected for this project.

Figure 3.17 Alternative approach to measuring effects of subsidy on area

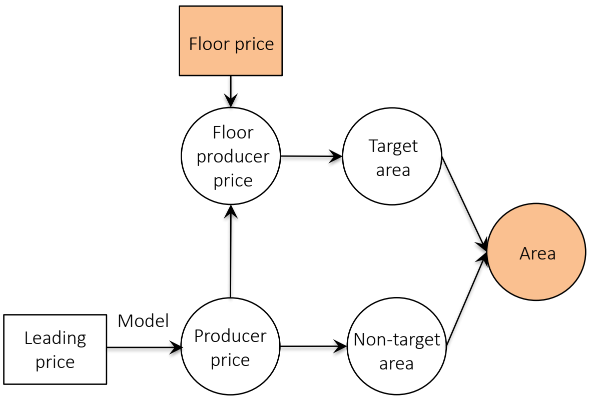


and yield, were not collected in this project. Thus, alternatively, the total amount of direct payments divided by production was assumed as a proxy representing Channel 1 in Figure 3.16 (Figure 3.17).

3.3.4 Price control

Price control including floor and ceiling price is restricted by the WTO rule. However, Cambodia, Laos, and Myanmar are exceptions to this rule and other countries can implement these measures in the framework of food aid, the amber box, etc. The model can be used to measure the effect of floor price (Figure 3.18). First, the target and non-target areas of floor price are exogenously assumed. When the exogenous floor price, a lower limit of the producer price, is higher than the producer price given in the model, the floor price is a substitute for the producer price. The future value of the target area is estimated using the

Figure 3.18 Estimation of area under floor price



floor producer price and that of the non-target area is decided by the normal producer price. Different yields can be applied to different areas, although Figure 3.18 assumes the same yield.

The price ceiling is implemented as food aid for a specific stratum in several countries such as Indonesia and the Philippines. Food aid can be a possible policy measure to ease malnutrition, which gains attention in Laos and Cambodia. To estimate the effect of ceiling price, which is similar to floor price, target and non-target populations are exogenously given (Figure 3.19). Then, a certain value for the per capita consumption of the target people is assumed. Total consumption as food can be calculated using

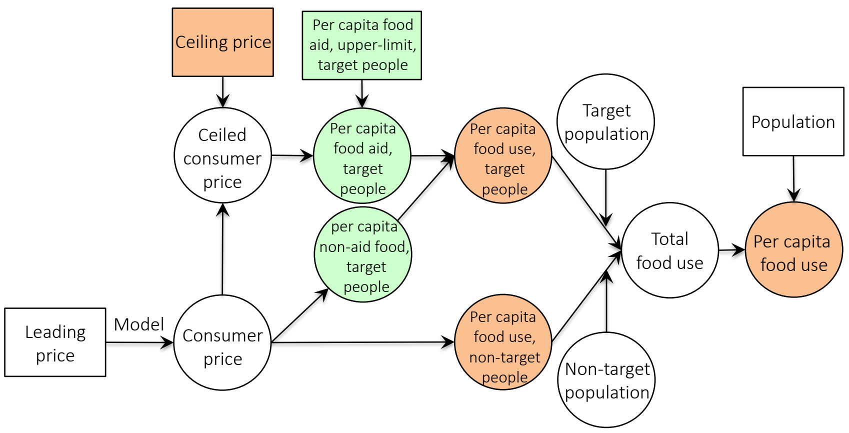
$$QFO = QFP_{tgt} \cdot POP_{tgt} + QFP_{non} \cdot POP_{non}, \qquad (3.2)$$

where *QFO* is the total quantity for food use, *QFP* is per capita food use, *POP* is population, subscripts *tgt* is target people, and *non* is non-target people. Thus, the per capita consumption of non-target people can be estimated using

$$QFP_{non} = \frac{QFO - QFP_{tgt} \cdot POP_{tgt}}{POP_{non}}.$$

A part of the per capita consumption by the target people is assumed to be provided with the exogenous ceiling price or the upper limit of the consumer price calculated in the model. The quantity of the per capita food aid for the target people is estimated with the ceiled consumer price and the other consumptions of target and non-target people are decided using the normal consumer price. The total amount of food use is calculated using equation (3.2). Finally, the average per capita consumption is estimated using total food use divided by total population.

Figure 3.19 Estimation of food consumption using ceiling price



3.4 Additional functions of welfare analysis

An Excel VBA program was prepared for a comparative static analysis using the model. The program can draw each country’s supply and demand curves and estimate equilibrium price, equilibrium quantity, and surplus in a specific year.

To draw supply and demand curves, the lowest producer price and highest consumer price are first assumed. The lowest producer price means that the price at which all producers stop production and the highest consumer price is the price at which all consumer including industries and the government stop consumption. The lower and higher limits of the market price are calculated on the basis of these prices. The supply and demand quantities are calculated by the model using a number of the given market prices under the assumption that all other exogenous values are fixed (*ceteris paribus*) (Table 3.7). The supply and demand curves are drawn using these data (Figure 3.20). On the other hand, the market price estimated by import and export prices in the model is drawn as a reference line of price. The intersection points of the reference price line with supply and demand curves correspond to the supply and demand quantities (Figure 3.20(a)). The difference between supply and demand quantities is the same as the supply–demand gap calculated using the model.

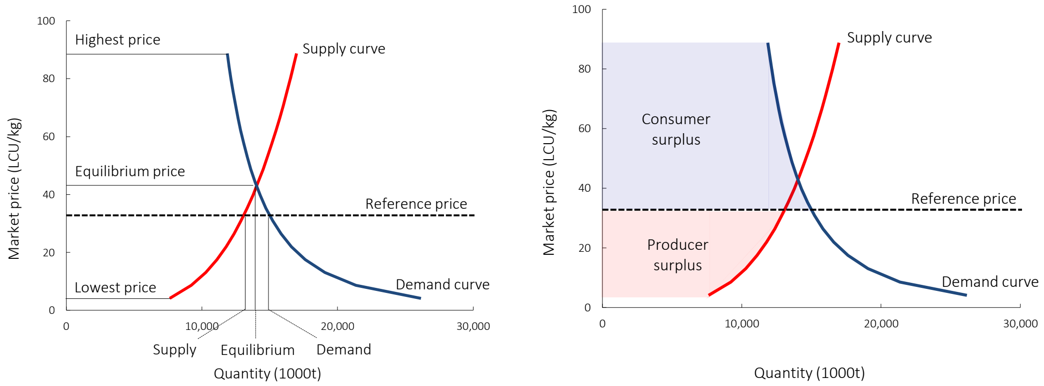
Table 3.7 Data used to draw supply and demand curves

Price	Supply	Demand
4	7,621	26,155
9	9,221	21,349
13	10,284	19,059
⋮	⋮	⋮
⋮	⋮	⋮
80	16,512	12,147
84	16,748	12,004
89	16,975	11,870

Note: The table shows supply and demand quantities estimated by the model when the market prices are sequentially given from 4 (lower limit) to 89 (upper limit).

Figure 3.20 Supply and demand curves and surpluses

(a) Price and quantity (b) Surplus



The intersection of the supply and demand curves is the equilibrium point indicating price and quantity when the country neither exports nor imports. The equilibrium price is

given such that the supply–demand gap equals zero. In this model, the equilibrium price is estimated by a convergence calculation using the goal seek function of the what-if analysis in Excel.

The surplus is estimated on the basis of the supply and demand curves. The producer and consumer surpluses represent the sum of individual producer and consumer benefits. For example, a producer (farmer) who can sell rice for USD 0.5/kg can earn a profit of USD 0.2/kg if he/she sells the rice for USD 0.7/kg. Similarly, a consumer who buys rice for USD 1/kg will earn a profit of USD 0.3/kg if he/she bought it for USD 0.7/kg . The sum of all producer and consumer benefits is the producer and consumer surplus. These surpluses are illustrated in Figure 3.20(b) as areas below and above the reference price line to the left of the supply and demand curves. The area is calculated using the composite Simpson's rule in the model.

4 Interpretation and utilization of results

4.1 Comparison of each country's simulation results

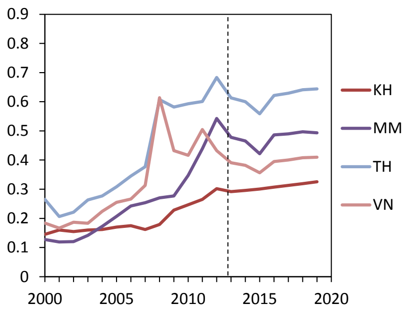
The major outputs of the rice models in each country are summarized in Figure 4.1. All prices expressed as nominal USD/kg show a gradual increasing trend. The supply–demand gap as export availability or import potential notably increases in Vietnam and decreases in Indonesia, Malaysia, and Philippines until 2019.

The supply and demand quantities are affected by the given price in the non-equilibrium model in this study. On the other hand, the international and domestic prices do not reflect changes in supply and demand, which can be adjusted using the partial equilibrium model. In other words, the projected prices (Figure 4.1) are consistent only when all of the projected supply–demand gaps are exported/imported or segregated from the domestic market.

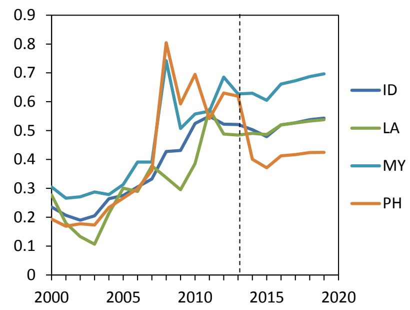
The leading price of rice, or the export price in Vietnam, affects all the countries' supply and demand in this model. According to OECD-FAO's baseline projection, the

Figure 4.1 Major outputs of the model

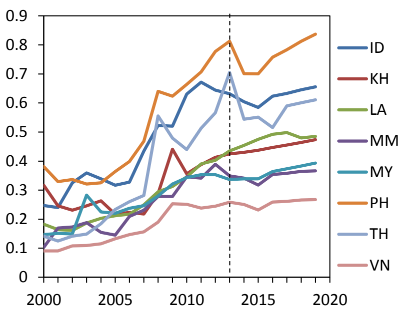
(a) Export price (USD/kg, nominal)



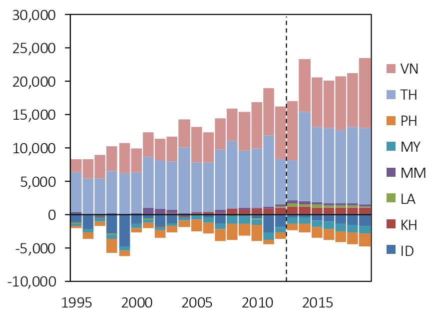
(b) Import price (USD/kg, nominal)



(c) Market price (USD/kg, nominal)



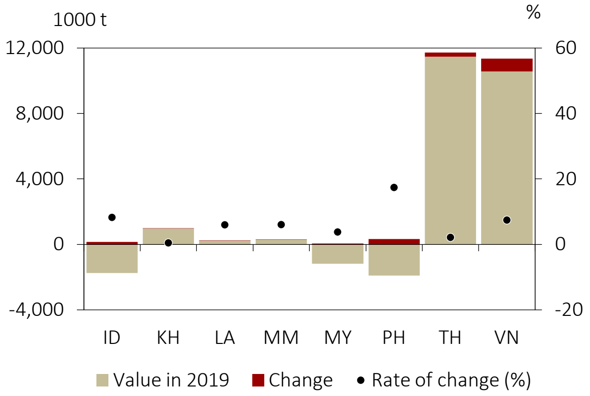
(d) SD-gap as export availability (1000 t)



Note: The base projection year is 2012 and differs by country.

international price ranges from USD 0.39/kg in 2013 to USD 0.41/kg in 2019. Figure 4.2 shows the effect of a 5% annual increase in the nominal leading price of rice from 2017 to 2019. Under this scenario, the leading price USD 0.46/kg in 2019 is 12% higher than the original value. The result shows an increase in supply compared to the demand in all countries. The increased quantity and its rate of the export availability is the largest in Vietnam and the Philippines, respectively.

Figure 4.2 Supply–demand gap under different international prices in 2019

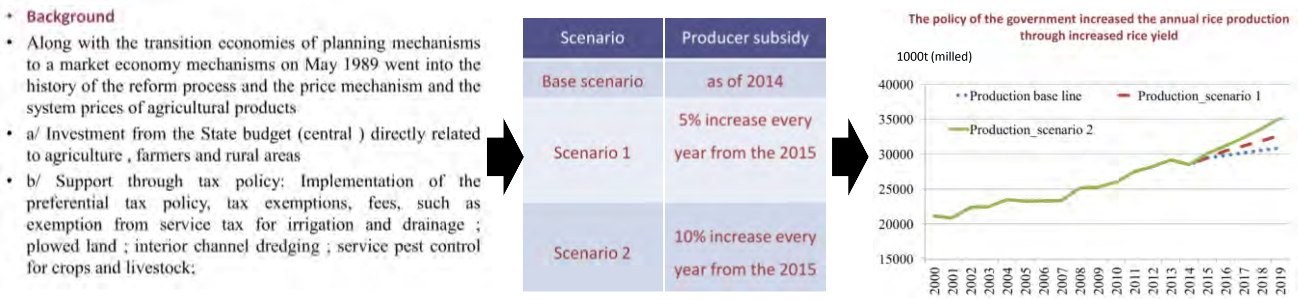


Notes: Values in 2019 indicate the supply–demand gap under the international price projected by OECD-FAO (2015). The change indicates a change in the supply–demand gap from the result of the baseline by a 5% annual increase in the international price from 2017 to 2019. The dots indicate the rate of change in the supply–demand gap from the baseline to the scenario.

4.2 Interpretation of each country's simulation results

The workshop participants from each country assumed scenarios on the basis of qualitative information and accordingly, performed projections (Figure 4.3). Summaries of these projections can be downloaded from the AFSIS website. This section presents examples on how to interpret simulation results.

Figure 4.3 Example of simulation by project participants (rice policy simulation in Vietnam)



Source: Workshop participants V. T. H. Thuy and N. L. Anh.

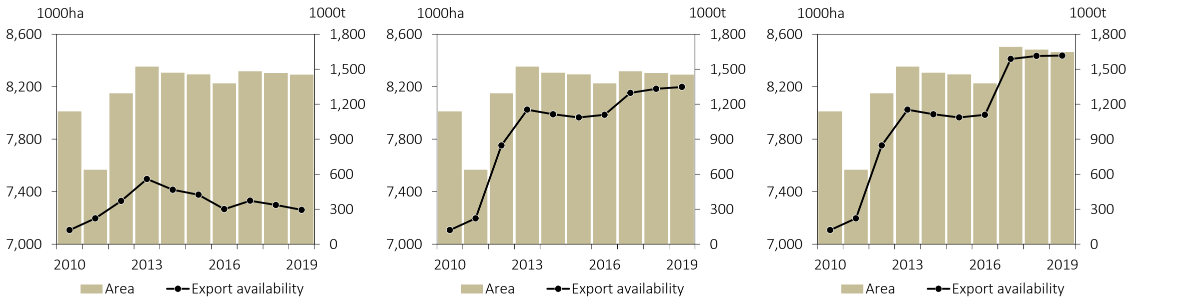
4.2.1 Projection of rice supply–demand in Myanmar

Parameters in Myanmar's rice model were estimated using data for the period 1998–2011, for which price data are available. The projection period of each variable depends on data availability but is mainly from 2012 to 2019. The exogenous variables, such as population, exchange rate, GDP deflator, and CPI, in the projection period were obtained from UNDESA and IMF, among other bodies listed in Table 3.1. The future value of rice yield was assumed as 2.55 t/ha because the yield from 2004 to 2011 hovers around this level.

According to the simulation result, the nominal producer price Kyat 200/kg in 2010 rises to Kyat 320/kg in 2019 because of the flat international price (USD/kg) and the increasing trend of the exchange rate (Kyat/USD) in the future. The real producer price in 2019 was projected at a level similar to that in 2010, since the CPI rises from 1.0 in 2010 to 1.6 in 2019. Consequently, the harvested area and production were stable from around 2013 to 2019 (Figure 4.4(a)).

Figure 4.4 Projected value of area and supply–demand gap as export availability in Myanmar

(a) Baseline (b) Fixed feed consumption (c) Fixed feed consumption + price rise



Notes: Fixed feed consumption denotes that the feed consumption value is fixed at the 2010 level. The figure (c) shows a 20% rise in producer price.

On the other hand, the domestic demand for rice shows an increasing trend. The per capita consumption of rice as food decreases according to the rice in the per capita real GDP and its negative elasticity (–0.19). A decline in the annual per capita consumption from 140 kg/person in 2010 to 130 kg/person in 2019 is consistent with the past trend, descending from 170 kg/person in the mid-1990s and 160 kg/person in 2000. Although the exogenous population increases, the total consumption of rice as food stands at around 7.3 million ton for 2010–2019.

The increase in domestic demand is mainly caused by rice consumption as feed, which increases from 4.0 million ton in 2010 to 4.9 million ton in 2019. However, the feed consumption, as interpreted by the workshop participants, is the subtracted value of the net export and consumption as food from production. This value contains unobservable values including loss, waste, underestimation of the net export, and overestimation of production. If

the feed consumption or sum of unobservable values is fixed at the 2010 level, the projected supply–demand gap, which originally reduces to 0.3 million ton, reaches 1.3 million ton in 2019 (Figure 4.4(b)).

As of 2015, the political condition in Myanmar is drastically changing. The nominal producer price of rice was estimated to be Kyat 290/kg in 2016. What if the price increases by 20% (Kyat 58/kg) in 2016 under the fixed feed consumption scenario? In this case, first, the area and the supply–demand gap would rapidly increase in 2017 (Figure 4.4(c)). Thereafter, area would gradually decline and the supply–demand gap would roughly hover along the original trend. This implies the necessity for a strong continuous incentive for production to enhance export in Myanmar.

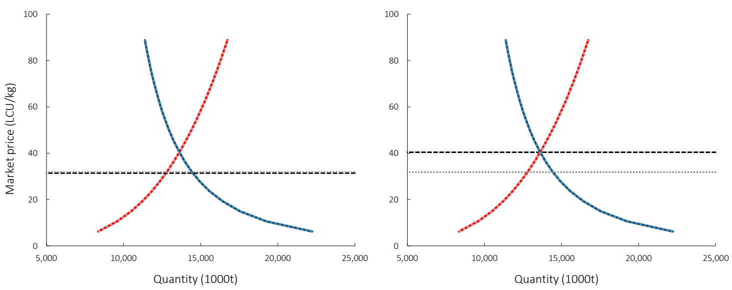
4.2.2 Welfare analysis of rice supply–demand in the Philippines

Parameters in the Philippines' rice model were estimated using data for 1987–2011. The projection period of each value is from around 2012 to 2019. It was assumed that the yield of 3.9 t/ha in 2013 reaches 4.3 t/ha in 2019 on the basis of the growth rate of past two decades (1.6%). To conduct a welfare analysis for 2016–2017, the lower and upper limits of the nominal market prices, Peso 6/kg and Peso 89/kg, in 2016 were estimated from those of the producer and market price, Peso 3/kg and Peso 100/kg. The lower and higher limits of producer and consumer prices were assumed by referring to the projected producer and consumer prices, Peso 16/kg and Peso 36/kg, for 2016.

Figure 4.5(a) shows the supply and demand curves, surpluses, and equilibrium quantity and price in 2017. The market (reference) price of rice estimated from export and

Figure 4.5 Results of welfare analysis for the Philippines' rice sector (baseline)

(a) Baseline (b) Import restriction



		Supply	Demand	Equilibrium
Quantity	1000t	12,746	14,490	13,618
Market price	LCU/kg (Nom)	31	31	40
Surplus	LCU (Nom) in billion	276	807	
Market price	USD/kg (Nom)	0.75	0.75	0.97
Surplus	LCU (Nom) in billion	6.60	19.31	

Supply	Demand	Equilibrium
13,618	13,618	13,618
40	40	40
395	703	
0.97	0.97	0.97
9.45	16.83	

Notes: The figure presents the simulation results for 2017. The red line is the supply curve and the blue line is the demand curve. The black line denotes the reference price. The small dotted lines indicate the result of the baseline simulation. Nom is nominal value.

import prices, expressed as the horizontal dotted line, is Peso 31/kg. Producers facing this price produce 12.7 million ton of rice, while consumers including factories and the government consume 14.5 million ton. The supply–demand gap or shortage of 1.7 million ton indicates possible import quantity.

The producer surplus is estimated at Peso 280 billion (USD 7 billion). This value expresses the total benefit of farmers who can sell rice at a lower price than the producer price determined by the market price (Peso 31/kg). Similarly, the consumer surplus Peso 800 billion, or USD 19 billion, shows the total benefit of consumers who can buy rice at a higher price than the consumer price. The per capita benefit of a rice producer and family members can be estimated at USD 460/person (=Peso 6.6 billion/14 million person) and that of consumers is USD 180/person (=USD 19 billion/105 million person); the number of producer and family members was estimated at 11.5 million person in 2004 (PANAP 2009) multiplied by the population growth rate for 2004–2017 (1.25).

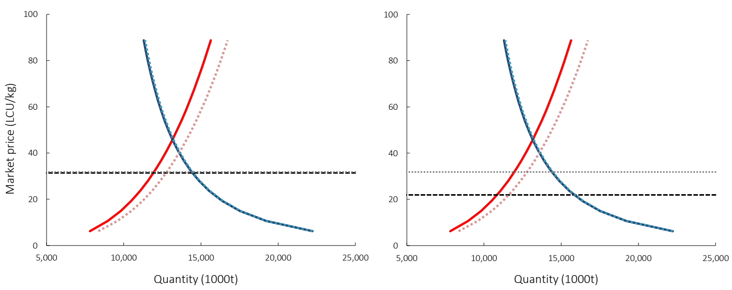
The intersection of the supply and demand curves indicates the equilibrium quantity and price when the Philippines does not import rice. The equilibrium quantity (13.6 million ton) and equilibrium price (Peso 40/kg) can be read from the X and Y axes of the figure. In other words, when the Philippines does not import deficit rice from the international market, the market price increases from Peso 31/kg to Peso 40/kg and the supply and demand quantities balances at 13.6 million ton. In this case, producer surplus increases by 43% (USD 200/person) and consumer surplus decreases by 13% (USD 20/person) in comparison to the baseline result (Figure 4.5(b)).

A crop failure could occur in the Philippines, for example, the rice yield fell by 8% in 1998 and by 5% in 2009. Figure 4.6 shows the result of a 5% decrease in the rice yield for 2017. The supply curve shifts to the left-hand side and the supply quantity decreases to 11.9 million ton from 12.7 million ton (Figure 4.6(a)). If the Philippines does not import rice, the

Figure 4.6 Results of welfare analysis for Philippines' rice sector (crop failure scenario)

(a) Crop failure + 2.5 million ton import

(b) Crop failure + 5.0 million ton import



		Supply	Demand	Equilibrium
Quantity	1000t	11,913	14,442	13,154
Market price	LCU/kg (Nom)	31	31	46
Surplus	LCU (Nom) in billion	258	809	
Market price	USD/kg (Nom)	0.75	0.75	1.10
Surplus	LCU (Nom) in billion	6.17	19.35	

Supply	Demand	Equilibrium
10,840	15,840	13,154
22	22	46
149	915	
0.52	0.52	1.10
3.57	21.88	

market price increases to Peso 46/kg, and the supply and demand quantity decreases by 9% in comparison to the baseline result. When the deficit quantity of 2.5 million ton is imported and the domestic demand is fulfilled, the producer surplus reduces by 7% (USD 30/person) and the consumer surplus is stagnant around the original level. The import quantity can increase if the international price is lower than the initial assumption. When 5.0 million ton of rice is imported and released to the domestic market, the market price falls to Peso 22/kg and the producer surplus reduces by 46% (USD 210/person) while consumer surplus increases by 13% (USD 30/person; Figure 4.6(b)).

4.3 Utilization of the food supply–demand model

4.3.1 Issues before utilizing the model for the AFSIS project

The parameters shown in Table 3.2 have room for improvement. The reliability of the parameters used in the model will increase with longer and more consistent data series and efforts to find more suitable explanatory variables and/or data period for the regression analysis. The suitable explanatory variables can be found from candidates including dummy variables, time trend, and variables with other lags (t or $t - 1$); for example, t year’s price could be more suitable than $t - 1$ year’s price to explain t year’s area. These efforts will allow the model to meet the minimum requirements for practical use.

More advanced econometric or statistical methods can bring about more persuasive parameters. The spurious regression, which can be perceived by a significantly low DW and high Adj. R^2, can be rigorously detected by the stationarity tests of data series and residuals (Briand and Carter 2011; pp. 294–309). Tests to determine when a structural change has occurred, such as the Chow test, will help decide the period of the dummy variables or data period for the regression analysis. A robust regression, which can overcome a bias caused by outliers in data, can be a substitute for the effort to apply dummy variables. A simultaneous estimation can be more effective in decreasing the prediction error in the simultaneous equation model, including the food supply–demand model, than the OLS for individual equations, although the simultaneous estimation is subject to its own limitations (Briand and Carter 2011; pp. 278–293).

4.3.2 Usefulness of the projection model

A high Adj. R^2 or low p-value for a regression model does not necessarily ensure high forecast performance. The forecasted value is inaccurate when the reliability of future exogenous variables, such as population, GDP, inflation, exchange rate, and crop yield, is low. The forecasting of economic variables including GDP, inflation, and exchange rate is a

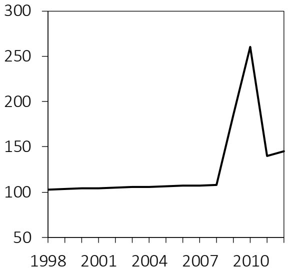
challenging issue. The medium-long-term model explained in this paper is a projection model that requires scenarios as a necessary antecedent, as opposed to forecasting models such as weather forecasts. The projection model can provide information on the medium-long-term trend of supply and demand in specific contexts. It can be said that the projection model serves its function when the projected results lead to the consideration of the possible opportunities or problems and the formulation of strategies to cope with these issues.

Figure 4.7 shows a comparison of projected and observed cereal price indexes. The projected value was obtained using a partial equilibrium model under the scenario of a 15% decrease in global crop yield over two successive years. The result suggests a value that is more than double the international crop price, even though the market can ease the extreme change in price through the supply–demand adjustment (Figure 4.7(a)). In reality, the crop price rapidly increased in 2007 and 2008 and was affected by several factors, including a decrease in crop yield caused by bad weather (Figure 4.7(b)). The projected value implies that the model, at least, can draw a seemingly reasonable trajectory on the basis of the scenario. To improve the persuasiveness of the result, further consideration of scenarios such as an increase in the international oil price or export ban on crops and strategies to cope with those issues will be required.

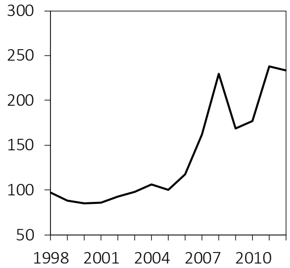
The structure of the model (Figures 3.3 and 3.7) should be well considered and changed as necessary. For example, production cost can be added as an explanatory variable to estimate the elasticity of the harvested area. The area can be divided into irrigated and non-irrigated areas and projected by different elasticities. To analyze the effects of the investment on yield, the yield should be endogenously projected in the model. For a detailed food consumption analysis, cross-price elasticity of consumption should be estimated. The structure and scenario of recent food supply–demand models targeting ASEAN countries (Table 4.1) will help improve the model explained in this paper and deepen the knowledge of medium-long-term projection.

Figure 4.7 Projected and observed cereal price index

(a) Projected value (Ohga 1998)



(b) Observed value (FAO 2014)



Notes: Cereal price index (nominal) in a global crop failure scenario simulated for 1998.
Sources: Ohga (1998), FAO (2014)

Table 4.1 Food supply–demand models

World models including ASEAN countries

OECD-FAO	AGLINK-COSIMO model	http://www.agri-outlook.org/database
		http://www.agri-outlook.org/abouttheoutlook
USDA	PEATSim model	http://www.ers.usda.gov/data-products/international-baseline-data.aspx
		http://www.ers.usda.gov/publications/tb-technical-bulletin/tb1933.aspx
IFPRI	IMPACT model	http://www.ifpri.org/program/impact-model
Arkansas University	AGRM	http://www.adb.org/publications/asean-and-global-rice-situation-and-outlook
		http://purl.umn.edu/102650
IRRI, FAPRI	Modified IGRM	http://www.sciencedirect.com/science/article/pii/S0306919215000871

Models targeting ASEAN countries

FAO-RAP, PRIMAFF	ASEAN model	http://www.maff.go.jp/primaff/koho/seika/project/20130331/sekai_shokuryo.html
		http://www.maff.go.jp/primaff/koho/seika/project/20130331/pdf/jukyu24-5secu.pdf
JIRCAS	REMEW-Mekong	http://www.jircas.affrc.go.jp/english/publication/working/WR68_index.html

References

AFSIS, http://www.afsisnc.org (Last accessed: Dec. 17, 2015).

ASEANa, 2012, Annex 2 (Tariff Schedules), http://www.asean.org/news/item/annex-2-tariff-schedules (Last accessed: Dec. 17, 2015).

ASEANb, Non-Tariff Measures Database, http://www.asean.org/communities/asean-economic-community/item/non-tariff-measures-database (Last accessed: Dec. 17, 2015).

Briand, G. and Carter, R. H., 2011, Using Excel for Principles of Econometrics, 4th edition, Wiley.

FAO, 2014, FAO Food Price Index, http://www.fao.org/worldfoodsituation/foodpricesindex/en (Last accessed: Dec. 17, 2015).

Food and Agricultural Policy Research Institute (FAPRI), Iowa State University, Ames, Iowa, http://www.fapri.iastate.edu (Last accessed: Dec. 17, 2015).

Furuya, J., Meyer, S., Kageyama, M., and Jin, S., 2010, Development of Supply and Demand Models of Rice in Lower Mekong River Basin Countries: REMEW-Mekong, JIRCAS Working Report, 68.

ILO, Social Security Department, 5.1.Raskin: Rice Subsidy for the Poor (Overview of schemes), http://www.ilo.org/dyn/ilossi/ssimain.viewScheme?p_lang=en&p_geoaid=360&p_scheme_id=3153 (Last accessed: Dec. 17, 2015).

Inoue, S., Nagasawa, J., and Nakagawa, M., 2000, World grain supply and demand model, Quarterly Journal of Agricultural Economics, 54 (3), 1–53 [in Japanese].

OECD-FAO, 2015, OECD-FAO Agricultural Outlook, 2015-2024 edition, http://www.agri-outlook.org (Last accessed: Dec. 17, 2015).

Oga, K., and Yanagishima, K., 1996, IFPSIM: International Food and Agricultural Policy Simulation Model (User’s guide), JIRCAS.

Ohga, K., 1998, JIRCAS ed., Projection for World Food Supply and Demand for 2020, Rural Culture Association [in Japanese].

Ohga, K., Isvilanonda, S., Furuhashi, G., and Sirisupluxana, P., 2008, FAO Project for Food and agriculture market projection model development, FAO Project Report, GCP/INT/895/JPN.

Pesticide Action Network Asia and the Pacific (PANAP), 2009, Rice Country Profile for Philippines, http://archive.panap.net/en/r/post/rice/280 (Last accessed: Dec. 17, 2015).

Wailes, E. J., and Chavez, E. C., 2011, 2011 Updated Arkansas Global Rice Model, Staff papers, Department of Agricultural Economics and Agribusiness, University of Arkansas, http://purl.umn.edu/102650 (Last accessed: Dec. 17, 2015).

WTOa, Tariff Download Facility, http://tariffdata.wto.org/Default.aspx?culture=en-US (Last accessed: Dec. 17, 2015).

WTOb, Consolidated Domestic Support Profiles, Agriculture Information Management System, http://agims.wto.org/Pages/Reports.aspx?ReportType=4 (Last accessed: Dec. 17, 2015).

WTOc, Agriculture Negotiations: Background Fact Sheet, https://www.wto.org/english/tratop_e/agric_e/agboxes_e.htm (Last accessed: Dec. 17, 2015).

WTOd, Secretariat Reports, Each Country, https://www.wto.org/english/tratop_e/tpr_e/tp_rep_e.htm (Last accessed: Dec. 17, 2015).

World Bank, 2015, Commodity Markets Outlook, A World Bank Quarterly Report, Q4, http://www.worldbank.org/en/research/commodity-markets (Last accessed: Dec. 17, 2015).

Appendix A. Supplemental explanation of price linkages

The relationships among prices in Figure 3.3 are more complicated than the FBS. To compensate for lacking data, a flexible approach is needed for model building. Tables A.1–A.4 indicate procedures on how to set equations for price linkage. The numbers and symbols in the figures corresponding to those in Table 3.1 are explained in Table B.2.

Table A.1 Setting trade prices

■ First, relationships among **nominal prices** are considered. Export prices of Thailand and Vietnam (USD) are converted to LCU (1) 9 PEX(TH,LCU,Nom) = PEX(TH,USD,Nom)*EXC(LCU/USD) (2) 10 PEX(VN,LCU,Nom) = PEX(VN,USD,Nom)*EXC(LCU/USD) Trade prices (USD) in your country are prepared (3) 11 PIM(USD,Nom) = Actual data = Import value (USD)/Import quantity (kg) (4) 12 PEX(USD,Nom) = Actual data = Export value (USD)/Export quantity (kg) Then, convert USD to LCU (5) 13 PIM(LCU,Nom) = PIM(USD,Nom)*EXC(LCU/USD) (6) 14 PEX(LCU,Nom) = PEX(USD,Nom)*EXC(LCU/USD)
■ **Tariff and export tax rates** are assumed at a certain level (7) 24 RTF = Actual data from WTO (8) 27 RTX = Actual data
■ Nominal prices are converted to **real prices** using CPI (9) 21 PEX(TH,LCU,Real) = PEX(TH,LCU,Nom)/CPI (10) 22 PEX(VN,LCU,Real) = PEX(VN,LCU,Nom)/CPI (11) 23 PIM(LCU,Real) = PIM(LCU,Nom)/CPI (12) 26 PEX(LCU,Real) = PEX(LCU,Nom)/CPI
■ Import price + tariff and export price + tax are calculated as follows: (13) 25 PIT(LCU,Real) = PIM(LCU,Real)*(1+RTF) (14) 28 PET(LCU,Real) = PEX(LCU,Real)/(1+RTX)

Table A.2 Setting domestic prices

■ We need a farmgate price (producer price), wholesale price (market price), and retail price (consumer price). If one or two of them are unavailable, we can estimate those variables using the following procedures. The farmgate price should be available on the FAOSTAT website.
■ When the **farmgate price (producer price)** is available,

<table>
<tr><td colspan="2">(1) 17 PPN(LCU,Nom) = Actual data
(2) 31 PPN(LCU, Real) = PPN(LCU,Nom)/GDD
■ Assume <u>producer subsidy</u>
(3) 19 SPR (LCU,Nom) = Assumed value
(4) 32 SPR (LCU,Real) = SPR(LCU,Nom)/GDD
■ Estimate subsidized producer price
(5) 33 PPR (LCU,Real) = PPN(LCU, Real) + SPR(LCU,Nom)

■ Is the <u>wholesale price (market price)</u> available?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>■ Use the wholesale price as the market price
(6) 16 PMK(LCU,Nom) = Actual data
(7) 29 PMK(LCU,Real) = PMK(LCU,Nom)/CPI

■ Conduct a backward estimation of <u>margin rate</u> using
$$Margin\ rate = 1 - \frac{Producer\ price}{Market\ price}$$
(8) 30 RMP =1–PPN(LCU, Real) / PMK(LCU,Real)</td><td>■Get <u>wholesale price</u> from GIEWS, if available
■Assume fixed <u>margin rate</u> for all periods using
$$Margin\ rate = 1 - \frac{Producer\ price}{Market\ price}$$
(6) 30 RMP = Assumed value

■ Conduct a backward estimation of <u>wholesale price</u> assuming subsidy and margin rates
(7) 29 PMK(LCU,Real) = PPN(LCU,Real)/(1 –RMP)
(8) 16 PMK(LCU,Nom) = PMK(LCU,Real)*CPI</td></tr>
<tr><td colspan="2">■ Assume <u>consumer subsidy</u>
(9) 20 SCS(LCU,Nom) = Assumed value
(10) 36 SCS(LCU,Real)= SCS(LCU,Nom)/CPI

■ Is the <u>retail price (consumer price)</u> available?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td>■ Use retail price as the consumer price
(11) 18 PCN(LCU,Nom) = Actual data
(12) 35 PCN(LCU,Real) = PCN(LCU,Nom)/CPI

■ Estimate subsidized consumer price
(13) 37 PCS(LCU,Real) = PCN(LCU,Real)
– SCS(LCU,Real)

■ Conduct a backward estimation of <u>margin rate</u> using</td><td>■Get <u>retail price</u> from GIEWS, if available
■Assume fixed <u>margin rate</u> for all periods using
$$1 - \frac{Market\ price}{Consumer\ price} = Margin$$
(11) 34 RMC = Assumed value

■ Conduct backward estimation of <u>retail price</u> using assumed subsidy and margin rates.
(12) 35 PCN(LCU,Real) = PMK(LCU,Real)/(1–RMC)
(13) 18 PCN(LCU,Nom) = PCN(LCU,Real)*CPI</td></tr>
</table>

$$1 - \frac{Market\ price}{Consumer\ price} = Margin$$ (14) 34 RMC =1–PMK(LCU, Real) / PCN(LCU,Real)	■ Estimate subsidized consumer price (14) 37 PCS(LCU,Real) = PCN(LCU,Real) – SCS(LCU,Real)

Table A.3 Setting trade prices for the projection

■ First, the **real trade prices** are estimated using the export prices of Thailand and Vietnam. Elast represents elasticity indicated in Figure 11. (1) 23 PIM(LCU,Real) = PIM(LCU,Real,t-1)* [PEX(TH,LCU,Real)/PEX(TH,LCU,Real,t-1)]^Elast *[PEX(VN,LCU,Real)/PEX(VN,LCU,Real,t-1)]^Elast (2) 26 PEX(LCU,Real) = PEX(LCU,Real,t-1)* [PEX(TH,LCU,Real)/PEX(TH,LCU,Real,t-1)]^Elast *[PEX(VN,LCU,Real)/PEX(VN,LCU,Real,t-1)]^Elast
■ **Nominal trade prices** are calculated using real prices and CPI (3) 13 PIM(LCU,Nom) = PIM(LCU,Real)*CPI (4) 14 PEX(LCU,Nom) = PEX(LCU,Real)*CPI
■ **Trade prices (USD)** are converted from nominal trade prices and exchange rate (5) 11 PIM(USD,Nom) = PIM(LCU,Nom)/EXC(LCU/USD) (6) 12 PEX(USD,Nom) = PEX(LCU,Nom)/EXC(LCU/USD)

Table A.4 Setting domestic prices for the projection

■ **Subsidy and margin rates** for a producer and consumer are exogenously given (1) 19 SPR (LCU,Nom) = Assumed value (2) 20 SCS(LCU,Nom) = Assumed value (3) 32 SPR (LCU,Real) = SPR(LCU,Nom)/GDD (4) 36 SCS(LCU,Real)= SCS(LCU,Nom)/CPI (5) 30 RMP = Assumed value (6) 34 RMC = Assumed value
■ **Real prices** are decided first. Projected prices begin with the **market price (real)**. Market price is estimated using trade prices and elasticities. (7) 29 PMK(LCU,Real) = PMK(LCU,Real,t-1) * [PIT(LCU,Real)/PIT(LCU,Real,t-1)]^Elast * [PET(LCU,Real)/PET(LCU,Real,t-1)]^Elast
■ The market price affects **producer and consumer prices** (8) 31 PPN(LCU,Real) = PMK(LCU,Real)*(1 –RMP) (9) 35 PCN(LCU,Real) = PMK(LCU,Real)/(1–RMC)

■ **Subsidized prices** are estimated using producer and consumer prices and subsidies

(10) 33 PPR(LCU,Real) = PPN(LCU,Real)+ SPR (LCU,Real)

(11) 37 PCS(LCU,Real) = PCN(LCU,Real) – SCS(LCU,Real)

■ **Nominal prices** are calculated using real prices and deflators

(12) 16 PMK(LCU,Nom) = PMK(LCU,Real)*CPI

(13) 17 PPN(LCU,Nom) = PPN(LCU,Real)*GDD

(14) 18 PCN(LCU,Nom) = PCN(LCU,Real)*CPI

■ The unit of the nominal market price is converted to USD for comparison

(15) 15 PMK(USD,Nom) = PMK(LCU,Nom)/ EXC(LCU/USD)

Appendix B. Supplementary data

Table B.1 Country and currency codes

Country name and ISO3166			Currency and ISO4217	
Brunei	BRN	BN	Dollar	BND
Cambodia	KHM	KH	Riel	KHR
Indonesia	IDN	ID	Rupiah	IDR
Lao PDR	LAO	LA	Kip	LAK
Malaysia	MYS	MY	Ringgit	MYR
Myanmar	MMR	MM	Kyat	MMK
Philippines	PHL	PH	Peso	PHP
Singapore	SGP	SG	Dollar	SGD
Thailand	THA	TH	Baht	THB
Viet Nam	VNM	VN	Dong	VND

Notes: Brunei and Singapore, although not included in the model, are shown for reference.

Table B.2 Abbreviations used in Table 3.1

Variables

Economic variables	
CPI	CPI
EXC	Exchange
GDD	GDP deflator
GDP	GDP per capita
POP	Population
Prices	
PCS	Consumer price (Retail)
PET	Export price (FOB) - export tax
PEX	Export price (FOB)
PIM	Import price (CIF)
PIT	Import price (CIF) + tariff
PMK	Market price (Wholesale)
PPR	Producer price (Farmgate)
PWD	International price (Projection)
RMC	Margin rate (consumer price)
RMP	Margin rate (producer price)
RSC	Subsidy rate (consumer price)
RSP	Subsidy rate (producer price)
RTF	Tariff rate
RTX	Export tax rate

FBS	
ARA	Area harvested
EXP	Exports
IMP	Imports
NEP	Net export (by prices)
NER	Export availability (as residual)
QDD	Demand
QDU	Domestic use
QFE	Feed use
QFO	Food use
QFP	Food use per capita
QOT	Other use
QPC	Processing use
QPM	Production milled
QPP	Production paddy
QSS	Supply
RML	Milling rate
SKB	Beginning stock
SKC	Stock change
SKE	Ending stock
YLD	Yield

Foreign

TH	Thailand
VN	Vietnam

Unit (currency)

LCU	Local currency unit
USD	US Dollar
THB	Thai Baht

Deflate

CPI	Deflated by CPI
GDD	Deflated by GDP defrator

Examples

ARA(t-2)	Area harvested, t-2 year
PEX(TH,USD,Nom)	Export price, Thailand, USD/kg, Nominal, t year
PIT(LCU,Real,t-1)	Import price + tariff, Own country, Local currency unit/kg, Real, t-1 year

Table B.3 Data sources

Assume	Assumed in the model		
Defin	Definitional identity		
Project	Projected data by using elasticity		
AFSIS1	Data Selected	Table 20: Rice balance sheet	http://www.afsisnc.org/statistics/data-selected
AFSIS2	Database Query		http://www.afsisnc.org/statistics/database-query
FAOSTAT	Production Trade Food supply Commodity Balances Price, Price archive		http://faostat3.fao.org/faostat-gateway/go/to/home/E
USDA	PSD Online	Perform a Custom Query	http://apps.fas.usda.gov/psdonline/psdHome.aspx
UNDESA	World Population Prospects: The 2012 Revision	Total Population - Both Sexes	http://esa.un.org/unpd/wpp/Excel-Data/population.htm
IMF	World Economic Outlook database	Entire Dataset	http://www.imf.org/external/ns/cs.aspx?id=28
WB	World Development Indicators		http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators#
UNSD	National Accounts Main Aggregates Database	GDP and its breakdown at current prices in National GDP and its breakdown at constant 2005 prices in National currency Exchange Rates and Population	http://unstats.un.org/unsd/snaama/dnlList.asp
OECD-FAO	Database - OECD-FAO Agricultural Outlook	World price (Milled, 5% broken, f.o.b, Ho chi Minh)	http://www.agri-outlook.org/database.html
GIEWS	FAO GIEWS Food Price Data and Analysis Tool		http://www.fao.org/giews/pricetool/
WTO	WTO Tariff Download Facility		http://tariffdata.wto.org/Default.aspx
Others	Other sources		

Appendix C. Selected data and baseline results of the rice models

	Prices, Nominal, Domestic prices, Market (Wholesale), USD/kg							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	0.37	0.00	0.28		0.30	0.44	0.00	0.10
1995	0.44	0.00	0.27		0.33	0.57	0.19	0.10
1996	0.43	0.00	0.30		0.33	0.63	0.21	0.10
1997	0.20	0.00	0.50		0.29	0.54	0.19	0.10
1998	0.30	0.32	0.30	0.12	0.14	0.41	0.21	0.09
1999	0.38	0.35	0.20	0.15	0.16	0.42	0.17	0.09
2000	0.25	0.32	0.18	0.10	0.15	0.38	0.14	0.09
2001	0.24	0.25	0.16	0.17	0.15	0.33	0.12	0.09
2002	0.33	0.23	0.16	0.17	0.15	0.34	0.14	0.11
2003	0.36	0.25	0.19	0.19	0.28	0.32	0.15	0.11
2004	0.34	0.26	0.20	0.15	0.22	0.32	0.18	0.12
2005	0.32	0.22	0.21	0.14	0.22	0.36	0.23	0.13
2006	0.33	0.22	0.22	0.21	0.24	0.40	0.26	0.15
2007	0.43	0.22	0.25	0.23	0.25	0.47	0.28	0.16
2008	0.52	0.29	0.29	0.28	0.28	0.64	0.56	0.19
2009	0.52	0.44	0.31	0.28	0.32	0.62	0.48	0.25
2010	0.63	0.36	0.35	0.35	0.34	0.66	0.44	0.25
2011	0.67	0.39	0.39	0.34	0.35	0.71	0.51	0.24
2012	0.64	0.41	0.40	0.39	0.35	0.78	0.57	0.24
2013	0.63	0.42	0.43	0.35	0.31	0.81	0.71	0.26
2014	0.60	0.43	0.45	0.34	0.34	0.70	0.53	0.25
2015	0.58	0.44	0.47	0.32	0.32	0.70	0.62	0.23
2016	0.62	0.45	0.49	0.35	0.34	0.76	0.60	0.26
2017	0.63	0.46	0.50	0.36	0.35	0.79	0.72	0.26
2018	0.65	0.46	0.48	0.36	0.36	0.82	0.72	0.27
2019	0.65	0.47	0.48	0.37	0.37	0.84	0.73	0.27
2020	0.66	0.48	0.49	0.37	0.37	0.80	0.71	0.27

	Prices, Nominal, Trade prices, Import, USD/kg							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	0.26		0.40		0.23	0.50	0.00	0.29
1995	0.15		0.33		0.22	0.29	0.00	0.30
1996	0.36		0.35	0.54	0.25	0.34	0.00	0.30
1997	0.31		0.39	0.34	0.29	0.29	0.00	0.30
1998	0.30		0.30	0.31	0.36	0.27	0.32	0.22
1999	0.28		0.29	0.26	0.31	0.26	0.29	0.33
2000	0.24		0.28	0.26	0.30	0.19	0.27	0.33
2001	0.21		0.18	0.15	0.27	0.17	0.21	0.25
2002	0.19		0.13	0.13	0.27	0.18	0.22	0.14
2003	0.20		0.11	0.19	0.29	0.17	0.25	0.27
2004	0.26		0.21	0.20	0.28	0.23	0.27	0.84
2005	0.28		0.30	0.27	0.31	0.27	0.31	0.63
2006	0.30		0.29	0.34	0.39	0.30	0.35	0.53
2007	0.33		0.38	0.34	0.39	0.36	0.38	0.54
2008	0.43		0.34	0.49	0.74	0.80	0.60	1.10
2009	0.43		0.30	0.50	0.51	0.59	0.58	0.69
2010	0.52		0.39	0.52	0.56	0.69	0.59	0.78
2011	0.55		0.57	0.52	0.57	0.54	0.59	0.54
2012	0.52	0.06	0.49	0.77	0.69	0.63	0.68	0.54
2013	0.52	0.06	0.48	0.65	0.63	0.62	0.66	0.55
2014	0.50	0.06	0.49	0.63	0.63	0.40	0.63	0.51
2015	0.48	0.06	0.49	0.53	0.60	0.37	0.63	0.43
2016	0.52	0.06	0.52	0.67	0.66	0.41	0.62	0.51
2017	0.53	0.06	0.53	0.67	0.67	0.42	0.63	0.51
2018	0.54	0.06	0.53	0.67	0.69	0.42	0.62	0.52
2019	0.54	0.06	0.54	0.65	0.69	0.42	0.62	0.51
2020	0.55	0.06	0.54	0.64	0.70	0.43	0.63	0.51

	Prices, Nominal, Trade prices, Export, USD/kg							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	0.00	0.00		0.22	0.20		0.25	0.21
1995	0.00	0.12		0.22	0.21		0.31	0.27
1996	0.00	0.13		0.23	0.30		0.37	0.28
1997	0.00	0.13		0.21	0.26		0.37	0.24
1998	0.42	0.14		0.22	0.18	0.75	0.32	0.27
1999	0.55	0.14		0.19	1.00	0.52	0.28	0.23
2000	0.27	0.15		0.13	1.00	0.55	0.26	0.19
2001	0.19	0.16		0.12	0.67	2.00	0.21	0.17
2002	0.25	0.15		0.12	0.25		0.22	0.22
2003	0.59	0.16		0.14	0.19	0.00	0.26	0.19
2004	0.33	0.16		0.17	0.14	0.07	0.28	0.23
2005	0.20	0.17		0.21	0.17	0.67	0.31	0.27
2006	0.49	0.17		0.24	0.08	0.14	0.35	0.27
2007	0.13	0.16		0.25	0.30	2.00	0.38	0.33
2008	0.77	0.18		0.27	0.66	2.73	0.61	0.61
2009	0.60	0.23		0.28	0.69	3.39	0.58	0.45
2010	0.69	0.25		0.35	1.00	3.54	0.59	0.47
2011	1.20	0.26		0.44	0.43	4.00	0.60	0.51
2012	1.22	0.30		0.54	0.61	4.66	0.68	0.53
2013	0.47	0.29		0.48	0.52	4.57	0.61	0.53
2014	0.45	0.30		0.47	0.50	2.42	0.60	0.33
2015	0.43	0.30		0.42	0.43	1.03	0.56	0.27
2016	0.46	0.31		0.49	0.50	1.54	0.62	0.30
2017	0.47	0.31		0.49	0.50	1.24	0.63	0.28
2018	0.48	0.32		0.50	0.51	1.04	0.64	0.27
2019	0.49	0.32		0.49	0.50	0.80	0.64	0.26
2020	0.49	0.33		0.49	0.50	0.62	0.65	0.24

	FBS, Supply, Production, Milled, 1000t							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	29,455	1,423	1,191	10,910	1,390	6,892	13,933	15,293
1995	33,496	2,207	1,013	11,520	1,383	6,894	14,530	16,226
1996	34,314	2,213	1,017	10,833	1,449	7,379	14,739	17,158
1997	33,125	2,186	1,151	10,864	1,378	7,370	15,563	17,891
1998	32,883	2,246	1,111	11,452	1,264	5,595	15,179	18,945
1999	33,802	2,586	1,401	10,897	1,325	7,708	15,953	20,406
2000	34,515	2,577	1,458	12,113	1,392	8,103	17,057	21,144
2001	33,409	2,623	1,542	11,530	1,362	8,472	18,546	20,870
2002	34,082	2,447	1,588	11,869	1,429	8,679	18,692	22,391
2003	34,493	3,015	1,510	11,899	1,468	8,829	19,681	22,470
2004	35,723	2,669	1,638	9,842	1,489	9,481	19,057	23,497
2005	35,771	3,831	1,666	11,766	1,504	9,550	20,228	23,264
2006	35,910	4,009	1,721	13,065	1,422	10,024	19,794	23,302
2007	37,702	4,305	1,758	12,963	1,480	10,621	21,435	23,347
2008	39,584	4,591	1,878	13,071	1,529	10,997	21,135	25,174
2009	42,266	4,855	1,961	12,990	1,599	10,638	21,383	25,282
2010	43,563	5,279	1,967	12,666	1,704	10,315	23,564	26,004
2011	42,899	5,619	1,966	11,963	1,994	10,911	25,148	27,511
2012	45,127	5,946	2,266	12,885	1,546	11,793	25,080	28,210
2013	45,056	6,163	2,454	13,207	1,544	12,059	24,537	29,182
2014	44,629	6,338	2,451	13,133	1,517	12,345	22,317	28,493
2015	45,029	6,526	2,450	13,112	1,529	12,524	22,406	28,301
2016	45,193	6,715	2,448	13,005	1,503	12,500	22,052	27,816
2017	45,504	6,923	2,449	13,150	1,508	12,792	22,510	28,776
2018	45,789	7,130	2,449	13,130	1,506	12,932	22,513	29,001
2019	46,075	7,344	2,428	13,110	1,505	13,088	22,523	31,309
2020	46,351	7,563	2,428	13,071	1,503	13,223	22,465	29,508

	FBS, Supply, Production, Paddy, Area, 1000ha							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	10,718	1,495	611	5,743	649	3,652	8,975	6,599
1995	11,421	1,924	560	6,033	678	3,759	9,113	6,766
1996	11,550	1,879	554	5,769	684	3,951	9,267	7,004
1997	11,126	1,929	601	5,408	688	3,842	9,913	7,100
1998	11,716	1,936	618	5,459	667	3,170	9,511	7,363
1999	11,963	2,079	718	6,211	687	4,000	9,970	7,654
2000	11,794	1,903	719	6,302	689	4,038	9,891	7,666
2001	11,490	1,980	747	6,413	665	4,065	10,125	7,493
2002	11,521	1,995	738	6,381	671	4,046	9,654	7,504
2003	11,488	2,237	756	6,528	666	4,006	10,164	7,452
2004	11,923	2,109	770	6,533	654	4,127	9,993	7,445
2005	11,839	2,414	736	7,384	665	4,070	10,225	7,326
2006	11,786	2,516	796	8,074	658	4,160	10,165	7,325
2007	12,148	2,567	781	8,011	673	4,273	10,669	7,181
2008	12,327	2,612	825	8,078	654	4,460	10,684	7,400
2009	12,884	2,675	841	8,058	670	4,532	11,140	7,440
2010	13,253	2,777	855	8,012	670	4,354	12,120	7,489
2011	13,204	2,677	817	7,567	681	4,537	11,957	7,651
2012	13,445	2,980	934	8,150	610	4,690	11,957	7,746
2013	13,835	2,998	931	8,354	609	4,746	11,710	7,912
2014	13,768	2,994	930	8,307	599	4,744	11,130	7,629
2015	13,776	2,993	930	8,294	603	4,735	11,175	7,485
2016	13,763	2,990	929	8,226	593	4,650	10,998	7,267
2017	13,778	2,993	930	8,318	595	4,682	11,227	7,428
2018	13,777	2,993	930	8,305	594	4,656	11,228	7,397
2019	13,776	2,993	921	8,292	594	4,636	11,233	7,388
2020	13,773	2,992	921	8,267	593	4,609	11,204	7,352

	FBS, Demand, Domestic use, 1000t							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	22,283	1,634	1,124	8,650	1,810	6,610	2,009	9,760
1995	22,342	1,700	1,140	8,819	1,842	7,166	2,106	9,993
1996	22,365	1,748	1,165	8,775	1,894	7,803	2,126	10,183
1997	22,150	1,797	1,201	8,779	1,950	7,837	2,247	10,685
1998	21,943	1,846	1,225	8,934	2,001	7,425	2,264	11,416
1999	21,711	1,892	1,271	9,815	2,026	8,386	2,323	11,628
2000	21,920	1,936	1,295	10,033	2,013	8,862	2,463	11,783
2001	22,495	1,967	1,321	10,143	1,957	9,119	2,674	11,841
2002	23,091	2,004	1,330	10,471	1,853	9,656	2,670	11,902
2003	23,566	1,926	1,345	10,594	1,903	9,767	2,813	12,358
2004	23,592	1,951	1,370	10,579	1,851	10,773	2,823	12,335
2005	23,491	1,990	1,391	10,789	2,004	11,199	2,890	11,108
2006	23,509	2,021	1,454	11,218	2,005	11,423	2,827	11,630
2007	22,939	2,055	1,463	11,169	2,057	12,335	3,063	12,064
2008	24,353	2,084	1,508	11,277	2,052	12,732	3,111	12,377
2009	24,066	2,163	1,546	11,316	2,104	12,135	3,068	12,830
2010	24,030	2,199	1,526	11,351	2,114	11,811	4,786	12,940
2011	24,813	2,253	1,563	11,232	2,179	12,303	4,872	13,250
2012	23,882	2,303	1,627	11,773	2,246	12,791	3,067	13,512
2013	24,118	2,338	1,682	11,858	2,378	12,727	3,037	13,657
2014	24,132	2,372	1,717	11,881	2,346	12,893	2,896	13,796
2015	24,332	2,406	1,754	11,852	2,474	13,297	2,676	13,996
2016	24,286	2,440	1,792	11,986	2,470	13,372	2,672	13,946
2017	24,402	2,472	1,829	12,062	2,492	13,615	2,653	14,046
2018	24,520	2,504	1,862	12,092	2,511	13,857	2,700	14,127
2019	24,678	2,537	1,895	12,109	2,537	14,132	2,701	14,222
2020	24,850	2,571	1,928	12,126	2,564	14,733	2,699	14,305

	FBS, Demand, Domestic use, Food per capita, kg/person/year							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	115	152	209	169	88	86	99	138
1995	113	152	209	170	87	93	96	139
1996	111	152	209	166	87	99	108	139
1997	109	152	209	164	87	97	107	139
1998	106	152	209	163	88	92	107	146
1999	104	152	209	162	87	100	106	146
2000	105	152	209	162	84	103	115	146
2001	106	152	209	162	80	104	110	145
2002	108	152	207	158	74	108	111	143
2003	108	143	207	156	75	107	112	146
2004	107	143	207	150	71	116	111	145
2005	105	143	207	146	76	119	120	127
2006	104	143	207	146	74	119	121	132
2007	100	143	204	142	75	126	119	134
2008	105	143	204	141	73	128	124	132
2009	102	143	204	141	74	120	133	136
2010	101	143	204	141	73	115	113	135
2011	103	143	205	141	74	117	114	136
2012	98	143	205	141	75	119	96	137
2013	97	142	206	139	78	116	100	138
2014	96	142	206	137	76	117	95	139
2015	96	141	207	135	79	120	95	140
2016	95	141	207	134	78	119	93	139
2017	94	140	208	132	77	120	96	140
2018	94	140	208	130	77	121	96	140
2019	93	139	208	129	77	122	96	140
2020	93	139	209	128	76	126	95	140

	FBS, SD-gap, Net export (estimated by prices), 1000t							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	-109	-26	-16	934	-334	0	4,733	1,983
1995	-1,306	-24	-16	354	-425	-263	5,939	1,977
1996	-2,150	-7	-27	92	-577	-862	5,251	3,003
1997	-345	-43	-20	27	-646	-722	5,272	3,575
1998	-2,895	-29	-41	119	-656	-2,171	6,319	3,729
1999	-4,742	-38	-5	48	-612	-834	6,137	4,503
2000	-1,361	-39	-14	241	-596	-639	6,141	3,477
2001	-635	-42	-22	926	-528	-808	7,685	3,727
2002	-1,798	-55	-26	778	-493	-1,196	7,334	3,201
2003	-1,437	235	-24	379	-357	-886	7,339	3,811
2004	-242	-150	-33	164	-519	-1,000	9,975	4,063
2005	-150	210	-22	178	-578	-1,882	7,493	5,250
2006	-439	310	-17	61	-784	-1,716	7,392	4,641
2007	-1,392	265	-25	356	-798	-1,806	9,189	4,556
2008	-288	50	-24	141	-1,096	-2,432	10,202	4,734
2009	-247	121	-43	227	-1,086	-1,755	8,543	5,968
2010	-687	100	-43	120	-930	-2,379	8,934	6,892
2011	-2,743	192	-17	221	-1,030	-707	10,696	7,110
2012	-1,926	166	-17		-737	-1,006	6,707	7,996
2013	-470	339	-7			-1,042	6,587	
2014		347				-1,006	6,501	
2015		300						
2016								
2017								
2018								
2019								
2020								

	FBS, Export availability (residual), 1000t							
	ID	KH	LA	MM	MY	PH	TH	VN
1994	-109	-26	-16	934	-334	0	4,733	1,983
1995	-1,306	-24	-16	354	-425	-263	5,939	1,977
1996	-2,150	-7	-27	92	-577	-862	5,251	3,003
1997	-345	-43	-20	27	-646	-722	5,272	3,575
1998	-2,895	-29	-41	119	-656	-2,171	6,319	3,729
1999	-4,742	-38	-5	48	-612	-834	6,137	4,503
2000	-1,361	-39	-14	241	-596	-639	6,141	3,477
2001	-635	-42	-22	926	-528	-808	7,685	3,727
2002	-1,798	-55	-26	778	-493	-1,196	7,334	3,201
2003	-1,437	235	-24	379	-357	-886	7,339	3,811
2004	-242	-150	-33	164	-519	-1,000	9,975	4,063
2005	-150	210	-22	178	-578	-1,882	7,493	5,250
2006	-439	310	-17	61	-784	-1,716	7,392	4,641
2007	-1,392	265	-25	356	-798	-1,806	9,189	4,556
2008	-288	50	-24	141	-1,096	-2,432	10,202	4,734
2009	-247	121	-43	227	-1,086	-1,755	8,543	5,968
2010	-687	100	-43	120	-930	-2,379	8,934	6,892
2011	-2,743	192	-20	221	-1,030	-707	10,696	7,110
2012	-1,926	166	94	370	-737	-1,006	6,707	7,996
2013	-470	497	504	604	-913	-1,042	5,934	8,827
2014	-470	684	420	525	-934	-1,328	13,482	7,912
2015	-900	885	365	549	-1,068	-1,573	11,283	7,492
2016	-1,078	1,086	346	335	-1,100	-1,670	11,348	6,991
2017	-1,361	1,310	313	419	-1,126	-1,648	11,028	7,956
2018	-1,634	1,532	292	394	-1,152	-1,763	11,479	8,118
2019	-1,925	1,758	249	371	-1,183	-1,897	11,483	10,571
2020	-2,213	1,988	209	334	-1,215	-2,377	11,489	8,486

Notes: Data were collected from the first version of the rice models developed by each country's participant. The projection period of each variable is mainly 2012–2020, although this depended on data availability. The projection period until 2019 explained in this paper was expanded.

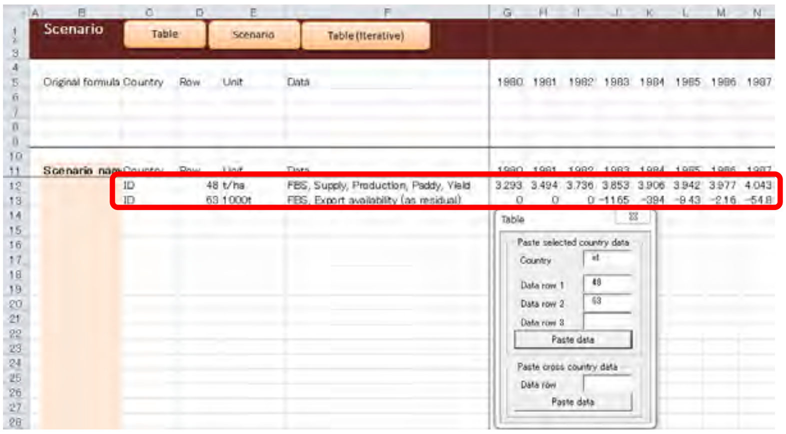
Appendix D. Tutorial on the functions in the model

The Excel file of the model, "AFSIS_Rice_model.xlsm," developed in this project contains several functions to ease the drawing of a graph and changing of values in the model in the case of a scenario analysis. Furthermore, there is an additional function to conduct a welfare analysis.

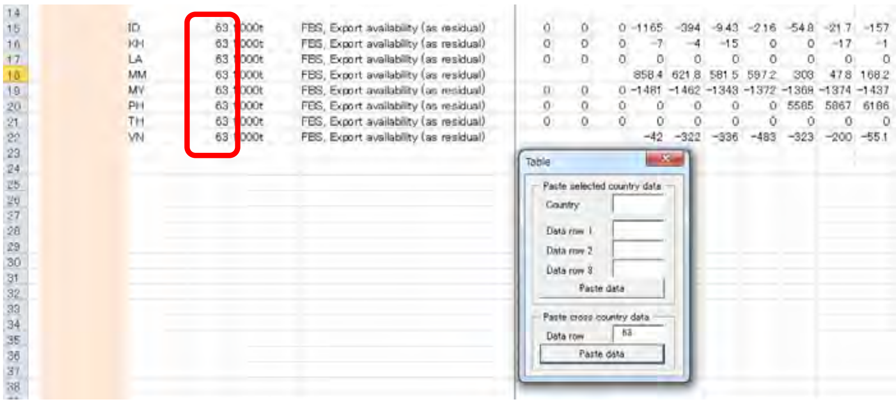
D.1 Table creation

The "Table" dialogue box can copy data in each country sheet and paste them in the "Scn" sheet. This function makes it easier for us to draw a graph and conduct a scenario analysis.

To copy and paste data, insert the abbreviated form of a country name, for example, "ID" or "id" for Indonesia or "KH" or "kh" for Cambodia in rows of data in the dialogue box; then click on the "Paste data" button.

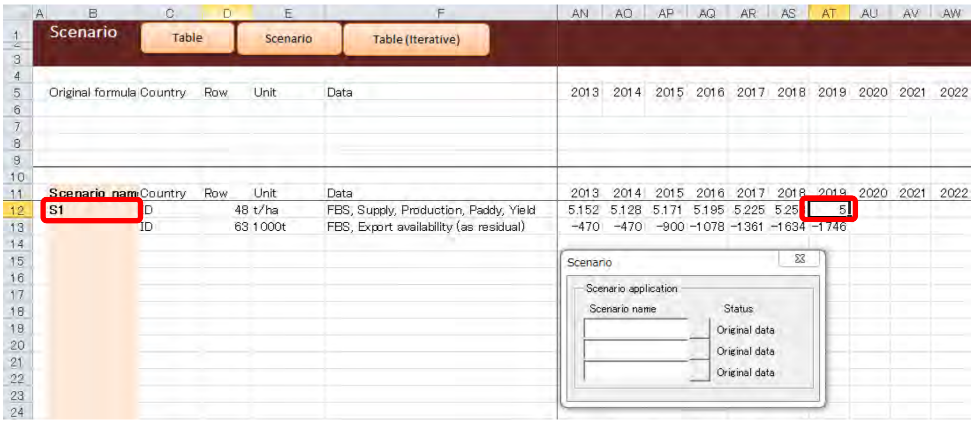


When you input a row number in the lower box, the data for all eight countries (ID, KH, LA, MM, MY, PH, TH, VN) are extracted.

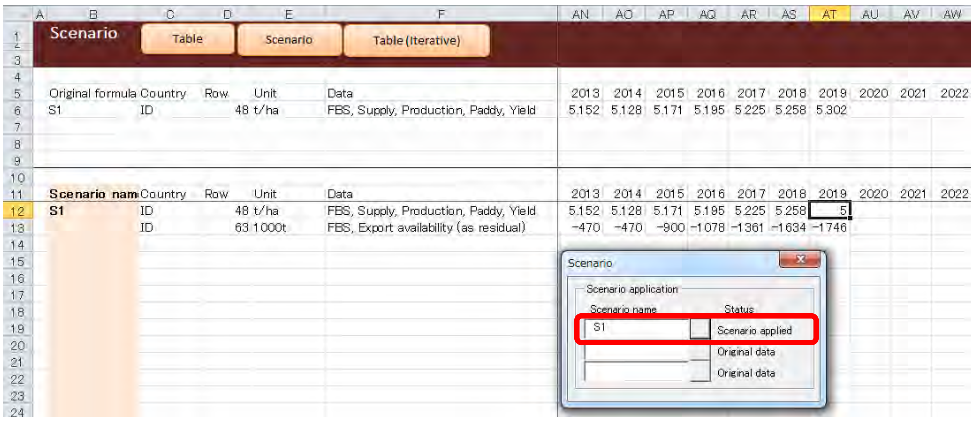


D.2 Scenario analysis (data replacement)

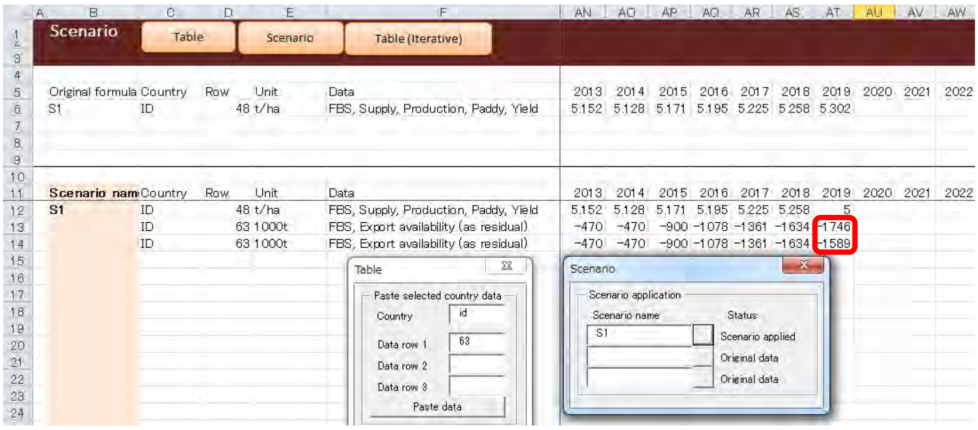
The “Scenario” dialogue box can replace rows in the “Scn” sheet with the original row in each country sheet. First, data from a certain row, which you want to replace, are pasted in the “Scn” sheet using the function of the “Table” dialogue box. Then, change any value in the pasted row in the “Scn” sheet as a scenario. Input a name into the cell in the “Scenario name” column, which is to the left of the target row. The following figure shows us an example in the case of Indonesia; the yield for 2019 was changed to 5 and this data scenario was named “S1.”



Input the name of the scenario into the blank space in the dialogue box and click on the button next to the blank. Then, the original row in each country sheet is replaced by the row created in the “Scn” sheet. Thereafter, the “Status” in the “Scenario” dialogue box will change from “Original data” to “Scenario applied.”



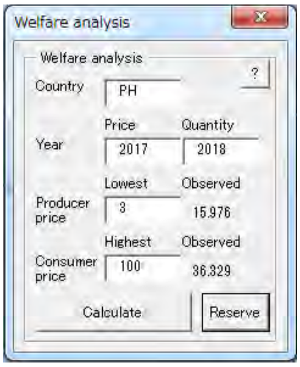
Outputs or endogenous variables in the model the reflect replaced values. The copy and paste function of the “Table” dialogue box will help compare outputs in the “Scn” sheet.



A combination of, at most, three scenarios can be applied using the “Scenario” dialogue box. The replacement of the rows is undone when the buttons in the dialogue box are clicked on or the dialogue box is closed.

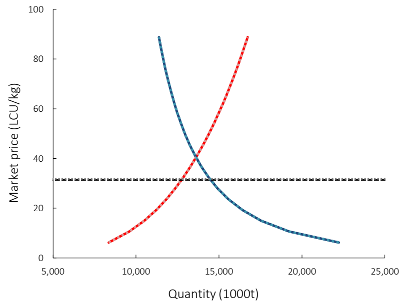
D.3 Welfare analysis

The “Welfare analysis” dialogue box in the “Wlf” sheet can be used to conduct a welfare analysis. First, the abbreviation of the country name, target years, the lowest nominal producer price (LCU/kg), and the highest nominal consumer price (LCU/kg) need to be inserted in the blanks. The target year must be in the projection period. A one-year lag between price and quantity results is a slant supply curve because the area is explained using $t - 1$’s price for most countries in the project. The observed producer and consumer prices are indicated next to the blanks for reference. The lowest producer price must be smaller and the highest consumer price must be larger than the observed prices. The results appear by clicking on the “Calculate” button.

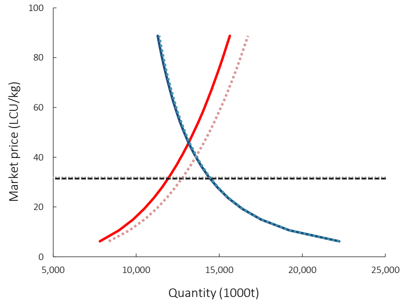


We obtain the estimated equilibrium price, equilibrium quantity, and surplus as follows:

		Supply	Demand	Equilibrium
Quantity	1000t	13,086	14,992	14,035
Market price	LCU/kg (Nom)	33	33	43
Surplus	LCU (Nom) in billion	315	855	
Market price	USD/kg (Nom)	0.82	0.82	1.07
Surplus	LCU (Nom) in billion	7.84	21.26	

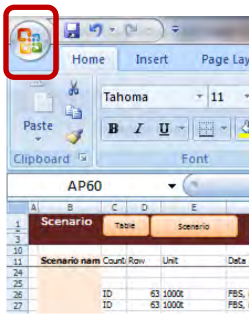


The “Reserve” button in the dialogue box allows us to copy and paste outputs from one table to the next. Apply any scenarios and click on the “Calculate” button again; then, compare the new results to the reserved ones (small dotted line).



Appendix E. Tutorial on the Excel file for the regression analysis

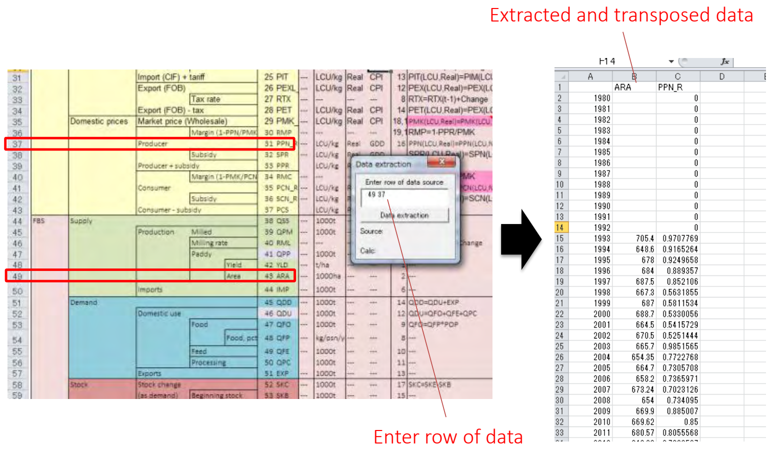
We use the Excel file "ols_by_vba8.xlsm" for the regression analysis. To use this file, activate "AnalysisToolPack-VBA" in Excel (click on the Windows button followed by Options → Add-Ins → AnalysisToolPack-VBA).



Click on the "Menu" icon to open the Menu dialogue box. There are three functions in this file.

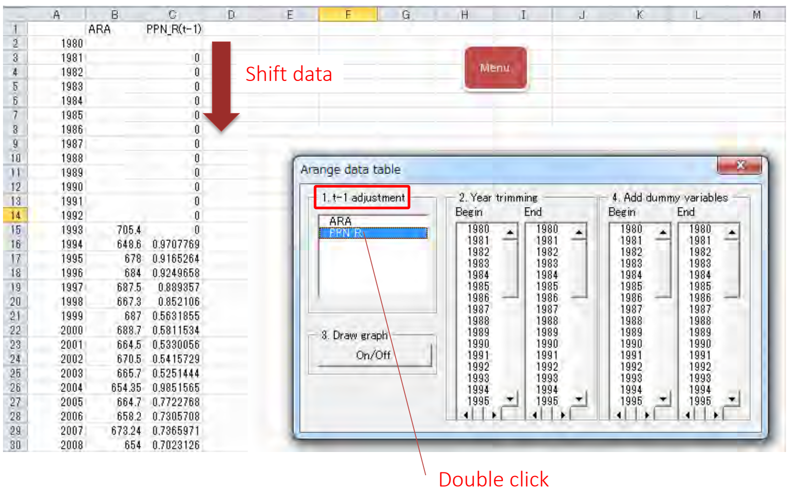
E.1 Data extraction

The first function is data extraction from the Excel file for the model to the abovementioned file for the regression analysis. Click on and activate the target worksheet in the model file and enter the row number of the model in the blank space provided in the dialogue box. Multiple numbers can be inserted and separated using a space. For example, click on the "PH" worksheet in the model file and insert "49 37" in the dialogue box. Then, click on the "Data extraction" button to import data from rows 49 and 37.

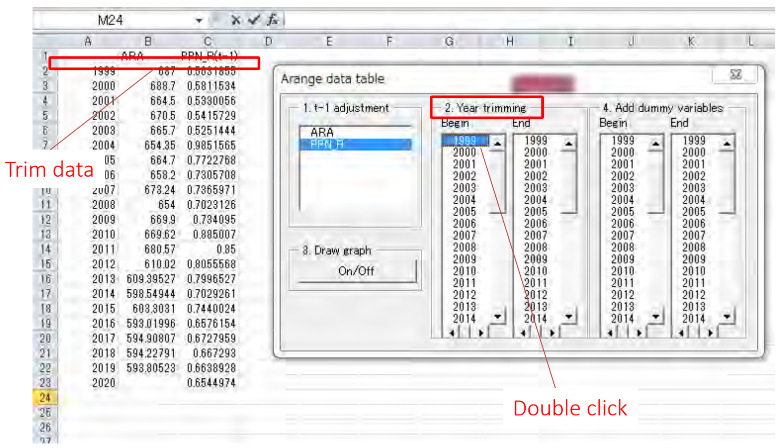


E.2 Data arrangement

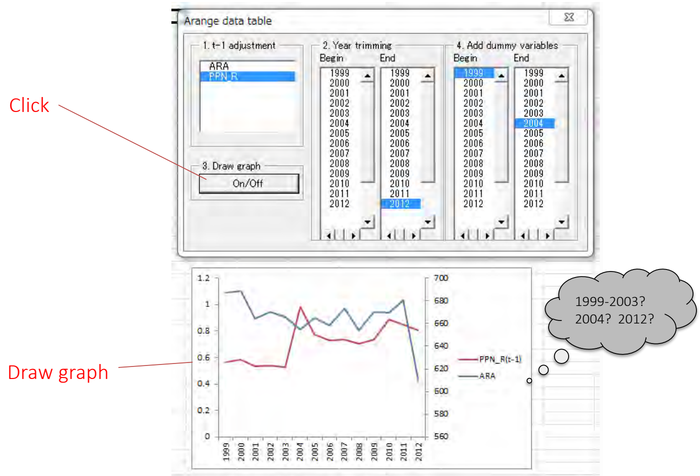
The second function is the arrangement of the extracted data. “1. t-1 adjustment” is a function to shift data by one year, which can be done by double clicking on the name assigned to the data.



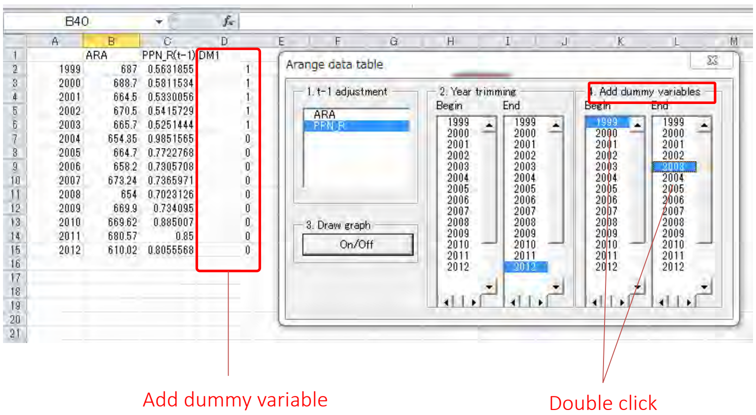
“2. Year trimming” is a function to delete the selected rows out of the range from “Begin” to “End.”



The “3. Draw graph” button will help draw a graph of the data. This button can be used to find an outlier or extreme change in the data.



The “4. Add dummy variables” is a function to input dummy variables. The dummy variable “DM*” is drawn when we double click on the years. Dummy variables can be also manually inserted. The name of dummy must be “DM*,” for example, DM1, DM2, DMa-1, or DM Disaster. Do not create a column that contains only zeros or ones.



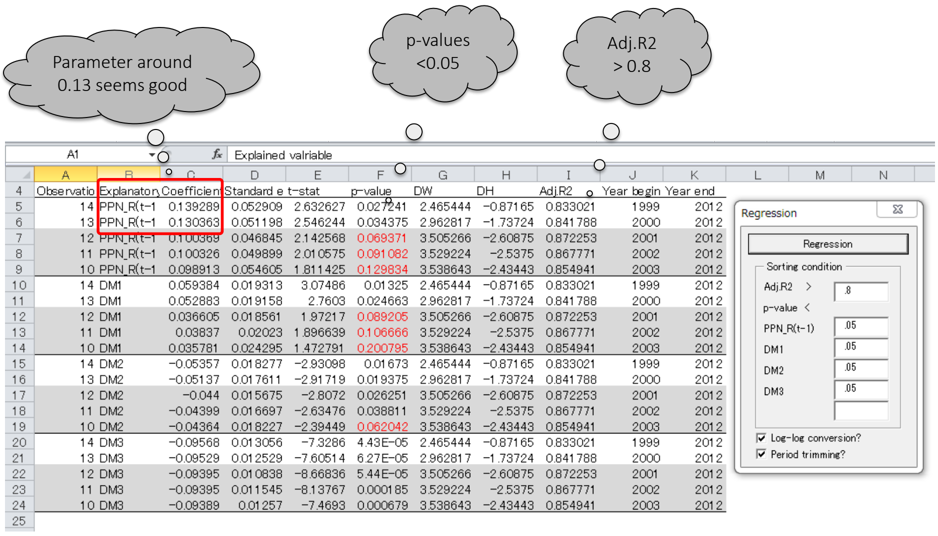
E.3 Regression analysis with data trimming

The third function is a dialogue box for regression analysis with data trimming. The variable in column B and those to the right-hand side of column C are explained and explanatory variables, respectively. The regression was iterated with data trimming from the oldest value.

Clicking on the “Regression” button will give you the result of the double-log model. Alternatively, you can input the criteria for the Adj. R^2 and p-values of coefficients in advance before clicking on the “Regression” button. The equation is automatically converted to a

double-log form, except for dummy variables. Thus, when you input a time trend (1, 2, 3,…) with a double-log form, you need to input the exponentially converted series of the time trend (EXP(1) = 2.718, EXP(2) = 7.389, EXP(3) = 20.086,…). Uncheck the “Log-log conversion?” box when estimating the linear form model. When you uncheck the “Period trimming?” box, you will see the regression result without data trimming.

The red numbers in the result sheet indicates a lower Adj. R^2 or a higher p-value than the criteria shown in the dialogue box. The gray cells indicate that the conditions for the Adj. R^2 or p-value in those rows have not been satisfied.



	A	B	C	D	E	F	G	H	I	J	K
4	Observatio	Explanatory	Coefficient	Standard e	t-stat	p-value	DW	DH	Adj.R2	Year begin	Year end
5	14	PPN_R(t-1	0.139289	0.052909	2.632627	0.027241	2.465444	−0.87165	0.833021	1999	2012
6	13	PPN_R(t-1	0.130363	0.051198	2.546244	0.034375	2.962817	−1.73724	0.841788	2000	2012
7	12	PPN_R(t-1	0.100369	0.046845	2.142568	0.069371	3.505266	−2.60875	0.872253	2001	2012
8	11	PPN_R(t-1	0.100326	0.049899	2.010575	0.091082	3.529224	−2.5375	0.867771	2002	2012
9	10	PPN_R(t-1	0.098913	0.054605	1.811425	0.129834	3.538643	−2.43443	0.854941	2003	2012
10	14	DM1	0.059384	0.019313	3.07486	0.01325	2.465444	−0.87165	0.833021	1999	2012
11	13	DM1	0.052883	0.019158	2.7603	0.024663	2.962817	−1.73724	0.841788	2000	2012
12	12	DM1	0.036605	0.018561	1.97217	0.089205	3.505266	−2.60875	0.872253	2001	2012
13	11	DM1	0.03837	0.02023	1.896639	0.106666	3.529224	−2.5375	0.867771	2002	2012
14	10	DM1	0.035781	0.024295	1.472791	0.200795	3.538643	−2.43443	0.854941	2003	2012
15	14	DM2	−0.05357	0.018277	−2.93098	0.01673	2.465444	−0.87165	0.833021	1999	2012
16	13	DM2	−0.05137	0.017611	−2.91719	0.019375	2.962817	−1.73724	0.841788	2000	2012
17	12	DM2	−0.044	0.015675	−2.8072	0.026251	3.505266	−2.60875	0.872253	2001	2012
18	11	DM2	−0.04399	0.016697	−2.63476	0.038811	3.529224	−2.5375	0.867771	2002	2012
19	10	DM2	−0.04364	0.018227	−2.39449	0.062042	3.538643	−2.43443	0.854941	2003	2012
20	14	DM3	−0.09568	0.013056	−7.3286	4.43E−05	2.465444	−0.87165	0.833021	1999	2012
21	13	DM3	−0.09529	0.012529	−7.60514	6.27E−05	2.962817	−1.73724	0.841788	2000	2012
22	12	DM3	−0.09395	0.010838	−8.66836	5.44E−05	3.505266	−2.60875	0.872253	2001	2012
23	11	DM3	−0.09395	0.011545	−8.13767	0.000185	3.529224	−2.5375	0.867771	2002	2012
24	10	DM3	−0.09389	0.01257	−7.4693	0.000679	3.538643	−2.43443	0.854941	2003	2012
25											

A more detailed output can be confirmed in another sheet. In addition to the fundamental output of the regression analysis using Excel, the following values are shown: Durbin-Watson Statistic (DW), Durbin’s h-statistic (DH), residual sum of squares (RSS), maximum likelihood (ML), maximum log likelihood (MLL), Akaike information criterion (AIC), corrected AIC (AICc), Bayesian information criterion (BIC), number of free parameters (f.param), and the number of explanatory variables (k) including the intercept (constant)).

Regresson Statistics					
Multiple R	0.859568201	DW	1.684113124	AIC	−49.54771338
R Square	0.738857492	DH	0.596091194	AICc	−45.10326894
Adjusted R Square	0.691377036	RSS	0.013442006	BIC	−46.99148407
Standard Error	0.034957124	ML	3.18913E−13	f.param.	4
Observations	14	MLL	28.77385669	k	3

ANOVA

	df	*SS*	*MS*	*F*	*Significance*
Regression	2	0.038031828	0.019015914	15.5612973	0.000620621
Residual	11	0.013442006	0.001222001		
Total	13	0.051473834			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	9.025997764	0.102409782	88.1360896	5.00305E−17	8.800595353	9.251400176
PPN_R	0.091709265	0.050101718	1.83046148	0.094382959	−0.018563873	0.201982402
DM1	0.091162205	0.027685001	3.292837365	0.007168533	0.030227929	0.152096481

Medium-long-term non-equilibrium projection model for the AFSIS project

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