Self-Sufficiency and International Trade Policy Strategies in the Malaysian Rice Sector: Approaches to Food Security Using Spatial Partial Equilibrium Analysis

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ABSTRACT

While the status quo of the national rice economy remains ambiguous, the Malaysian rice policy stand and tendency is more likely to move to a self-sufficiency strategy. Despite this, Malaysia has made an extreme policy decision to pursue an autarky economy in its primary staple, i.e., rice, thus closing its borders from international markets. The existing body of evidence shows that self-sufficiency is not an efficient policy strategy to address food security concerns and to alleviate poverty. Thus, this study evaluates and analyzes the impact of two alternative approaches to achieve food security. In particular, these approaches are through pursuing rice self-sufficiency and through free trade in rice. The results indicate that although Malaysia could achieve rice self-sufficiency, the net welfare impact on Malaysia would be negative and would be driven primarily by consumer welfare losses. This is because pursuing rice self-sufficiency may result in significantly higher rice prices, which would accordingly offset the gains acquired in producers' welfare. On the other hand, free trade results in lower consumer prices and greater rice consumption. This would consequently increase consumers' welfare and would yield a net welfare gain for Malaysia. However, this approach may deteriorate producer welfare due to higher import competition and lower producer prices.

Keywords: self-sufficiency, free trade, rice, Malaysia, food security
JEL Classification: Q18, Q11, Q13

INTRODUCTION

The severe aftermath of the 2007/2008 food crisis has strained many rice-deficit regions, particularly in Asia, where rice is the basic food staple. Consequently, rice-importing countries have now moved toward a self-sufficiency approach to address food security concerns. Malaysia has relied on rice imports for many years due to its inadequate domestic rice production; it has been one of the largest rice importers globally for decades. Previous policy agendas had strongly stated that the country has decided to make the same move toward rice self-sufficiency (Ministry of Agriculture and Agro-based Industry, Malaysia).

The food crisis in 2007/2008 caused a food supply crunch, which resulted when rice prices in the global market had spiraled up. This translated to a tremendous cost increase in rice imports in Malaysia, which consequently placed financial strains on both the government and consumers. In addition, rice-exporting countries imposed more shipment restrictions and even stopped supplying rice due to pressure from their domestic demands (Dawe and Slayton 2010). The Malaysian government then tightened security on its national food reserve by tremendously increasing its national rice buffer stocks. This worsened the situation of the world market price for rice (Dawe 2010).[1]

Subsequently, in its most recent policy goal reformulation, the government has decided to pursue rice self-sufficiency and now aims to achieve total rice self-sufficiency by the year 2020. This target date has been recently extended to 2050 under the new masterplan (i.e., the National Transformation 2050 [2020–2050]); thus, the government seeks to eliminate rice imports in the future. The self-sufficiency strategy not only concerns food security, but also rice farmers' welfare, since poverty mitigation among poor farmers has been the goal since the origins of this national rice policy.

Despite having contributed a relatively marginal share to national income, rice remains a crucial agricultural food crop in Malaysia. Rice holds a stake in Malaysian economics considering it is the primary food staple of the nation and because it is a source of livelihood for local farmers. Relative to the major agricultural cash or plantation crops (e.g., palm oil and rubber), rice has made an essentially minor contribution to national GDP value, ranging between USD 625.0 and USD 737.0 million in 2009–2013 (FAO 2014) (Figure 1) from the total GDP of USD 202.3 to USD 323.3 billion in the same period (DOSM 2017).

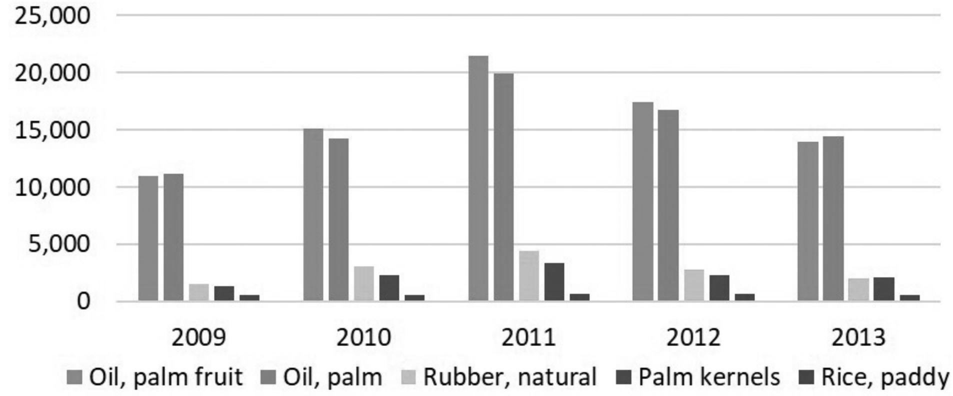
Self-sufficiency has been brought to the world's attention and has moved up in the policy agenda in order to address food security concerns in most rice-staple and rice-deficit regions among developing countries. Despite criticism for not being an efficient approach, self-sufficiency has been promoted and adopted as the pertinent solution to achieve food security objectives, especially in light of the 2007/2008 global food crisis (FAO 2016).

Malaysia previously announced its intention to pursue self-sufficiency by the year 2020 (Economic Planning Unit, Prime Minister's Department, Malaysia 2015). This pursuit is not only for food security reasons, but also as a result of a political economy and social construction policy theory that prioritizes farmers' interests and strives to guarantee the welfare of rice farmers. Since majority of rice farmers are poor smallholders, self-sufficiency may help ameliorate poverty among farmers.

Food self-sufficiency is not a new policy strategy in Malaysia as the country has historically focused on supported domestic rice production to obtain high degree of self-

1 The Malaysian government decided to immediately expand the national rice buffer stocks six-fold, which was administered by *Padiberas Nasional Bhd*, an import monopoly (Dawe 2010).

Figure 1. Gross production value (in USD million) of major agricultural crops

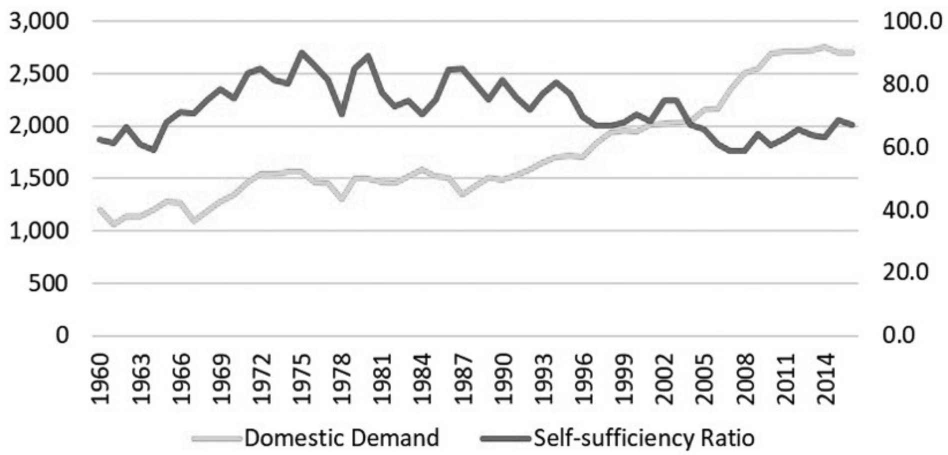


Source: FAO (2014)

sufficiency. As domestic demand for rice grows, self-sufficiency goals become more challenging (Figure 2). Increasing the intensity of rice production has been one way to improve land productivity and output. Currently, crop intensity of rice is considerably high, ranging between 170 percent and 180 percent, yet domestic production remains constrained by its marginal productivity (Mailena et al. 2014). The expansion of rice acreage is highly constrained in Malaysia since most arable land is under permanent palm oil and rubber crops. Pursuing self-sufficiency with a constrained land supply requires significant gains in productivity; otherwise, this will lead to higher market prices, and consequently reduced consumer welfare.

Although food self-sufficiency and food security are interconnected, the Malaysian government's stance on self-sufficiency is misconstrued and is often equated to food security. According to FAO, food self-sufficiency is "the extent to which a country can

Figure 2. Domestic demand (in tons) and rice self-sufficiency ratio (in %)



Source: USDA (2017)

satisfy its food needs from its own domestic production," "closing borders adopting complete autarky for the food sector," and "a country producing sufficient food to cover its own needs" (Clapp 2017; FAO 2016; FAO 1999). Food security, on the other hand, pertains to food availability, accessibility, nutrition, and stability across the three dimensions (FAO 2008). Food security makes no reference to the source of food (Clapp 2014), and therefore food security and self-sufficiency are divergent and express different concepts. The World Bank stresses that "food self-sufficiency should be weighed against the benefits of cheaper imports" (World Bank 2012). In fact, self-sufficiency has also been claimed as the outcome when a country prioritizes political decisions over economic rationale in its food policy choices that are characterized by conflicting interests. On one hand, there are those that support local production, on the other, there are those that believe that self-sufficiency is a costlier path, and thus worsens public investments (Clapp 2017).

Self-sufficiency has been criticized because it embraces policies that are inefficient and distort the market. This consequently weakens incentives for food production and leads to higher food prices in the long run (Naylor and Falcon 2010). Strongly emphasizing on self-sufficiency goals diverts governments' attention from addressing the more pressing food security concerns at the household level (Von Braun and Paulino 1990). Other countries are also discovering that self-sufficiency is more likely to cause negative consequences (Mosavi and Esmaeili 2012). Instead, many developing countries are now realizing that free trade is an effective approach to sustainable development. For instance, Latin America and East Asia indicated significant economic development growth in 1985 to 2005 when practicing free trade (OECD 2008). Accordingly, there were positive relationships between free trade and economic growth in the two regions (Von Braun and Diaz-Bonilla 2008). Likewise, the World Bank reviewed many studies on trade globalization with the aim of reducing poverty and concluded that the degree of trade openness of a country plays a significant role in improving its integration into the world economy (World Bank 2002). In fact, a rice import tariff will not help local producers; it may even punish local consumers (Jolly, Bayard, and Nguyen 2011).

Malaysia has been actively participating in free trade agreements (FTAs) at both bilateral and regional levels. Currently, it is involved in 13 FTAs and is a member of the World Trade Organization (WTO) (Table 1). Nevertheless, Malaysia has excluded rice in the FTAs and declared the commodity as a sensitive product, which allows it to extend protection to the local rice industry. Under the ASEAN-Australia-New Zealand Regional Free Trade Agreement, rice remains excluded from Malaysia's tariff commitments until 2023, when its tariff will be bound at 30 percent and then reduced annually until it is eliminated in 2026 (MITI 2006).

Despite the Malaysian government's substantial efforts to expand the rice production area in the country, to upgrade technologies and R&D, to develop and maintain infrastructures, and to invest in subsidy and incentive programs, domestic production is still insufficient. Malaysia's domestic production of long grain rice covers only 60–65 percent of the total domestic demand.

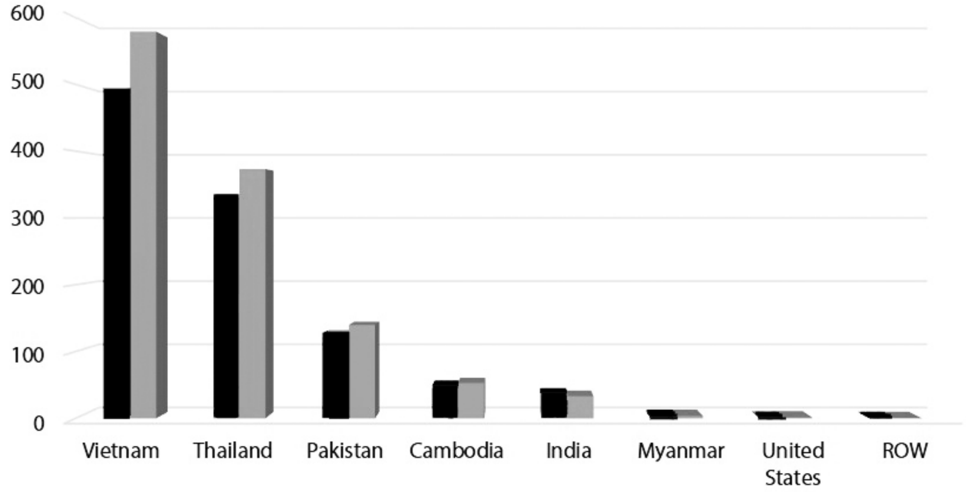
Malaysia has been a net rice importer for many years, depending on rice imports to satisfy the required domestic demand. Projections up to 2020 still suggest that Malaysia would still significantly rely on rice importation to meet its domestic requirements (Figure 3). Therefore, the government's decision to eliminate rice trades is pondered as an extreme policy strategy since Malaysia is not a competitive rice producer. Thus, considering that the country is using a massive public investment—and

Table 1. Current bilateral and regional free trade agreements of Malaysia

	Free Trade Agreements	Date Joined
Bilateral	Malaysia-Japan Economic Partnership Agreement	13 July 2006
	Malaysia-Pakistan Closer Economic Partnership Agreement	1 January 2008
	Malaysia-New Zealand Free Trade Agreement	1 August 2010
	Malaysia-India Comprehensive Economic Cooperation Agreement	1 July 2011
	Malaysia-Chile Free Trade Agreement	25 February 2012
	Malaysia-Australia Free Trade Agreement	1 January 2013
	Malaysia-Turkey Free Trade Agreement	1 August 2015
Regional	ASEAN-China Free Trade Agreement	1 July 2003
	ASEAN-Korea Free Trade Agreement	1 July 2006
	ASEAN-Japan Comprehensive Economic Partnership	1 February 2009
	ASEAN-Australia-New Zealand Free Trade Agreement	1 January 2010
	ASEAN-India Free Trade Agreement	1 January 2010
	ASEAN Trade in Goods Agreement	17 May 2010

Source: MITI (2006)

Figure 3. Bilateral rice trades (in thousand tons) from Malaysian trading partners



	Vietnam	Thailand	Pakistan	Cambodia	India	Myanmar	United States	ROW
2013-2015	493.15	336.38	126.81	48.48	36.67	3.90	1.22	0.46
2020	579.00	373.20	139.78	52.89	33.20	3.73	1.38	0.53

Source: RICEFLOW Database (2017)

Note: ROW = rest of the world

implicitly, taxpayers' dollars—to support a highly subsidized crop in order to achieve the self-sufficiency goal, it is crucial to evaluate the policies and analyze the impact of a long-held policy strategy at the national level.

From the discussion above, this study therefore attempts to answer the following overarching questions:

1. What are the consequences of enforcing a total rice self-sufficiency policy?
2. What are the main limitations to achieve self-sufficiency?
3. Is rice self-sufficiency an efficient approach to pursue?

Accordingly, the main objective of this study is to evaluate and analyze the impact of rice self-sufficiency policy and of international free trade policy in Malaysia as an alternative to the former. The specific objectives are as follows:

1. Simulate the impacts of self-sufficiency policy on total rice output and consumption.
2. Estimate the subsidy and production input requirements to achieve rice self-sufficiency.
3. Measure the country's potential gains or losses from rice self-sufficiency.
4. Assess the effects of removing rice trade restrictions on rice production and consumption.

This study utilizes a spatial partial equilibrium model of the global rice economy to simulate two main policy scenarios: rice self-sufficiency in Malaysia and the complete removal of import tariffs on rice in Malaysia. The self-sufficiency policy scenario is simulated by eliminating Malaysia's bilateral import volume, whereas, the free trade is simulated by removing the existing import tariffs that affect rice imports in Malaysia.

Prior to the simulation analysis, a baseline for the year 2020 is established to be consistent with the policy goal timelines. As such, the results would be more realistic and representative. From the self-sufficiency scenarios, we further estimate the policy requirements on subsidy, production input, technology efficiency, and the government potential revenues and losses.

MATERIALS AND METHODS

The most recent policy evaluation on Malaysian rice production has found that Malaysia is not a competitive rice producer. Moreover, the study determined that the country has no comparative advantage relative to rice imports (Roslina et al. 2016). In particular, the study used the policy analysis matrix (PAM) approach to estimate social price levels. The analysis was based on a scenario that eliminates production input subsidies (i.e., seed price, fertilizers, pesticides, and chemicals) and producer price supports (i.e., guaranteed price) in Malaysia using data for a particular period. Thus, the results were stationary; the technology, market environment, and factor prices were assumed to be constant. The result of comparative advantage in PAM was analyzed relative to rice imports only; the key assumption of the analysis was that domestic and imported rice were perfectly substitutable. In addition, PAM analysis showed that the Malaysian production system is not competitive, with the implication that Malaysia should not produce rice on economic grounds.

This study, on the other hand, applies the spatial, partial equilibrium analysis of the RICEFLOW model, which utilizes a multiregional database of the average market situation in 2013–2015 for 76 regions worldwide. The RICEFLOW model maintains production subsidies to simulate scenarios, whereas, the PAM analysis removes the producer's input and product price subsidies. As earlier noted, imported rice and domestic rice were considered perfect substitutes in the PAM analysis. The RICEFLOW analysis, meanwhile, specifies a preference for domestic rice relative to imported rice. Therefore, RICEFLOW serves a more precise methodology for evaluating and analyzing policy impacts.

Modeling Framework

A spatial partial equilibrium model of the global rice economy (Durand-Morat and Wailes 2010) simulates the behavior of the entire rice supply chain—from input markets all the way up to the aggregate final demand—in multiple countries/regions (set *R*) around the world. Producing endogenous rice commodities (set *CE*)[2] is specified as a weakly-separable, constant returns to scale production function.

$$Y_{c,r} = H_{c,r}\{G_{c,r}(FAC_{c,r}), INT_{c,r}\}\ \forall c \in CE, r \in R \quad (1)$$

where:[3]

Y = output,
H, G = technology functional forms,
FAC = set of factors of production, and
INT = set of intermediate inputs.

Defining *G* in Equation (1) as a constant elasticity of substitution (*CES*) function, the derived demand for factor of production, *QFC* is

$$QFC_{f,c,r} * AFC_{f,c,r} = QVA_{c,r} * SVA_{f,c,r} * \left[\frac{PFC_{f,c,r}}{PVA_{c,r} * AFC_{f,c,r}}\right]^{-\sigma VA_{c,r}} \forall f \in FAC, c \in CE, r \in R \quad (2)$$

2 *CE = {LGP, LGB, LGW, MGP, MGB, MGW, FRP, FRB, FRW}*, where *LG, MG,* and *FR* stand for long grain, medium/short grain, and fragrant rice, and *P, B, W* stand for paddy/rough, brown/whole, and white/milled rice.

3 *FAC = {L, T, K}*, where *L* is land, *T* is labor, and *K is* capital.

INT = {seeds, herbicides, pesticides, water, energy, *LGP, LGB, MGP, MGB, FRP, FRB}*

$$PVA_{c,r} = \left[\sum_f SVA_{f,c,r} * \left(\frac{PFC_{f,c,r}}{AFC_{f,c,r}}\right)^{1-\sigma VA_{c,r}}\right]^{\frac{1}{1-\sigma VA_{c,r}}} \quad \forall c \in CE, r \in R \quad (3)$$

where:

AFC, PFC, SVA = factor-, sector-, and region-specific augmenting technical change variable, factor price variable, and cost share in value added, respectively;
QVA, PVA = sector- and region-specific derived demand and price for the value-added composite, respectively; and
σVA = sector- and region-specific elasticity of substitution in value-added.

We assume that *σVA* equals zero (fixed proportion Leontief production function) for the production of primary rice commodities *(LGP, MGP, FRP)* and *1* (Cobb Douglas) for the production of brown and milled rice *(LGB, LGW, MGB, MGW, FRB, FRW).*

Defining *H* in Equation (1) as a *CES* function, the derived demands for intermediate inputs *QIC* and for the composite value added $QVA_{c,r}$ are

$$QIC_{i,c,r} * AIC_{i,c,r} = \frac{Y_{c,r}}{AY_{c,r}} * SITC_{i,c,r} * \left[\frac{PIC_{i,c,r}}{PY_{c,r}} * AIC_{f,c,r} * AY_{c,r}\right]^{-\sigma Y_{c,r}}, \forall i \in INT, c \in CE, r \in R \quad (4)$$

$$QVA_{c,r} * AVA_{c,r} = \frac{Y_{c,r}}{AY_{c,r}} * SVATC_{c,r} * \left[\frac{PVA_{c,r}}{PY_{c,r}} * AVA_{c,r} * AY_{c,r}\right]^{-\sigma Y_{c,r}}, \forall c \in CE, r \in R \quad (5)$$

where:

AIC, PIC, SITC	=	input-, sector-, and region-specific input-augmenting technical change variable, input price variable, and input cost share in total cost, respectively;
AVA, AY, PY, SVATC	=	sector- and region-specific value-added augmenting technical change variable, output-augmenting technical change variable, output price variable, and value-added cost share in total cost, respectively; and
σY	=	sector- and region-specific elasticity of substitution in final output. We assume σY equals zero (Leontief) for all rice production sectors.

The model assumes zero profits[4] in production [Equation (6)] and equilibrium in output markets [Equation (7a) for paddy rice commodities,[5] and Equation (7b) for other rice commodities].

(6)

$$PY_{c,r} = \frac{\left[SVATC_{c,r} * \left(\frac{PVA_{c,r}}{AVA_{c,r}}\right)^{1-\sigma Y_{c,r}} + \sum_i SITC_{i,c,r} * \left(\frac{PIC_{i,c,r}}{AIC_{i,c,r}}\right)^{1-\sigma Y_{c,r}}\right]^{\frac{1}{1-\sigma Y_{c,r}}}}{AY_{c,r}},$$

$$\forall c \in CE, r \in R,$$

and

(7a)

$$Y_{c,r} = QD_{c,r} + \sum_s QBX_{c,r,s} + QK_{c,r}, \forall c \in CP, r \in R,$$

(7b)

$$Y_{c,r} = QD_{c,r} + \sum_s QBX_{c,r,s}, \forall c \in CCP, r \in R$$

4 Zero profit conditions are used to guarantee that no extra profits exist in any production activity. By forcing equality between costs and revenues, these conditions ensure that the factors receive their normal rates of return.

5 Set *CP = {LGP, MGP, FRP}*. *CP ϵ CE.*

where:[6]

QD	=	volume of output *c* sold in the domestic market,
QK	=	change in stocks of good *c*, and
QBX	=	volume of bilateral exports of *c* from region *r* to region *s*.

Import demand follows the Armington approach (Armington 1969), in which imports by source and domestic production are treated as heterogeneous products. Agents first decide on the sourcing of imports [Equation (8)] based on the relative level of prices from each source [Equation (9)].

(8)

$$QBX_{c,s,r} = QM_{c,r} * SMS_{c,s,r} * \left[\frac{PMMS_{c,s,r}}{PMM_{c,r}}\right]^{-\sigma M_{c,r}},$$

$$\forall c \in CE, r \in R, s \in R$$

and

(9)

$$PMM_{c,r} = \left[\sum_s SMS_{c,s,r} * PMMS_{c,s,r}{}^{1-\sigma M_{c,r}}\right]^{\frac{1}{1-\sigma M_{c,r}}},$$

$$\forall c \in CE, r \in R$$

where:

PMMS	=	market price of import good *c* into region *r* from source *s*,
PMM	=	composite market price of import good *c* in *r*;
QM	=	demand for the composite import good *c* in *r*;
SMS	=	value-share of good *c's* imports into *r* by source *s*, and
$\sigma M_{c,r}$	=	elasticity of substitution of imported good *c* in *r* by source.

After sourcing imports, agents decide on the optimal mix of imported and domestic products [Equations (10) and (11)] based on their relative price levels [Equation (12)].

6 Only stocks of paddy rice are allowed. Thus $QK_{c,r}$ is defined over the commodity subset *CP*.

(10)

$$QM_{c,r} = QQ_{c,r} * SMQ_{c,r} * \left[PMM_{c,r}/PQ_{c,r}\right]^{-\sigma Q_{c,r}},$$
$$\forall c \in CE, r \in R,$$

and

(11)

$$QD_{c,r} = QQ_{c,r} * SDQ_{c,r} * \left[PY_{c,r}/PQ_{c,r}\right]^{-\sigma Q_{c,r}},$$
$$\forall c \in CE, r \in R,$$

(12)

$$PQ_{c,r} = \left[SMQ_{c,r} * PMM_{c,r}{}^{1-\sigma Q_{c,r}} + SDQ_{c,r} * PY_{c,r}{}^{1-\sigma Q_{c,r}}\right]^{\frac{1}{1-\sigma Q_{c,r}}}, \forall c \in CE, r \in R$$

where:

PQ	=	the market price of composite good *c* in region *r;*
QQ	=	output of composite good *c* in *r;*
SMQ, SDQ	=	value-shares of the import composite and domestic good *c* in *r;* and
$\sigma Q_{c,r}$	=	elasticity of substitution between domestic and imported good *c* in *r.*

The final demand for milled rice $c \in CFC$[7] in region *r* is the product of population and per-capita demand $D_{c,r}$, which is specified as a double log function of income and prices [Equation (13]). Z_r represents income by region, φr is the income demand elasticity, and $\omega c,g,r$ is the matrix of own and cross-price demand elasticities. The change in consumer surplus is estimated exogenously by recalibrating the demand function to the new prices and quantities demanded, and then by estimating the change in consumer surplus as the change in the area below the demand curve and above the market price. Given the assumption of constant returns to scale, the rice supply function is perfectly elastic, and therefore, no producer surplus exists. We approximate the change in producer welfare by estimating the change in the value of the land asset as it tends to be the main asset owned by rice producers; it is the only factor of production with an imperfect supply function. Therefore, the gains or losses associated with policy changes will be capitalized in the value of land.

(13)

$$\log D_{c,r} = \varphi_r * \log Z_r + \textstyle\sum_{g \in FC} \omega_{c,g,r} * \log PQ_{g,r}, \forall c \in CFC, r \in R$$

The supply of exogenous intermediate inputs (seeds, fertilizers, pesticides, energy, and water), capital, and labor are specified as perfectly elastic, and thus their prices (*PIC* for intermediate inputs and *PFC* for factors of production) are treated as constant, exogenous variables. Land is considered the only factor with limited supply. Hence, sectoral output *Y* is constrained only by the supply of land $L_{c,r}$ used in the production of paddy rice, which is represented by a double log function of land rental rates $PL_{c,r}$.

(14)

$$\log L_{c,r} = \theta_{c,r} \log PL_{c,r}, \forall c \in CP, r \in R$$

The land own-price supply elasticity $\theta_{c,r}$ is calibrated following Keller (1976) to reflect rice supply elasticities found in the literature.

Database

The database disaggregates rice into nine commodities across 76 regions in the world and covers over 90 percent of global production, consumption, and trade. The nine commodities result from the combination of three rice types (long grain, medium/short grain, and fragrant rice) and three milling degrees (paddy, brown, and white rice). The database represents global rice market situation in 2013–2015.

Data on rice production and stock changes come primarily from the USDA's Production, Supply, and Demand database and from

7 Set *CFC = {LGW, MGW, FRW}*. *CFC ϵ CE*

FAOSTAT. Rice production by type comes from many different sources, including national statistics offices, USDA's Global Agricultural Information Network reports, and industry publications such as Creed Rice Market Report and The Rice Trader.

Data on producer and consumer prices come from many of the sources cited above and from FAO's Global Information and Early Warning System. Rice trade data come primarily from the UN's COMTRADE database. Information on rice trade by type comes from many sources, including Thailand's Ministry of Commerce, India's Ministry of Commerce and Industry, Pakistan Bureau of Statistics, and USDA's Global Agricultural Trade System.

Information on trade policies is compiled from many sources, including the WTO, ASEAN, the Organization of American States' Foreign Trade Information System, and other national reporting agencies.

The elasticities of rice supply and demand come primarily from the Food and Agricultural Policy Research Institute. The Armington elasticities are taken from the Global Trade Analysis Project.

RICE POLICY SCENARIOS

This section describes the procedure used to estimate the relevant scenarios specified in this study. The scenarios consist of baseline analysis for the year 2020, self-sufficiency scenario, and international free trade scenario.

Baseline Analysis for the Year 2020

The baseline for the year 2020 is constructed by shocking the 2013–2015 database using the projected population growth and GDP growth that were developed by Global Insights (see Appendix Tables 1 and 2).

Self-Sufficiency Scenario

The self-sufficiency scenario simulates the situation in which Malaysia would eliminate its bilateral trade in long-grain rice by the year 2020. The closure of the model is altered to exogenize the variable representing bilateral import volumes (originally endogenous) while endogenizing the variable representing the power of bilateral import policies. This change in the closure allows us to find the power of import tariffs needed to bring import volumes to a target level. In this study, the target is to reduce the volume of long grain rice imports by 95 percent. Imports of medium grain and fragrant rice are not restricted due to the following reasons:

1. They represent a marginal part of the total domestic rice market.
2. They are consumed primarily by high-income households, and therefore contribute little to improving food security in Malaysia.

Free Trade Scenario

In this study's free trade scenario, import tariffs on rice in Malaysia are removed. The country would then apply different levels of import tariffs across trade partners (see Appendix Table 3). We incorporate free trade in the model by shocking the power of the bilateral import tariffs to zero (see Appendix Table 4).

EMPIRICAL RESULTS AND DISCUSSIONS

This section presents and discusses the main results of each of the relevant scenarios defined above. In the baseline analysis for the year 2020, the changes in the variables represent how these variables have evolved relative to their state in 2013–2015. The self-sufficiency and free trade scenarios used the 2020 baseline results as the starting points. Thus, the changes in the variables resulting from these two scenarios represent the state of these variables relative to that in 2020 without the shocks implied by the self-sufficiency and free trade scenarios.

Baseline Analysis for the Year 2020

The results of the 2020 baseline reveal that self-sufficiency in 2020 will be at 66.7 percent, slightly higher than the current average of 65 percent. In other words, given the projected market conditions and levels of intervention by the Malaysian government, Malaysia would continue to depend strongly on the international rice market to service a growing rice demand.

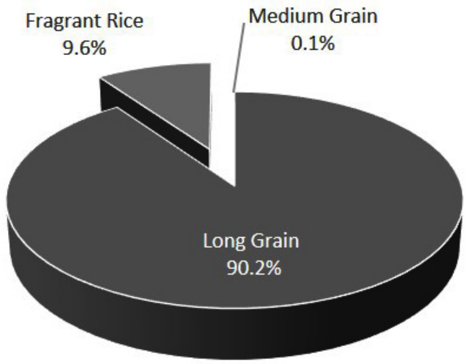
Based on the results of the simulation, the domestic production of long grain paddy would marginally grow at 6.8 percent and would increase in the milling industry by 6.6 percent (Table 2). The producer prices (i.e., cost of production) are estimated to increase by 17.8 percent and 17.2 percent for long grain paddy and long grain white, respectively. With the increases in producer prices, consumer prices would increase by 17.6 percent for long grain white rice. The aggregate demand for each type of rice is expected to grow, primarily due to the growing population. Imports of all rice types would increase (Table 2 and Figure 4). Vietnam and Thailand would remain as the main rice suppliers of the Malaysian market (see Appendix Table 1).

Table 2. Results of baseline analysis for year 2020

Parameters	2013–2015 Benchmark	Baseline 2020	
		%	Level
Producer Price (MYR/t)			
Long grain paddy	1,733.4	17.8	2,041.4
Long grain brown	1,745.0	17.6	2,052.4
Long grain white	1,791.3	17.2	2,099.0
Consumer Price (MYR/t)			
Long grain white	2,908.6	17.6	3,421.4
Medium grain white	4,873.8	10.8	5,399.0
Fragrant white	6,193.2	31.2	8,128.0
Domestic production (‘000 t milled basis)			
Long grain paddy	1,764.6	6.8	1,885.0
Long grain brown	1,837.0	6.6	1,958.0
Long grain white	1,837.7	6.6	1,958.0
Imports (‘000 t milled basis)			
Long grain white	941.3	3.3	975.4
Medium grain white	1.4	11.9	1.5
Fragrant white	103.6	10.5	114.5
Demand (‘000 t milled basis)			
Long grain white	2,779.0	5.5	2,932.0
Medium grain white	1.4	11.6	1.5
Fragrant white	103.7	10.7	114.8
Self-Sufficiency Level in Long Grain (%)	66.1	66.7	

Notes: MYR = Malaysian Ringgit (2017)
t = metric ton

Figure 4. Projections on Malaysia's rice imports by 2020



Self-Sufficiency Scenario

The results of the self-sufficiency scenario for rice commodities in Malaysia are presented in Table 3. Recall that this scenario assumes that imports of long grain rice would decrease by 95 percent. Thus, the massive decrease in rice imports is projected to stimulate domestic production, and thereby increase by 53.3 percent. However, this would only be possible with a 170.3 percent increase in producer price. By the underlying zero-profit condition,[8] this increase also implies increase in production cost, which is mostly derived from a constraint in land factor. The higher production cost of paddy rice and the consequential increase in the market price of paddy rice translate to higher consumer prices. As a result, the demand for long grain white rice would decline by 23.9 percent.

Rice producers would gain as a result of the self-sufficiency policy (higher land asset values). However, rice consumers would be worse off since the market prices would be much higher (i.e., decrease in consumer surplus), and hence, rice self-sufficiency would entail significant welfare shifts from consumers to producers.

The government is projected to lose USD 121.5 million in import tariff revenues as a result of self-sufficiency in long grain rice. This projected loss is derived from the difference between market price and cost, insurance, and freight (CIF) price of bilateral import, which are valued at USD 652.9 million and USD 531.4 million, respectively. Despite feasibly achieving rice self-sufficiency by the year 2020, the government would suffer from a rice import tariff revenue loss. Malaysia is an important player in the international rice market, and therefore, achieving rice self-sufficiency is expected to have sizable spillover effects into other regions. Vietnam, the main supplier of rice to Malaysia, is expected to lose the most as its export volume drops by 3.05 percent, followed by India, Myanmar, Pakistan, and the United States (Table 4).

The results above show that rice self-sufficiency will generate significant welfare redistributions from consumers and from the government to rice producers in Malaysia and will have significant spillover effects onto the rice global market. The options available to counter the projected significant price spikes under rice self-sufficiency are limited, and their assessments suggest that harmonizing the goals of self-sufficiency and food security through stable rice prices will be extremely challenging.

8 By the virtue of the zero-profit condition, the product price by activity equals the unitary cost of production (Durand-Morat and Wailes 2010)

Table 3. Results of the self-sufficiency scenario

Parameters	2013–2015 Benchmark	Baseline 2020		Self-Sufficiency	
		%	Level	%	Level
Producer Price (MYR/t)					
Long grain paddy	1,733.4	17.8	2,041.4	170.3	5,516.9
Long grain brown	1,745.0	17.6	2,052.4	168.9	5,519.3
Long grain white	1,791.3	17.2	2,099.0	165.3	5,567.6
Consumer Price (MYR/t)					
Long grain white	2,908.6	17.6	3,421.4	165.3	9,075.3
Medium grain white	4,873.8	10.8	5,399.0	0.0	5,399.0
Fragrant white	6,193.2	31.2	8,128.0	0.2	8,146.7
Domestic Production ('000 t)					
Long grain paddy	1,764.6	6.8	1,885.0	53.3	2,890.5
Long grain brown	1,837.0	6.6	1,958.0	51.4	2,965.0
Long grain white	1,837.7	6.6	1,958.0	51.2	2,959.9
Imports ('000 t milled basis)					
Long grain white	9,41.3	3.3	975.4	−95.0	48.8
Medium grain white	1.4	11.9	1.5	7.1	1.6
Fragrant white	103.6	10.5	114.5	7.1	122.6
Demand ('000 t milled basis)					
Long grain white	2,779.0	5.5	2,932.0	−23.9	2,231.8
Medium grain white	1.4	11.6	1.5	7.1	1.6
Fragrant white	103.7	10.7	114.8	7.1	122.9
Welfare change					
Land asset value (billion USD)					2.8
Consumer surplus (billion USD)					−3.5
Self-Sufficiency in Long Grain (%)	66.1		66.7		97.8

Table 4. Global impacts of self-sufficiency policy in Malaysia

Exporting Regions	% Change in Export Volume
Vietnam	−3.05
Thailand	−0.14
Pakistan	−1.54
Myanmar	−1.63
India	−1.70
United States	−1.53
ROW (Rest of the World)	−1.83

Output subsidy requirements

One option to offset the rice price increase resulting from rice self-sufficiency is to expand producer subsidies. The subsidy expansion would bring the consumer prices down at the pre-self-sufficiency level. The required subsidy and the cost of the subsidy program can be estimated using the producer prices and domestic production in the self-sufficiency scenario. The total subsidy (in local currency per metric ton) is estimated at Malaysian Ringgit (MYR) 3,475.5/t (USD 810/t). The total cost of subsidy program is estimated at MYR 10.04 billion (USD 2.34 billion). The current total subsidy program is MYR 1.8 billion (DOA 2010). Thus, the government would need a substantial additional expenditure to realize self-sufficiency in rice while maintaining prices at the baseline level (Table 5).

Requirements of production input

As previously explained, the primary rice production technology is specified as a Leontief production function (no substitution between production inputs). Additionally, all factors of production are assumed to be perfectly and elastically supplied except for land. This specification of production and input markets means that the changes in the rice market will be primarily dictated by the specification of land markets.

In the self-sufficiency scenario, the growth of domestic production would translate into a 53.3 percent increase in land demand. Given the assumption of inelastic land supply, such an expansion in land demand would significantly increase land rental rates (Table 6). The increase in required land in the self-sufficiency scenario would also lead to an incredibly higher production cost, which would subsequently transfer to much higher consumer prices.

Majority of the agricultural land in Malaysia is used to produce palm oil and rubber, the most important agricultural commodities contributing to national income. Thus, rice farmland is limited to less than 10 percent of the total agricultural land (Figure 5). The land substitution possibilities between an annual

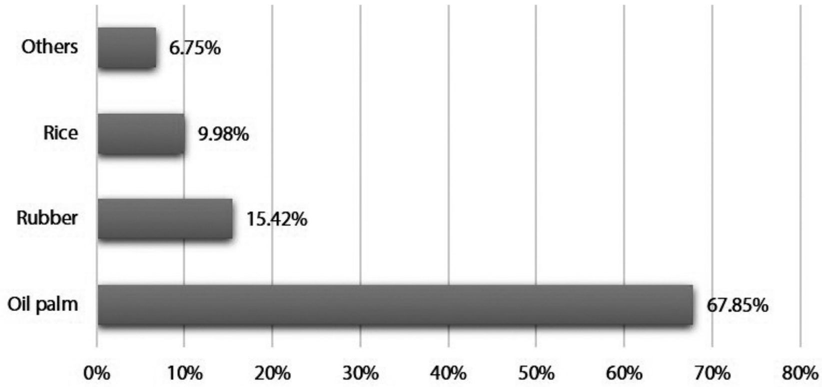
Table 5. Required subsidy and total subsidy program for self-sufficiency

Parameter	Producer Prices (MYR/t)		MYR/t
	Baseline 2020	Self-sufficiency	
Required subsidy	2,041.4	5,516.9	3,475.50
	Total Subsidy (MYR/t)	Domestic Production (‘000 t in paddy basis)	MYR (billion)
Required total subsidy	3,475.5	2,890.5	10.04

Table 6. The required land input of production

Parameters	Baseline 2020	Self-Sufficiency
Rice acreage at baseline (‘000 ha)	690.0	736.9
Growth in required land input (%)	6.8	53.3
Required land acreage (‘000 ha)	736.9	1,129.8
Domestic rice production (‘000 t, paddy basis)	1,885.0	2,890.5

Figure 5. Agricultural land use (area harvested) in Malaysia, by commodity (2014)



Source: FAOSTAT (2017)

crop (e.g., rice) and permanent crops (e.g., rubber and palm oil) are limited by the high investment required in the latter.

Some possible solutions to address land constraint is through utilizing technology and R&D, such as developing non-irrigated farmlands. However, this will still be challenging for Malaysia in terms of land availability. Another way to expand rice acreage is to increase rice-land-use intensity (number of rice crops produced per year on the same field). However, the existing crop intensity in Malaysia is relatively high, ranging from 170 to 180 percent.

Requirement for technological efficiency

Technological efficiency is based on improved productivity, primarily land productivity. Producing higher yields per hectare can enable Malaysia to achieve higher output without increasing acreage. Therefore, the required crop yield to achieve self-sufficiency, which represents the needed productivity improvement, is measured by swapping the derived demand for land to produce long grain paddy rice ($QFC_{land,LGP,Malaysia}$) with $AFC_{land,LGP,Malaysia}$, which is the augmenting technical change variable.

In the baseline 2020, producing 1,958 (thousand t, milled basis) of rice from a land acreage of 690 (thousand ha) would require crop yield to be 2.83 t/ha[9] (milled basis) or 4.73 t/ha (paddy basis). In the self-sufficiency scenario, the required land acreage would be 736.9 (thousand ha) such that 2,959.9 (thousand t, milled basis) of rice could be produced. Accordingly, the required crop yield would be 4.02 t/ha (milled basis) or 6.18 t/ha (paddy basis). At this productivity gain, domestic rice production can be achieved at the self-sufficiency level. Consumer prices would remain at the pre-self-sufficiency level, and thus prevent prices from surging up (Table 7).

Most of the tropical rice-growing countries in Asia have high population growth rates and have limited land for rice cultivation. Thus, to be a food-secure nation, productivity gain is crucial. Accordingly, hybrid rice adoption could be a way to meet this objective (FAO 2004). The hybrid rice technology aims to increase the yield potential of rice beyond the level of

9 The crop yield is estimated as the division of domestic production (1,885 in thousand t, paddy basis) to the land acreage (736.9 in thousand ha).

Table 7. Required technological efficiency on productivity

Parameters	Baseline 2020	Self-Sufficiency
Land acreage (in '000 ha)	690.00	736.90
Domestic production (in '000, milled basis)	1,958.00	2,959.90
Required crop yield t/ha (in milled basis)	2.83	4.02
Required crop yield t/ha (in paddy basis)	4.73	6.18

inbred high-yielding varieties by exploiting the phenomenon of hybrid vigor or heterosis. However, a number of challenges have been identified with its use, thereby affecting the large-scale adoption of hybrid rice. These challenges include inferior grain quality and high cost of seed (FAO 2004).

Another potential technology for limited irrigated land is the cultivation of upland rice, which is grown in well-drained, non-puddled, and non-saturated soils. With good management practices, upland rice (aerobic rice) can produce at least 4–6 t/ha. However, more weed species tend to grow in ricefields that are not permanently flooded than in flooded rice, especially in the tropic environments. Also, soil-borne pests and diseases (e.g., nematodes, root aphids, and fungi) have been found to occur more in upland rice (Maclean, Hardy, and Hettel 2013).

Since 2005, Malaysia has ventured in both hybrid and upland rice varieties through the research efforts of the Malaysian Agricultural Research and Development Institute. However, hybrid rice does not perform well when the direct-seeding approach—the most used planting approach in Malaysia—is applied. Thus, farmers need to apply high-technology machinery for planting, which is not available to most small rice farmers. As a result, previous works on hybrid rice in Malaysia were unsuccessful (GRAIN 2008).

Using aerobic rice, which is a combination of upland and high-yield lowland rice varieties (Tuong and Bouman 2003), is another effort that could be used to achieve rice self-sufficiency. However, although aerobic rice yields stable productivity, it produces lower crop yields than irrigated lowland rice, producing only 2.2 t/ha to 3.6 t/ha. In fact, aerobic rice tends to experience higher weed infestation due to the poor soil structure in adverse non-irrigated environment. Thus, it consistently requires higher inputs. With most rice farmers in Malaysia belonging to the low-income group, this condition would be the most challenging to maintain production performance (Chan et al. 2012).

Free Trade Scenario

As described above, the free trade scenario assumes that all existing long grain rice import tariffs in Malaysia would be removed (see Appendix Table 3.3 for information on the actual levels of import protection administered by Malaysia).

With free trade, the producer price for long grain rice in Malaysia is projected to decrease by 11.9 percent and domestic production by 5.3 percent, and thus would yield a self-sufficiency level of 61.8 percent. The increased competition in the Malaysian rice market would then reduce consumer prices by 14.74 percent, which would increase the domestic consumption of long grain white rice by 4.44 percent. The higher domestic demand is further expected to expand rice imports by 19.85 percent (Table 8).

These results are consistent with the trade theory. This theory posits that rice producers would stand to lose with international free trade policy, but consumers would gain and be better

Table 8. Results of free trade scenario

Parameters	2013–2015 Benchmark	Baseline 2020		Free Trade Policy	
		%	Level	%	Level
Producer Price (MYR/t)					
Long grain paddy	1,733.40	17.80	2,041.40	−11.90	1,798.47
Long grain brown	1,744.90	17.60	2,052.40	−11.81	1,810.01
Long grain white	1,791.30	17.20	2,099.00	−11.55	1,856.57
Consumer Price (MYR/t)					
Long grain white	2,908.60	17.60	3,421.40	−14.74	2,917.09
Medium grain white	4,874.00	10.80	5,399.00	0.01	5,399.54
Fragrant white	6,193.00	31.20	8,128.00	−0.04	8,124.75
Domestic Production (‘000 t)					
Long grain paddy	1,764.60	6.80	1,885.00	−5.30	1,785.10
Long grain brown	1,837.00	6.60	1,958.00	−5.11	1,857.95
Long grain white	1,837.70	6.60	1,958.00	−5.08	1,858.53
Imports (‘000 t milled basis)					
Long grain white	941.30	3.30	975.40	19.85	1,169.02
Medium grain white	1.40	11.90	1.50	−1.08	1.48
Fragrant white	103.60	10.50	114.50	−1.08	113.26
Demand (‘000 t milled basis)					
Long grain white	2,779.00	5.50	2,932.00	4.44	3,062.18
Medium grain white	1.40	11.60	1.50	−1.08	1.48
Fragrant white	103.70	10.70	114.80	−1.08	113.56
Welfare change					
Land asset value (million USD)					−125.80
Consumer surplus (million USD)					328.00
Self-Sufficiency in Long Grain (%)	66.13		66.73		61.82

off with it. From the consumers’ perspectives, a free trade scenario appears to provide a more food-secure economy as compared to a self-sufficiency scenario. The free trade will not punish consumers at the price level, and thus consumers will gain from the free trade. However, producers would be worse off (i.e., decrease in land asset value), and the government will lose tariff revenues from the free trade.

Self-sufficiency policy would improve the welfare of rice producers, albeit they are a minor segment of the total population. However, implementing such policy would substantially increase consumer prices and would cost the government significantly. On the other hand, a free trade policy could improve the welfare of most of the population as rice remains a primary food staple.

From a policy perspective, the government and policymakers should gauge the implications of the policies on the overall economy. The government’s stance on self-sufficiency needs to be reconsidered as this policy strategy is economically misguided. The significant differences in welfare allocation between the two scenarios described above imply that the political economy becomes even more crucial in deciding the policy output. Since Malaysia is pursuing self-sufficiency, the forces supporting a small group of the population are winning the battle at the expense of the much larger consumer group.

CONCLUSIONS

Rice self-sufficiency has become a policy cornerstone in Malaysia and is believed by proponents to be the best strategy to address food security concerns. Various strategies can be utilized to achieve a desired level of self-sufficiency that would lead to substantial public investment to support domestic rice production. As a result, rice has become a highly subsidized and protected food crop. The government's mandate is to seriously pursue rice self-sufficiency and to achieve this policy goal by the year 2020. Most recently, this goal has been extended to 2050.

With this mandate, the government aims to close all trading borders and to eliminate rice imports coming from international markets and suppliers. As Malaysia is not a competitive rice producer, this extreme policy decision will require a massive additional expenditure at the production level. On the other hand, liberalizing rice trade would have more positive effects on food security, and implicitly, on the economic growth of Malaysia since the country has actively participated in both bilateral and regional free trade agreements.

This study has evaluated and analyzed the impact of self-sufficiency and free trade policies on the Malaysian rice sector at the national level using a spatial partial equilibrium model. As expected, the results have corresponded to economic theory, with self-sufficiency greatly benefitting rice farmers at the expense of consumers and the government, but yielding a net welfare loss to society. On the other hand, the free trade policy has shown the opposite impact. Farmers' welfare would worsen while increasing consumers' welfare, thus yielding a net welfare gain to society. Self-sufficiency would create massive welfare shifts from the consumers and government to rice producers. Despite improving the welfare of rice producers, albeit they are but a small group, imposing a self-sufficiency policy would punish consumers—and indirectly, rice producers—due to the significant increase in consumer price.

Affordable food price is one of the key concepts of food security. Thus, a self-sufficiency policy does not guarantee food security at the national level. The government stands to lose from self-sufficiency. Thus, pursuing a self-sufficiency policy is highly challenging for Malaysia.

As part of ASEAN, Malaysia could instead participate in a regional approach to strengthen food security and to address its rice-deficit issue. A free trade policy offers a more food secure economy. With free trade, rice producers would be worse off to a marginal degree and the government would stand to lose from import tariff revenues. However, consumers would be better off due to decreasing prices resulting from a more competitive market environment coming from external rice suppliers.

This study has focused on rice in terms of final consumption. However, the model used in this study does not allow substitution for other sources of calories, which means consumers continue to consume rice with no substitutions. As dictated by elasticities, consumers are not allowed to switch to other final consumption goods such as wheat or corn. Thus, further analysis should be done, which will focus on substitution for other food sources in the final consumption.

Also, the estimations done on each parameter have been based on the fact that

Malaysia would pursue total rice self-sufficiency goal by the year 2020 as mandated by the government in the national agricultural policy for 2010–2020. However, the government has recently extended the self-sufficiency goal to 2050 under the national masterplan for 2020–2050. Thus, the country has another 30 years to improve its rice sector to achieve self-sufficiency in the future.

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Appendix Table 1. Population growth projections by region

Regions	In million								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Argentina	42.5	43.0	43.4	43.8	44.3	44.7	45.1	45.5	43.0	5.9
Australia	23.3	23.6	24.0	24.3	24.6	25.0	25.3	25.6	23.6	8.4
Bangladesh	157.2	159.1	161.0	162.9	164.8	166.7	168.6	170.5	159.1	7.2
Benin	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	10.6	16.6
Bolivia	10.4	10.6	10.7	10.9	11.1	11.2	11.4	11.5	10.6	9.3
Brazil	204.3	206.1	207.8	209.6	211.2	212.9	214.5	216.0	206.1	4.8
Burkina Faso	17.1	17.6	18.1	18.6	19.2	19.7	20.3	20.9	17.6	18.6
Canada	35.1	35.5	35.8	36.2	36.6	37.0	37.4	37.8	35.5	6.5
Cambodia	15.1	15.3	15.6	15.8	16.1	16.3	16.6	16.8	15.3	9.7
Cameroon	22.2	22.8	23.3	23.9	24.5	25.1	25.7	26.3	22.8	15.6
Chile	17.6	17.8	17.9	18.1	18.3	18.5	18.7	18.8	17.8	6.1
China	1,362.5	1,369.4	1,376.0	1,382.3	1,388.2	1,393.7	1,398.6	1,402.8	1369.3	2.4
Colombia	47.3	47.8	48.2	48.7	49.1	49.5	49.9	50.2	47.8	5.1
Costa Rica	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.0	4.8	6.0
Cote D'Ivoire	21.6	22.2	22.7	23.3	23.8	24.4	25.0	25.6	22.2	15.4
Cuba	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	−0.1
Ecuador	15.7	15.9	16.1	16.4	16.6	16.9	17.1	17.3	15.9	9.0
Egypt	87.6	89.6	91.5	93.4	95.2	97.0	98.8	100.5	89.6	12.2
El Salvador	6.1	6.1	6.1	6.1	6.2	6.2	6.2	6.2	6.1	2.0
European Union	504.3	504.8	505.3	505.9	506.5	507.1	507.7	508.2	504.8	0.7
Gambia	1.9	1.9	2.0	2.1	2.1	2.2	2.3	2.3	1.9	20.5
Ghana	26.2	26.8	27.4	28.0	28.6	29.2	29.7	30.3	26.8	13.3
Guatemala	15.7	16.0	16.3	16.7	17.0	17.3	17.7	18.0	16.0	12.5
Guinea	11.9	12.3	12.6	12.9	13.2	13.5	13.8	14.1	12.3	15.1
Guinea Bissau	1.8	1.8	1.8	1.9	1.9	2.0	2.0	2.1	1.8	14.9

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Appendix Table 1. Continued

Regions	In million								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Guyana	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	3.0
Haiti	10.4	10.6	10.7	10.8	11.0	11.1	11.2	11.4	10.6	7.6
Honduras	7.8	8.0	8.1	8.2	8.3	8.4	8.5	8.7	8.0	8.6
Hongkong	7.2	7.2	7.3	7.3	7.4	7.5	7.5	7.6	7.2	4.6
India	1,279.5	1,295.3	1,311.1	1,326.8	1,342.5	1,358.1	1,373.6	1,388.9	1,295.3	7.2
Indonesia	251.3	254.5	257.6	260.6	263.5	266.4	269.1	271.9	254.4	6.9
Iran	77.2	78.1	79.1	80.0	80.9	81.8	82.6	83.4	78.1	6.7
Iraq	34.1	35.3	36.4	37.5	38.7	39.8	40.9	42.0	35.3	19.0
Japan	127.0	126.8	126.6	126.3	126.0	125.7	125.4	125.0	126.8	−1.4
Kenya	43.7	44.9	46.1	47.3	48.5	49.7	50.9	52.2	44.9	16.3
Laos	6.6	6.7	6.8	6.9	7.0	7.2	7.3	7.4	6.7	10.6
Liberia	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	4.4	14.5
Malaysia	29.5	29.9	30.3	30.8	31.2	31.6	32.0	32.4	29.9	8.3
Mali	16.6	17.1	17.6	18.1	18.7	19.3	19.9	20.5	17.1	19.7
Mexico	123.7	125.4	127.0	128.6	130.2	131.8	133.4	134.9	125.4	7.6
Myanmar	53.0	53.4	53.9	54.4	54.8	55.3	55.8	56.2	53.4	5.2
Nicaragua	5.9	6.0	6.1	6.2	6.2	6.3	6.4	6.4	6.0	6.7
Niger	18.4	19.1	19.9	20.7	21.6	22.4	23.4	24.3	19.1	27.1
Nigeria	172.8	177.5	182.2	187.0	191.8	196.8	201.7	206.8	177.5	16.5
Pakistan	181.2	185.0	188.9	192.8	196.7	200.7	204.6	208.4	185.1	12.6
Panama	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	3.9	9.4
Paraguay	6.5	6.6	6.6	6.7	6.8	6.9	7.0	7.1	6.6	7.9
Peru	30.6	31.0	31.4	31.8	32.2	32.6	32.9	33.3	31.0	7.6
Philippines	97.6	99.1	100.7	102.3	103.8	105.3	106.9	108.4	99.1	9.4
Rwanda	11.1	11.3	11.6	11.9	12.2	12.4	12.7	13.0	11.3	14.6
Russia	143.4	143.4	143.5	143.4	143.4	143.3	143.1	142.9	143.4	−0.4

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Appendix Table 1. Continued

Regions	In million								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Saudi Arabia	30.2	30.9	31.5	32.2	32.7	33.3	33.8	34.4	30.9	11.3
Senegal	14.2	14.7	15.1	15.6	16.1	16.5	17.0	17.5	14.7	19.2
Singapore	5.4	5.5	5.6	5.7	5.8	5.9	5.9	6.0	5.5	9.1
Sierra Leone	6.2	6.3	6.5	6.6	6.7	6.9	7.0	7.2	6.3	13.6
South Korea	49.8	50.1	50.3	50.5	50.7	50.9	51.1	51.3	50.1	2.4
South Africa	53.4	54.0	54.5	55.0	55.4	55.9	56.3	56.7	54.0	5.0
Sri Lanka	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	20.6	2.6
Suriname	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.5	5.0
Taiwan	23.3	23.4	23.5	23.5	23.6	23.6	23.7	23.7	23.4	1.4
Tanzania	50.2	51.8	53.5	55.2	56.9	58.6	60.4	62.3	51.8	20.1
Thailand	67.5	67.7	68.0	68.1	68.3	68.4	68.5	68.6	67.7	1.3
Togo	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	7.1	16.5
Turkey	76.2	77.5	78.7	79.6	80.4	81.1	81.7	82.3	77.5	6.2
UAE	9.0	9.1	9.2	9.3	9.4	9.5	9.7	9.8	9.1	8.0
Uganda	36.6	37.8	39.0	40.3	41.7	43.0	44.4	45.9	37.8	21.3
Uruguay	3.4	3.4	3.4	3.4	3.5	3.5	3.5	3.5	3.4	2.2
USA	317.1	319.5	322.0	324.5	327.1	329.8	332.4	335.0	319.5	4.8
Venezuela	30.3	30.7	31.1	31.5	31.9	32.3	32.7	33.1	30.7	7.9
Vietnam	91.4	92.4	93.4	94.4	95.4	96.4	97.3	98.2	92.4	6.2

Appendix Table 2. GDP projections by region

Regions	Billion USD								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Argentina	458.1	446.7	457.5	450.0	476.3	476.3	489.9	502.0	454.1	10.6
Australia	1,357.4	1,395.3	1,428.9	1,463.4	1,537.7	1,537.7	1,583.1	1,627.3	1,393.8	16.7
Bangladesh	137.7	146.0	155.6	166.5	188.6	188.6	200.9	213.7	146.4	45.9
Benin	7.5	8.0	8.3	8.7	9.4	9.4	9.8	10.2	7.9	28.6
Bolivia	23.2	24.5	25.7	26.6	28.6	28.6	29.8	31.1	24.4	27.2
Brazil	2,412.8	2,424.9	2,333.4	2,250.5	2,307.1	2,307.1	2,385.4	2,475.5	2,390.3	3.6
Burkina Faso	10.8	11.4	11.9	12.4	13.8	13.8	14.5	15.3	11.4	34.6
Canada	1,735.2	1,779.7	1,796.5	1,820.2	1,901.6	1,901.6	1,945.0	1,984.2	1,770.4	12.1
Cambodia	13.9	14.8	15.9	17.0	19.4	19.4	20.7	22.0	14.9	48.3
Cameroon	27.2	28.8	30.1	31.6	34.9	34.9	36.6	38.3	28.7	33.4
Chile	253.1	257.7	263.6	267.6	279.6	279.6	288.7	300.2	258.1	16.3
China	7,748.4	8,314.0	8,889.9	9,485.2	10,717.2	10,717.2	11,370.2	12,062.3	8,317.4	45.0
Colombia	334.2	348.9	359.6	366.8	383.8	383.8	394.7	407.6	347.6	17.3
Costa Rica	41.6	42.8	44.4	46.1	49.6	49.6	51.6	53.7	42.9	25.1
Cote D'Ivoire	28.8	31.2	33.7	36.3	41.5	41.5	43.5	45.3	31.2	45.0
Cuba	70.0	70.7	73.8	74.3	78.9	78.9	82.3	86.2	71.5	20.6
Ecuador	83.2	86.5	86.6	84.5	87.0	87.0	89.4	91.9	85.4	7.5
Egypt	228.0	233.1	242.9	253.6	277.3	277.3	290.9	305.3	234.7	30.1
El Salvador	22.7	23.0	23.6	24.1	25.1	25.1	25.6	26.2	23.1	13.1
European Union	17,240.3	17,521.1	17,895.8	18,226.8	18,506.3	18,812.2	19,110.3	19,406.4	17,552.4	10.6
Gambia	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.0	25.8
Ghana	43.0	44.8	46.5	48.1	54.4	54.4	57.7	60.5	44.8	35.1
Guatemala	46.0	47.9	49.9	51.6	55.1	55.1	57.1	59.2	47.9	23.6
Guinea	5.2	5.3	5.3	5.5	6.0	6.0	6.4	6.8	5.3	29.1
Guinea Bissau	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	0.9	28.6

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Appendix Table 2. Continued

Regions	Billion USD								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Guyana	2.3	2.4	2.4	2.5	2.7	2.7	2.8	2.9	2.4	23.9
Haiti	7.6	7.8	7.9	8.0	8.3	8.3	8.5	8.7	7.8	12.5
Honduras	17.6	18.1	18.8	19.5	20.8	20.8	21.6	22.4	18.2	23.2
Hong Kong	252.0	258.3	264.7	268.8	278.7	278.7	284.7	291.4	258.3	12.8
India	1,895.6	2,032.1	2,185.5	2,336.9	2,702.8	2,702.8	2,913.5	3,137.6	2,037.7	54.0
Indonesia	897.3	942.3	987.5	1,037.3	1,147.3	1,147.3	1,208.3	1,274.6	942.4	35.3
Iran	444.5	463.8	470.5	491.4	538.0	538.0	564.2	590.6	459.6	28.5
Iraq	162.0	155.7	152.7	158.0	169.2	169.2	177.1	186.2	156.8	18.7
Japan	5,910.5	5,924.9	5,998.7	6,057.6	6,176.2	6,176.2	6,218.9	6,229.6	5,944.7	4.8
Kenya	46.9	49.4	52.2	55.2	61.9	61.9	65.2	68.2	49.5	37.8
Laos	8.5	9.1	9.7	10.4	11.9	11.9	12.7	13.5	9.1	48.6
Liberia	1.3	1.4	1.4	1.5	1.6	1.6	1.7	1.8	1.4	31.7
Malaysia	296.5	314.3	330.0	343.6	372.9	372.9	391.1	411.2	313.6	31.1
Mali	9.8	10.5	11.1	11.7	12.8	12.8	13.4	14.0	10.5	33.8
Mexico	1,153.5	1,179.6	1,210.7	1,238.1	1,290.9	1,290.9	1,327.0	1,367.2	1,181.3	15.7
Myanmar	51.1	55.0	59.1	63.2	72.6	72.6	77.7	83.0	55.1	50.7
Nicaragua	10.2	10.7	11.2	11.7	12.7	12.7	13.2	13.8	10.7	28.3
Niger	6.8	7.3	7.7	8.1	9.1	9.1	9.6	10.1	7.3	39.0
Nigeria	425.4	452.3	464.9	455.6	465.2	465.2	479.9	499.0	447.5	11.5
Pakistan	193.7	202.9	214.1	226.4	250.3	250.3	263.8	277.4	203.6	36.3
Panama	37.7	39.9	42.2	44.2	47.6	47.6	49.4	51.3	39.9	28.3
Paraguay	23.6	24.7	25.4	26.3	27.9	27.9	28.8	29.6	24.6	20.7
Peru	176.3	180.7	186.7	194.0	207.7	207.7	216.2	225.9	181.2	24.6
Philippines	236.3	251.0	265.8	283.9	320.9	320.9	340.9	361.3	251.1	43.9
Rwanda	7.0	7.5	7.9	8.4	9.4	9.4	10.0	10.5	7.5	40.6
Russia	1,783.1	1,796.2	1,730.0	1,719.5	1,759.9	1,759.9	1,798.7	1,849.9	1,769.7	4.5

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Appendix Table 2. Continued

Regions	Billion USD								%	%
	2013	2014	2015	2016	2017	2018	2019	2020	Baseline (2013–2015)	Change (2020)
Saudi Arabia	626.8	649.6	672.2	680.6	711.3	711.3	730.8	755.2	649.5	16.3
Senegal	14.2	14.8	15.7	16.7	18.7	18.7	19.7	20.8	14.9	39.6
Singapore	272.5	281.4	287.0	291.2	301.0	301.0	308.3	316.7	280.3	13.0
Sierra Leone	3.8	4.0	3.2	3.4	3.6	3.6	3.8	4.0	3.7	9.1
South Korea	1,194.8	1,234.7	1,266.9	1,302.0	1,375.5	1,375.5	1,413.4	1,450.6	1,232.1	17.7
South Africa	406.3	412.9	418.1	419.1	432.3	432.3	443.6	456.0	412.4	10.6
Sri Lanka	70.0	75.2	79.8	84.3	93.8	93.8	99.2	104.8	75.0	39.7
Suriname	4.9	5.0	4.9	4.5	4.7	4.7	4.8	4.9	4.9	−0.3
Taiwan	483.5	502.9	506.6	512.5	531.8	531.8	544.3	558.8	497.7	12.3
Tanzania	37.8	40.5	43.3	46.2	52.3	52.3	55.4	58.6	40.5	44.6
Thailand	378.6	381.7	392.5	404.8	429.9	429.9	443.4	458.0	384.2	19.2
Togo	3.7	3.9	4.1	4.4	4.8	4.8	5.1	5.4	3.9	38.5
Turkey	847.2	872.9	907.2	920.2	965.9	965.9	994.1	1,024.3	875.8	17.0
UAE	336.7	347.1	360.2	365.6	387.4	387.4	404.4	422.7	348.0	21.5
Uganda	22.5	23.6	24.8	26.2	29.3	29.3	31.1	33.2	23.6	40.5
Uruguay	45.9	47.4	47.8	48.1	50.3	50.3	51.7	53.3	47.0	13.3
USA	1,5802.9	16,177.5	16,597.5	16,855.7	17,696.4	17,696.4	18,102.8	18,478.7	16,192.6	14.1
Venezuela	266.9	256.5	241.7	213.5	195.2	195.2	196.9	198.7	255.0	−22.1
Vietnam	136.0	144.1	153.7	163.0	184.3	184.3	196.1	208.7	144.6	44.3

Source: Arkansas Global Rice Model (AGRM)

Appendix Table 3. Bilateral trades import volume and import tariffs

Exporting Regions	Commodities	Trade Volume ('000 t)	Ad valorem Tariff
Vietnam	Long grain white	548.4	20%
	Fragrant white	30.6	
Thailand	Long grain brown	0.7	20%
	Fragrant brown	0.0	
Pakistan	Long grain white	346.6	40%
	Fragrant white	25.9	
Cambodia	Long grain white	125.9	20%
	Fragrant white	13.9	
	Long grain white	20.2	
	Fragrant white	32.7	
India	Long grain brown	0.1	40%
	Long grain white	22.1	
	Fragrant White	11.0	
Myanmar	Long grain white	3.7	20%
United States	Long grain brown	0.1	40%
	Long grain white	0.3	
	Medium grain white	1.0	
Rest of the World (ROW)	Long grain white	0.0	40%
	Medium grain white	0.5	

Source: RICEFLOW Database (2017)

Appendix Table 4. Bilateral trades import volume and import tariffs

Regions	Rice Commodities	Import Tariffs (%)	
		Ad valorem	Free Trade
India	Long grain paddy	40	1–1.40/1.40 = −28.57
	Long grain brown		
	Long grain white		
Thailand	Long grain brown	20	1–1.20/1.20 = −16.67
	Long grain white		
USA	Long grain brown	40	1–1.40/1.40 = −28.57
	Long grain white		
Vietnam	Long grain white	20	1–1.20/1.20 = −16.67
Cambodia	Long grain white	20	1–1.20/1.20 = −16.67
Myanmar	Long grain white	40	1–1.40/1.40 = −28.57
Pakistan	Long grain white	40	1–1.40/1.40 = −28.57
ROW	Long grain white	40	1–1.40/1.40 = −28.57

Source: RICEFLOW Database (2017)