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RESEARCH ARTICLE

Rice Buffer Stock Maintenance Post-Rice Tariffication Law (RA11203): An Application of a Partial Equilibrium model for Buffer Stock Level Optimization

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The *Rice Tariffication Law* or *RA 11203* was created for the purpose of achieving food security, lowering prices at the consumer level, and making the rice industry more competitive. The opening up of the domestic rice market led to the removal of the National Food Authority's (NFA) licensing & regulatory powers which shifted their mandate solely on maintaining an optimal level of buffer stock primarily for emergency situations. To fulfill this mandate, the NFA must anticipate and account for emergencies & uncertain events in their current operations.

This paper presents an application of a Partial Equilibrium Rice Model to determine which regions NFA should purchase palay/rice to maintain the optimal level of buffer stock. Without additional imports, if a 10% disruption in palay production in region 3 was introduced, the palay reduction is 4.75% relative to the base, amounting to 27,409 MT in Semester 1 and 53,662 MT in Semester 2. In this scenario NFA had to procure palay from increases its procurement in regions 1, Region 2, Region 4b, Region 6, & Region 12 to maintain the buffer stock in Sem 2 to maintain the buffer stock at its optimal level. In the event of a disruption in production during the year, the Model can guide policy makers where to procure depending on which region will be badly hit by any type of calamity.

Keywords: *Buffer Stock, Partial Equilibrium, Public Stockpiles, Optimization, Farmgate price, Wholesale Price, Disaster Affected Population*

JEL classification:

The *Rice Tariffication Law* or *RA 11203,* enacted on March 5, 2019, was created for the purpose of achieving food security, lowering prices at the consumer level, and making the rice industry more competitive. It is expected to make relatively cheaper rice more available to benefit the majority of the population, especially the poor households who spend 29% of their food expenditure on this staple grain. In addition, the law helps the Philippines fulfill its international agreement with the World Trade Organization (WTO) to tariff rice with the expiration of the Waiver on its Special Treatment on June 30, 2017. With Quantitative Restrictions (QR) on Rice replaced with Tariff, the law also paved the way for developing the Rice Competitiveness Enhancement Fund (RCEF) to assist rice farmers with seeds, farm machineries, credit and technical extension.

The opening up of the domestic rice market led to the removal of the National Food Authority's (NFA) licensing & regulatory powers which shifted their mandate solely on maintaining an optimal level of buffer stock, sourced only from local farmers, primarily for emergency situations and to sustain the government's disaster relief programs during natural or man-made calamities. Before and during the passage of *RA 11203*, the NFA adopted an optimal level of rice inventory equivalent to 15 to 30 days of national rice consumption that should be maintained at all times and only to be released when emergencies occur.

In order to fulfill this mandate, the NFA must anticipate and account for emergencies & uncertain events in their current operations. Furthermore, it is imperative that the stocks maintained in each NFA regional office that makes up national rice buffer stock is strategically positioned for distribution to address the needs of the persons affected by the natural and/or man-made calamity. Several researchers & policy makers all over the world have utilized different numerical models such as Linear Programming Models, Partial Equilibrium Models, & Computable General Equilibrium Models, to simulate different scenarios and study the interaction and interdependence of buffer stock systems between different elements.

This paper presents an application of a Partial Equilibrium Rice Model, with the general modeling specifications developed by the authors, to determine which regions NFA should purchase palay/rice to maintain the optimal level of buffer stock. The paper is organized as follows. Section 1 gives a brief introduction on the Rice Tariffication Law and Buffer Stock Modeling. Section 2 will cover the different types of public stockpiling that is maintained by countries in Asia and the purpose of each stockpile. Section 3 gives a brief review of literature that details existing research on buffer stock models. Section 4 & 5 details the blocks, variables, and equations that's included in the model, the data sets and scenarios projected in the study. Section 6 discusses the results of the three simulations. Section 7 summarizes & concludes the study.

Types of Public Stockpiling

Implementing and maintaining public stockpiles of key commodities such as rice is a common policy seen in many countries around the world. Public stockpiling schemes were first put to action during the World Wars to ease food insecurity and up until now it is still seen as a viable option in national food policies. Countries that have public stockpiling schemes are those with dense populations such as India, China, United Arab Emirates, and most of the ASEAN countries believe that maintaining public stockpiles can counteract international trade uncertainties and volatility. According to Caballero, Maxim, Shrestha, Nair & Lassa (May 2015), public stockpiles can be defined as "directly owned, monitored and administered by governments via state owned enterprises such as Food Corporation of India, Bulog in Indonesia, Bernas in Malaysia, National Food Authority in the Philippines and Public Warehouse Organization in Thailand." The policy brief also included the four different types of public stockpiles:

1. *Emergency/humanitarian stocks*: stocks to be maintained to protect access to food, for vulnerable groups in the event a food shortage happens. The release of such stocks happens in the event of any type of emergencies or as part of bigger post-disaster safety nets, as deemed necessary by governments.
2. *Stocks for food security (buffer stocks)*: stocks used to ensure stability in the availability and price of food.
3. *Safety net stocks*: stocks that target lower-income segments of society (based on defined poverty lines) and are often sold at highly subsidized prices.

$$S_i^F = 0 \text{ if } i = (\#2, \#9) \text{ in Table 1} \quad ; \quad 1 > \frac{S_i^F}{\sum_{i=1}^{K^c} S_i^F} > S_i^F > 0 \text{ if } i \neq (\#2, \#9)\,.$$

4. *Stocks for trade*: public stock held by exporting countries to guarantee minimum profit margins.

In Asia, the following countries have the following stockpile types maintained for different policies (RSIS, 2015) : China maintains a food security stockpile that consists of rice, wheat, corn, soya & sugar; Japan maintains a food security stockpile that consist of rice, soybean & wheat and emergency stock that consist of rice porridge and other emergency food supplies; India maintains all four types of stockpiles which consist of rice & wheat; Indonesia maintains a food security stockpile of rice & frozen beef, emergency stock for rice, and export stock for corn; The Philippines maintains food security stockpiles for rice, corn, & sugar, an emergency stockpile for rice and export stock for corn; Malaysia maintains a food security stockpile for rice; Thailand maintains an export stock for rice & cassava; Singapore maintains a food security stockpile for rice; Lastly, Vietnam maintains a food security stockpile for soybean and export stock for rice. At the Regional Level, we have the ASEAN plus Three Emergency Rice Reserve (APTERR), the South Asian Association for Regional Cooperation (SAARC), & Economic Community of West African States (ECOWAS) maintaining an emergency stock for rice.

Emergency stocks are stocks to be maintained to protect access to food, for vulnerable groups in the event a food shortage happens. This kind of stockpile will act as a buffer or protection for governments, both at the country or regional level, for any type of emergency or unforeseen disaster. Japan is often cited as an example that maintains emergency food stockpiles for anticipated local disasters; their government maintains 2 weeks' worth of food rations at both municipal and household levels. Additionally, Japan has also pledged 150,000 MT of rice to the APTERR which makes them the third largest country to pledge rice reserve stock among the member countries.

Food Security stocks (buffer stocks) are stocks used to ensure stability in the availability and price of food. This concept was first introduced in the 1996 World Food Summit with the following elements: Food Security stocks must be available at all times, it should be physically and economically accessible, and should abide by certain dietary or nutritional requirements (Lassa et al, 2018). Governments maintain this kind of stockpile by procuring rice or produce from farmers and releasing stocks when market prices are at level higher than regular local consumers can afford. Apart from Thailand, all ASEAN plus Three Countries maintain food security stockpiles for rice. In the case of India, the Food Corporation of India (FCI) maintains a food security stockpiling mechanism to offer rice support for farmers and optimize domestic production and distribute food grains across the country through their Public Distribution System (PDS) to ensure availability (Caballero-Anthony et al, 2016). The concept of PDS is to sell the rice procured by the FCI to state governments at an administered price called the central issue price (CIP). Since India maintains all four types of stockpiles, these public stock levels are reassessed every five years by experts & policy makers which consider annual fluctuations in production and their government's commitment in distributing subsidized food.

Safety Net Stocks are stocks that target lower-income segments of society (based on defined poverty lines) and are often sold at highly subsidized prices. This type of stockpile is maintained & stored alongside food security stocks by governments such as Indonesia and India, but are released for groups who belong below the poverty line. Groups that are classified to be below the poverty line experience chronic food insecurity and therefore need easily accessible and available food stocks.

Stocks for Trade is a public stock held by exporting countries to guarantee minimum profit margins. This kind of stockpile aims to provide more opportunities and promote local production as well as stabilize exports but is not usually maintained by most countries. Due to this stock being used only for trade, there is little to no urgency in releasing the stock therefore governments must establish and maintain technologies in order to minimize approximately 30% yield losses at the post-harvest and storage phase.

NFA's new mandate is a unique case compared to other countries such as Indonesia's BULOG or India's Food Corporation where they handle all four types of public stockpiles. Under the rice tariffication law, NFA will now only handle stocks for emergency/disaster relief operations. In most of the literature, buffer stocks are meant to be used for food security measures. If the NFA is now only strictly for calamities & disasters then the consulting team recommends that the right term to be used is Emergency Reserve Stock instead of Buffer Stock as seen in literature and the terms mentioned above. Even if such distinctions are made in terms of public stockpiling, countries may find it ambiguous if the objectives of maintaining national stockpiles are not properly clarified from the start.

Buffer Stock Models

Generally, the countries with rice buffer stock systems mentioned in this section were assessed by different researchers and policymakers through the use of buffer stock models. Bahagia et. al. (2008) developed a buffer stock model that aims to stabilize commodity prices under a limited time of supply due to factors such as harvest and planting season, production factors and trade regulation while being continuously consumed by the public. The researchers used to formulate the objective function and Mixed Linear Integer Programming Model of the Price Band Policy. The results in the study show that inelastic supply of commodities minimizes financial losses compared to when it's elastic. The proposed model has significant effects in minimizing financial loss for the producer, consumer and government. The researchers also concluded that government intervention plays a major role in price stabilization due to the following: keeping buffer stocks benefit both producers and consumers, the proposed model can obtain a buffer stock program and the revenue of price intervention can cause the same amount of reduction in total market revenue fluctuations.

Pu and Zheng's study (2018) propose a modified stochastic simulation model for the Buffer Stock system of China that allows price band levels and storage capacities. The researchers used a partial equilibrium model for a grain product that takes into account a closed market and government intervention and found that: a narrow price band is necessary to achieve the policy goals and prevent price fluctuations, whatever change done to the price band the storage capacity will have marginal decreasing effects on policy performances, and a narrow symmetric band is effective if the government lacks the means to pay for large public storage.

Abokyi et. al (2018) investigated the effectiveness of Ghana's rice stabilization policy in reducing price volatility. The researchers of the study empirically evaluated the policy using the real monthly wholesale prices of rice and maize acquired from MoFA from three major cereal markets as well as conducted the following econometric tests: the Augmented Dickey-Fuller (ADF) Test and the Coefficient of Variation (CV) and the Corrected Coefficient of Variation (CCV). After empirical evaluation, the researchers conclude that the buffer stock operations of Ghana did minimize the volatility of rice and maize prices and urge the government of Ghana to scale up the policy to other regions where cereal production is rigorous, but buyers have limited access to. The buffer stock operations provide safe storage to farmers and traders to maintain the quality of produce during lean periods that leads to the creation of a Warehouse Receipt System (WRS) that lets farmers have access to credit for loan recovery.

Chen and Villoria (2019) evaluated the effects of imports and buffer stocks on the intra-annual coefficient of variation (CV) of real monthly maize prices of the following regions: Africa, Asia and Latin America. The researchers of the study delved more into the significance of international trade and buffer stock while also considering climate shocks. The researchers utilized regression analysis in order to quantify the effects of domestic yield shocks, imports and buffer stocks on the intra-annual CV of real monthly maize prices in 27 countries. The results of the study show that maize prices tend to be stable in countries whose domestic consumption is heavily reliant on imports, which imply that international markets serve as a stabilizer amidst international food price volatility occurring through turbulent periods.

Briones (2013) utilized a CGE model that integrates an endogenous area allocation under an aggregate land constraint. The study emphasizes the need to generate scenarios that evaluate future trends of land allocation, food demand, domestic production, and the Philippines' dependence on foreign markets. The baseline scenario developed was an equilibrium solution from 2016 to 2030 that covers the Sustainable Development Goals (SDG) Period while the alternative scenario evaluated in the study was on a Drafted Tariffication Law that replaces Quantitative Restrictions with Tariffs of 35% for ASEAN imports, 40% tariffs in-quota, and a tariff ceiling of 180% out-quota. The results of the baseline scenario indicate that existing growth patterns can be sustained within 2016 to 2030 if productivity trends within industry and service sectors carry on. Furthermore, growth in yield and minor changes in area harvested is seen throughout the major crops included in the study except for bananas. The results of the alternative scenario indicate that tariffication has a negative impact to the palay sector in terms of area harvested, yield, and production and that the agricultural sector of the Philippines as a whole will experience a slowdown in growth. However, the results also indicate an increase in household per capita expenditure as well as overall growth to GDP; imports are also larger which results to a more cost-effective consumer price of rice and an overall increase in rice demand.

Cororaton and Yu (2019) also conducted a study that evaluated the impact of poverty and alternative rice policies in the Philippines by utilizing a computable general equilibrium model CGE Model with poverty microsimulation. The researchers have examined four rice policy scenarios: (i) 50 percent reduction in rice imports, (ii) absence of imported rice quota, (iii) substituting a rice tariff (48.9%) for import quota wherein the revenue generated be allocated to low-income households as cash transfers, (iv) the 25 percent reduction of rice tariffs generated in the 3rd simulation over 10 years and with the same cash transfer scheme as well. After the policy simulations, the results of their study show that having strict restrictions in rice will set back the industry due to the high domestic price of rice and dampening poor household budget and consumption. The 50 percent reduction in rice imports will lead to a 203 thousand increase of poor people in the population. The absence of imported rice quota or quantitative restrictions will lead to a 515 thousand decrease in poverty. Implementing a cash transfer scheme for poor households with the tariff revenue generated will reduce poverty by 10 million in 10 years but it is critical that the government identifies the means of distributing these rice tariff revenues to achieve these simulated results. The simulations indicate that the rice farmers will struggle to make income with the influx of imported rice but the positive welfare effects of the rice liberalization policy should not be disregarded. As a result, the researchers implore that the government must ensure that the cash transfer scheme should be targeted towards the rice farmers to offset the price shock attributed by increased rice supply and that training farmers for crop diversification and livelihood mechanisms must be implemented as well.

Bahagia et. al. (2008) developed a buffer stock model that aims to stabilize commodity prices under a limited time of supply due to factors such as harvest and planting season, production factors and trade regulation while being continuously consumed by the public. The researcher first began his study by looking at the overview of the current supply-demand chain network of Indonesia then mapping previous price stabilization models using buffer stocks. The results in the study show that inelastic supply of commodities minimizes financial losses compared to when it is elastic.

In summary, all current buffer stock models used by researchers and policy makers only mention that buffer stocks will be used for food security and price stabilization. Since this is no longer the mandate of the National Food Authority (NFA), as stated in RA11203, this study will look partial equilibrium models that will take into account the new role of NFA, that is, to maintain and determine the optimal level of buffer stocks to be used for emergency and disaster relief operations at any given time.

Model Specification

RA 11203 limits the role and influence of the NFA in the domestic rice market. The NFA cannot regulate the inflows of rice imports under the present rice law. The national government imposes tariffs on imported rice directly in the current law. The NFA's new role is to supply rice to government funded support programs such as the conditional cash transfers and other local government rice demand in cases of palay disruptions due to calamities.

The NFA can purchase domestically produced rice/palay only. It maintains a certain level of rice buffer stock. If the stock of rice of the NFA reaches below a certain specified level, the NFA increases its purchases of rice/palay across palay-surplus regions.

However, even with the limited role, the NFA affects the overall rice market conditions, or vice versa. For example, changes in rice imports by the private sector (either to due gaps in the domestic supply because of calamities or to speculative purposes) which affect the overall domestic supply and price of rice will also impact on NFA's purchases of domestic palay/rice as well as in order to maintain NFA's inventory management. Thus, the NFA buffer stock system must be modeled within the overall rice market in the country.

The NFA buffer stock system is specified within a partial equilibrium rice model. That is, except for rice, all other goods in the consumption basket of the consumers are fixed. However, the model is economy-wide in the sense that the model allows for interactions among all palay-producing regions (16 regions excluding the National Capital Region, NCR). A Partial Equilibrium model was used in this study due to the buffer stock being procured across regions in a single country. Moreover, it can also take into account calamities/disasters which is the mandate of the buffer stock being set by NFA

The model consists of three blocks: (a) demand for rice; (b) supply of rice/palay, and (c) rice market equilibrium and buffer stock. The model incorporates two buffer stock systems, one for the NFA and another for the private sector.

Demand Structure.

Figure 4.1 presents the demand structure of the model. A representative consumer has rice and all other goods in his/her utility function. The consumer maximizes utility subject to an income constraint, which generates the demand for rice and for all other goods. Since the demand for all other goods is fixed in the model (partial equilibrium), only the demand for rice is incorporated in the model. For more details on the demand structure model please see Appendix 4.

The consumer has the option of buying domestically produced rice or imported rice. The demand for domestically produced rice is disaggregated into regional demand by the private sector and the NFA. Regional demand is further disaggregated into semester 1 and semester 2.

Another component of rice demand is the ending rice inventory of the private sector. The ending inventory is fixed and is maintained through purchases of domestically produced and imported rice.

Formally, the representative consumer maximizes utility in equation (1) subject to an income constraint in equation (2)

(1) $$Max \quad U_s = \left(\beta_s^{\frac{1}{\sigma_1}} \cdot QR_s^{\frac{\sigma_1 - 1}{\sigma_1}} + (1-\beta_s)^{\frac{1}{\sigma_1}} \cdot QO_s^{\frac{\sigma_1 - 1}{\sigma_1}}\right)^{\frac{\sigma_1}{\sigma_1 - 1}}$$

where U_s is utility of the consumer in semester s (semester 1 and semester 2)[1]; QR_s quantity of rice; QO_s quantity of all other goods; β_s a share parameter in the CES utility function[2]; and σ_1 the elasticity of substitution in the first stage. The income constraint is

(2) $$I_s = PR_s \cdot QR_s + PO_s \cdot QO_s$$

where I_s is income (represented by GDP); PR_s the wholesale price of rice; and the wholesale price of all other goods (represented by the implicit price deflator of GDP).

The first order condition for utility maximization generates the following uncompensated demand for rice where QRC_s is inversely related to its price PR_s.

(3) $$QRC_s = \frac{\alpha_s \cdot PR_s^{-\sigma_1} \cdot I_s}{\alpha_s \cdot PR_s^{1-\sigma_1} + (1-\alpha_s)}$$

In the second stage of the nested consumption structure, the consumer has the choice of buying domestically produced or imported rice. The CES demand for domestically produced rice is

(4) $$QD_s = \left(\frac{QRC_s}{\kappa_s}\right)\left(\frac{\kappa_s \cdot \theta_s \cdot PR_s}{PD_s}\right)^{\sigma_2}$$

where θ_s is share parameter for domestically produced rice; σ_2 elasticity of substitution in the second stage (where $\sigma_2 > \sigma_1$); κ_s is scale parameter; PD_s is the price of domestically produced rice in semester s; and QD_s is the quantity of rice bought;

(5) $$QM_s = \left(\frac{QRC_s}{\kappa_s}\right)\left(\frac{\kappa_s \cdot (1-\theta_s) \cdot PR_s}{PM_s}\right)^{\sigma_2}$$

where PM_s the consumer price of imported rice; QM_s and the volume of imported rice.

The unit cost function in the second stage is

(6) $$PR_s = (1/\alpha_s) \cdot \left(\theta_s{}^{\sigma_2} PD_s{}^{(1-\sigma_2)} + (1-\theta_s)^{\sigma_2} PM_s{}^{(1-\sigma_2)}\right)^{1/(}$$

where a_s is scale parameter.

The domestic price of imported rice is

(7) $$PM_s = PWM_s(1 + tm_s)$$

where PWM_s is world price of rice in semester s and tm_s is the tariff rate in semester s imposed by the government on imported rice.

The domestic demand for rice consists of demand by the private sector (QPR_s) and the demand for other uses of rice ($QOTH_s$) which is defined in the equation (10) that is

(8) $$QD_s = QPR_s + QOTH_s$$

Let the sum of the private sector demand (QPR_s) and the NFA demand ($QNFA_s$) be

(9) $$TQD_s = QPR_s + QNFA_s$$

The demand for other uses of rice ($QOTH_s$) is

(10) $$QOTH_s = QHS_s + QINV_s - TQD_s$$

where QHS_s is rice demand by households; $QINV_s$ is rice ending inventory of the private sector.

The regional demand for rice is

(11) $$QR_{r,s} = \left(\frac{TDD_s}{\gamma_s}\right)\left(\frac{\gamma_s \cdot \omega_{r,s} \cdot PD_s}{PRD_{r,s}}\right)^{\sigma_3}$$

where γ is scale parameter; w_{rs} is share parameter; $PRD_{r,s}$ regional price of domestically produced rice; σ_3 is elasticity of substitution in the third stage (where $\sigma_3 > \sigma_2$);

The unit cost in the third stage is also in equations (4) and (5) which given by

(12) $$PD_s = (1/\gamma_s) \cdot \left(\sum_r \omega_{r,s}{}^{\sigma_3} PRD_{r,s}{}^{(1-\sigma_3)}\right)^{1/(1-\sigma_3)}$$

The last element in the demand structure is the specification of the regional private sector demand for rice ($QRPR_{r,s}$) and the regional NFA demand for rice ($QRNFA_{r,s}$). The regional private sector demand for rice is

(13) $$QRPR_{r,s} = \left(\frac{QR_{r,s}}{\mu_{r,s}}\right)\left(\frac{\mu_{r,s} \cdot \delta_{r,s} \cdot TPQR_{r,s}}{PRD_{r,s}}\right)^{\sigma_{2a}}$$

where $TPQR_{r,s}$ is a composite price defined below.
The regional NFA demand for rice is

(14) $$QRNFA_{r,s} = \left(\frac{QR_{,rs}}{\mu_{r,s}(1+adj\_rnfa_{r,s})}\right) \left(\frac{\mu r,s \cdot (1-\delta_{r,s}) \cdot TPQR_{r,s}}{PRD_{r,s}}\right)^{\sigma_{2a}}$$

where $adj\_rnfa_{r,s}$ is a regional-semester adjustment factor related to the NFA buffer stock which is given by

(15) $$adj\_rnfa_{r,s} = rsh_{r,s} \cdot adj\_nfa_s$$

where $rsh_{r,s}$ is a constant matrix determined by whether a region is a palay-surplus or palay-deficit region[3]; adj_nfa_s is NFA semester adjustment factor[4].

The NFA semestral demand for rice is the sum across regions, that is

(16) $$QNFA_s = \sum_r QRNFA_{r,s}$$

In both (12) and (13) $\mu_{r,s}$ is scale parameter; $\delta_{r,s}$ is share parameter; σ_{2a} is elasticity of substitution (where $\sigma_{2a} > \sigma_2$) $TPQR_{r,s}$ is composite price which is given by

(17) $$TPQR_{r,s} = (1/\mu_{r,s}) \cdot \left(\delta_{r,s}{}^{\sigma_{2a}} PRD_{r,s}{}^{(1-\sigma_{2a})} + (1-\delta_{r,s})^{\sigma_{2a}} PRD_{r,s}{}^{(1-\sigma_{2a})}\right)^{1/(1-\sigma_{2a})}$$

Supply Structure. Palay supply is a positive function of its price. A palay producers has the choice of selling in semester 1 or semester 2 depending upon the relative semestral farmgate prices. For more details on the supply structure model please see Appendix 5.

Formally, the supply function of palay in region *r* is

(18) $$RX_r = \varphi_r + \varepsilon \cdot RPX_r$$

where RX_r is regional palay supply; φ_r scale parameter; ε supply price elasticity[5]; and RPX_r unit price defined below.

A representative palay producer is facing a CET supply transformation frontier[6]. Given the farmgate prices of palay in semester 1 and semester 2, the palay producer maximizes revenue subject to the CET transformation frontier. The first order conditions for revenue maximization generate the supply of palay in semester 1 and semester 2.

(19) $$XR_{r,s} = \pi_{r,s} \cdot \left(\frac{RX_r}{\xi_r}\right) \cdot \left(\frac{PX_{r,s}}{\xi_r \cdot \psi_{r,s} \cdot RPX_r}\right)^{\upsilon}$$

where $\pi_{r,s}$ a calamity parameter[7] in region *r* and semester *s*; ξ_r is scale parameter; $\psi_{r,s}$ is share parameter; $PX_{r,s}$ is farmgate price in region *r* and semester *s*; and *v* is CET elasticity of transformation.

The unit price is

(20) $$RPX_r = \left(\frac{1}{\xi_r}\right) \cdot \sum_{r,s}\left({\psi_{r,s}}^{-\upsilon} {PX_{r,s}}^{(1+\upsilon)}\right)^{1/(1+\upsilon)}$$

The relationship between the regional and semestral price of domestically produced rice and the regional and semestral farmgate price is the regional and semestral transaction cost ($tc_{r,s}$) which is fixed, that is

(21) $$PRD_{r,s} = PX_{r,s} \cdot (1 + tc_{r,s})$$

Market Equilibrium and Buffer Stock. The regional market for palay-rice is cleared by adjustments in $PRD_{r,s}$ (hence $PX_{r,s}$) so that the regional demand for rice ($QR_{r,s}$) and the regional supply of palay ($XR_{r,s}$) in rice equivalent are equal, that is,

(22) $$QD_{r,s} = XR_{r,s} \cdot conv$$

where *conv* is palay-rice conversion factor which is 0.6545.

The equilibrium in the external sector (rice imports) is

(23) $$SM_s = QM_s$$

where SM_s is the supply of imported rice.

i. *Rice Imports*. The model can be used to simulate two cases: fixed and flexible rice imports.

Fixed Rice Imports. This case can be used to simulate shocks originating from the foreign suppliers of rice to the Philippines. External shocks are captured in the model by reducing the level of rice imports (SM_s). In this case, equation (23) determines PWM_s in equation (7). Since QM_s which is defined in equation (5) is endogenous, with fixed SM_s (i.e., the supply of imported rice is vertical), any change in QM_s will get reflected in PWM_s. If SM_s is not changed (i.e., no external shocks), there will be no change in the quantity of rice imports. However, if rice imports are reduced (external shock), the domestic price of rice imports will increase through equation (5).

The semestral food balance equation is

(24) $$QB_s + conv \cdot \sum_r XR_{r,s} + QM_s = QHS_s + QINV_s$$

where QB_s is the beginning stocks in semester *s*; QHS_s household consumption of rice; and the variables $XR_{r,s}$, QM_s, $QINV_s$, are defined above. The variables QB_s and $QINV_s$ are fixed. Thus, equation (22) defines QHS_s.

The NFA buffer stock equation is given by

(25) $$\overline{QNFA_s} \geq QNFA_s$$

where $\overline{QNFA_s}$ is the optimal level of NFA buffer stock of rice, which is fixed. If $QNFA_s$ in equation (16) is below the optimal NFA buffer stock ($\overline{QNFA_s}$), the $adj\_rnfa_{r,s}$ as well as $adj\_rfa_{r,s}$ defined in equation (15) are both negative, which in turn will result in higher NFA purchases of rice in equation (14).

ii. *Flexible (Endogenous) Rice Imports.* For rice imports to change endogenously (i.e., not fixed), several modifications must be introduced. A buffer stock of the private sector which is not under the control of the NFA will have to be incorporated. To define the private stock buffer stock, the private sector ending inventory $QINV_s$ which is fixed above will now have the following equation

(26) $$QINV_s = QB_s + conv \cdot \sum_r XR_{r,s} \cdot + QM_s - QHS_s$$

The buffer equation of the private sector is

(27) $$\overline{QINV_s} \geq QINV_s$$

where $\overline{QINV_s}$ is the desired buffer stock of rice of the private sector, which is fixed. If $QINV_s$ in equation (27) is below the desired level, then adj_priv_s in the modified rice import demand defined below will be negative so rice imports will increase. Instead of equation (5), the modified equation for the demand for rice imports is,

(28) $$QM_s = \left(\frac{QRC_s}{\kappa_s \cdot (1 + adj\_priv_s)}\right)\left(\frac{\kappa_s \cdot (1-\theta_s) \cdot PR_s}{PM_s}\right)^{\sigma_2}$$

Thus, adj_priv_s is defined in equation (27).

The last modification is to define an upward sloping import supply function. The equilibrium in the external sector (rice imports) in equation (23) will be retained, but SM_s, which is fixed in the previous case, will be relaxed with the following upward sloping import supply function

$$SM_s = \xi_s + \eta \cdot PWM_s \quad (29)$$

where ξ_s is a constant (calibrated) coefficient η; the slope of the supply function; and the world price of rice which is defined earlier will clear equations (28) and (29)[8]. Note that PM_s and PWM_s are related through equation (7).

Data Set & Scenarios

The NFA buffer stock model was calibrated using the data averages for 2016-2018. The model requires estimates of the optimal NFA buffer stock level which is determined historically. This study uses NDRRM Data on Disaster Affected Population in Person-Days to determine the appropriate & optimal buffer stock levels for each region (See Appendix 1-3). The NDRRM Data provides details on the year, month, region, province, type of calamity (natural or man-made), major or minor, number of affected families and population and the period of disaster or estimated number of days of the calamity. Historical NDRRM data suggests that the annual average disaster affected person-days is at 308 million while the maximum disaster affected person-days is at 941 million. With the maximum disaster affected person-days and the average rice consumption at 120 kg/capita per year, the National Rice Buffer Stock level will translate to 309,268 MT per year. For the purposes of this study, the optimal buffer stock level that NFA must maintain is 300,000 MT per year (rounded-off). The buffer is inputted into the model where NFA allocates its rice/palay purchases across regions in semesters 1 and 2 to maintain the optimal level of the buffer (Figure 5.1).

NFA buys the stock in this buffer across palay-surplus regions in semester 1 and semester 2. However, if a palay production disruption occurs in a region where NFA buys palay, NFA may have to reduce its purchases from that region. If this happens, NFA may have to buy from other regions in order to maintain the 300,000 MT buffer stock. Additionally historical data also suggests that a disruption in palay production is largely caused by typhoons which usually occur in semester 2.

<u>Base Scenario</u>

The base values in Table 5.2 are averages for 2016-2018. The total annual demand for rice is 12 million MT. The average wholesale price of rice in semester 1 (Php 34.15/kg) is slightly lower compared to in semester 2 (Php36.52/kg). The total annual rice imports are 1.6 million MT, representing 13.2% of total annual rice consumption. Rice imports in semester 1 (1.35

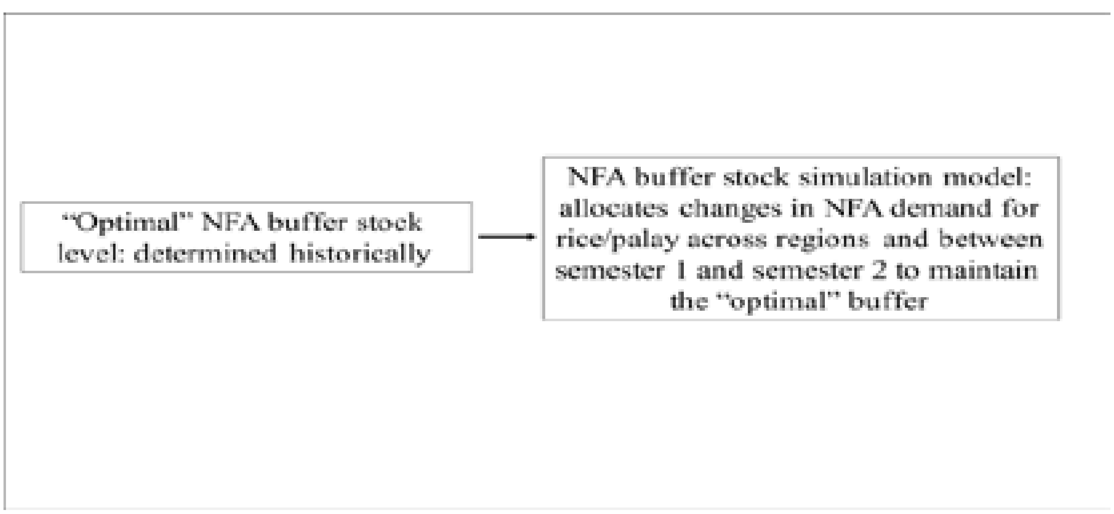

Figure 5.1.

Determination of Optimal NFA Buffer Stock

Table 5.2. *Base Values (Average, 2016-2018)*

	Metric tons		Php/kg	
	Semester 1	Semester 2	Semester 1	Semester 2
Demand/Price of Rice (a)	6,034,167	6,034,167	34.15	36.52
Rice Imports/Price of Imports (b)	1,350,883	245,873	27.00	27.00
Regional Palay Production/Palay Farmgate Price (c)				
CAR Cordillera Administrative Region	133,113	122,665	18.78	18.91
Reg1 Ilocos Region	313,938	862,635	19.25	19.87
Reg2 Cagayan Valley	945,447	661,054	18.19	18.89
Reg3 Central Luzon	1,178,465	1,130,724	18.99	19.40
Reg4a CALABARZON	143,863	126,057	17.11	17.44
Reg4b MIMAROPA	288,789	467,925	18.50	18.27
Reg5 Bicol	428,184	435,300	16.52	16.94
Reg6 Western Visayas	368,574	709,605	18.01	17.74
Reg7 Central Visayas	155,679	341,384	19.50	19.44
Reg8 Eastern Visayas	350,783	269,914	18.19	18.67
Reg9 Zamboanga	173,181	265,073	20.21	19.59
Reg10 Northern Mindanao	198,222	285,385	20.50	20.33
Reg11 Davao Region	134,112	157,941	20.39	20.31
Reg12 SOCCSKSARGEN	303,597	538,581	19.92	18.65
Reg13 CARAGA Region	178,224	138,944	18.29	18.37
ARMM Autonomous Region	141,152	242,710	17.71	16.71

	Metric tons	
Regional NFA procurement, rice equiv.	Sem 1	Sem 2
CAR_Cordillera Administrative Region	1,766	1,301
Reg1_Ilocos Region	623	44,345
Reg2_Cagayan Valley	48,636	36,082
Reg3_Central Luzon	34,489	37,816
Reg4a_Calabarzon	0	0
Reg4b_Mimaropa	6,775	22,406
Reg5_Bicol	4,469	5,958
Reg6_Western Visayas	0	21,281
Reg7_Central Visayas	0	0
Reg8_Eastern Visayas	5,222	0
Reg9_Zamboanga	0	3,286
Reg10_Northern Mindanao	0	1
Reg11_Davao Region	0	0
Reg12_Soccsksargen	1,979	21,057
Reg13_Caraga Region	1,038	0
ARMM_Autonomous Region	0	1,465
Semestral NFA buffer	105,000	195,000
Total NFA buffer	**300,000**	

million MT) is 5.5 times higher than in semester 2. The domestic price of import rice is Php 27.00/kg. This is inclusive of the 35% tariffs on import rice.

Region 3 is the largest producer of palay/rice in both semesters 1 and 2. Region 2 is also a major producer in semester 1, and Region 1 in semester 2.

NFA maintains a buffer stock of 300,000 MT. Based on historical rice relief data, 65% of the stock (255,000 MT) is held in semester 2 when disruptions in palay production occur. In semester 1, the bulk of NFA purchases is in region 2 and Region 3. In semester 2, NFA buys a large of part of its stock from Luzon, particularly in regions 1, 2, 3 and 4b. In Visayas, Region 6 is the major source, while in Mindanao, Region 12.

Disruptions in Palay Production and World Market Price for Imports

The study incorporates a disruption in regional palay production by changing the regional and semestral $\pi_{r,s}$ in equation (19). There are six sets of results presented in the next section that illustrates disruptions occurring in region 3 (Luzon), Region 6 (Visayas), and Region 12 (Mindanao) during the second semester. For the first three scenarios projected, procurement of stocks in Semester 1 is at 35% while the procurement of stocks in Semester 2 is at 65% based on the input and ground level experience from NFA's Operations Team. In all scenarios the parameter $\pi_{r,s}$ is reduced from 1 to 0.9. The fourth, fifth, and sixth scenario projected takes into account a scenario of the world market rice for imported rice increases to 10% for both Semester 1 and 2 in regions 3, 6, and 12 all while experience a 10% reduction in palay production.

Results

Region 3, 65% Stock Procured in Semester 2

In this scenario, the disruptions taken into account is a 10% reduction in palay production. The disruption in region 3 reduces production to 29,168 (-2.58%) in Semester 2. The NFA procurement of palay from the region in semester 2 declines by 297.4 MT. The farmgate price in the region in Semester 2 increases by Php 0.21/ kg (1.082%). The overall level of demand for rice in the country in Semester 2 will drop by 0.24% (14,467 MT) while the level of imports remains unchanged. The import price however, has increased by Php 0.0164/kg (0.06%). Because of the production disruption, farmgate prices in all palay production regions will increase in both semester 1 and 2 and palay production will increase in all regions (indirect effects) except region 3.

To retain the 195,000 MT buffer stock level in semester 2, NFA still needs to buy palay from the rest of the palay-surplus regions to cover for the reduction in region 3. NFA will increase procurement in region 1 by 64.6 MT in semester 2, 59.8 MT in Region 2, 48.4 MT in Region 4B, 45.8 MT in Region 6, 46.2 MT in Region 2 and a combined total of 32.7 MT from the rest of the palay-producing regions. To maintain the 105,000 MT buffer stock in semester 1, NFA will increase its palay purchases in all palay-surplus regions outside of region 3. The combined total increase of NFA's purchase from the all palay-producing regions is 220.4 MT.

Region 6, 65% Stock Procured in Semester 2.

Similar exercise is conducted in region 6, semester 2. The same disruptions are simulated in region 6, semester 2. Palay Production in Region 6 in semester 2 will drop by 11,024 MT (-1.55%) due to the 10% decrease in palay production as simulated in the rest of the other scenarios. The NFA will not be purchasing in region 6 for semester 1 due to region's limited capacity to supply consumption.

The disruption in palay production in region 6 semester 2 will result in the reduction of NFA purchases by 100.7 MT. Rice imports remain unchanged however the import price increases by Php 0.0067/kg (0.02) in semester 2. The overall demand for rice in semester 2 will decrease by 5,934 MT, and palay production will slightly increase in all regions except for Region 6. This increase in palay production outside of region 6 is due to the indirect effects arising from the increase in the wholesale price in semester 2 by Php 0.0067 / kg (0.20%). To maintain the 195,000 MT buffer stock level in semester 2, NFA will have to increase procurement in the rest of the regions; NFA will be increasing procurement by 19.3 MT in Region 1, 18.0 MT in Region 2, 17.7 MT in Region 3, 17 MT in Region 4b, 16.4 MT in Region 12 and a combined total of 12.4 MT in the rest of the regions. In semester 1 of the following year, palay production in region 6 will still be reduced by 5,805 (-1.57%). Since Region 6 is not a

Table 6.1 *Disruption in Palay Production in Region 3, 65% Stock Procured in Semester 2*

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-19,122	-14,467	-0.32	-0.24
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	386	351	0.29	0.29
Reg1_Ilocos Region	799	2,165	0.25	0.25
Reg2_Cagayan Valley	2,274	1,566	0.24	0.24
Reg3_Central Luzon	-30,358	-29,168	-2.58	-2.58
Reg4a_Calabarzon	415	359	0.29	0.28
Reg4b_Mimaropa	773	1,236	0.27	0.26
Reg5_Bicol	1,120	1,123	0.26	0.26
Reg6_Western Visayas	939	1,782	0.25	0.25
Reg7_Central Visayas	434	939	0.28	0.28
Reg8_Eastern Visayas	963	731	0.27	0.27
Reg9_Zamboanga	489	738	0.28	0.28
Reg10_Northern Mindanao	557	791	0.28	0.28
Reg11_Davao Region	387	450	0.29	0.29
Reg12_Soccsksargen	807	1,412	0.27	0.26
Reg13_Caraga Region	512	394	0.29	0.28
ARMM_Autonomous Region	398	675	0.28	0.28

Simulation results				
	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0778	0.0681	0.23	0.19
Change in import price of rice in domestic prices	0.0200	0.0164	0.07	0.06
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	0.0011	0.0005	0.006	0.003
Reg1_Ilocos Region	0.0036	0.0031	0.019	0.016
Reg2_Cagayan Valley	0.0044	0.0039	0.024	0.021
Reg3_Central Luzon	0.2061	0.2099	1.086	1.082
Reg4a_Calabarzon	0.0011	0.0006	0.006	0.003
Reg4b_Mimaropa	0.0026	0.0020	0.014	0.011
Reg5_Bicol	0.0027	0.0022	0.016	0.013
Reg6_Western Visayas	0.0034	0.0028	0.019	0.016
Reg7_Central Visayas	0.0019	0.0013	0.010	0.007
Reg8_Eastern Visayas	0.0021	0.0015	0.012	0.008
Reg9_Zamboanga	0.0018	0.0011	0.009	0.005

Reg10_Northern Mindanao	0.0019	0.0012	0.009	0.006
Reg11_Davao Region	0.0013	0.0006	0.006	0.003
Reg12_Soccsksargen	0.0029	0.0021	0.015	0.011
Reg13_Caraga Region	0.0013	0.0007	0.007	0.004
ARMM_Autonomous Region	0.0016	0.0009	0.009	0.006

Buffer Stock Reallocation	Metric tons			
Change in regional NFA procurement, rice equiv.	change		**New NFA buffer level**	
CAR_Cordillera Administrative Region	5.3	3.7	1,771	1,304
Reg1_Ilocos Region	1.8	64.6	625	44,410
Reg2_Cagayan Valley	155.4	59.8	48,792	36,142
Reg3_Central Luzon	-220.5	-297.4	34,268	37,518
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	20.2	48.4	6,795	22,454
Reg5_Bicol	13.2	15.7	4,483	5,973
Reg6_Western Visayas	0.0	45.8	0	21,327
Reg7_Central Visayas	0.0	0.0	0	0
Reg8_Eastern Visayas	15.6	0.0	5,237	0
Reg9_Zamboanga	0.0	9.1	0	3,295
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	5.8	46.2	1,985	21,103
Reg13_Caraga Region	3.1	0.0	1,041	0
ARMM_Autonomous Region	0.0	4.2	0	1,470
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer			**300,000**	

palay-surplus region in semester 1, palay procurement will not be conducted in the region. There will be small reallocations made by the NFA in the rest of the regions such as increasing procurement to 2.9 MT in Region 4b to maintain the buffer stock of 105,000 MT.

Region 12, 65% Stock Procured in Semester 2.

Region 12 is the largest palay-producing region in Mindanao. A disruption in palay production in region 12 reduces production by 6,472 MT (-1.20%). As a result, NFA will reduce is palay procurement from the region by 77.4 MT. Similar to the previous cases, imports will remain unchanged but import price will increase to Php 0.0038/ kg (0.01%). Overall Demand for rice in semester 2 will decrease by 3,415 MT and wholesale prices will increase by Php 0.0160 / kg (0.04%).

To maintain the 195,000 MT buffer stock in semester 2, NFA must increase their procurements by 17.7 MT in Region 1, 14.9 MT in Region 2, 15.1 MT in Region 3, 11.5 MT in Region 4b, 11 MT in Region 6, and a combined total of 7.2 MT in the rest of the palay producing regions.

For Semester 1 the following year, Region 12's production is still reduced by 3,683 MT (-1.21%) so the NFA purchase will also be reduced by 7.7 MT. To maintain the buffer stock level of 105,000 MT in semester 1, NFA will reduce its purchase in region 2 by 0.6 MT but slightly increase its procurement in Regions CAR, 1, 3, 4b, 5, 8, and 13.

Table 6.2. *Disruption in Palay Production in Region 6, 65% Stock Procured in Semester 2*

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-2,781	-5,934	-0.05	-0.10
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	89	109	0.07	0.09
Reg1_Ilocos Region	216	782	0.07	0.09
Reg2_Cagayan Valley	485	483	0.05	0.07
Reg3_Central Luzon	582	805	0.05	0.07
Reg4a_Calabarzon	95	111	0.07	0.09
Reg4b_Mimaropa	195	417	0.07	0.09
Reg5_Bicol	260	359	0.06	0.08
Reg6_Western Visayas	-5,805	-11,024	-1.57	-1.55
Reg7_Central Visayas	116	328	0.07	0.10
Reg8_Eastern Visayas	214	223	0.06	0.08
Reg9_Zamboanga	123	245	0.07	0.09
Reg10_Northern Mindanao	139	262	0.07	0.09
Reg11_Davao Region	94	145	0.07	0.09
Reg12_Soccsksargen	204	479	0.07	0.09
Reg13_Caraga Region	114	119	0.06	0.09
ARMM_Autonomous Region	101	227	0.07	0.09

Simulation results				
	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0113	0.0278	0.03	0.08
Change in import price of rice in domestic prices	0.0029	0.0067	0.01	0.02
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	-0.0016	0.0022	-0.008	0.011
Reg1_Ilocos Region	-0.0017	0.0021	-0.009	0.011
Reg2_Cagayan Valley	-0.0005	0.0032	-0.003	0.017
Reg3_Central Luzon	-0.0004	0.0035	-0.002	0.018
Reg4a_Calabarzon	-0.0014	0.0021	-0.008	0.012
Reg4b_Mimaropa	-0.0016	0.0021	-0.009	0.011
Reg5_Bicol	-0.0010	0.0023	-0.006	0.014
Reg6_Western Visayas	0.1092	0.1111	0.606	0.626
Reg7_Central Visayas	-0.0022	0.0017	-0.011	0.009
Reg8_Eastern Visayas	-0.0011	0.0025	-0.006	0.014
Reg9_Zamboanga	-0.0020	0.0020	-0.010	0.010

Reg10_Northern Mindanao	-0.0019	0.0021	-0.009	0.010
Reg11_Davao Region	-0.0019	0.0021	-0.009	0.010
Reg12_Soccsksargen	-0.0017	0.0021	-0.008	0.011
Reg13_Caraga Region	-0.0013	0.0023	-0.007	0.012
ARMM_Autonomous Region	-0.0018	0.0016	-0.010	0.010

Buffer Stock Reallocation	Metric tons			
Change in regional NFA procurement, rice equiv.	change		New NFA buffer level	
CAR_Cordillera Administrative Region	0.9	1.4	1,767	1,302
Reg1_Ilocos Region	0.3	19.3	624	44,365
Reg2_Cagayan Valley	-9.5	18.0	48,627	36,100
Reg3_Central Luzon	-0.3	17.7	34,488	37,833
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	2.9	17.0	6,778	22,423
Reg5_Bicol	2.0	5.9	4,471	5,963
Reg6_Western Visayas	0.0	-100.7	0	21,181
Reg7_Central Visayas	0.0	0.0	0	0
Reg8_Eastern Visayas	2.2	0.0	5,224	0
Reg9_Zamboanga	0.0	3.5	0	3,290
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	1.0	16.4	1,980	21,073
Reg13_Caraga Region	0.5	0.0	1,039	0
ARMM_Autonomous Region	0.0	1.6	0	1,467
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer			**300,000**	

Table 6.3. Disruption in Palay Production in Region 12, 65% Stock Procured in Semester 2

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-1,824	-3,415	-0.03	-0.06
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	54	64	0.04	0.05
Reg1_Ilocos Region	129	454	0.04	0.05
Reg2_Cagayan Valley	298	285	0.03	0.04
Reg3_Central Luzon	356	472	0.03	0.04
Reg4a_Calabarzon	58	65	0.04	0.05
Reg4b_Mimaropa	117	244	0.04	0.05
Reg5_Bicol	158	211	0.04	0.05
Reg6_Western Visayas	144	359	0.04	0.05

Reg7_Central Visayas	69	191	0.04	0.06
Reg8_Eastern Visayas	131	132	0.04	0.05
Reg9_Zamboanga	74	143	0.04	0.05
Reg10_Northern Mindanao	84	153	0.04	0.05
Reg11_Davao Region	57	85	0.04	0.05
Reg12_Soccsksargen	-3,683	-6,472	-1.21	-1.20
Reg13_Caraga Region	70	70	0.04	0.05
ARMM_Autonomous Region	61	133	0.04	0.05

Simulation results

	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0074	0.0160	0.02	0.04
Change in import price of rice in domestic prices	0.0019	0.0038	0.01	0.01
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	-0.0008	0.0012	-0.004	0.006
Reg1_Ilocos Region	-0.0009	0.0012	-0.004	0.006
Reg2_Cagayan Valley	-0.0002	0.0018	-0.001	0.009
Reg3_Central Luzon	-0.0001	0.0019	0.000	0.010
Reg4a_Calabarzon	-0.0007	0.0011	-0.004	0.006
Reg4b_Mimaropa	-0.0008	0.0011	-0.004	0.006
Reg5_Bicol	-0.0005	0.0013	-0.003	0.008
Reg6_Western Visayas	-0.0007	0.0012	-0.004	0.007
Reg7_Central Visayas	-0.0011	0.0009	-0.006	0.005
Reg8_Eastern Visayas	-0.0006	0.0014	-0.003	0.007
Reg9_Zamboanga	-0.0010	0.0011	-0.005	0.005
Reg10_Northern Mindanao	-0.0010	0.0011	-0.005	0.006
Reg11_Davao Region	-0.0010	0.0011	-0.005	0.006
Reg12_Soccsksargen	0.0924	0.0885	0.464	0.474
Reg13_Caraga Region	-0.0007	0.0012	-0.004	0.007
ARMM_Autonomous Region	-0.0009	0.0009	-0.005	0.005

Buffer Stock Reallocation	Metric tons			
Change in regional NFA procurement, rice equiv.	change		**New NFA buffer level**	
CAR_Cordillera Administrative Region	0.6	0.8	1,767	1,301
Reg1_Ilocos Region	0.2	17.7	624	44,363
Reg2_Cagayan Valley	-0.6	14.9	48,636	36,097
Reg3_Central Luzon	2.5	15.1	34,491	37,831
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	1.9	11.5	6,777	22,417
Reg5_Bicol	1.3	3.5	4,471	5,961
Reg6_Western Visayas	0.0	11.0	0	21,292
Reg7_Central Visayas	0.0	0.0	0	0

Reg8_Eastern Visayas	1.5	0.0	5,223	0
Reg9_Zamboanga	0.0	2.0	0	3,288
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	-7.7	-77.4	1,971	20,979
Reg13_Caraga Region	0.3	0.0	1,038	0
ARMM_Autonomous Region	0.0	0.9	0	1,466
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer			**300,000**	

Importation Scenario for Regions 3, 6, and 12: 20% increase in World Market Price

In this section, the authors have simulated a 20% increase in world market price all while regions 3, 6, and 12 experience a 10% reduction in palay production. Based on the simulation results (to see the simulation results, please go to Appendices 6, 7, and 8), the overall demand for rice decreases for all three scenarios. When Region 3 experiences a 10% reduction in palay production, the overall demand for rice is reduced by 14,506 MT (-0.24%) in semester 2. When Region 6 experiences a 10% reduction in palay production, the overall demand for rice is reduced by 5,943 MT (-0.10%) in semester 2. When Region 12 experiences a 10% reduction in palay production, the overall demand for rice is reduced by 3,420 MT (-0.06%) in semester 2. Imports for all three scenarios remain unchanged but the import prices for regions 3, 6, and 12 will slightly increase. It is important to note that in all three scenarios projected, even with the 10% increase in World Market Price the reallocation of buffer stock levels remains the same as seen in the first three scenarios written in the previous sections.

Conclusion

This study provides a buffer stock model that determines which regions NFA should purchase palay/rice when a disruption occurs to maintain the optimal level of buffer stock. Compared to previous buffer stock models done in existing studies for Price Stabilization purposes, this model supports the NFA's new mandate in RA 11203 of maintaining an optimal level of buffer stock primarily for emergency situations.

The Base Scenario details the historical procurement inventory ratios being followed by the NFA for rice relief. 35% of the stock is procured during Semester 1 while 65% of the stock is held in semester 2 when disruptions in palay production occur. In semester 1, the bulk of NFA purchases is in region 2 and Region 3. In semester 2, NFA buys a large of part of its stock from Luzon, particularly in regions 1, 2, 3 and 4b. In Visayas, Region 6 is the major source, while in Mindanao, Region 12.

The first three scenarios generated details what NFA's purchases will be when a 10% reduction in palay production occurs in regions 3, 6, and 12 during Semester 2 while the fourth, fifth and sixth scenario takes into account a 10% increase in world market price alongside the production disruption. For Region 3, NFA must increase procurement in regions 1, 2, 4b, 6, and 12. For Region 6, NFA must increase procurement from regions 1, 2, 3, 4B and 12. For Region 12, NFA must increase procurement from regions 1, 2, 3, 4b, and 6.

Through the application of a Partial Equilibrium Model, policy makers can be guided on where to procure depending on which region will be badly hit by any type of calamity. In the case of the NFA, their Grains Marketing Operations Department can use the model to anticipate future disruptions (natural and/or man-made calamities), revise their existing operational guidelines according to their new mandate stated in RA11203, develop marketing & risk management plans, and adjust their operations & logistics accordingly.

Notes

[1] Semester 1 (January to June); semester 2 (July to December).

[2] Constant elasticity of substitution (CES). If there are many goods in the consumption basket, the elasticity of substitution in the CES utility function is equal to the demand price elasticity. In the model, the price elasticity is 0.8.

[3] From the database one can determine whether a region is a palay-surplus or palay-deficit region. If the

region is a palay-surplus region, NFA buys from that region, otherwise NFA skips that region. However, since the model is non-linear, it cannot allow non-zero NFA regional purchases. Thus, the NFA must buy a very small amount of palay in palay-deficit regions so the model will solve. In equation (14), $rsh_{r,s}$ is the regional weight of the excess between palay production and consumption in semester 1 and semester 2.

[4] adj_nfa_s is defined in the NFA buffer equation specified below.

[5] The model uses supply price elasticity of 1.4.

[6] CET is constant elasticity of transformation.

[7] The calamity parameter is 1≥π_(r,s)>0;

[8] η_sis a small number so the inflow of imports will not displace domestic production of palay. Its value is 0.001

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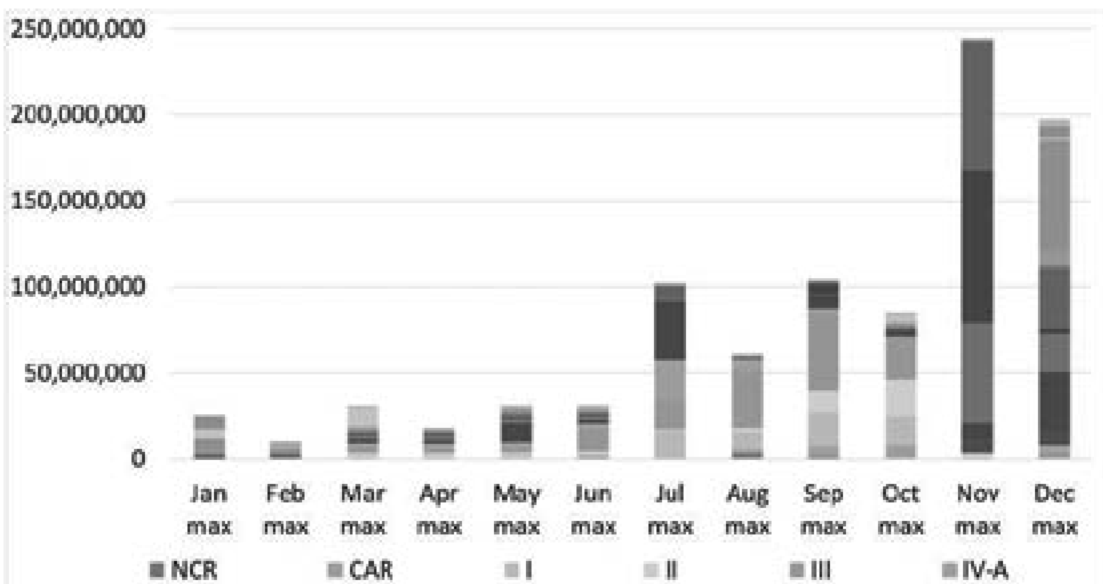
Appendix

Appendix 1. *Disaster Affected Population in PERSON-DAYS, 2010-2019 Monthly Maximum by Region (in '000 & %)*

Month	NCR	CAR	I	II	III	IV-A	IV-B	V	VI	VII	VIII	IX	X	XI	XII	CARAGA	BARMM	PHILS	% of Total
Jan max	60	0	-	-	92	72	136	1,426	735	106	750	28	1,590	6,757	5,319	7,958	310	17,109	2
Feb max	375	6	0	10	29	150	102	2	9	297	2,128	176	127	3,311	1,068	1,376	749	5,574	1
Mar max	66	7	1,807	1,807	3,162	2,258	0	2,258	2,258	903	11	1,355	1,811	1,128	10,786	25	1,077	18,639	2
Apr max	189	8	1,748	1,748	3,060	2,185	2	2,185	2,185	874	15	1,321	1,748	442	60	-	464	18,156	2
May max	307	-	1,807	1,807	3,162	2,258	895	10,907	2,258	903	1,357	1,355	1,808	723	155	5	1,169	18,960	3
Jun max	1,091	1	1,748	1,748	13,094	3,083	13	2,185	2,185	874	19	1,311	1,748	437	130	187	1,121	20,103	3
Jul max	505	482	14,669	1,287	16,516	23,894	682	33,377	493	81	8,200	683	119	41	462	144	526	70,851	11
Aug max	3,524	2,180	9,377	3,110	33,445	6,207	457	19	1,442	3	301	11	139	10	831	17	292	54,894	7
Sep max	1,572	5,993	19,563	12,599	45,276	1,990	890	7,359	236	6,361	1	1,782	22	23	151	36	4	68,949	11
Oct max	133	7,861	16,895	21,243	23,878	628	709	4,351	803	171	153	672	48	1,912	3,862	3	1,488	47,938	8
Nov max	362	675	44	2,146	64	406	6,993	10,380	58,115	88,649	75,232	4	296	78	40	1,049	184	241,213	26
Dec max	376	5	-	8	4,462	3,043	6,896	35,813	21,954	3,607	34,254	2,350	7,848	64,431	1,741	6,780	3,843	92,437	21
Sum of Monthly Max (Annual)	8,560	17,217	67,858	47,512	146,239	46,275	17,775	110,264	92,675	102,831	122,425	11,047	17,304	79,294	24,605	17,580	11,230	940,689	100
% of Total Phils	1	2	7	5	16	5	2	12	10	11	13	1	2	8	3	2	1	100	

Source of Basic Data: NDRMM 2020

Appendix 2. *Maximum Affected Person Days by Month, 2010-2019*



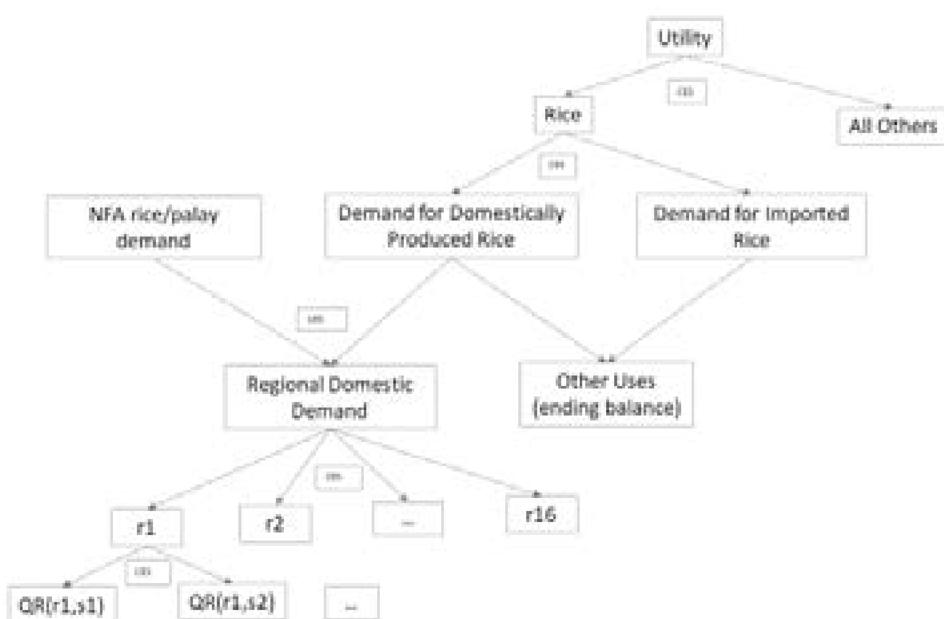
Source of Basic Data: NDRMM 2020

Appendix 3. *Estimated Maximum Regional Rice Support Needs of Disaster Affected Population*

Region	Disaster Affected Population (in '000 Person Days)	Rice support needs of disaster affected population (in MT)	300,000 MT Buffer Stock based on Rice support needs of disaster affected population (in MT)
NCR	8,560	2,814	2,730
CAR	17,217	5,660	5,491
I	67,858	22,309	21,641
II	47,512	15,620	15,152
III	146,239	48,079	46,638
IV-A	46,275	15,214	14,758
IV-B	17,775	5,844	5,669
V	110,264	36,251	35,165
VI	92,675	30,468	29,555
VII	102,831	33,807	32,794
VIII	122,425	40,249	39,043
IX	11,047	3,632	3,523
X	17,304	5,689	5,519
XI	79,294	26,069	25,288
XII	24,605	8,089	7,847
CARAGA	17,580	5,780	5,607
BARMM	11,230	3,692	3,581
PHILS	940,689	309,268	300,000

Source: Based on the maximum estimates of regional rice support needs of disaster affected population in Appendix 1

Appendix 4. Demand Structure in the Rice Model



Appendix 5. *Supply Structure in the Rice Model*

Appendix 6 *Simulation Results for Region 3 (10% Disruption, and 20% Increase in WMP for Rice)*

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-19,202	-14,506	-0.32	-0.24
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	384	350	0.29	0.29
Reg1_Ilocos Region	796	2,163	0.25	0.25
Reg2_Cagayan Valley	2,259	1,561	0.24	0.24
Reg3_Central Luzon	-30,374	-29,174	-2.58	-2.58
Reg4a_Calabarzon	412	358	0.29	0.28
Reg4b_Mimaropa	769	1,234	0.27	0.26
Reg5_Bicol	1,113	1,120	0.26	0.26
Reg6_Western Visayas	934	1,779	0.25	0.25
Reg7_Central Visayas	432	938	0.28	0.27
Reg8_Eastern Visayas	957	729	0.27	0.27
Reg9_Zamboanga	486	736	0.28	0.28
Reg10_Northern Mindanao	554	790	0.28	0.28
Reg11_Davao Region	385	449	0.29	0.28
Reg12_Soccsksargen	803	1,409	0.26	0.26
Reg13_Caraga Region	509	393	0.29	0.28
ARMM_Autonomous Region	395	673	0.28	0.28

Simulation results

	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0781	0.0682	0.22	0.19
Change in import price of rice in domestic prices	0.0237	0.0197	0.07	0.06
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	0.0010	0.0006	0.005	0.003

Reg1_Ilocos Region	0.0035	0.0031	0.018	0.016
Reg2_Cagayan Valley	0.0043	0.0040	0.024	0.021
Reg3_Central Luzon	0.2060	0.2100	1.085	1.082
Reg4a_Calabarzon	0.0010	0.0006	0.006	0.004
Reg4b_Mimaropa	0.0025	0.0020	0.013	0.011
Reg5_Bicol	0.0026	0.0023	0.016	0.013
Reg6_Western Visayas	0.0033	0.0028	0.018	0.016
Reg7_Central Visayas	0.0018	0.0013	0.009	0.007
Reg8_Eastern Visayas	0.0020	0.0016	0.011	0.009
Reg9_Zamboanga	0.0017	0.0011	0.008	0.006
Reg10_Northern Mindanao	0.0018	0.0013	0.009	0.006
Reg11_Davao Region	0.0012	0.0007	0.006	0.003
Reg12_Soccsksargen	0.0028	0.0022	0.014	0.012
Reg13_Caraga Region	0.0012	0.0007	0.006	0.004
ARMM_Autonomous Region	0.0015	0.0010	0.008	0.006

	Metric tons			
Change in regional NFA procurement, rice equiv.	change		New NFA buffer level	
CAR_Cordillera Administrative Region	5.3	3.7	1,771	1,304
Reg1_Ilocos Region	1.8	64.6	625	44,410
Reg2_Cagayan Valley	155.9	59.8	48,792	36,142
Reg3_Central Luzon	-220.5	-297.4	34,268	37,518
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	20.1	48.4	6,795	22,454
Reg5_Bicol	13.1	15.7	4,483	5,973
Reg6_Western Visayas	0.0	45.8	0	21,327
Reg7_Central Visayas	0.0	0.0	0	0
Reg8_Eastern Visayas	15.5	0.0	5,237	0
Reg9_Zamboanga	0.0	9.1	0	3,295
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	5.8	46.2	1,985	21,103
Reg13_Caraga Region	3.1	0.0	1,041	0
ARMM_Autonomous Region	0.0	4.2	0	1,470
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer		**300,000**		

Appendix 7 *Simulation Results for Region 6 (10% Disruption, and 20% Increase in WMP for Rice)*

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-2,794	-5,943	-0.05	-0.10
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	89	109	0.07	0.09
Reg1_Ilocos Region	216	781	0.07	0.09
Reg2_Cagayan Valley	483	482	0.05	0.07
Reg3_Central Luzon	580	804	0.05	0.07
Reg4a_Calabarzon	95	110	0.07	0.09
Reg4b_Mimaropa	194	417	0.07	0.09
Reg5_Bicol	259	358	0.06	0.08
Reg6_Western Visayas	-5,805	-11,024	-1.58	-1.55
Reg7_Central Visayas	115	328	0.07	0.10
Reg8_Eastern Visayas	213	223	0.06	0.08
Reg9_Zamboanga	122	245	0.07	0.09
Reg10_Northern Mindanao	138	261	0.07	0.09
Reg11_Davao Region	93	144	0.07	0.09
Reg12_Soccsksargen	203	478	0.07	0.09
Reg13_Caraga Region	114	119	0.06	0.09
ARMM_Autonomous Region	101	227	0.07	0.09

Simulation results				
	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0113	0.0278	0.03	0.08
Change in import price of rice in domestic prices	0.0034	0.0080	0.01	0.02
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	-0.0016	0.0022	-0.008	0.011
Reg1_Ilocos Region	-0.0018	0.0021	-0.009	0.011
Reg2_Cagayan Valley	-0.0005	0.0033	-0.003	0.017
Reg3_Central Luzon	-0.0004	0.0035	-0.002	0.018
Reg4a_Calabarzon	-0.0014	0.0021	-0.008	0.012
Reg4b_Mimaropa	-0.0016	0.0021	-0.009	0.011
Reg5_Bicol	-0.0010	0.0023	-0.006	0.014
Reg6_Western Visayas	0.1092	0.1111	0.606	0.626
Reg7_Central Visayas	-0.0022	0.0017	-0.011	0.009
Reg8_Eastern Visayas	-0.0011	0.0026	-0.006	0.014
Reg9_Zamboanga	-0.0020	0.0020	-0.010	0.010

Reg10_Northern Mindanao	-0.0020	0.0021	-0.010	0.010
Reg11_Davao Region	-0.0019	0.0021	-0.009	0.010
Reg12_Soccsksargen	-0.0017	0.0021	-0.009	0.011
Reg13_Caraga Region	-0.0013	0.0023	-0.007	0.013
ARMM_Autonomous Region	-0.0018	0.0016	-0.010	0.010
	Metric tons			
Change in regional NFA procurement, rice equiv.	change		**New NFA buffer level**	
CAR_Cordillera Administrative Region	0.9	1.4	1,767	1,302
Reg1_Ilocos Region	0.3	19.3	624	44,365
Reg2_Cagayan Valley	-9.4	18.0	48,627	36,100
Reg3_Central Luzon	-0.3	17.7	34,488	37,834
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	2.9	17.0	6,778	22,423
Reg5_Bicol	1.9	5.8	4,471	5,963
Reg6_Western Visayas	0.0	-100.7	0	21,181
Reg7_Central Visayas	0.0	0.0	0	0
Reg8_Eastern Visayas	2.2	0.0	5,224	0
Reg9_Zamboanga	0.0	3.5	0	3,290
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	1.0	16.4	1,980	21,073
Reg13_Caraga Region	0.5	0.0	1,039	0
ARMM_Autonomous Region	0.0	1.6	0	1,467
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer			**300,000**	

Appendix 8 *Simulation Results for Region 12 (10% Disruption, and 20% Increase in WMP for Rice)*

Simulation results				
	Metric tons		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall demand for rice	-1,832	-3,420	-0.03	-0.06
Change in rice imports	0.0	0.0	0.00	0.00
Change in regional palay production, rice equiv.				
CAR_Cordillera Administrative Region	54	64	0.04	0.05
Reg1_Ilocos Region	129	453	0.04	0.05
Reg2_Cagayan Valley	297	284	0.03	0.04
Reg3_Central Luzon	355	471	0.03	0.04
Reg4a_Calabarzon	58	65	0.04	0.05
Reg4b_Mimaropa	117	243	0.04	0.05
Reg5_Bicol	157	210	0.04	0.05
Reg6_Western Visayas	144	359	0.04	0.05

Reg7_Central Visayas	69	191	0.04	0.06
Reg8_Eastern Visayas	130	131	0.04	0.05
Reg9_Zamboanga	74	143	0.04	0.05
Reg10_Northern Mindanao	83	153	0.04	0.05
Reg11_Davao Region	56	85	0.04	0.05
Reg12_Soccsksargen	-3,683	-6,472	-1.21	-1.20
Reg13_Caraga Region	69	70	0.04	0.05
ARMM_Autonomous Region	61	132	0.04	0.05

Simulation results

	Php/kg		% change	
Relative to base	Sem 1	Sem 2	Sem 1	Sem 2
Change in overall price of rice, wholesale	0.0074	0.0160	0.02	0.04
Change in import price of rice in domestic prices	0.0022	0.0046	0.01	0.01
Change in regional palay farmgate prices				
CAR_Cordillera Administrative Region	-0.0008	0.0012	-0.004	0.006
Reg1_Ilocos Region	-0.0009	0.0012	-0.005	0.006
Reg2_Cagayan Valley	-0.0002	0.0018	-0.001	0.010
Reg3_Central Luzon	-0.0001	0.0019	0.000	0.010
Reg4a_Calabarzon	-0.0007	0.0011	-0.004	0.006
Reg4b_Mimaropa	-0.0008	0.0011	-0.004	0.006
Reg5_Bicol	-0.0005	0.0013	-0.003	0.008
Reg6_Western Visayas	-0.0007	0.0012	-0.004	0.007
Reg7_Central Visayas	-0.0011	0.0009	-0.006	0.005
Reg8_Eastern Visayas	-0.0006	0.0014	-0.003	0.007
Reg9_Zamboanga	-0.0010	0.0011	-0.005	0.005
Reg10_Northern Mindanao	-0.0010	0.0011	-0.005	0.006
Reg11_Davao Region	-0.0010	0.0011	-0.005	0.006
Reg12_Soccsksargen	0.0924	0.0885	0.464	0.474
Reg13_Caraga Region	-0.0007	0.0012	-0.004	0.007
ARMM_Autonomous Region	-0.0009	0.0009	-0.005	0.005

	Metric tons			
Change in regional NFA procurement, rice equiv.	change		**New NFA buffer level**	
CAR_Cordillera Administrative Region	0.6	0.8	1,767	1,301
Reg1_Ilocos Region	0.2	17.8	624	44,363
Reg2_Cagayan Valley	-0.6	14.9	48,636	36,097
Reg3_Central Luzon	2.5	15.1	34,491	37,831
Reg4a_Calabarzon	0.0	0.0	0	0
Reg4b_Mimaropa	1.9	11.5	6,777	22,417
Reg5_Bicol	1.3	3.5	4,471	5,961
Reg6_Western Visayas	0.0	11.0	0	21,292
Reg7_Central Visayas	0.0	0.0	0	0
Reg8_Eastern Visayas	1.5	0.0	5,223	0
Reg9_Zamboanga	0.0	2.0	0	3,288
Reg10_Northern Mindanao	0.0	0.0	0	1
Reg11_Davao Region	0.0	0.0	0	0
Reg12_Soccsksargen	-7.7	-77.4	1,971	20,979
Reg13_Caraga Region	0.3	0.0	1,038	0
ARMM_Autonomous Region	0.0	0.9	0	1,466
Semestral NFA buffer	0.0	0.0	105,000	195,000
Total NFA buffer			**300,000**	