



## A Buffer Stock Model to Ensure Price Stabilization and Availability of Seasonal Staple Food under Free Trade Considerations

Wahyudi Sutopo<sup>1</sup>, Senator Nur Bahagia<sup>2</sup>, Andi Cakravastia<sup>2</sup> & T.M.A. Arisamadhi<sup>2</sup>

<sup>1</sup> Department of Industrial Engineering, Sebelas Maret University, Surakarta 57126, Indonesia

<sup>2</sup> Department of Industrial Engineering, Bandung Institute of Technology (ITB), Bandung 40132, Indonesia  
Email: sutopo@uns.ac.id

**Abstract.** The price volatility and scarcity have been become a great problem in the distribution system of seasonal staple food produced by agro industry. It has salient supply disparity during the harvest and planting season. This condition could cause disadvantages to the stakeholders such as producer, wholesaler, consumer, and government. This paper proposes a buffer stock model under free trade considerations to substitute quantitative restrictions and tariffs by indirect market intervention instrument. The instrument was developed through buffer stock scheme in accordance with warehouse receipt system (WRS) and collateral management system. The public service institution for staple food buffer stock (BLUPP) is proposed as wholesaler's competitor with main responsibility to ensure price stabilization and availability of staple food. Multi criteria decision making is formulated as single objective a mixed integer non linear programming (MINLP). The result shows that the proposed model can be applied to solve the distribution problem and can give more promising outcome than its counterpart, the direct market intervention instrument.

**Keywords:** *BLUPP; buffer stocks; indirect market intervention; MINLP; price stabilization; staple food availability; warehouse receipt system.*

### 1 Introduction

The price volatility and scarcity have been greatly became a problem in the distribution system of seasonal staple food produced by agro industry [1-2]. For instance, there are three causes of salient supply disparity during the harvest and planting season in the sugar distribution in Indonesia. The period of consumption is twelve months while the period of supply is only six months in a whole year [3-4]. Total demand is growing along with population growth. Every household consumes approximately 14.6 kg per year, while the estimated quantity of supply could only fulfill around 80% of the total demand [4-5]. The staple food from global market may be cheaper than domestic because the

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domestic supply has several weaknesses such as a low level of sugarcane productivity per hectare, a low level of sugar plant efficiency, and the price distortion in the global market [6-7].

The three causes mentioned above, that can cause price volatility and scarcity, will bring disadvantages and market risks to all stakeholders such as producer, wholesaler, consumer, and government [1-2], [4-6]. The producer is forced to sell staple food at the lowest price in excess supply periods. Conversely, the consumer has to deal with the scarcity of staple food and price hikes in excess demand periods. On the other hand, the wholesaler suffers a larger procurement cost in the harvest season and lack of stock in the planting season. Thus, the government is not really success to ensure food security for people and welfare for business entities involved in the sugar distribution system.

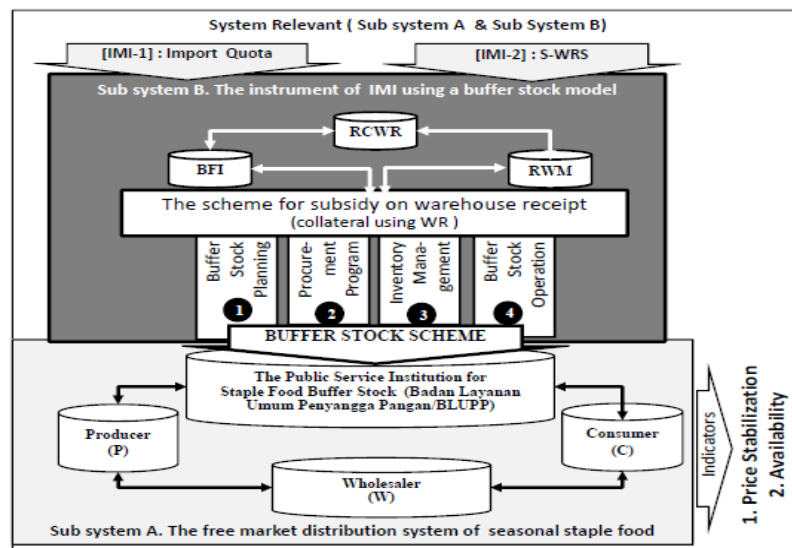
There were many models of direct market intervention (DMI) to tackle price volatility and scarcity problems. The government in each country could implement diverse approaches such as floor ceiling prices [1-2], [4-6], [8-9], buffer funds [10-14], export or import taxes [15-17], and subsidies [18-19]. Unfortunately, since countries involved in general agreement on trade and tariff (GATT), each country must reduce the instruments of DMI in accordance with GATT principles to minimize barrier and quantitative restrictions in international trade [20]. Therefore, this situation forced each government to explore a new instrument that conforming to GATT principles in free market (FM). None of the papers cited above provides appropriate model to solve the case study by considering the three causes of salient supply disparity in the sugar distribution in Indonesia, *i.e.* supply shortage, expensive price, and price distortion in global market.

This research tries to address a gap that currently exists in both literature availability and real problem in sugar distribution in Indonesia. As in the papers cited above, none of the models is appropriate to solve the real problem and conform the principles of GATT. Nur Bahagia [22] presented the buffer stock scheme consists of program planning, procurement, inventory, and operation. The buffer stock scheme could be utilized as collateral credit. The Warehouse Receipt System (WRS) is a proven system to obtain financial security by keeping the goods in a warehouse [22]. In Indonesia, the WRS is back up by Warehouse Receipt System Law No. 9 year 2006 [23]. The buffer stock scheme in accordance with WRS and collateral management system (CMS) might be able to solve the problems mentioned above. A buffer stock scheme should be modified as an instrument of indirect market intervention (IMI) to conform GATT principles in intervened market (IM). Therefore, this paper proposes an IMI instrument which aims to relieve the government in order to ensure price stabilization and availability of seasonal staple food.

This paper is organized as follows. Section 1 describes the background of the research, including the problems in real system, and indicates the research gap. The IMI approach is presented in Section 2. Section 3 contains the mathematical model to solve the IMI instrument. The solution method and analysis are explained in Section 4. And finally in Section 5, the conclusion and future research are delivered.

## 2 The Indirect Market Intervention Approach

Figure 1 (sub system A) describes the distribution system of seasonal staple food. There is no damage when the staple food is being stored in warehouse and it cannot be replaced by substitute products. The current distribution system consists of three main structural entities namely producer (P), wholesaler (W), and consumer (C). In harvest season, producer sells staple food to wholesaler and wholesaler sells them to consumer. The purchasing price and selling price are set by the basic laws of supply and demand. In planting season, only wholesaler sells staple food to consumer and it is often that wholesaler with excess inventory will speculate the market by increasing price. In the proposed system, a new entity namely BLUPP (the public service institution for staple food buffer stock) is recommended as wholesaler's competitor. The performance of distribution system is measured by price stability and availability.



**Figure 1** An overview of seasonal staple food distribution system by using indirect market intervention instrument.

Figure 1 (sub system B) shows the instrument of IMI using a buffer stock model. The staple food distribution system will be intervened by IMI instrument where the government indirectly influences the market supply and demand equilibrium in intervened market (IM). The BLUPP develops buffer stock scheme in accordance with WRS and CMS as IMI instrument namely the scheme for subsidy on warehouse receipt system (S-WRS). There are three institutions involved for implementing the S-WRS *i.e.* Registered Warehouse Management (RWM), Bank or Financial Institutions (BFI), and Registration Center for Warehouse Receipt (RCWR) [23-24]. The RWM refers to the management that operates the warehouse as a business entity which keeps, maintains, and supervises the staple food stored by owner and authorizes to issue a warehouse receipt (WR). The WR means a document which is a proof of staple food ownership stored in RWM, issued by RWM manager. The BFI means a commercial bank or a financial company that finances and administers the funding of S-WRS. The RCWR means a legal business entity that administers WR and its derivatives.

Indirect market intervention (IMI) approach is summarized in system relevant (sub system A & sub system B). The proposed model assumes that total production is lower than total consumption. Consequently, BLUPP is permitted to import staple food in accordance with quota to anticipate the market shortage (IMI-1). BLUPP has privilege to access the S-WRS (IMI-2) in order to perform its responsibility. BLUPP gives WR to BFI for accessing loan. In turn, this action would not only lead to the increasing of selling price, but also give the BLUPP cash to cover its operational cost. The BLUPP then can obtain back their pawned from RWM and sell them under profitable selling price, by returning their loan to BFI along with administration and interest charge. The financial facilities are not given to BLUPP directly, but it given to BFI as an attractive interest rate on S-WRS to reduce the quantitative restrictions and tariffs. In this paper, BLUPP receives loan from bank or financial institution to perform its responsibilities to guarantee the availability and to stabilize the price in the consumer market. Interest cost is incurred as the operational cost burden. Attractive S-WRS determined by government plays role as source of additional income for BLUPP to perform its activities while assuring profit gain. Hence, it is clear that S-WRS only affects BLUPP profit directly, and S-WRS rate doesn't influence the price competition in the market directly.

A buffer stock scheme must be able to determine the instrument which is required for indirect market intervention program as mentioned above. The scheme must consider the expectation of stakeholders. Both producer and consumer obtain a reasonable price for their transaction with the wholesaler. Reasonable price for consumer is price below the maximum price determined by the government in price stabilization program. From the data studied for the

past 5 years, the maximum buying price for consumer is 9,600 IDR. Hence, consumer can expect the reasonable price below 9,600 IDR. Reasonable price for producer is price that can cover the producer's costs with additional profit margin. The producer's cost is 7,000 IDR; hence the reasonable price for producer must be above 7,000 IDR.

The price must be determined in high enough to cover the seller's costs and a reasonable margin. The non-speculative wholesaler expects all stocks can be sold with reasonable profit. Reasonable profit for wholesaler is the price that high enough to cover the seller's costs in reasonable margin. Using this fact, we can assume that reasonable price for consumer  $\geq$  reasonable price for wholesaler  $\geq$  reasonable price for producer. BLUPP can execute its responsibility with minimum cost and reasonable profit. As a result, the government can keep away the staple food crisis and enhances welfare for business actors.

### 3 The Buffer Stock Model Formulation

Before presenting mathematical formulation, the following are the assumptions and notations.

#### 3.1 Assumptions

The buffer stock model formulation in this paper is developed based on the following assumptions. Table 1 lists some relevant market situation along the planning horizon of supply and demand. The length of the planning horizon is 12 months ( $t_1$  to  $t_{12}$ ) and can be divided as 4 periods, starts with the beginning of harvest season, the end of harvest season, the beginning of planting season, and ends with the end of planting season. In indirect market intervention (IMI), the market price is determined by the theory of supply and demand and buffer stock schemes organized by BLUPP. In harvest season, BLUPP affects the amount of staple food in market by determining both the amount of staple food guaranteed as WR and the amount directly sold to the market. Conversely, the BLUPP can manipulate the market's availability in planting season when they obtain back their pawned from the RWM and sell them to market. This phenomenon represents short-term supply and demand problem so that could be solved by implementing IMI instruments (IMI-1 and IMI-2).

From the data exploration for the past 5 years, production and consumption are assumed deterministic because little changes in production and consumption, *i. e.* both quantity are relatively stable and can be predicted from year to year. To the best of our knowledge, there has no massive policy imposed by government to increase the staple production whether by increasing staple food farms and

plants, or applying innovative production technique for the last 5 years. Hence, we can conclude that the quantity of staple production can be considered deterministic.

Domestic demand is assumed proportional to number of population, *i. e.* calculated by the multiplication of per capita consumption and number of population. Since the population growth can be acquired from authorized reliable source (BPS) and the number is commonly small (2-4%), we can assume that the quantity of sugar consumption also follow the same growth. Using the same analogy for sugar production, *i. e.* the quantity can be well predicted, the rationale for sugar production can be applied to sugar consumption, hence both can be assumed as deterministic. This model also assumes that production quantity is smaller than consumption as reflected by real condition in Indonesia.

**Table 1** List of market assumptions in a free market.

Periods	$p_1(t_1, t_2, t_3)$	$p_2(t_4, t_5, t_6)$	$p_3(t_7, t_8, t_9)$	$p_4(t_{10}, t_{11}, t_{12})$
1. Season	harvest	harvest	planting	planting
2. Production	normal	booming	none	none
3. Consumption	stable	stable	stable	stable
4. Availability	sufficient	surplus	sufficient	shortage
5. Price control	-----price support-----		-----price stabilization-----	

### 3.2 Objective Function

The proposed model has four stakeholders, each has different criterion. The criterion of producer, BLUPP, and wholesaler is total benefit while the consumer criterion total cost. Producer expects maximum benefit from its activities. The total benefit of producer ( $TB^P$ ) is calculated from total revenue obtained from selling staple food during harvest period, deduced by total production cost. Thus, this can be expressed as:

$$TB^P = \sum_{t=1}^6 P_t^{p1} - c_p q_t^s \tag{1}$$

BLUPP objective is to maximize its benefit ( $\tau B^B$ ) in (2). The first two terms of this objective is the total revenue of BLUPP from selling staple food to market. Revenue from selling staple food to consumer is depicted in the first term, whereas income from guarantying staple food to the S-WRS is presented in the second term. The loan-to-value ratio or credit ratio is reflected by the relationship between the amounts of money the BFI lends to the value of the collateral. The subsequent three terms represent BLUPP total cost, which consists of cost for buying staple food from producer, cost for buying back staple food in S-WRS, and cost for importing staple food to ensure staple food availability in market.

$$\begin{aligned}
TB^B = & \sum_{t=1}^{12} Y_t P_t^{s1} Q_t^{BC} + \sum_{t=1}^6 c_r Q_t^{WR} P_t^{p1} - c_{wr} - \sum_{t=1}^6 P_t^{p1} Q_t^{PB} \\
& - \sum_{t=1}^6 c_r Q_t^{WR} P_t^{p1} - c_{wr} (1 + i_{wr})^6 - \sum_{t=1}^{12} X_t Q_t^{OI} p_i + c_i
\end{aligned} \quad (2)$$

Eq. (3) states the wholesaler objective in its staple food business activities. The wholesaler total benefit ( $TB^W$ ) is calculated from total revenue for selling staple food to consumer as expressed in the first term of equation, subtracted by total cost for buying staple food from producer as stated in the second term of equation.

$$TB^W = \sum_{t=1}^{12} P_t^{s1} Q_t^{WC} - \sum_{t=1}^6 P_t^{p1} Q_t^{PW} \quad (3)$$

The last stakeholder in the proposed model is consumer whose objective is to minimize total cost for consuming staple food for whole periods. This objective is expressed in (4). The first term of the objective depicts the consumer total cost for buying staple food in price support period, whereas the second term describes the consumer total cost ( $TC^C$ ) for buying staple food in price stabilization period.

$$TC^C = \sum_{t=1}^6 Q_t^{WC} + Q_t^{BC} P_t^{s1} + \sum_{t=6}^{12} Q_t^{WC} + Q_t^{WRR} P_t^{s1} \quad (4)$$

All of the objectives functions above can be formulated as single objective of mixed integer non linear programming (MINLP). Note that although not explicitly expressed in symbol, each objective is set to have equal weight (importance). The objective function is finally expressed as follows:

$$\text{Max } Z = TB^P + TB^W - TC^C + TB^B \quad (5)$$

### 3.3 Constraints Set

Eqs. (6) and (7) are used to determine producer selling price and consumer buying price under free market. From (6), it can be inferred that price will drop when staple food availability in market is high. Hence (8) is introduced as intervention price in order to protect producer from price plunge. Conversely, consumer will face price rise when consumption is higher than staple food availability, and (9) is utilized to ensure that consumer will not suffer heavily by price hike. These two conditions are controlled by using price indicators as expressed in (10) and (11) respectively.

$$P_t^{p0} = p_0^{p0} - c \ln q_t^A, t = 1, \dots, 6 \quad (6)$$

$$P_t^{s0} = p_t^{p0} + c_d + \ln q_t^C, t = 1, \dots, 12 \quad (7)$$

$$P_t^{p1} = p_t^{p0} - c \ln BIQ_t^W, t = 1, \dots, 6 \tag{8}$$

$$P_t^{s1} = P_t^{p1} + c_d + \ln IQ_t^C, t = 1, \dots, 12 \tag{9}$$

$$P_t^{p1} \geq CIP, t = 1, \dots, 6 \tag{10}$$

$$P_t^{s1} \leq CIC, t = 1, \dots, 12 \tag{11}$$

The staple food availability and consumption are used to determine non-intervention price in (6) and (7). Staple food availability and consumption are defined in (12) and (13). For intervened producer selling price, the beginning inventory of staple food is used for every period owned by wholesaler in (14), whereas the accumulative wholesaler ownership of the staple food at certain period in (15) is used to determine the consumer intervention buying price.

$$q_t^A = q_{t-1}^A + q_t^s, t = 1, \dots, 6 \tag{12}$$

$$q_t^C = q_{t-1}^C + q_t^d, t = 1, \dots, 12 \tag{13}$$

$$BIQ_t^W = BIQ_{t-1}^W + Q_t^{PW} - Q_t^{WC}, t = 1, \dots, 12 \tag{14}$$

$$IQ_t^C = IQ_{t-1}^C + Q_t^{WC}, t = 1, \dots, 12 \tag{15}$$

Equation (16) states that the amount of staple food availability, *i.e.* staple food produced by producer, is equal to the amount of staple food purchased by BLUPP and wholesaler. BLUPP then will determine the amount of staple food directly sold to consumer and guaranteed to the S-WRS. These expressions are reflected in (17) and (18) respectively. To ensure the staple food availability in market during the harvest season, equation (19) is enforced stating that BLUPP must sell the amount of staple food directly to customer to ensure the availability in market, along with the amount of staple food imported, and the amount of staple food sold by wholesaler.

$$Q_t^{PB} = q_t^A - q_{t-1}^A - Q_t^{PW}, t = 1, \dots, 6 \tag{16}$$

$$Q_t^{BC} = \text{Min } Q_t^{PB}, q_t^d, t = 1, \dots, 6 \tag{17}$$

$$Q_t^{WR} = Q_t^{PB} - Q_t^{BC}, t = 1, \dots, 6 \tag{18}$$

$$Q_t^{BC} = q_t^d - Q_t^{WC} - X_t Q_t^{OI}, t = 1, \dots, 6 \tag{19}$$

During the price stabilization period, *i.e.* in period 7 up to period 12, producer is assumed no longer providing staple food supply. Thus BLUPP must redeem its staple food in the S-WRS in order to sell it in the market or import the



necessary amount staple food. Wholesaler also couldn't purchase additional staple food for its merchandise, hence the amount of staple sold by wholesaler during this period only from the total amount of staple food purchased in price support period minus the amount of staple food that have already sold to customer during period 1 up to 6. These conditions are expressed in (20). Equation (21) is used to ensure that total amount of staple food sold to consumer during period 7 through period 12 by BLUPP equals to total amount of staple food guaranteed in the S-WRS during period 1 up to 6. The same mechanism is applied in (21) to ensure that total amount of staple food sold by wholesaler to market must equal to total amount purchased from producer in (22).

$$Q_t^{WRR} = q_t^d - Q_t^{WC} - X_t Q_t^{OI}, t = 7, \dots, 12 \quad (20)$$

$$\sum_{t=7}^{12} Q_t^{WRR} = \sum_{t=1}^6 Q_t^{WR} \quad (21)$$

$$\sum_{t=1}^{12} Q_t^{WC} = \sum_{t=1}^6 Q_t^{PW} \quad (22)$$

Import of the staple food is imposed if the staple food consumption is greater than its availability as expressed in (23). Equation (24) is to enforce non-negative values for decision variables.

$$Q_t^{OI} = \max \{0, q_t^C - q_t^A\}, \forall t \in T = 1, \dots, 12 \quad (23)$$

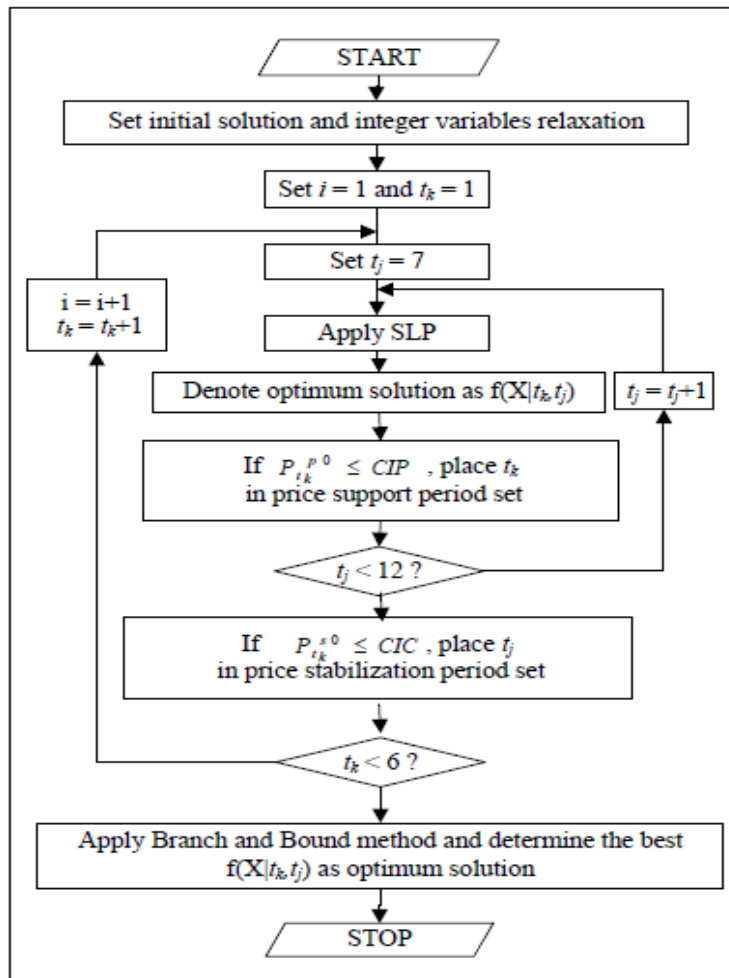
$$Q_t^{PB}, Q_t^{BC}, P_t^{p1}, P_t^{s1}, Q_t^{WR}, Q_t^{WRR}, Q_t^{PW}, Q_t^{WC}, Q_t^{OI} \geq 0 \quad (24)$$

## 4 Solution Method and Analysis

In this section, the solution method and the numerical examples are presented, and analyze them to illustrate the capabilities of proposed model.

### 4.1 The Solution Method

The characteristics of objective function and constrain sets of Mixed Integer Nonlinear Programming (MINLP) constructed above are investigated to obtain an appropriate solution method. The objective function is a concave maximization problem and has set of constraints in a polyhedron then the model has an optimal solution. Sequential linier programming (SLP) and branch-and-bound (BB) methods are used to find the optimal solution from MINLP formulation. In this research, Branch and bound (BB) is used to find optimal solution in discrete and combinatorial optimization [25]. In this case, one integer LP problem has to be solved in each stage. All feasible values for integer variables are enumerated while applying SLP using relaxed value to find optimum solution. The solution procedure is described in Figure 2.



**Figure 2** Solution procedure for solving MINLP using sequential linear programming and branch-and-bound methods.

Hereafter, the price support period is referred to as period 1 up to 6 and period 7 up to 12 as the price stabilization period. Let  $t_k$  and  $t_j$  denote the elements of price support period set and price stabilization period set respectively. The first step of iteration begins with decision variables initialization and binary variables relaxation. Then, the SLP method enumerates all possible values in the price support period set and the price stabilization period set. The solution procedure compares the producer non-intervention selling price in (6) with (10) and the consumer non-intervention buying price in (7) with (11) in every step of iteration. If the values of  $t_k$  and  $t_j$  violate (10) and (11), then the solution

algorithm assigns the corresponding values in intervention period set, and the intervention price in (8) and (9) are applied. The last step of iteration is to use branch-and-bound method for binary variables. This process is repeated until all values in price support and stabilization sets are enumerated.

In order to verify the solution, we investigate the convexity of the objective functions. All objectives function in (1)-(4) can be classified as linear and non-linear. Linear function is convex or concave in nature, so no further investigation needed. For non-linear function in objective functions, readers can see that all non-linear functions are in  $Z = f(X, Y)$  terms, which is multiplication of two decision variables. It can be found in most optimization literatures that such function is quasi concave for  $X, Y \geq 0$ . Putting it up all together, we conclude that all objective functions are concave, hence the solution is optimum.

## 4.2 Numerical Examples and Analysis

In this section, numerical examples are used to test the proposed model. MINLP formulation is solved using Sequential Linear Programming (SLP) and branch-and-bound methods by Lingo 9 solver. Table 2 shows the parameters, price functions, and S-WRS lending interest rate that are used in numerical examples. BLUPP receive loan from Bank and Financial Institution (BFI) and must pay the loan along with its rate in which called SRG rate. All unit cost and price measurements are in Indonesian domestic rupiahs (IDR). Table 3 shows the supply and demand of the staple food for one planning period, *i.e.* 12 periods. Supply and demand unit are in thousands tons. Supply and demand of staple food is based on staple food production and consumption in 2010 [26].

**Table 2** Parameters, price functions parameters, and S-WRS lending interest rate.

$c_p$	$c_h$	$c_d$	$P_{t0}^{p0}$	$c_i$	$p_i$	$CIP$	$CIC$
7,000	200	400	8,500	300	5,000	7,800	9,600
$c$	$d$	$i_n$	$i_{wr}$	$c_{wr}$	$c_r$		
3	9	0.0117	0.0042	30	0.8		

Table 4 presents the numerical results of decision variables and its performance criteria for each stakeholder. From the given supply and demand data in Table 2 and Table 3, it can be inferred that there is a supply shortage in staple food market about 590 thousand tons for one year period. In order to satisfy market demand, BLUPP must import staple food from overseas. Because import price is cheaper than domestic price, BLUPP gets attractive profit by selling imported good than selling domestic production from producer. However, the main objective of import is to cover the domestic shortage, not to gain high profit. If

profit is the main objective, then producer will suffer because producer's price couldn't compete with import.

**Table 3** Staple food supply and demand data.

Period	1	2	3	4	5	6	7	8	9	10	11	12
$q_t^s$ ( $\times 10^3$ tons)	240	280	480	630	470							
$q_t^d$ ( $\times 10^3$ tons)	200	230	230	260	280	280	260	230	240	240	240	210

Total supply of staple food for 1 year period is 2,850 tons. Wholesaler purchased 1,510 tons, while BLUPP purchased the rest of the staple food supply 1,390 tons. BLUPP sold the staple food directly to consumer 540 tons, and guaranteed the rest of it in the S-WRS. In price stabilization period, BLUPP redeemed the staple food in order to fulfill consumer demand in that period. Hence, total cost of consumer is decrease up to 30% compared with previous system as proposed by Sutopo, *et al.* [6]. It is clear that BLUPP gains more benefit than wholesaler because selling imported good, receive revenue from selling domestic good, and benefit from S-WRS schema.

**Table 4** Decision variables and its performance criteria for each stakeholder.

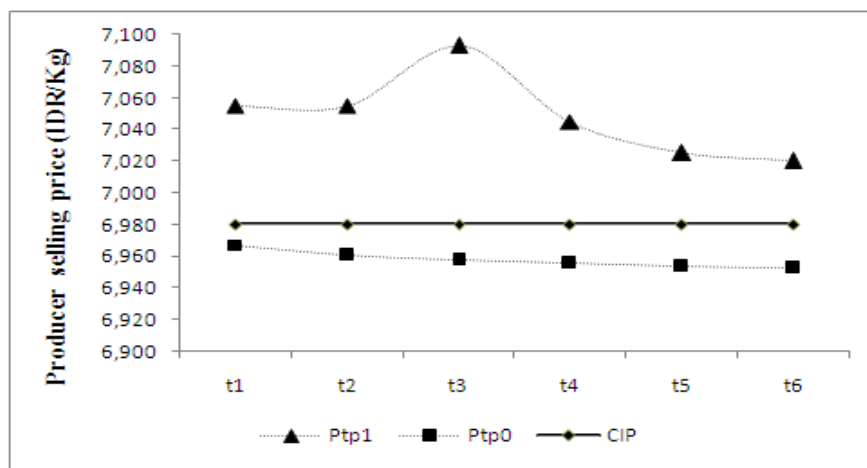
Decision variables (DVs)	Quantity or Value of DVs	Unit
Amount purchased by BLUPP	1.390	thousand tons
Amount imported by BLUPP	590	thousand tons
Amount guaranteed to W/M	800	thousand tons
Amount purchased by wholesaler	1.510	thousand tons
Total benefit of producer	1.162.397,00	million IDR
Total benefit of wholesaler	912.051,90	million IDR
Total benefit of BLUPP	5.066.810,00	million IDR
Total cost of consumer	19.777.253,00	million IDR

Hereafter the staple food selling price is referred as the price that faced by the producer to sell staple food to BLUPP and wholesaler, and the staple food buying price as the price transacted by consumer to buy staple food from BLUPP and wholesaler. The non-intervention selling price and non-intervention buying price are defined as the price affected by supply and demand theory as in (6) and (7), and the intervention price as the price intervened by BLUPP as part of indirect intervention mechanism to control price stability as in (8) and (9).

Indirect intervention mechanism of price support program for producer works as follows: government gives authorities and privileges to BLUPP as described in the previous sections, whose responsibility is to ensure staple food price stabilization while ensuring producer welfare. BLUPP determines CIP as an

alert system to check whether the staple food selling price lies below CIP and must be intervened or the selling price lies above CIP and no intervention is required. When the non-intervention selling price lies beyond CIP due to excessive supply, BLUPP buy staple food so that it will decrease as the selling price reach the steady state and lies above CIP.

Figure 3 describes the indirect intervention mechanism in the price support program period. Note that non-intervention selling price lies below CIP. Hence, BLUPP must determine the quantity of staple food bought from producer such that the selling price increases and reaches the steady state above CIP. In period 1 up to 6 when supply excess occurred, producer will suffer potential benefit loss due to price plunge which causes the selling price lies below CIP. In order to protect producer from this potential loss, BLUPP purchases the staple food by using intervention price which is greater than CIP as in (8). As the result, the selling price reaches equilibrium state and lies above CIP as the staple food supply decreases. Moreover, this brings advantage to producer because it receives revenue by using intervention price which is greater than by using non-intervention price.

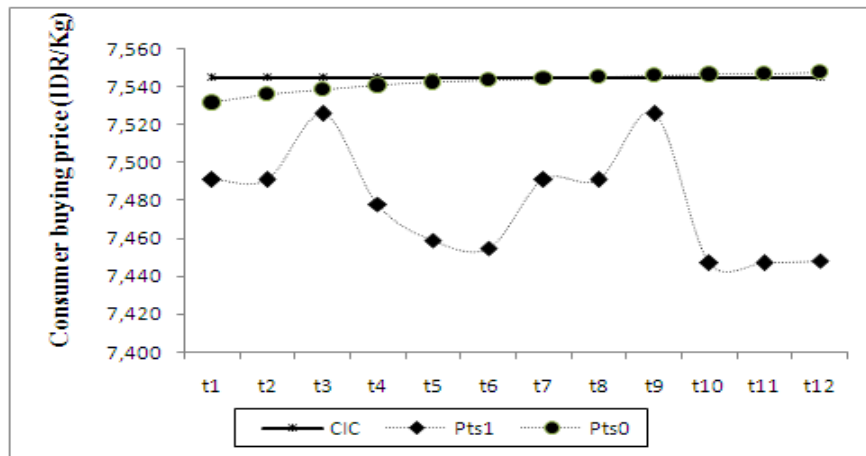


**Figure 3** The impact of BLUPP accessing the S-WRS to support producer selling price during in the harvest season.

The same mechanism is applied for price stabilization program for consumer. BLUPP determines CIC as an alert system to control the buying price in market. Prices lie above CIC will bring discomfort to consumer as the buying price is considered high due to staple food shortage. Thus, BLUPP must determine the quantity of staple food to be sold to customer aside the quantity sold by the wholesaler, such that the staple food availability and price are maintained.

Moreover, this brings advantages for consumer because BLUPP’s indirect intervention in staple food market will make the buying price decrease as the staple food supply increase. As a result, consumer spends less money to buy the staple food using the intervention price which is smaller than CIC.

Indirect intervention mechanism in buying price is described in Fig. 4. For period 1 until 7, non-intervention buying prices lie beyond CIC. Thus, no intervention is required and customer buys staple food by using non-intervention buying price in (7). However, indirect intervention is required for period 8 until period 12. The staple food shortage in these periods causes price soaring, hence BLUPP intervenes the market by sold its staple food stored in W/S so that the buying price decreases as the supply increases. Hence, consumer uses the buying price as in (9) in these periods.



**Figure 4** The impact of BLUPP accessing the S-WRS to stabilize consumer buying price during the harvest and planting season.

All above numerical results describe the indirect intervention mechanism as part of the BLUPP responsibilities to ensure staple food availability and price stabilization. Hence, the following propositions are developed based on mathematical formulation and numerical results:

**Proposition 1 (Price stabilization formulation).** *The proposed model can be applied to administer the price support program for producer and the price stabilization program for consumer by utilizing buffer stock scheme under S-WRS system.*

**Proof.** The proof is trivial. First, a formal proof for producer price support program by selling price intervention is presented. One can choose arbitrary values for  $P_t^{p0}$  less than CIP and  $P_t^{p1}$ . Let  $\Phi$ ,  $\Theta$ , and  $\Psi$  denote the value of (1) when the selling price is  $P_t^{p0}$ , CIP, and  $P_t^{p1}$  respectively. Since (1) is concave, then  $\Psi$  is always greater than  $\Phi$ . If intervention is not conducted, producer will face potential loss in the amount of  $\Theta - \Phi$ . However by indirect intervention mechanism, producer will get benefit in the amount of  $\Psi - \Phi$ . Next, the same procedure is applied for price stabilization program. Let  $\Phi$ ,  $\Theta$ , and  $\Psi$  denote the value of (4) when the buying price is  $P_t^{s0}$ , CIC, and  $P_t^{s1}$  respectively. Since (4) is monotonous decreasingly,  $\Psi$  is always smaller than  $\Phi$ . If intervention is not conducted, consumer will expedite additional consumption cost in the amount of  $\Phi - \Theta$ . BLUPP's indirect intervention will make consumer to reduce consumption cost in the amount of  $\Phi - \Psi$ .

**Proposition 2 (Staple food availability formulation).** *The proposed model can be applied to secure staple food availability throughout horizon planning by implementing buffer stock model which considers the expectations of the stakeholders in staple food industry.*

**Proof.** During the harvesting period (season), staple food availability is greater than consumption. Producer sells staple food to BLUPP and wholesaler, and subsequently BLUPP and wholesaler sell it to consumer. Since its availability is greater than its demand, there will be remaining staple food owned by BLUPP or/and wholesaler. Equation (16)-(18) reflects this condition. However during planting period (season) when producer cannot provide the staple food supply, the remaining staple food owned by BLUPP and wholesaler isn't sufficient to cover the consumption. BLUPP imposes import to overcome this condition. The amount of import must exceed the shortage. This condition is reflected in (20)-(23). Hence, the proposed model can determine the quantity of the staple food sold by producer, bought by wholesaler and BLUPP, and imported by BLUPP which satisfies the quantity of staple food consumed by consumer for entire planning period.

**Proposition 3 (BLUPP responsibility).** *The main responsibility of BLUPP is to ensure staple food availability while expecting the benefit from its market activities.*

**Proof.** The objective function of BLUPP in (2) could describe BLUPP activities in the staple food market. The first term of (2) expresses BLUPP as the staple food provider. BLUPP sells the staple food along all periods. BLUPP also gets cash compensation from W/M by staple food pawning. This is expressed in the second term. While undertaking its main responsibility to ensure the staple food

availability, BLUPP expects to gain profit. However, BLUPP can also suffer profit loss. Let's assume BLUPP only sells the staple food from import, *i.e.* BLUPP doesn't buy the staple food from producer. Thus (2) become:

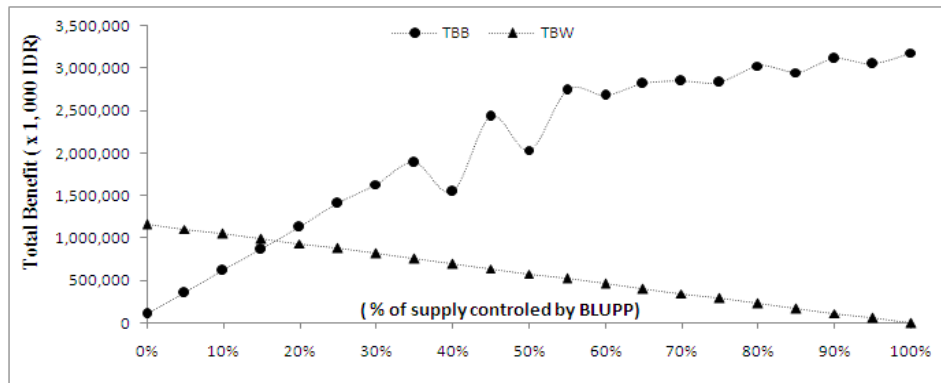
$$TB^B = P_t^{s1} Q_t^{OI} - Q_t^{OI} p_i + c_i \tag{25}$$

Notice that (25) can have negative, zero, or positive value depends on staple food selling price, its price in the global market, and import cost per unit. If the staple food selling price is greater than sum of staple food price and import cost per unit, (25) will be positive. Conversely, (25) will be negative if the previous condition contradicts.

To illustrate the proposition 3, equation (17) is replaced with the following expression:

$$\sum_{t=1}^6 Q_t^{PB} = \alpha \sum_{t=1}^6 q_t^s \tag{26}$$

with  $\alpha$  ranges from 0, which means BLUPP doesn't get any staple food supply from producer, up to 100% which means BLUPP totally control of the staple food supply.



**Figure 5** The relationship between staple food supply control and total benefit.

Figure 5 shows the relationship between staple food supply and total benefit. BLUPP still get revenue from selling imported staple food even though BLUPP has no control on staple food. On the contrary, the total benefit of wholesaler is zero when it has no power to control staple food supply. The total benefit of BLUPP and wholesaler increase as the staple food control increases. However, there is a little difference in shape of each graphic. The wholesaler total benefit tends to decrease linearly as the staple food control decreases, whereas the BLUPP total benefit increases logarithmically as the staple food increases. This



can be explained by the fact that the objective function of BLUPP is not pure linear, while the objective of the wholesaler is linear.

**Table 5** The BLUPP benefit.

The staple food controlled by BLUPP (%)	The S-SRG lending rate (%)	BLUPP's Profit (Million IDR)
30.00	4.00	686,053.00
40.00	10.00	704,439.00
50.00	12.00	1,043,603.00

Sensitivity analysis is conducted to depict effect of staple food controlled by BLUPP and S-SRG lending rate to BLUPP benefit (Table 5). This means that BLUPP will get large benefit if the interest rate is small. Conversely, the BLUPP will gain smaller benefit if interest charge is high. This model can provide same recommendations related to the staple food controlled by BLUPP, the rate of S-SRG, and the estimation of BLUPP's profit.

## 5 Conclusions

A buffer stock model has been developed in accordance with warehouse receipt and collateral management system for solving the scarcity and price fluctuation of seasonal staple food. The S-WRS facilities and direct access to market are privileges given to BLUPP in order to perform its responsibility to ensure price stabilization and availability of seasonal staple food under free trade considerations. MINLP approach was used to determine the decision variables of buffer stock scheme as an indirect market intervention policy. The numerical analysis showed that the model can be used to determine the stock level and the amount of import, and to solve buffer stock problem considering the interest of stakeholders.

Further research is needed to extend the model which considers the dynamic of global market price that can influence the domestic price. Other features can be added to make the model more realistic in order to represent the real system closely such as stochastic factors in supply, demand, and prices. Goal programming, stochastic programming, dynamic programming, and robust optimization, to name a few, can be considered as the alternative approaches to describe the model extensively. The feasibility study of BLUPP structure is required to support government to implement the proposed model.

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## Nomenclature

The following notations are used to develop the proposed model:

$BIQ_t^W$	=	the wholesaler's inventory in the beginning of period- $t$
$c$	=	a natural log. parameter of price function
$c_d$	=	distribution cost of wholesaler per unit
$c_h$	=	holding cost per unit per year
$c_i$	=	import cost per unit
$c_p$	=	production cost per unit
$c_r$	=	credit ratio by collateral value
$c_{wr}$	=	administration cost to get the WR
$CIC$	=	crisis indicator for consumer of the selling price
$CIP$	=	crisis indicator for producer of the purchasing price
$i_n$	=	normal lending interest rate
$i_{wr}$	=	S-WRS lending interest rate
$IQ_t^C$	=	cumulative staple food sold by wholesaler
$p_i$	=	staple food price in the global market
$P_t^{p0}$	=	producer selling price in the FM in period $t$
$P_t^{p1}$	=	purchasing price in the IM period $t$
$P_t^{s0}$	=	consumer buying price in the FM in period $t$
$P_t^{s1}$	=	selling price in the IM period $t$
$q_t^A$	=	market's availability in period $t$
$q_t^C$	=	amount of consumption in period $t$
$q_t^s$	=	supplies of staple food in period $t$
$q_t^d$	=	demand of staple food in period $t$
$Q_t^{BC}$	=	amount of BLUPP and consumer transaction
$Q_t^{OI}$	=	import quota
$Q_t^{PB}$	=	amount of producer and BLUPP transaction
$Q_t^{PW}$	=	amount of producer and wholesaler transaction
$Q_t^{WC}$	=	amount of wholesaler and consumer transaction
$Q_t^{WR}$	=	the amount of staple food guaranteed in the S-WRS
$Q_t^{WRR}$	=	the amount of buffer stock distributed to market

$X_t$  = BLUPP decision to import staple food.

$$X_t = \begin{cases} 1, & \text{if } q_t^C \geq q_t^A, \forall t \in T = 1, \dots, 12 \\ 0, & \text{otherwise} \end{cases}$$

$Y_t$  = BLUPP decision to sell staple food to consumer.

$$Y_t = \begin{cases} 1, & \text{if } Q_t^{PB} \neq 0, \forall t \in T = 1, \dots, 6 \\ 0, & \text{otherwise} \end{cases}$$

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