# Chapter 5
# Development of the Rice Econometric Model with Endogenous Water in Vietnam (REMEW-VIET)

## 5-1. Introduction

The international price of rice surged from $385/metric ton (MT) in January 2008 to $962/MT in May 2008. The drought in Australia and the sharp rise in demand for biofuels lead a higher price for wheat and maize. The price spikes of these crops contributed to the increase in rice prices; however, cold weather damage of rice in Vietnam was thought to be the primary factor in the price spike of rice.

Vietnam's share in world rice trade increased from 15.5% in 2007 to 20.2% in 2008. As Vietnams trade share has increased, the domestic price of rice in Vietnam in increasingly linked to the world price of rice. Modeling supply and demand for rice in this country is then critical for the evaluation of impacts of environmental changes on the world rice market.

## 5-2. Agricultural policies related to rice production

In the winter season from 2007 to 2008, most nursery rice was stunned decayed due to cold weather in the region. Concerned about domestic supplies, the Government of Vietnam banned the export of rice. Vietnamese rice exports are controlled by the Rice Export Management Committee which is headed by the Prime Minister.

IFPRI (1996) examined impacts of elimination of rice the export quota on the rice price and farm income using a spatial equilibrium model. They also examined the impacts of elimination of internal trade restrictions on the rice market. David (1994) summarized the price policies of agricultural products in 1990's.

## 5-3. Model

The model in Vietnam is regional model for eight regions and the basic structure of the model is same as those of other countries. There are three types of cultivation, i.e., spring, summer, and winter season rice. Transplanting of spring season rice occurs in December and the harvest occur from April to May. Transplanting period for summer season rice is from May to June and harvest runs from September to October. Transplanting occurs from September to October for winter season rice and the harvesting occurs during December in the Mekong Delta region. These cultivation periods are based on the cropping calendars in USDA(1994). The spring and summer season rice are cultivated in irrigated fields as a two season crop while the winter season rice is cultivated in rain-fed fields as single season crop. The generalized forms of the supply and demand model of rice are as follows:

Yield function of spring season:

$$YS^i = f_{YS}(T, ET_{DEC,t-1}^i, \dots, ET_{JLY,t}^i) \quad (5\text{-}1)$$

Planted Area function of spring season:

$$AS^i_t = f_{AS}(FP_{t-1}, EYS^i_t, ET_{JAN\,t}^i) \quad (5\text{-}2)$$

Planted Area function of spring season in the Mekong Delta region:

$$AS^{MDR}t = f_{ASM}(T, AS^{MDR}_{t-1}, FP_{t-1}, EYS^{MDR}_t, ET_{JAN\,t}^i, ET_{FEB\,t}^i) \quad (5\text{-}3)$$

Production of spring season:

$$QS^i = YS^i AS^i, \; QS = \sum_i QS^i \quad (5\text{-}4)$$

Yield function of summer season:

$$YM_i = f_{YM}(T, ET_{MAR,t}^i, \dots, ET_{OCT,t}^i) \quad (5\text{-}6)$$

Planted Area function of summer season:

$$AM^i_t = f_{AM}(FP_{t-1}, EYM^i_t, ET_{JAN\,t}^i, \dots, ET_{AUG\,t}^i) \quad (5\text{-}7)$$

Planted Area function of summer season in the Mekong Delta region:

$$AM^{MDR}_t = f_{AMM}(T, FP_{t-1}, EYM^{MDR}_t, ET_{MAY\,t}^i) \quad (5\text{-}8)$$

Production of summer season:

$$QM^i = YM^i AM^i, \; QM = \sum_i QM^i \quad (5\text{-}9)$$

Yield function of winter season:

$$YW^i = f_{YW}(T, ET_{JUN,t-1}^i, \dots, ET_{NOV,t}^i) \quad (5\text{-}10)$$

Planted Area function of winter season:

$$AW^i_t = f_{AW}(T, FP_{t-1}, EYW^i_t, ET_{JUN\,t}^i, \dots, ET_{OCT\,t}^i) \quad (5\text{-}11)$$

Planted Area function of winter season in the Mekong Delta region:

$$AW^{MDR}_t = f_{AWM}(T, FP_{t-1}, EYW^{MDR}_t, ET_{JUN\,t}^i, ET_{JLY\,t}^i) \quad (5\text{-}12)$$

Production of winter season:

$$QW^i = YW^i AW^i, \; QW = \sum_i QW^i \quad (5\text{-}13)$$

Total production:

$$Q = 0.667(QS + QM + QW) \quad (5\text{-}14)$$

Export function:

$$EXP = f(WP^*EXR, Q) \quad (5\text{-}15)$$

Stock change function:

$$STC = f(FP_{t,t-1}, Q_{t,t-1}) \quad (5\text{-}16)$$

Total supply:

$$QD = Q + IMP - EXP - STC \quad (5\text{-}17)$$

Demand function:

$$QD/POP = f(RP, GDP/POP) \quad (5\text{-}18)$$

Price linkage function:

$$FP = f(RP), \quad (5\text{-}19)$$

where $i$ is the region, $t$ denotes that the data are measured at time $t$, $T$ is a time trend, $ET_{JAN}^{i}$ through $ET_{DEC}^{i}$ are monthly evapotranspiration values for January through December, *YS*, *AS*, *EYS*, and *QS* are yield, planted area, expected yield, and production of spring season rice, *YM*, *AM*, *EYM*, and *QM* are yield, planted area, expected yield, and production of summer season rice, *YW*, *AW*, *EYW*, and *QW* are yield, planted area, expected yield, and production of winter season rice, *Q* is total rice production, *IMP* is imports, *EXP* is exports, *STC* is the annual change of stocks, i.e., ending stock minus beginning stock, *QD* is total supply, *POP* is population, *GDP* is gross domestic products, *EXR* is exchange rate, *WP* is the world price of rice (Thailand, 35% broken, FOB), *FP* is the producer price, *RP* is the retail price. All functions are specified as linear functions.

The planted area function is based on the naïve expectation model because Mekong Delta region, where is the main production region, located in lower Mekong River. Water harvesting and forecasting of water supply changes in the lower elevation regions are easier than those in upper regions, therefore the

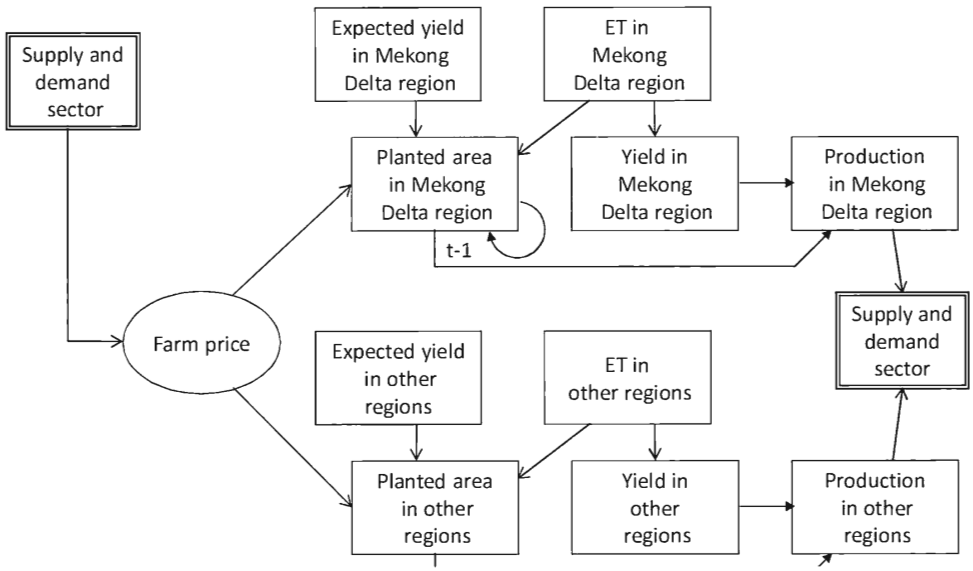


Fig. 5-1. Flowchart of the rice production sector of Vietnam rice model

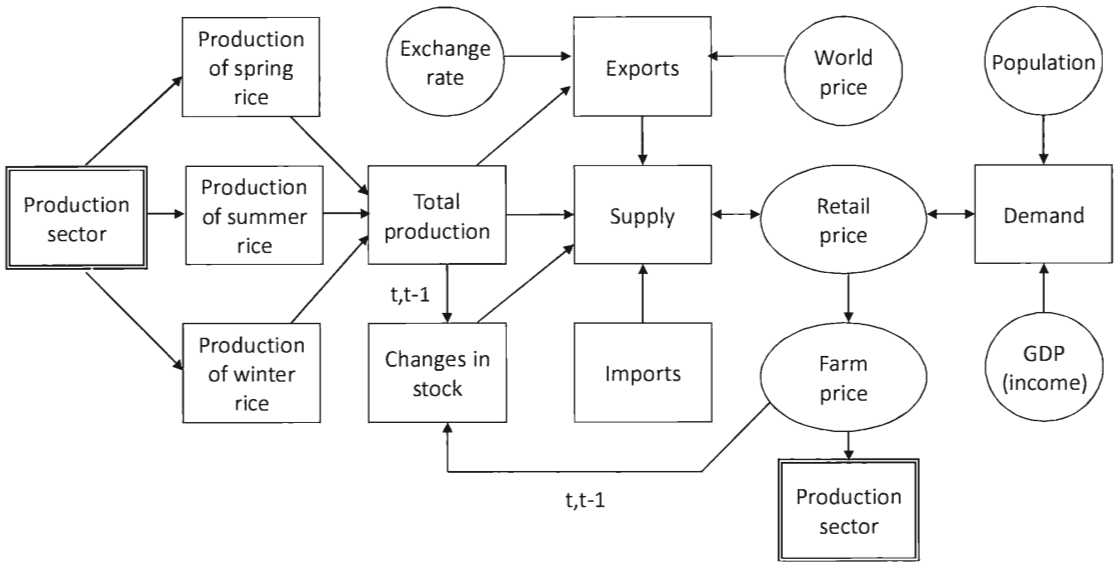


Fig. 5-2. Flowchart of supply and demand sector of Vietnam rice model

planted area functions of the Vietnamese model take a simpler form than those of the Laotian and Cambodian models.

## 5-4. Data

The time series data for each region for production and planted area for the three types of rice cultivation is provided by the General Statistics Office of the Statistical Publishing House of Vietnam. The rice farm price is obtained from FAO-STAT and the retail rice price is obtained from the USDA. These prices are national average prices for Vietnam. CPI, GDP, GDP deflator and population are from the ADB and the exchange rate and the world price of rice are numbers from the IMF. The estimation period for the yield and planted area functions in the Mekong Delta region, imports, stock change, and demand functions for the country as a whole are from 1985 to 2000 which starts in the earliest available year for CPI and ends in the last year of available ET values. Functions for yield and planted area in regions except the Mekong Delta region are estimated using pooled data from 1985 to 2000 for the seven regions.

## 5-5. Estimation results of all functions

The yield functions of spring, summer, and winter season rice are not estimated for each region due to the lack of time series data. Parameters are obtained by estimating one function which includes provincial dummies using pooled data. The data set of spring and winter season rice consists of eight regions for sixteen years, and those for summer rice consists of five regions for sixteen years.

The estimation periods of these yield functions are from 1985 to 2000 which starts in the earliest available year for statistics of production of the three seasons and ends in the last year of available ET values.

The planted area functions of the three types of rice are also estimated using pooled data; however, the planted area functions in the Mekong Delta region are estimated using only time series data because the trend of the planted area is quite different from other regions.

Finally, estimated results of export, stock change, demand, and price linkage function are shown. The estimation method of all functions is OLS.

### 5-5-1. Yield functions

### 5-5-1-1. Yield function of spring season rice

**5-5-1-1-1. Yield function of spring season rice pooled**

YS= 27.27637
(0.98)
+ 1.05535*TREND
(10.27)
+ 1.43780*TREND*DR81
(5.35)
- 0.41899*TREND*DR88
(-1.67)
- 4.58713*ln(ETDECt-1)
(-2.15)
+ .00279*ln(ETDECt-1)*DR88
(5.14)
+ 7.63748*ln(ETJAN)
(4.58)
- 10.7256*ln(ETJAN)*DR81
(-3.11)
+ 6.80434*ln(ETFEB)*DR81
(-2.73)
- 22.97368*ln(ETMAR)*DR86
(1.88)
+ 24.38146*ln(ETAPR)*DR86
(-2.52)
+ 11.35640*ln(ETMAY)
(2.73)
- 16.18149*ln(ETJUL)
(4.87)

Adj $R^2$ = 0.8321 DW=1.725

| | |
|---|---|
| YS | Yield of spring rice |
| TREND | Linear time trend 1976=1 |
| DR81 | Treatment variable for Region 81, Red River Delta |
| DR86 | Treatment variable for Region 86, Central Highlands |
| DR88 | Treatment variable for Region 88, Mekong River Delta |
| ETDECt-1 | Evapotranspiration value for December (previous calendar year) |
| ETJAN | Evapotranspiration value for January |
| ETFEB | Evapotranspiration value for February |
| ETMAR | Evapotranspiration value for March |
| ETAPR | Evapotranspiration value for April |
| ETMAY | Evapotranspiration value for May |
| ETJUL | Evapotranspiration value for April |

**5-5-1-1-2. Yield function of spring season rice in Red River Delta region**

YS_RRD = + 27.2673
+ 2.49315 * TREND
- 4.58713 * ln(ETRRD_DECt-1)
- 3.08812 * ln(ETRRD_JAN)
+ 6.80434 * ln(ETRRD_FEB)
+ 11.35640 * ln(ETRRD_MAY)
- 16.18149 * ln(ETRRD_JLY)

| | |
|---|---|
| YS_RRD | Yield of spring season rice in Red River Delta region |
| TREND | Linear time trend 1976=1 |
| ETRRD_DECt-1 | Evapotranspiration for December (previous calendar year) in Red River Delta region |
| ETRRD_JAN | Evapotranspiration for January in Red River Delta region |
| ETRRD_FEB | Evapotranspiration for February in |

Red River Delta region
ETRRD_MAY Evapotranspiration for May in Red River Delta region
ETRRD_JLY Evapotranspiration for July in Red River Delta region

**5-5-1-1-3. Yield function of spring season rice in North East region**

YS_NE = +27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETNE_DECt-1)
+ 7.63748*ln(ETNE_JAN)
+ 11.35640*ln(ETNE_MAY)
- 16. 18149*ln(ETNE_JLY)
YS_NE Yield of spring rice in North East region
TREND Linear time trend 1976=1
ETNE_DECt-1 Evapotranspiration for December (previous calendar year) in North East region
ETNE_JAN Evapotranspiration for January in North East region
ETNE_MAY Evapotranspiration for May in North East region
ETNE_JLY Evapotranspiration for July in North East region

**5-5-1-1-4. Yield function of spring season rice in North West region**

YS_NW = + 27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETNW_DECt-1)
+ 7.63748*ln(ETNW_JAN)
+ 11.35640*ln(ETNW_MAY)
- 16. 18149*ln(ETNW_JLY)
YS_NW Yield of spring rice in North West region
TREND Linear time trend 1976=1
ETNW_DECt-1 Evapotranspiration for December (previous calendar year) in North West region
ETNW_JAN Evapotranspiration for January in North West region
ETNW_MAY Evapotranspiration for May in North West region
ETNW_JLY Evapotranspiration for July in North West region

**5-5-1-1-5. Yield function of spring season rice in North Central region**

YS_NC = + 27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETNC_DECt-1)
+ 7.63748*ln(ETNC_JAN)
+ 11.35640*ln(ETNC_MAY)
- 16. 18149*ln(ETNC_JLY)
YS_NC Yield of spring rice in North Central region
TREND Linear time trend 1976=1
ETNC_DECt-1 Evapotranspiration for December (previous calendar year) in North Central region
ETNC_JAN Evapotranspiration for January in North Central region
ETNC_MAY Evapotranspiration for May in North Central region
ETNC_JLY Evapotranspiration for July in North Central region

**5-5-1-1-6. Yield function of spring season rice in South Central region**

YS_SC = + 27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETSC_DECt-1)
+ 7.63748*ln(ETSC_JAN)
+ 11.35640*ln(ETSC_MAY)
- 16. 18149*ln(ETSC_JLY)
YS_SC Yield of spring rice in South Central region
TREND Linear time trend 1976=1
ETSC_DECt-1 Evapotranspiration for December (previous calendar year) in South Central region
ETSC_JAN Evapotranspiration for January in South Central region
ETSC_MAY Evapotranspiration for May in South Central region
ETSC_JLY Evapotranspiration for July in South Central region

**5-5-1-1-7. Yield function of spring season rice in Central Highlands region**

YS_CH = + 27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETCH_DECt-1)
+ 7.63748*ln(ETCH_JAN)
- 22.97368*ln(ETCH_MAR)
+ 24.38146*ln(ETCH_APR)
+ 11.35640*ln(ETCH_MAY)
- 16. 18149*ln(ETCH_JLY)
YS_CH Yield of spring rice in Central Highlands region
TREND Linear time trend 1976=1
ETCH_DECt-1 Evapotranspiration for December (previous calendar year) in Central Highlands region
ETCH_JAN Evapotranspiration for January in Central Highlands region
ETCH_MAR Evapotranspiration for March in Central Highlands region
ETCH_APR Evapotranspiration for April in Central Highlands region
ETCH_MAY Evapotranspiration for May in Central Highlands region
ETCH_JLY Evapotranspiration for July in Central Highlands region

**5-5-1-1-8. Yield function of spring season rice in South East region**

YS_SE = + 27.27637
+ 1.05535 * TREND
- 4.58713 * ln(ETSE_DECt-1)
+ 7.63748*ln(ETSE_JAN)
+ 11.35640*ln(ETSE_MAY)
- 16. 18149*ln(ETSE_JLY)
YS_SE Yield of spring rice in South East region
TREND Linear time trend 1976=1
ETSE_DECt-1 Evapotranspiration for December (previous calendar year) in South East region
ETSE_JAN Evapotranspiration for January in South East region
ETSE_MAY Evapotranspiration for May in South East region
ETSE_JLY Evapotranspiration for July in South East region

**5-5-1-1-9. Yield function of spring season rice in Mekong River Delta region**

YS_MRD = + 27.27637
+ 0.63636 * TREND
+ 0.41566 * ln(ETMRD_DECt-1)
+ 7.63748*ln(ETMRD_JAN)
+ 11.35640*ln(ETMRD_MAY)
- 16. 18149*ln(ETMRD_JLY)

YS_MRD Yield of spring rice in Mekong River Delta region
TREND Linear time trend 1976=1
ETMRD_DECt-1 Evapotranspiration for December (previous calendar year) in Mekong River Delta region
ETMRD_JAN Evapotranspiration for January in Mekong River Delta region
ETMRD_MAY Evapotranspiration for May in Mekong River Delta region
ETMRD_JLY Evapotranspiration for July in Mekong River Delta region

## 5-5-1-2. Yield function of summer season rice

**5-5-1-2-1. Yield function of summer season rice pooled**

YM= 57.36595
(4.03)
+ 178.23544*DR84
(2.52)
+ 0.13312*TREND
(2.02)
+ 5.11125*TREND*DR84
(5.37)
- 68.15874*ln(TREND)*DR84
(-4.26)
+ 0.38684*TREND*DR85
(7.32)
+ 0.11091*TREND*DR88
(2.35)
+ 2.65131*ln(ETMAR)
(2.16)
+ 24.22034*ln(ETMAY)*DR86
(2.80)
- 32.78468*ln(ETJUL)*DR84
(-3.23)
- 27.27385*ln(ETAUG)*DR84
(-4.05)
+ 43.10634*ln(ETSEP)*DR84
(3.43)
- 25.55856*ln(ETSEP)*DR86
(-3.03)
- 8.054090*ln(ETOCT)
(-2.56)

Adj $R^2$ = 0.9046 DW = 2.403

YM Yield of summer rice
TREND Linear time trend 1976=1
DR84 Treatment variable for Region 84, North Central Coast
DR85 Treatment variable for Region 85, South Central Coast
DR86 Treatment variable for Region 86, Central Highlands
DR88 Treatment variable for Region 88, Mekong River Delta
ETMAR Evapotranspiration value for March
ETMAY Evapotranspiration value for May
ETJUL Evapotranspiration value for July
ETAUG Evapotranspiration value for August
ETSEP Evapotranspiration value for September
ETOCT Evapotranspiration value for October

**5-5-1-2-2. Yield function of summer season rice in North Central region**

YM_NC = +235.60139
+ 5.24437*TREND
- 68.15874*ln(TREND)
+2.65131*ln(ETNC_MAR)
- 32.78468*ln(ETNC_JLY)
- 27.27386*ln(ETNC_AUG)
+ 43.10634*ln(ETNC_SEP)
- 8.05409*ln(ETNC_OCT)

YM_NC Yield of summer season rice in North Central region
TREND Linear time trend 1976=1
ETNC_MAR Evapotranspiration for March in North Central region
ETNC_JLY Evapotranspiration for July in North Central region
ETNC_AUG Evapotranspiration for August in North Central region
ETNC_SEP Evapotranspiration for September North Central region
ETNC_OCT Evapotranspiration for October in North Central region

**5-5-1-2-3. Yield function of summer season rice in South Central region**

YM_SC= +57.36595
+ 0.51996*TREND
+ 0.65131*ln(ETSC_MAR)
- 8.05409*ln(ETSC_OCT)

YM_SC Yield of summer season rice in South Central region
TREND Linear time trend 1976=1
ETSC_MAR Evapotranspiration for March in South Central region
ETSC_OCT Evapotranspiration for October in South Central region

**5-5-1-2-4. Yield function of summer season rice in Central Highlands region**

YM_CH= +57.36595
+ 0.13312*TREND
+ 2.65131*ln(ETCH_MAR)
+ 24.22034*ln(ETCH_MAY)
- 25.55856*ln(ETCH_SEP)
- 8.05409*ln(ETSC_OCT)

YM_CH Yield of summer season rice in Central Highlands region
TREND Linear time trend 1976=1

ETCH_MAR Evapotranspiration for March in Central Highlands region
ETCH_MAY Evapotranspiration for May in Central Highlands region
ETCH_SEP Evapotranspiration for September in Central Highlands region
ETCH_OCT Evapotranspiration for October in Central Highlands region

**5-5-1-2-5. Yield function of summer season rice in South East region**

YM_SE= +57.36595
+ 0.13312*TREND
+ 2.65131*ln(ETSE_MAR)
- 8.05409*ln(ETSE_OCT)

YM_SE Yield of summer season rice in South East region
TREND Linear time trend 1976=1
ETSE_MAR Evapotranspiration for March in South East region
ETSE_OCT Evapotranspiration for October in South East region

**5-5-1-2-6. Yield function of summer season rice in Mekong River Delta region**

YM_MRD= +57.36595
+ 0.24403*TREND
+ 2.65131*ln(ETMRD_MAR)
- 8.05409*ln(ETMRD_OCT)

YM_MRD Yield of summer season rice in Mekong River Delta region
TREND Linear time trend 1976=1
ETMRD_MAR Evapotranspiration for March in Mekong River Delta region
ETMRD_OCT Evapotranspiration for October in Mekong River Delta region

## 5-5-1-3. Yield function of winter season rice

**5-5-1-3-1. Yield function of winter season rice pooled**

YW= -21.19495
(-1.31)
- 305.42596*DR81
(-4.64)
- 45.80576*DR84
(-1.25)
+ 146.09079*DR85
(2.56)
+ 0.50778*TREND
(8.59)
+ 0.81935*TREND*DR81
(5.92)
+ 0.39529*TREND*DR82
(3.16)
+ 0.17788*TREND*DR84
(1.36)
- 0.39177*TREND*DR87
(-3.00)
- 18.78781*ln(ETJUN)*DR85
(-2.78)
-1.49071*ln(ETJUN)*DR86
(-9.14)
+ 39.4286*ln(ETJUL)*DR81
(3.57)
+ 6.65991*ln(ETJUL)*DR83
(1.53)
-9.93575*ln(ETAUG)*DR81
(-1.59)
-8.72378*ln(ETAUG)*DR83
(-1.99)
-21.24006*ln(ETAUG)*DR85
(-2.38)
+16.49354*ln(ETAUG)*DR87
(1.86)
+8.89444*ln(ETSEP)
(2.51)
+ 41.95199*ln(ETSEP)*DR81
(3.33)
-15.86032*ln(ETSEP)*DR87
(-1.78)
+12.77038*ln(ETOCT)*DR84
(1.75)
+8.23481*ln(ETOCT)*DR85
(1.41)
-9.36005*ln(ETNOV)*DR81
(-2.31)
-2.24949*ln(ETNOV)*DR82
(-3.94)
-5.37945*ln(ETNOV)*DR84
(-1.33)

Adj $R^2$ = 0.9060 DW = 1.98

YW Yield of winter rice
Trend Linear time trend 1976=1
DR81 Treatment variable for Region 81, Red River Delta
DR82 Treatment variable for Region 82, North East
DR83 Treatment variable for Region 83, North West
DR84 Treatment variable for Region 84, North Central Coast
DR85 Treatment variable for Region 85, South Central Coast
DR86 Treatment variable for Region 86, Central Highlands
DR87 Treatment variable for Region 87, South East
DR88 Treatment variable for Region 88, Mekong River Delta
ETJUN Evapotranspiration value for June
ETJUL Evapotranspiration value for July
ETAUG Evapotranspiration value for August
ETSEP Evapotranspiration value for September
ETOCT Evapotranspiration value for October
ETNOV Evapotranspiration value for November

**5-5-1-3-2. Yield function of winter season rice in Red River Delta region**

YW_RRD = - 326.62091
+ 1.32713 * TREND
+ 39.42860 * ln(ETRRD_JLY)
- 9.93575 * ln(ETRRD_AUG)
+ 50.84643 * ln(ETRRD_SEP)

- 9.36005 * ln(ETRRD_NOV)

YW_RRD Yield of winter season rice in Red River Delta region
TREND Linear time trend 1976=1
ETRRD_JLY Evapotranspiration for July in Red River Delta region
ETRRD_AUG Evapotranspiration for August in Red River Delta region
ETRRD_SEP Evapotranspiration for September in Red River Delta region
ETRRD_NOV Evapotranspiration for November in Red River Delta region

**5-5-1-3-3. Yield function of winter season rice in North East region**

YW_NE = - 21.19495
+ 0.90307 * TREND
+ 8.89444 * ln(ETNE_SEP)
- 2.24949 * ln(ETNE_NOV)

YW_NE Yield of winter season rice in North East region
TREND Linear time trend 1976=1
ETNE_SEP Evapotranspiration for September in North East region
ETNE_NOV Evapotranspiration for November in North East region

**5-5-1-3-4. Yield function of winter season rice in North West region**

YW_NW = - 21.19495
+ 0.50778 * TREND
+ 6.65991*ln(ETNW_JLY)
- 8.72378*ln(ETNW_AUG)
+ 8.89444 * ln(ETNW_SEP)

YW_NW Yield of winter season rice in North West region
TREND Linear time trend 1976=1
ETNW_JLY Evapotranspiration for July in North West region
ETNW_AUG Evapotranspiration for August in North West region
ETNW_SEP Evapotranspiration for September in North West region

**5-5-1-3-5. Yield function of winter season rice in North Central region**

YW_NC = - 67.00071
+ 0.68566 * TREND
+ 8.89444 * ln(ETNC_SEP)
+ 12.77038 * ln(ETNC_OCT)
- 5.37945 * ln(ETNC_NOV)

YW_NC Yield of winter season rice in North Central region
TREND Linear time trend 1976=1
ETNC_SEP Evapotranspiration for September in North Central region
ETNC_OCT Evapotranspiration for October in North Central region
ETNC_NOV Evapotranspiration for November in North Central region

**5-5-1-3-6. Yield function of winter season rice in South Central region**

YW_SC = - 124.89584
+ 0.50778 * TREND
- 18.78781 * ln(ETSC_JUN)
- 21.24006 * ln(ETSC_AUG)
+ 8.89444*ln(ETSC_SEP)
+8.23481*ln(ETSC_OCT)

YW_SC Yield of winter season rice in South Central region
TREND Linear time trend 1976=1
ETSC_JUN Evapotranspiration for June in South Central region
ETSC_AUG Evapotranspiration for August in South Central region
ETSC_SEP Evapotranspiration for September in South Central region
ETSC_OCT Evapotranspiration for October in South Central region

**5-5-1-3-7. Yield function of winter season rice in Central Highlands region**

YW_CH = - 21.19495
+ 0.50778 * TREND
- 1.49071 * ln(ETCH_JUN)
+ 8.89444*ln(ETCH_SEP)

YW_CH Yield of winter season rice in Central Highlands region
TREND Linear time trend 1976=1
ETCH_JUN Evapotranspiration for June in Central Highlands region
ETCH_SEP Evapotranspiration for September in Central Highlands region

**5-5-1-3-8. Yield function of winter season rice in South East region**

YW_SE = - 21.19495
+ 0.11601 * TREND
+ 16.49354 * ln(ETSE_AUG)
- 6.96588*ln(ETSE_SEP)

YW_SE Yield of winter season rice in South East region
TREND Linear time trend 1976=1
ETSE_AUG Evapotranspiration for August in South East region
ETSE_SEP Evapotranspiration for September in South East region

**5-5-1-3-9. Yield function of winter season rice in Mekong River Delta region**

YW_MRD =- 21.19495
+ 0.50778 * TREND
+ 8.89444*ln(ETMRD_SEP)

YW_MRD Yield of winter season rice in Mekong River Delta region
TREND Linear time trend 1976=1
ETMRD_SEP Evapotranspiration for September in Mekong River Delta region

## 5-5-2. Planted area functions

### 5-5-2-1. Planted area function of spring season rice

**5-5-2-1-1. Planted area function of spring season rice pooled**

**(Less Mekong River Delta Region)**

APS = 25.07395
(11.36)
+ 531.39551*DR81
(123.03)
+ 113.38698*DR82
(5.31)
+ 287.99908*DR84
(108.88)
+ 135.37101*DR85
(51.15)
-295.38267*DR87
(3.65)
+ 0.00055282 * ((RPPDt-1/NGDPD) * EYS)
* SHIFT89
(3.12)
+ 0.00132 * ((RPPDt-1/NGDPD) * EYS)
* SHIFT89 * DR81
(3.85)
+ 0.00085279 * ((RPPDt-1/NGDPD) * EYS)
* SHIFT89 * DR82
(1.77)
- 0.00033167 * ((RPPDt-1/NGDPD) * EYS)
* SHIFT89 * DR83
(-1.25)
+ 0.00232 * ((RPPDt-1/NGDPD) * EYS) * DR87
(3.40)
+ 8.89679 * ln(ETJAN) * DR82
(1.33)
+ 73.82035 * ln(ETJAN) * DR87
(3.86)

Adj $R^2$ = 0.9976 DW = 1.336

| | |
|---|---|
| APS | Planted are of spring season rice |
| DR81 | Treatment variable for Region 81, Red River Delta |
| DR82 | Treatment variable for Region 82, North East |
| DR83 | Treatment variable for Region 83, North West |
| DR84 | Treatment variable for Region 84, North Central Coast |
| DR85 | Treatment variable for Region 85, South Central Coast |
| DR87 | Treatment variable for Region 87, South East |
| ETJAN | Evapotranspiration value for January |
| SHIFT89 | Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |
| EYS | Expected (trend) yield of spring season rice |

**5-5-2-1-2. Planted area function of spring season rice in Red River Delta region**

APS_RRD = + 556.46946
+ 0.0018728 * RPPDt-1/(NGDPD/100)
*EYS_RRD * SHIFT89

| | |
|---|---|
| APS_RRD | Planted area of spring season rice in Red River Delta region |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |
| EYS_RRD | Expected (trend) yield of spring season rice in Red River Delta region |
| SHIFT89 | Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before |

**5-5-2-1-3. Planted area function of spring season rice in North East region**

APS_NE = + 138.46093
+ 0.00140561 * RPPDt-1/(NGDPD/100)
* EYS_NE * SHIFT89
+8.89679 * ln(ETNE_JAN)

| | |
|---|---|
| APS_NE | Planted area of spring season rice in North East region |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |
| EYS_NE | Expected (trend) yield of spring season rice in North East region |
| SHIFT89 | Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before |
| ETNE_JAN | Evapotranspiration for January in North East region |

**5-5-2-1-4. Planted area function of spring season rice in North West region**

APS_NW = + 25.07395
+ 0.00022115 * RPPDt-1/(NGDPD/100)
* EYS_NW * SHIFT89

| | |
|---|---|
| APS_NW | Planted area of spring season rice in North West region |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |
| EYS_NW | Expected (trend) yield of spring season rice in North West region |
| SHIFT89 | Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before |

**5-5-2-1-5. Planted area function of spring season rice in North Central region**

APS_NC = + 313.07303
+ 0.00055282 * RPPDt-1/(NGDPD/100)
* EYS_NC * SHIFT89

| | |
|---|---|
| APS_NC | Planted area of spring season rice in North Central region |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |
| EYS_NC | Expected (trend) yield of spring season rice in North Central region |
| SHIFT89 | Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before |

**5-5-2-1-6. Planted area function of spring season rice in South Central region**

APS_SC = + 160.44496
+ 0.00055282 * RPPDt-1/(NGDPD/100)
* EYS_SC * SHIFT89

| | |
|---|---|
| APS_SC | Planted area of spring season rice in North West region |
| RPPDt-1 | Retail paddy price lagged (000dong/MT) |
| NGDPD | GDP Deflator |

EYS_SC Expected (trend) yield of spring season rice in South Central region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before

**5-5-2-1-7. Planted area function of spring season rice in Central Highlands region**

APS_CH = + 25.07395
+ 0.00055282 * RPPDt-1/(NGDPD/100)
* EYS_CH * SHIFT89

APS_CH Planted area of spring season rice in Central Highlands region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYS_CH Expected (trend) yield of spring rice in Central Highlands region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before

**5-5-2-1-8. Planted area function of spring season rice in South East region**

APS_SE = - 270.30872
+ 0.00055282 * RPPDt-1/(NGDPD/100)
* EYS_SE * SHIFT89
+ 0.00232 * RPPDt-1/(NGDPD/100)
* EYS_SE
+ 73.82035 * ln(ETSE_JAN)

APS_SE Planted area of spring season rice in South East region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYS_SE Expected (trend) yield of spring rice in South East region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETSE_JAN Evapotranspiration for January in South East region

**5-5-2-1-9. Planted area function of spring season rice in Mekong River Delta region**

APS_MRD = - 618.98587
(-2.00)
+ 0.75036 * APS_MRDt-1
(4.96)
+ 16.35357 * TREND
(1.50)
+ 0.00310 * RPPDt-1/(NGDPD/100)
* EYS_MRD * SHIFT89
(2.96)
- 40.88202 * D94
(-2.43)
+ 85.58497 * ln(ETMRD_JAN)
(3.72)
+ 54.99330 * ln(ETMRD_FEB)
(1.00)

Adj $R^2$ = 0.9976 DW = 2.334

APS_MRD Planted area of spring season rice in Mekong River Delta region
APS_MRDt-1 Planted area lagged of spring season rice in Mekong River Delta region
TREND Linear time trend 1976=1
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYS_MRD Expected (trend) yield of spring rice in Mekong River Delta region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETMRD_JAN Evapotranspiration for January in Mekong River Delta region
ETMRD_FEB Evapotranspiration for February in Mekong River Delta region

## 5-5-2-2. Planted area function of summer season rice

**5-5-2-2-1. Planted area function of summer season rice pooled**
**(Less Mekong River Delta Region)**

APM = 338.21281
(2.36)
+ 262.30685*DR85
(-1.40)
- 126.79262*DR86
(-23.23)
- 1540.97457*DR87
(-6.32)
+ 0.00282 * ((RPPDt-1/NGDPD) * EYM)
* SHIFT89
(5.59)
+ 0.00232 * ((RPPDt-1/NGDPD)*EYM)
* SHIFT89 * DR85
(-3.70)
+ 0.0019 * ((RPPDt-1/NGDPD)*EYM)
* SHIFT89 * DR87
(2.11)
- 0.00378 * ((RPPDt-1/NGDPD)*EYM)
* DR87
(-3.06)
- 50.50563 * ln(ETJUL)
(-1.66)
+ 57.92589 * ln(ETJUL)*DR85
(1.45)
+ 35.9262 * ln(ETMAY) * DR87
(1.45)
+ 295.61269 * ln(ETAUG) * DR87
(5.12)

Adj $R^2$ = 0.9320 DW = 1.478

APM Planted area of summer season rice
DR85 Treatment variable for Region 85, South Central Coast
DR86 Treatment variable for Region 86, Central Highlands
DR87 Treatment variable for Region 87, South East
ETJAN Evapotranspiration value for January
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before

VNRPPt-1 Retail paddy price (000dong/MT)
VNGDPD GDP Deflator
EYM Expected (trend) yield of summer season rice

**5-5-2-2-2. Planted area function of summer season rice in North Central region**

APM_NC = - 338.21281
+ 0.00282 * RPPDt-1/(NGDPD/100)
* EYM_NC * SHIFT89
- 50.50563 * ln(ETNC_JLY)

APM_NC Planted area of summer season rice in North Central region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYM_NC Expected (trend) yield of summer season rice in North Central region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETNC_JLY Evapotranspiration for July in North Central region

**5-5-2-2-3. Planted area function of summer season rice in South Central region**

APM_SC = + 75.90596
+ 0.00050 * RPPDt-1/(NGDPD/100)
* EYM_SC * SHIFT89
+ 7.42026 * ln(ETSC_JLY)

APM_SC Planted area of summer season rice in South Central region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYM_SC Expected (trend) yield of summer season rice in South Central region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETSC_JLY Evapotranspiration for July in South Central region

**5-5-2-2-4. Planted area function of summer season rice in Central Highlands region**

APM_CH = + 211.42019
+ 0.00282 * RPPDt-1/(NGDPD/100)
* EYM_CH * SHIFT89
- 50.50563 * ln(ETCH_JLY)

APM_CH Planted area of summer season rice in Central Highlands region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYM_CH Expected (trend) yield of summer season rice in Central Highlands region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETCH_JLY Evapotranspiration for July in Central Highlands region

**5-5-2-2-5. Planted area function of summer season rice in South East region**

APM_SE = - 1202.76176
+ 0.00472 * RPPDt-1/(NGDPD/100)
* EYM_SE * SHIFT89
- 0.00378 * RPPDt-1/(NGDPD/100)
* EYM_SE
+ 35.92620 * ln(ETSE_MAY)
- 50.50563 * ln(ETSE_JLY)
+ 295.61269 * ln(ETSE_AUG)

APM_SE Planted area of summer season rice in South East region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYM_SE Expected (trend) yield of summer season rice in South East region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETSE_MAY Evapotranspiration for May in South East region
ETSE_JLY Evapotranspiration for July in South East region
ETSE_AUG Evapotranspiration for August in South East region

**5-5-2-2-6. Planted area function of summer season rice in Mekong River Delta region**

APM_MRD = - 2259.04485
(-3.86)
+ 89.48408 * TREND
(26.56)
+ 0.00845 * RPPDt-1/(NGDPD/100)
* EYM_MRD * SHIFT89
(1.72)
+ 402.13189 * ln(ETMRD_MAY)
(3.08)
+ 189.50938 * D99
(3.27)

Adj $R^2$ = 0.9877 DW = 1.521

APM_MRD Planted area of summer season rice in Mekong River Delta region
TREND Linear time trend 1976=1
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYM_MRD Expected (trend) yield of summer season rice in Mekong River Delta region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETMRD_MAY Evapotranspiration for May in Mekong River Delta region
D99 Dummy variable, D99=1 in 1999, otherwise 0

## 5-5-2-3. Planted area function of winter season rice

**5-5-2-3-1. Planted area function of winter season rice pooled (Less Mekong River Delta Region)**

APW = 390.12531
(6.37)
- 4.73004*TREND*DR84
(-8.26)
- 0.51195*TREND*DR86
(-3.82)
+ 1.76444*TREND*DR87
(4.33)
+ 0.00034398*((RPPDt-1/NGDPD)*EYW)

*SHIFT89
(1.56)
+ .00116*((RPPDt-1/NGDPD)*EYW)
*DR81
(2.13)
+ .00179*((RPPDt-1/NGDPD)*EYW)
*DR81
(1.51)
- 17.54514*ln(ETJUN)
(-1.72)
+ 93.45954*ln(ETJUL)*DR81
(72.99)
+ 74.1484*ln(ETJUL)*DR82
(3.71)
+ 36.67058*ln(ETJUL)*DR84
(23.06)
- 35.9352*ln(ETAUG)
(-4.03)
+ 33.97683*ln(ETAUG)*DR83
(2.43)
- 33.14568*ln(ETOCT)*DR83
(-1.57)
- 42.0415*ln(ETOCT)*DR83
(-2.92)
+ 18.80624*ln(ETOCT)*DR87
(11.39)

Adj $R^2$ = 0.9980 DW = 1.187

TREND Linear time trend 1976=1
DR81 Treatment variable for Region 81, Red River Delta
DR82 Treatment variable for Region 82, North East
DR83 Treatment variable for Region 83, North West
DR84 Treatment variable for Region 84, North Central Coast
DR86 Treatment variable for Region 86, Central Highlands
DR87 Treatment variable for Region 87, South East
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
RPPDt-1 Retail paddy price (000dong/MT)
NGDPD GDP Deflator
EYW Expected (trend) yield of winter season rice
ETJUN Evapotranspiration value for June
ETJUL Evapotranspiration value for July
ETAUG Evapotranspiration value for August
ETOCT Evapotranspiration value for October

**5-5-2-3-2. Planted area function of winter season rice in Red River Delta region**

APW_RRD = + 390.12531
+ 0.00034398 * RPPDt-1/(NGDPD/100)
*EYW_RRD * SHIFT89
+ 0.00116 * RPPDt-1/(NGDPD/100)
*EYW_RRD
- 17.54514 * ln(ETRRD_JUN)
+ 93.45954 * ln(ETRRD_JLY)
- 35.93520 * ln(ETRRD_AUG)

APW_RRD Planted area of winter season rice in Red River Delta region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_RRD Expected (trend) yield of winter season rice in Red River Delta region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETRRD_JUN Evapotranspiration for June in Red River Delta region
ETRRD_JLY Evapotranspiration for July in Red River Delta region
ETRRD_AUG Evapotranspiration for August in Red River Delta region

**5-5-2-3-3. Planted area function of winter season rice in North East region**

APW_NE = + 390.12531
+ 0.00034398 * RPPDt-1/(NGDPD/100)
*EYW_NE * SHIFT89
- 17.54514 * ln(ETNE_JUN)
+ 74.14840 * ln(ETNE_JLY)
- 35.93520 * ln(ETNE_AUG)
- 33.14568 * ln(ETNE_OCT)

APW_NE Planted area of winter season rice in North East region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_NE Expected (trend) yield of winter season rice in North East region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETNE_JUN Evapotranspiration for June in North East region
ETNE_JLY Evapotranspiration for July in North East region
ETNE_AUG Evapotranspiration for August in North East region
ETNE_OCT Evapotranspiration for October in North East region

**5-5-2-3-4. Planted area function of winter season rice in North West region**

APW_NW = + 390.12531
+ 0.00034398 * RPPDt-1/(NGDPD/100)
*EYW_NW * SHIFT89
- 17.54514 * ln(ETNW_JUN)
- 1.95837 * ln(ETNW_AUG)
- 42.04150 * ln(ETNW_OCT)

APW_NW Planted area of winter season rice in North West region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_NW Expected (trend) yield of winter season rice in North West region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETNW_JUN Evapotranspiration for June in North West region
ETNW_JLY Evapotranspiration for July in North West region
ETNW_AUG Evapotranspiration for August in North West region
ETNW_OCT Evapotranspiration for October in North West region

**5-5-2-3-5. Planted area function of winter season rice in North Central region**

APW_NC = + 390.12531
- 4.73004 * TREND
+ 0.00034398 * RPPDt-1/(NGDPD/100) *EYW_NC * SHIFT89
+ 0.00179 * RPPDt-1/(NGDPD/100) *EYW_NC
- 17.54514 * ln(ETNC_JUN)
+ 36.67058 * ln(ETNC_JLY)
- 35.93520 * ln(ETNC_AUG)

APW_NC Planted area of winter season rice in North Central region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_NC Expected (trend) yield of winter season rice in North Central region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETNC_JUN Evapotranspiration for June in North Central region
ETNC_JLY Evapotranspiration for July in North Central region
ETNC_AUG Evapotranspiration for August in North Central region

**5-5-2-3-6. Planted area function of winter season rice in South East region**

APW_SC = + 390.12531
+ 0.00034398 * RPPDt-1/(NGDPD/100) *EYW_SC * SHIFT89
- 17.54514 * ln(ETSC_JUN)
- 35.93520 * ln(ETSC_AUG)

APW_SC Planted area of winter season rice in South Central region
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_SC Expected (trend) yield of winter season rice in South Central region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETSC_JUN Evapotranspiration for June in South Central region
ETSC_AUG Evapotranspiration for August in South Central region

**5-5-2-3-7. Planted area function of winter season rice in Central Highlands region**

APW_CH = + 390.12531
- 0.51195 * TREND
+ 0.00034398 * RPPDt-1/(NGDPD/100) *EYW_CH * SHIFT89
- 17.54514 * ln(ETCH_JUN)
- 35.93520 * ln(ETCH_AUG)

APW_CH Planted area of winter season rice in Central Highlands region
TREND Linear time trend 1976=1
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_CH Expected (trend) yield of winter season rice in Central Highlands region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETCH_JUN Evapotranspiration for June in Central Highlands region
ETCH_AUG Evapotranspiration for August in Central Highlands region

**5-5-2-3-8. Planted area function of winter season rice in South East region**

APW_SE = + 390.12531
+ 1.76444 * TREND
+ 0.00034398 * RPPDt-1/(NGDPD/100) *EYW_SE * SHIFT89
- 17.54514 * ln(ETSE_JUN)
- 35.93520 * ln(ETSE_AUG)
+ 18.80624 * ln(ETSE_OCT)

APW_SE Planted area of winter season rice in South East region
TREND Linear time trend 1976=1
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_SE Expected (trend) yield of winter season rice in South East region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETSE_JUN Evapotranspiration for June in South East region
ETSE_AUG Evapotranspiration for August in South East region
ETSE_OCT Evapotranspiration for October in South East region

**5-5-2-3-9. Planted area function of winter season rice in Mekong River Delta region**

APW_MRD = + 1606.51866
(2.21)
- 40.25703*TREND
(-14.62)
- 0.00526 * RPPDt-1/(NGDPD/100)) *EYW_MRD*SHIFT89
(-1.45)
+ 0.00714 * RPPDt-1/(NGDPD/100)) *EYW_MRD
(1.81)
+ 199.47094 * ln(ETMRD_JUN)
(1.67)
- 214.79842 * ln(ETMRD_JUL)
(-1.46)
- 72.42217 * D89
(-2.11)
- 47.92462 * D96
(-1.92)

Adj $R^2$ = 0.9865 DW = 1.574

APW_MRD Planted area of winter season rice in Mekong River Delta region
TREND Linear time trend 1976=1
RPPDt-1 Retail paddy price lagged (000dong/MT)
NGDPD GDP Deflator
EYW_MRD Expected (trend) yield of winter season rice in

Mekong River Delta region
SHIFT89 Intercept Shift, SHIFT89=1 in 1989 and beyond, zero before
ETMRD_JUN Evapotranspiration for June in Mekong River Delta region
ETMRD_AUG Evapotranspiration for August in Mekong River Delta region
ETMRD_OCT Evapotranspiration for October in Mekong River Delta region

## 5-5-3. Production identities

### 5-5-3-1. Production identities of spring season rice

**5-5-3-1-1. Production identity of spring season rice in Red River Delta region**

QS_RRD = (YS_RRD/10)*APS_RRD
QS_RRD Spring season rice production, Red River Delta (1000 metric tons)
YS_RRD Spring season rice yield, Red River Delta (100kg/hectare)
APS_RRD Spring season rice planted area, Red River Delta (1000 hectares)

**5-5-3-1-2. Production identity of spring season rice in North East region**

QS_NE = (YS_NE/10)*APS_NE
QS_NE Spring season rice production, North East (1000 metric tons)
YS_NE Spring season rice yield, North East (100kg/hectare)
APS_NE Spring season rice planted area, North East (1000 hectares)

**5-5-3-1-3. Production identity of spring season rice in North West region**

QS_NW = (YS_NW/10)*APS_NW
QS_NW Spring season rice production, North West (1000 metric tons)
YS_NW Spring season rice yield, North West (100kg/hectare)
APS_NW Spring season rice planted area, North West (1000 hectares)

**5-5-3-1-4. Production identity of spring season rice in North Central region**

QS_NC = (YS_NC/10)*APS_NC
QS_NC Spring season rice production, North Central Coast (1000 metric tons)
YS_NC Spring season rice yield, North Central Coast (100kg/hectare)
APS_NC Spring season rice planted area, North Central Coast (1000 hectares)

**5-5-3-1-5. Production identity of spring season rice in South Central region**

QS_SC = (YS_SC/10)*APS_SC
QS_SC Spring season rice production, South Central Coast (1000 metric tons)
YS_SC Spring season rice yield, South Central Coast (100kg/hectare)
APS_SC Spring season rice planted area, South Central Coast (1000 hectares)

**5-5-3-1-6. Production identity of spring season rice in Central Highlands region**

QS_CH = (YS_CH/10)*APS_CH
QS_CH Spring season rice production, Central Highlands (1000 metric tons)
YS_CH Spring season rice yield, Central Highlands (100kg/hectare)
APS_CH Spring season rice planted area, Central Highlands (1000 hectares)

**5-5-3-1-7. Production identity of spring season rice in South East region**

QS_SE Spring season rice production, South East (1000 metric tons)
QS_SE = (YS_SE/10)*APS_SE
YS_SE Spring season rice yield, South East (100kg/hectare)
APS_SE Spring season rice planted area, South East (1000 hectares)

**5-5-3-1-8. Production identity of spring season rice in Mekong River Delta region**

QS_MRD = (YS_MRD/10)*APS_MRD
YS_MRD Spring season rice yield, Mekong Delta (100kg/hectare)
QS_MRD Spring season rice production, Mekong Delta (1000 metric tons)
APS_MRD Spring season rice planted area, Mekong Delta (1000 hectares)

### 5-5-3-2. Production identities of summer season rice

**5-5-3-2-1. Production identity of summer season rice in North Central region**

QM_NC = (YM_NC/10)*APM_NC
QM_NC Summer season rice production, North Central Coast (1000 metric tons)
YM_NC Summer season rice yield, North Central Coast (100kg/hectare)
APM_NC Summer season rice planted area, North Central Coast (1000 hectares)

**5-5-3-2-2. Production identity of summer season rice in South Central region**

QM_SC = (YM_SC/10)*APM_SC
QM_SC Summer season rice production, South Central Coast (1000 metric tons)
YM_SC Summer season rice yield, South Central Coast (100kg/hectare)
APM_SC Summer season rice planted area, South Central Coast (1000 hectares)

**5-5-3-2-3. Production identity of summer season rice in Central Highlands region**

QM_CH = (YM_CH/10)*APM_CH

QM_CH Summer season rice production, Central Highlands (1000 metric tons)
YM_CH Summer season rice yield, Central Highlands (100kg/hectare)
APM_CH Summer season rice planted area, Central Highlands (1000 hectares)

**5-5-3-2-4. Production identity of summer season rice in South East region**

QM_SE = (YM_SE/10)*APM_SE
QM_SE Summer season rice production, South East (1000 metric tons)
YM_SE Summer season rice yield, South East (100kg/hectare)
APM_SE Summer season rice planted area, South East (1000 hectares)

**5-5-3-2-5. Production identity of summer season rice in Mekong River Delta region**

QM_MRD = (YM_MRD/10)*APM_MRD
QM_MRD Summer season rice production, Mekong Delta (1000 metric tons)
YM_MRD Summer season rice yield, Mekong Delta (100kg/hectare)
APM_MRD Summer season rice planted area, Mekong Delta (1000 hectares)

## 5-5-3-3. Production identities of winter season rice

**5-5-3-3-1. Production identity of winter season rice in Red River Delta region**

QW_RRD = (YW_RRD/10)*APW_RRD
YW_RRD Winter season rice yield, Red River Delta (100kg/hectare)
QW_RRD Winter season rice production, Red River Delta (1000 metric tons)
APW_RRD Winter season rice planted area, Red River Delta (1000 hectares)

**5-5-3-3-2. Production identity of winter season rice in North East region**

QW_NE = (YW_NE/10)*APW_NE
QW_NE Winter season rice production, North East (1000 metric tons)
YW_NE Winter season rice yield, North East (100kg/hectare)
APW_NE Winter season rice planted area, North East (1000 hectares)

**5-5-3-3-3. Production identity of winter season rice in North West region**

QW_NW = (YW_NW/10)*APW_NW
QW_NW Winter season rice production, North West (1000 metric tons)
YW_NW Winter season rice yield, North West (100kg/hectare)
APW_NW Winter season rice planted area, North West (1000 hectares)

**5-5-3-3-4. Production identity of winter season rice in North Central region**

QW_NC = (YW_NC/10)*APW_NC
QW_NC Winter season rice production, North Central Coast (1000 metric tons)
YW_NC Winter season rice yield, North Central Coast (100kg/hectare)
APW_NC Winter season rice planted area, North Central Coast (1000 hectares)

**5-5-3-3-5. Production identity of winter season rice in South Central region**

QW_SC = (YW_SC/10)*APW_SC
QW_SC Winter season rice production, South Central Coast (1000 metric tons)
YW_SC Winter season rice yield, South Central Coast (100kg/hectare)
APW_SC Winter season rice planted area, South Central Coast (1000 hectares)

**5-5-3-3-6. Production identity of winter season rice in Central Highlands region**

QW_CH = (YW_CH/10)*APW_CH
QW_CH Winter season rice production, Central Highlands (1000 metric tons)
YW_CH Winter season rice yield, Central Highlands (100kg/hectare)
APW_CH Winter season rice planted area, Central Highlands (1000 hectares)

**5-5-3-3-7. Production identity of winter season rice in South East region**

QW_SE = (YW_SE/10)*APW_SE
QW_SE Winter season rice production, South East (1000 metric tons)
YW_SE Winter season rice yield, South East (100kg/hectare)
APW_SE Winter season rice planted area, South East (1000 hectares)

**5-5-3-3-8. Production identity of winter season rice in Mekong River Delta region**

QW_MRD = (YW_MRD/10)*APW_MRD
QW_MRD Winter season rice production, Mekong Delta (1000 metric tons)
YW_MRD Winter season rice yield, Mekong Delta (100kg/hectare)
APW_MRD Winter season rice planted area, Mekong Delta (1000 hectares)

## 5-5-3-4. Production identities for regions

**5-5-3-4-1. Production identity in Red River Delta region**

QT_RRD = QS_RRD + QW_RRD
QS_RRD Spring Season Rice Production, Red River Delta (1000 metric tons)
QW_RRD Winter Season Rice Production, Red River Delta (1000 metric tons)

**5-5-3-4-2. Production identity in North East region**

QT_NE = QS_NE + QW_NE

QS_NE Spring Season Rice Production, North East (1000 metric tons)

QW_NE Winter Season Rice Production, North East (1000 metric tons)

**5-5-3-4-3. Production identity in North West region**

QT_NW = QS_NW + QW_NW

QS_NW Spring Season Rice Production, North West (1000 metric tons)

QW_NW Winter Season Rice Production, North West (1000 metric tons)

**5-5-3-4-4. Production identity in North Central region**

QT_NC = QS_NC + QM_NC + QW_NC

QS_NC Spring Season Rice Production, North Central Coast (1000 metric tons)

QM_NC Summer Season Rice Production, North Central Coast (1000 metric tons)

QW_NC Winter Season Rice Production, North Central Coast (1000 metric tons)

**5-5-3-4-5. Production identity in South Central region**

QT_SC = QS_SC + QM_SC + QW_SC

QS_SC Spring Season Rice Production, South Central Coast (1000 metric tons)

QM_SC Summer Season Rice Production, South Central Coast (1000 metric tons)

QW_SC Winter Season Rice Production, South Central Coast (1000 metric tons)

**5-5-3-4-6. Production identity in Central Highlands region**

QT_CH = QS_CH + QM_CH + QW_CH

QS_CH Spring Season Rice Production, Central Highlands (1000 metric tons)

QM_CH Summer Season Rice Production, Central Highlands (1000 metric tons)

QW_CH Winter Season Rice Production, Central Highlands (1000 metric tons)

**5-5-3-4-7. Production identity in South East region**

QT_SE = QS_SE + QM_SE + QW_SE

QS_SE Spring Season Rice Production, South East (1000 metric tons)

QM_SE Summer Season Rice Production, South East (1000 metric tons)

QW_SE Winter Season Rice Production, South East (1000 metric tons)

**5-5-3-4-8. Production identity in Mekong River Delta region**

QT_MRD = QS_MRD + QM_MRD + QW_MRD

QS_MRD Spring Season Rice Production, Mekong Delta (1000 metric tons)

QM_MRD Summer Season Rice Production, Mekong Delta (1000 metric tons)

QW_MRD Winter Season Rice Production, Mekong Delta (1000 metric tons)

## 5-5-3-5. Production identities for rice types

**5-5-3-5-1. Production identity of spring season rice**

QS = QS_RRD + QS_NE + QS_NW + QS_NC + QS_SC + QS_CH + QS_SE + QS_MRD

QS_RRD Spring Season Rice Production, Red River Delta (1000 metric tons)

QS_NE Spring Season Rice Production, North East (1000 metric tons)

QS_NW Spring Season Rice Production, North West (1000 metric tons)

QS_NC Spring Season Rice Production, North Central Coast (1000 metric tons)

QS_SC Spring Season Rice Production, South Central Coast (1000 metric tons)

QS_CH Spring Season Rice Production, Central Highlands (1000 metric tons)

QS_SE Spring Season Rice Production, South East (1000 metric tons)

QS_MRD Spring Season Rice Production, Mekong Delta (1000 metric tons)

**5-5-3-5-2. Production identity of summer season rice**

QM = QM_NC + QM_SC + QM_CH + QM_SE + QM_MRD

QM_NC Summer Season Rice Production, North Central Coast (1000 metric tons)

QM_SC Summer Season Rice Production, South Central Coast (1000 metric tons)

QMCH Summer Season Rice Production, Central Highlands (1000 metric tons)

QM_SE Summer Season Rice Production, South East (1000 metric tons)

QM_MRD Summer Season Rice Production, Mekong Delta (1000 metric tons)

**5-5-3-5-3. Production identity of winter season rice**

QW = QW_RRD + QW_NE + QW_NW + QW_NC + QW_SC + QW_CH + QW_SE + QW_MRD

QW_RRD Winter Season Rice Production, Red River Delta (1000 metric tons)

QW_NE Winter Season Rice Production, North East (1000 metric tons)

QW_NW Winter Season Rice Production, North West (1000 metric tons)

QW_NC Winter Season Rice Production, North Central Coast (1000 metric tons)

QW_SC Winter Season Rice Production, South Central Coast (1000 metric tons)

QW_CH Winter Season Rice Production, Central Highlands (1000 metric tons)

QW_SE Winter Season Rice Production, South East (1000 metric tons)

QW_MRD Winter Season Rice Production, Mekong Delta (1000 metric tons)

## 5-5-3-6. Production identity for whole country

Q = QS + QM + QW

QS Spring Season Rice Production, Vietnam (1000 metric tons)
QM Summer Season Rice Production, Vietnam (1000 metric tons)
QW Winter Season Rice Production, Vietnam (1000 metric tons)

### 5-5-3-7. Production identity for milled rice

QME = (1000*Q*0.6667)

QME Total rice production, milled equivalent (metric tons)
Q Total (All Seasons) Rice Production, Vietnam (1000 metric tons)

### 5-5-4. Rice export function

FEX = - 1626586
(-3.40)
+ 0.15504*QME
(4.26)
+ 605.98133*(WP*NEXGI) / (NGDPD/100)
(2.76)
+327.07807*(WP*NEXGI) / RRPD * SHIFT90
(1.51)
+1325.5420*(WP*NEXGI) / RRPD * SHIFT96
(4.32)
+ 1086048*D99
(3.44)

Adj $R^2$ = 0.9539 DW = 2.52

QME Rice production (milled equivalent)
WP Thai 35% broken price in $US as reported by USDA
NEXGI Exchange rate
NGDPD Gross Domestic Product Deflator
RRPD Retail rice price(units)
SHIFT90 Intercept Shift, SHIFT90=1 in 1990 and beyond, zero before
SHIFT96 Intercept Shift, SHIFT96=1 in 1996 and beyond, zero before
D99 Dummy variable, D99=1 in 1999, otherwise 0

### 5-5-5. Rice stock change function

STC = - 263803
(-1.42)
+ 0.55952*(QME-QMEt-1)
(2.89)
-10644*((RRPD/(NGDPD/**100**))-lag(NRRP/(NGDPD/**100**)))*SHIFT96
(-2.43)
+ 2587487*SHIFT01
(6.61)

Adj $R^2$ = 0.7103 DW = 2.294

QME Rice production (milled equivalent)
RRPD Retail rice price (1000dong/metric tons)
NGDPD Gross Domestic Product Deflator
SHIFT01 Intercept Shift, SHIFT01=1 in 2001 and beyond, zero before

### 5-5-6. Supply identity

Total supply

QD = QME + IMPME – EXPME – STCME

QD Total supply
QME Total rice production, milled equivalent (metric tons)
IMPME Rice imports, milled equivalent (metric tons)
EXPME Rice exports, milled equivalent (metric tons)
STCME Stock change, milled equivalent (metric tons)

### 5-5-7. Consumption identity

Consumption per capita

QC = QD / POP / 1000

QC Rice consumption per capita (kilo gram/person)
QD Rice supply (metric tons)
POP Population (million people)

### 5-5-8. Rice demand function

QC*1000 = 182382
(21.79)
+ 25789*D86
(5.95)
- 18.15899*(RRPD/(NGDPD/100)
(-50.73)
+ 103217*(NGDPRGI/POP)
(2.32)
+ 6609.72483*SHIFT96
(2.26)
- 6252.26201*(Y89+Y90)
(-2.92)

Adj $R^2$ = 0.9684 DW = 1.877

RRPD Retail rice price (1000dong/metric ton)
NGDPD Gross Domestic Product Deflator
NGDPRGI Gross Domestic Product (real)
POP Population (million person)
D86 Dummy variable, D86=1 in 1986, otherwise 0

### 5-5-9. Price linkage function

RPME = - 533.20297
(-2.47)
+ 1.47755*RPPD
(30.02)
+ 249.9007*log(TREND)
(2.61)

Adj $R^2$ = 0.9968 DW = 1.271

RRPD Retail paddy rice price (1000dong/metric ton)
RPME Retail milled rice price (1000dong/metric ton)
TREND Linear time trend 1975=1

Table 5-1. Elasticities of yield of spring season rice for evapotranspiration and trend

| Region | Trend | Dec. | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. |
|---|---|---|---|---|---|---|---|---|---|
| Red River Delta | 1.007 | -0.106 | -0.071 | 0.157 | | | 0.262 | | -0.374 |
| North East | 0.619 | -0.154 | 0.256 | | | | 0.380 | | -0.542 |
| North West | 0.585 | -0.145 | 0.242 | | | | 0.360 | | -0.513 |
| North Central | 0.551 | -0.137 | 0.228 | | | | 0.339 | | -0.483 |
| South Central | 0.524 | -0.130 | 0.217 | | | | 0.322 | | -0.459 |
| Central Highlands | 0.443 | -0.110 | 0.183 | | -0.551 | 0.585 | 0.272 | | -0.388 |
| South East | 0.539 | -0.134 | 0.223 | | | | 0.331 | | -0.472 |
| Mekong River Delta | 0.230 | 0.009 | 0.158 | | | | 0.234 | | -0.334 |

Table 5-2. Elasticities of yield of summer season rice for evapotranspiration and trend

| Region | Trend | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. |
|---|---|---|---|---|---|---|---|---|---|
| North Central | 0.852 | 0.096 | | | | -1.184 | -0.985 | 1.556 | -0.291 |
| South Central | 0.225 | 0.066 | | | | | | | -0.199 |
| Central Highlands | 0.384 | 0.473 | | 3.991 | | | | -4.212 | -1.327 |
| South East | 0.073 | 0.083 | | | | | | | -0.252 |
| Mekong River Delta | 0.121 | 0.075 | | | | | | | -0.229 |

Table 5-3. Elasticities of yield of winter season rice for evapotranspiration and trend

| Region | Trend | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. |
|---|---|---|---|---|---|---|---|
| Red River Delta | 0.613 | | 1.041 | -0.262 | 1.342 | | -0.247 |
| North East | 0.579 | | | | 0.326 | | -0.082 |
| North West | 0.453 | | 0.339 | -0.445 | 0.453 | | |
| North Central | 0.553 | | | | 0.410 | 0.558 | -0.248 |
| South Central | 0.338 | -0.716 | | -0.809 | 0.339 | 0.314 | |
| Central Highlands | 0.416 | -0.070 | | | 0.416 | | |
| South East | 0.080 | | | 0.653 | -0.276 | | |
| Mekong River Delta | 0.315 | | | | 0.316 | | |

Table 5-4. Elasticities of planted area of spring season rice

| Region | Trend | Price | ET | |
|---|---|---|---|---|
| | | (t-1) | Jan. | Feb. |
| Red River Delta | | 0.035 | | |
| North East | | 0.060 | 0.050 | |
| North West | | 0.065 | | |
| North Central | | 0.015 | | |
| South Central | | 0.030 | | |
| Central Highlands | | 0.193 | | |
| South East | | 0.445 | 1.045 | |
| Mekong River Delta | 0.305 | 0.040 | 0.091 | 0.059 |

Table 5-5. Elasticities of planted area of summer season rice

| Region | Trend | Price (t-1) | ET | | | |
|---|---|---|---|---|---|---|
| | | | May | Jun. | Jly. | Aug. |
| North Central | | 0.164 | | | -0.419 | |
| South Central | | 0.044 | | | 0.064 | |
| Central Highlands | | 3.689 | | | -31.94 | |
| South East | | -0.027 | 0.375 | | -0.527 | 3.087 |
| Mekong River Delta | 1.316 | 0.063 | 0.338 | | | |

Table 5-6. Elasticities of planted area of winter season rice

| Region | Trend | Price (t-1) | ET | | | | |
|---|---|---|---|---|---|---|---|
| | | | Jun. | Jly. | Aug. | Sep. | Oct. |
| Red River Delta | | 0.030 | -0.029 | 0.157 | -0.060 | | |
| North East | | 0.007 | -0.051 | 0.216 | -0.105 | | -0.096 |
| North West | | 0.015 | -0.158 | | -0.018 | | -0.379 |
| North Central | -0.339 | 0.062 | -0.072 | 0.150 | -0.147 | | |
| South Central | | 0.016 | -0.122 | | -0.250 | | |
| Central Highlands | -0.066 | 0.014 | -0.130 | | -0.265 | | |
| South East | 0.118 | 0.008 | -0.067 | | -0.138 | | 0.072 |
| Mekong River Delta | -0.828 | 0.036 | 0.234 | -0.252 | | | |

## 5-6. Simulation results

### 5-6-1. Results of estimation of yield functions

Table 5-1 through Table 5-3 show elasticities of yield for ET of spring, summer, and winter season rice respectively.

The planting of spring season rice occurs from December to February and harvesting occurs from June to July. The planting and harvest time of summer season rice is May to June and September to October. The summer season rice is cultivated only in southern regions because typhoons hit the northern regions during the harvesting period. Winter season rice follows spring season rice in the northern regions, and planting occurs during June to July and harvest time is September to October.

The estimation results for spring season rice show that higher ET in January and May leads higher yield. These results suggest that water supply during the planting and flowering period is important for the growth of spring season rice, and if water supply decreases 1% in May in Mekong River Delta region, yield will decrease 0.234%. The results of summer rice show that higher ET in March leads higher yield. The water supply during the flowering season is not as critical due to high precipitation in July and August. The results for winter season rice show that higher ET in September, which is the flowering time, is important for the growth of the rice, and if ET decreases 1% in September in Red River Delta region, yield will decrease 1.342%.

### 5-6-2. Results of estimation of planted area functions

Planted area function of spring, summer, and winter season rice are specified as linear functions based on a naïve expectation model. The explanatory variables are time trend, one-year lagged price, and current ET for each month. The elasticities evaluated at the average are shown in Table 5-4 through Table 5-6.

The elasticities of planted area of spring season rice for ET are null in most regions; however, in the South East region it is quite sensitive, i.e., if ET increases 1% in January in the region, the planted area will increase 1.045%. The elasticities of planted area of summer rice for ET in May in Southern regions are high. These results suggest that if the water supply increases during the planting season of spring and summer season rice, the planted area will increase in southern regions. Results for winter season rice differ from other two season rices. The elasticities of planted area of winter season rice for ET are negative in June and August. These results suggest that the excess supply of water during the rainy season will decrease the planted area of winter season rice.

### 5-6-3. Simulation results of supply and demand model

The simulation term is from 2003 to 2015. The assumptions of the simulation are as follows; (1) the growth value of GDP deflator for the simulation period is the average annual growth between 1999 and 2004, (2) the growth value of real GDP is the average

annual growth between 1996 and 2003, (3) the growth value of the exchange rate is the average annual growth between 1998 and 2004, (4) the growth value of population is the average annual growth between 1996 and 2003, (5) the linear trend of the yield functions are continued, (6) the trend of planted area functions are flat.

Figure 5-3 and Figure 5-4 show the simulation results for the production of spring and summer season rices in Mekong River Delta region, and Figure 5-5 through Figure 5-7 show the simulation results of the production of spring, summer, and winter season rices for the country as a whole.

The production of spring rice in Mekong River Delta region will increase 524 thousand metric tons (MT) from 2010 to 2015. On the other hand, the production of summer rice in the region will be stable at around 7.5 million MT (mMT). Summer rice production in the Mekong River Delta region drastically increased from 7.7 mMT in 2003 to 8.6 mMT in 2004; however, the model did not follow the change.

The production of spring, summer, and winter season rice will increase 1.6 mMT, 0.4 mMT, and 0.9 mMT respectively.

Figure 5-8 shows per capita rice consumption, and it will be stable around 200 kilogram (KG) Figure 5-9 shows the simulation result of the equilibrium real price. These prices are converted to real currency units using a CPI whose value is 100 in 1989. The farm price is estimated to be stable at around 200 thousand Dong per KG.

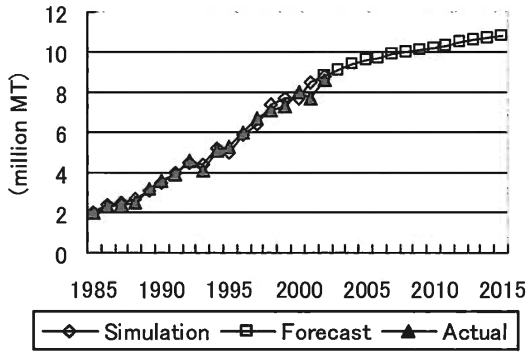


Fig. 5-3. Production of spring season rice in Mekong River Delta region

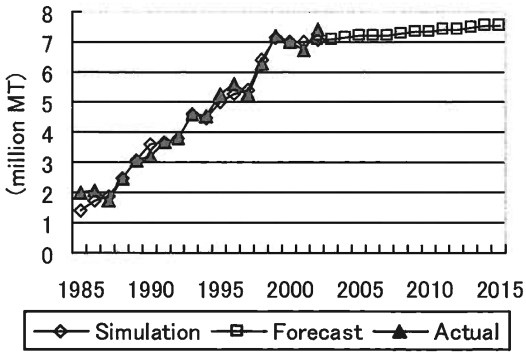


Fig. 5-4. Production of summer season rice in Mekong River Delta region

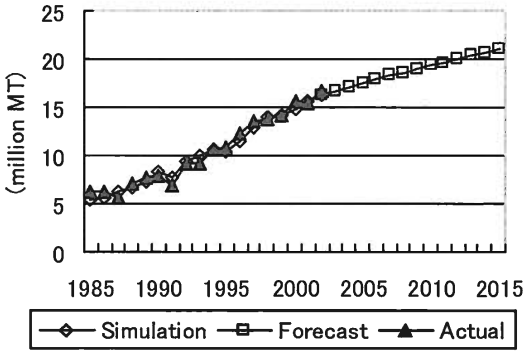


Fig. 5-5. Production of spring season rice for whole country

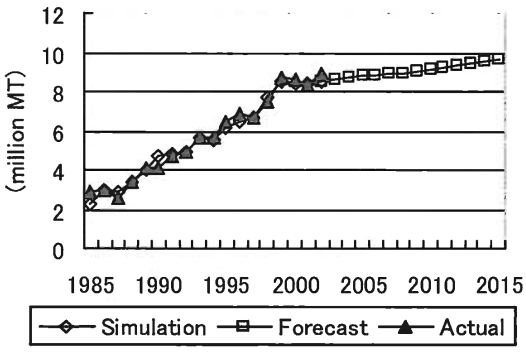


Fig. 5-6. Production of summer rice for whole country

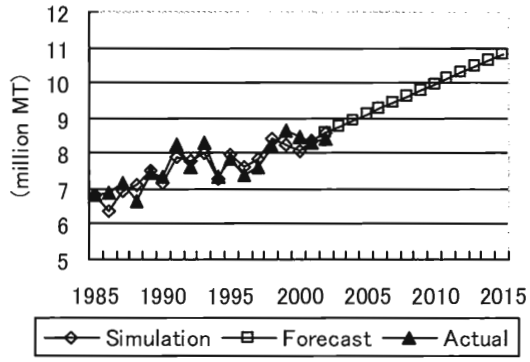


Fig. 5-7. Production of winter rice for whole country

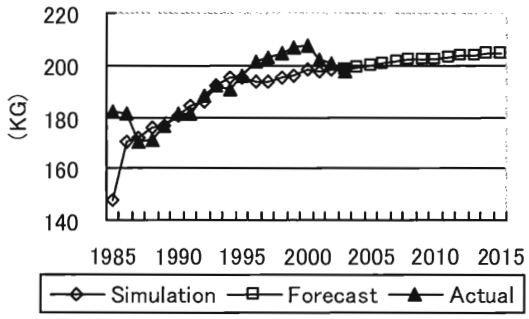


Fig. 5-8. Per capita consumption

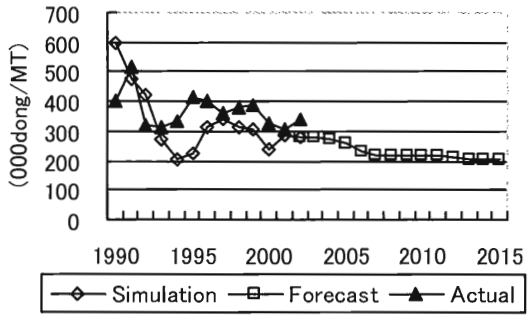


Fig. 5-9. Realized retail price (base year: 1989)

## 5-7. Conclusions

The supply and demand model presented can analyze changes in yield and planted area independently and consider supply responses and demand changes to the market price for rice while equating supply and demand. The baseline analysis indicates that productions of all season rice steadily increases due to an increase in yield. The planted area for the country as a whole has been decreasing in recent years and is a trend that is expected to continue in the outlook.

The cold weather and the insect disease outbreak in Vietnam are significant contributors to the sharp increase in the world price of rice in 2008. Not only high yield but climate change tolerant varieties of rice are necessary for stable rice farm management.