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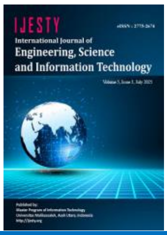

The Impact of Government Cooking Oil Subsidies on Social Welfare: Elasticity-Based Multimarket Approach

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Abstract

This paper explores the influence of the Indonesian government's palm cooking oil subsidy policies on the welfare of communities in Aceh Province. The Policy aims to stabilise prices, to support producers, and to increase access to affordable cooking oil for consumers. However, empirical evidence shows that the market price frequently exceeds the government-determined ceiling price, which raises concerns about the Policy's effectiveness. To evaluate the actual impact of the subsidy, this study employs a multimarket analytical model in conjunction with an interest-maximising function approach to identify the optimal subsidy level that maximises social welfare. The analysis includes palm and coconut cooking oil as interrelated commodities, with supply and demand modelled using Cobb-Douglas functions. The study focuses on elasticity as a key determinant in understanding the effectiveness of the subsidy, given that inelastic behaviour in supply and demand significantly affects the price gap between market equilibrium and subsidy-induced outcomes. Simulation results reveal that the optimal subsidy rates are 16% for palm oil and 26% for coconut oil. Furthermore, sensitivity analysis across four scenarios shows that lower elasticity necessitates higher subsidies, while higher elasticity can reduce the required subsidy without diminishing welfare gains. The results indicate that producers enjoy most of the welfare gains, although consumers also benefit from lower market prices. Therefore, a well-calibrated subsidy policy, based on empirical elasticity values and multimarket interactions, can lead to a more balanced welfare distribution. The findings underscore the importance of data-driven policy formulation to enhance efficiency and equity in government subsidy programs. Ultimately, this research recommends that future subsidy frameworks integrate elasticity parameters and economic modelling to ensure affordability and sustainability in essential commodity markets.

Keywords: *Cooking Oil Subsidy, Palm Cooking Oil, Social Welfare, Supply Elasticity, Supply and Demand.*

1. Introduction

Trade liberalisation has been linked to increased price instability, negatively impacting farmer incomes and consumer welfare [1][2]. In Indonesia, cooking oil is a vital export commodity and a staple household necessity. Its fluctuating prices have led the government to implement various subsidy policies to control affordability and maintain food security[3]. Historically, the Indonesian government subsidised agricultural inputs, including fertilisers such as TSP and KCL. However, this approach lost momentum after the 1990s. By 1994, subsidies for TSP and KCL were withdrawn, followed by the discontinuation of soil fertiliser subsidies in 1998 [4]. Subsidised palm cooking oil for TSP and KCL was diminished in 1994, while in 1998, the subsidies for soil fertiliser were reduced [5]. Today, the government relies on price ceiling mechanisms to stabilise cooking oil prices and support farmer incomes. Nonetheless, market prices frequently surpass these ceilings, rendering the Policy ineffective. This shift indicates a decline in the use of input subsidies for palm oil as a strategy to support the agricultural sector [6].

Beyond input subsidies, the government has also applied output-level pricing interventions—such as setting base prices—to stabilise cooking oil prices for end consumers and enhance farmer revenue. In practice, however, retail prices consistently exceed these government-imposed limits. This suggests that base pricing strategies are failing to meet their intended objectives.

This ineffectiveness can result from the government's poor judgment in fixing the ceiling of palm cooking oil without considering the actual market situation regarding the demand and supply of these commodities [7].

Historically, base price calculations have relied mainly on cost-benefit estimates from farmer data, without integrating broader market indicators [8]. To set more accurate price ceilings, policymakers must incorporate elasticity-informed models that reflect market behaviour. If these base prices are understood as an output subsidy, they should be aligned with optimal subsidy levels determined by market-responsive data [9], [10].

Forecasting and market modelling are crucial in formulating effective subsidy policies. Recent studies emphasise the importance of predictive analytics and efficient resource planning in agricultural commodities. For instance, a survey of plantation crop production employed linear regression and single exponential smoothing to forecast production volumes—reporting Mean Absolute Percentage Errors (MAPE) below 20% for most crops, including oil palm—thus demonstrating the utility of quantitative forecasting tools for policy implementation [11][12].

Integrating such predictive methodologies enhances the accuracy of subsidy calibration and supports more equitable welfare outcomes.

Improving the agricultural sector requires enhancing farmer incomes, which raises overall sector performance [13]. However, expanding production without favourable trade conditions could lead to market oversupply and falling prices—ultimately reducing, not increasing, farmer earnings [14]. Thus, providing output-based subsidies, such as guaranteed cooking oil prices, may be a more effective incentive for encouraging production while safeguarding farmer welfare.

This research seeks to identify the optimal subsidy levels for palm and coconut cooking oil that can enhance household access. It also explores how demand and supply elasticity influence these subsidy levels and examines the broader welfare implications of implementing such subsidies in Indonesia.

2. Literature Review

2.1. Elasticity Role Against Optimum Subsidy

Giving subsidies to farmers is expected to bring down the palm cooking oil market (balance) so that farmers and consumers enjoy its benefits. It is likely to indicate that it is not always the case that giving subsidies will cut down market palm cooking oil, but it is dependent on supply and demand elasticity. Verification was carried out by using the following formula [15].

$$\frac{\vartheta H}{\vartheta S} = \left[\frac{-1}{1-\eta/_{\varepsilon}}\right] \quad (1)$$

Where:
H = Level of palm cooking oil input
S = Level of palm cooking oil output
η = Palm cooking oil elasticity of demand
ε = Palm cooking oil elasticity of supply

If η =0 and ε= ~, hence dH/d = -1. This result indicates that if the subsidy increases by 10%, palm cooking oil will decrease by 10%. It implies that the consumer will benefit from the entire subsidy, even though it was given to the farmer. On the contrary, if η =~, and s= 0, hence dH/dS=0, the subsidy will not influence the market of palm cooking oil and implies that the farmer will enjoy the entire benefit derived.

2.2. Simultaneous Equation

The Policy of agricultural development aims to alter the performance of agricultural sector to achieve desired results. Bearing this in mind, it is essential to know beforehand the information about the variable factors or dominants that will influence the performance of the sector mentioned so that in future these variables will become instruments for Policy making [15]. Mathematically, a simultaneous equation can be written as follows:

Supply function

$$Q_t^s = \alpha_1 + \alpha_2 P_t + \varepsilon_{1t} \quad (2)$$

Demand Function

$$Q_t^d = \beta_1 + \beta_2 P_t + \beta_3 P_t + \varepsilon_{1t} \quad (3)$$

Identity

$$Q_t^s = Q_t^d \quad (4)$$

Where:
Q_t^s = Amount of commodities demanded
Q_t^d = Amount of commodities supplied
T = Time
P = Palm cooking oil
Y = Level of earnings
a, P = Parameter
ε = Problem of disturbance

Equations (2) and (3) are structural equations because they represent the reflection of the behaviour of the decision maker (Sellers and Buyers). In contrast, Equation (4) represents the identity equation expressing the balance between supply and demand. The use of the Technique of Ordinary Least Squares (OLS) is to estimate parameters to a single equation, with the fulfilment of all assumptions that will yield a parameter which is unbiased and has minimum variance or is known by the term BLUE (Best Linear Unbiased Estimator).

However, using an OLS technique to anticipate structural parameters is not the case. To prove the above, we can follow the following steps: Equations (2) and (3) are written in the form of deviation.

$$q_s = \alpha_2 P_t + \varepsilon_{1t} \quad (5)$$

$$q_d = \beta_2 P_t + \beta_3 Y_t + \varepsilon_{1t} \quad (6)$$

Estimation of α2 with OLS yields:

$$\alpha_2 = \frac{\sum p_1 q_1}{\sum {p_1}^2} \quad (7)$$

By plugging equation (5) into equation (7) we get anticipation:

$$\alpha_2 = \frac{\sum p_t(\alpha_2 q_1 + \varepsilon_1)}{\sum P_1^2} \quad (8)$$

$$\alpha_2 = \alpha_2 + \frac{\sum p_1 \varepsilon_1}{\sum P_1^2} \quad (9)$$

From equations (5) and (6) we drive an equation reduced to the following from:

$$q_t = \frac{\alpha_2 \beta_3}{\alpha_2 - \beta_2} Y_t + \frac{\alpha_2 \varepsilon_{2t} - \beta_2 \varepsilon_{1t}}{\alpha_2 - \beta_2} = \pi_{12} Y_t + \mu_{1t} \quad (10)$$

Where:

$$\pi_{12} = \frac{\beta_3}{\alpha_2 - \beta_2} \quad and \quad \mu_{1t} = \frac{\varepsilon_{2t} - \varepsilon_{1t}}{\alpha_2 - \beta_2}$$

$$q_t = \frac{\beta_3}{\alpha_2 - \beta_2} Y_t + \frac{\varepsilon_{2t} - \beta_2}{\alpha_2 - \beta_2} = \pi_{12} Y_t + \mu_{2t} \quad (11)$$

Where:

$$\pi_{22} = \frac{\beta_3}{\alpha_2 - \beta_2} \quad and \quad \mu_{2t} = \frac{\varepsilon_{2t} - \varepsilon_{1t}}{\alpha_2 - \beta_2}$$

Analyzing equations (9) and (11), we can calculate:

$$E(\sum P_1 \varepsilon_u) = \frac{\beta_3}{\alpha_2 - \beta_2} E(\sum y_1 \varepsilon_u) \frac{1}{\alpha_2 - \beta_2} E(\sum \mu_1 \varepsilon_u) - \frac{1}{\alpha_2 - \beta_2} E(\sum \varepsilon_u^2)$$

$$E(\sum P_1 \varepsilon_u) = \frac{\beta_3}{\alpha_2 - \beta_2} E(\sum \mu_1 \varepsilon_u) - \frac{1}{\alpha_2 - \beta_2} E(\sum \varepsilon_u^2)$$

$$E(\sum P_1 \varepsilon_u) = \frac{TCov\,(\sum \mu_1 \varepsilon_u) - TVarE\,(\sum \varepsilon_u)}{\alpha_2 - \beta_2} \quad (12)$$

From equation (12) we can see that $E(\sum p_{1t}\, \varepsilon_{1t})$ is based on the condition of the mistakes of u and sit, which reflects the correlation between the two simultaneous equations and in fact, E (u, s_{it}) is never equal to zero-analysing thereby equations (9) and (12), α_2 (OLS)≠α. In other words, when OLS estimates the parameters of simultaneous equations, the result will be biased and inconsistent. This means the business will remain present, although the sample is enlarged to infinity. Identification of the Problem is intended to show whether the structural parameter obtained from the coefficient is in a reduced form. The coefficient of Equation (5) is obtainable from the reduced form equations of (10) and (11) as follows:

$$\alpha_2 = \frac{\pi_{12}}{\pi_{22}} = \frac{\alpha_2 - \beta_3}{\beta_3} x \frac{\alpha_2 \beta_3}{\alpha_2 - \beta_2} \quad (13)$$

Suppose a structural parameter is foreseeable from the coefficient of the reduced form. In that case, the Equation mentioned can be identified. This way of anticipation is called Indirect Least Squares; however, if unforeseeable, the abovementioned Equation will be under-identified. If the value of the structural parameter obtained is unique, then that Equation is referred to as precisely identified; conversely, if there is more than one, it is known as over-identified.

An equation can be identified if the amount of variable which is not covered within the Equation mentioned but is covered in another equation, in simultaneous equations, must have the same, and if not, more than the Sum of equations in the simultaneous Equation, reduced by one or can be formulated as the following:

(K-M)>(G-I) (14)

Where:

G = Sum of equations in the model (number of endogenous variables)
K = Sum up the variables in the model
M = Sum up fixed variables in the model

If (K-M) = (G-1), then the Equation mentioned is known as precisely identified and if (K-M)>(G-1), that Equation is referred to as over-identified.

The follow the following steps:

1. To avoid correlation between P_t and s_u of equation (6) hance it was made regression between P_t with all exogen variables by using OLS, so as to obtain:
   $Pt = \pi_1 y_t + \pi_2 S_i$ (15)
   $Pt = Pt + e_t$ (16)

2. By substituting P_t from equation (16) into equation (6) and uses OLS to anticipate equation (5) as follow:
   $q_s = \beta_2(P_t + e_t) + \beta_1 Y_t + \varepsilon_{2t}$
   $q_s = \beta_2 P_t + \beta_1 Y_t + (\beta_2 e_t + \varepsilon_{2t})$ (17)
   Where:
   $\mu_t = \beta_2 e_t + \varepsilon_{2t}$

3. Methods

3.1. Optimum Subsidy Level

Providing subsidies to producers is intended to lower the market prices of palm cooking oil, thereby creating a balanced benefit shared between producers and consumers. To achieve such equitable outcomes, it is essential to determine a subsidy level that maximises net gains for farmers and society at large, including other stakeholders who benefit from the subsidy scheme.

The optimal subsidy for palm cooking oil output refers to financial assistance allocated to producers based on their total production volume. Given the substantial potential scale of such subsidies, which are distributed among producers, consumers, and taxpayers, it becomes critical to consider the distributional equity among these three groups. Thus, any formulation of subsidy policy aimed at enhancing social welfare must be guided by a framework that explicitly accounts for their respective interests and contributions.

Maximizing $W = C_s + SP_s + G$ (18)

Subject to:

$C_S = \int_0^x D(X)\vartheta X - H_P X$ (19)

$P_S = H_S X - \int S(X)\vartheta X$ (20)

$G = (H, H_P)X$ (21)

Where:

W = Public Welfare
Cs = Consumer Surplus
Ps = Producer Surplus
G = Tax paid by the Taxpayer
δ = Welfare Instrument
H_p = Palm cooking oil in demand
H_s = Palm cooking oil supply
H_t = Palm cooking oil accepted by the producer after the implementation of the subsidy

If X represents the production level, which is realised immediately after the implementation of palm cooking oil H_t, therefore maximising W through obtaining X with equation substituting (19), (20) and (21) into Equation (18), resulting in the following:

$W = \int_0^x D(X)\vartheta X - H_p X + \delta\left(H_s X - \int_0^x S(X)\vartheta X\right) + \left(H_t - H_p\right)X$ (22)

From equation (22) we can get $\left(\frac{\vartheta W}{\vartheta X}\right)$,

$$\frac{\vartheta W}{\vartheta X} = D(X) - D(X) - XD'(X) + \delta\{\delta(X) + XS'(X) - S(X)\} - S'(X)X + D(X) + XD'(X) = 0 \quad (23)$$

To strive for a balance in the beginning H_P=D(X); H_S=S(X) and at the end H_t=S(X), With substituting this into the equations (23) and hereinafter divided by H_s and thus transforming S(X) and D(X) into elasticity, hence we obtained:

$$\frac{\delta}{\varepsilon} - 1 - \frac{1}{\varepsilon} + \frac{H_d}{H_t^*} = 0$$

$$\frac{H_d}{H_t^*} = 1 - \left[\left(\frac{1}{\varepsilon}\right)(\delta - 1)\right] \quad (24)$$

Where:

H_t^* = Optimum from H_t

ε = elasticity

The parameter *S* serves as an indicator of subsidy transfer dynamics. When *S=1*, it implies no net transfer of financial burden from consumers or taxpayers to producers. Conversely, if *S>1* – for instance, 1.25—this suggests that for every one rupiah transferred to producers, both consumers and taxpayers collectively bear the cost [15].

The variable *H∗* denotes the optimal level of palm cooking oil derived from H_t, signifying that the supply level (*Hs*) is the key determinant. Identifying the optimal production level of palm cooking oil is equivalent to determining H∗, which is operationalised by applying Equation (24) to estimate the corresponding optimal subsidy level [18].

To illustrate, assume the baseline market prices of palm and coconut cooking oil are denoted by *H* and *Hj*, respectively. If the government decides to subsidise both commodities at rates *Si* and *Sj*, reflecting their respective shares in market consumption, and if the initial prices *H* and *Hj* are normalised to 1, then the post-subsidy market-adjusted prices will be *Si=1+Si* for palm oil and *Sj=1+Sj* for coconut oil. Then, the function of supply and demand for the two commodities mentioned in the elementary equation form of Cobb-Douglas can be written as follows:

Palm cooking oil demand function:

$$X_i^d = \gamma_1 H_i^{\eta i} H_i^{\eta ij} \quad (25)$$

Supply function:

$$X_i^s = \gamma_2 (S_i H_i)^{\varepsilon i} (S_j H_j)^{\varepsilon ij} \quad (26)$$

Coconut cooking oil Demand Function:

$$X_j^d = \gamma_3 H_i^{\eta i} H_i^{\eta ij} \quad (27)$$

Supply function:

$$X_j^s = \gamma_4 (S_i H_i)^{\varepsilon j} (S_j H_j)^{\varepsilon ji} \quad (28)$$

Where:

X_i and X_j = the break-even amount of palm cooking oil and coconut cooking oil

$\gamma_1, \gamma_2, \gamma_3, \gamma$ = constant

η_{ij} and η_j = Palm cooking oil elasticity for demand

εi and εj = Palm cooking oil elasticity for supply

η_{1i} and η_{ji} = crossed palm cooking oil elasticity for demand

$\varepsilon 1$ and $\varepsilon j 1$ = crossed palm cooking oil elasticity for supply

By analogy, solving the system of supply and demand equations—namely equations (25) through (28) – allows for the derivation of demand and supply elasticities within a multimarket framework. This approach facilitates quantifying how responsive quantities are to changes in price across interrelated commodity markets (Buse, 1958).

Analogically, solving the equations for supply and demand (25), (26), (27) and (28) will help show the elasticity of demand and supply derived (multimarket) [19] as follows:

$$\varepsilon_{ig} = \varepsilon_i + \varepsilon_j \left[\frac{\varepsilon_{ji} - \eta_{ji}}{\eta_j - \varepsilon_j}\right] \quad (29)$$

$$\varepsilon_{jg} = \varepsilon_i + \varepsilon_{ji} \left[\frac{\varepsilon_{ij}-\eta_{ij}}{\eta_i-\varepsilon_i}\right] \tag{30}$$

$$\eta_{ig} = \eta_i + \eta_{ij} \left[\frac{\varepsilon_{ji}-\eta_{ji}}{\eta_j-\varepsilon_j}\right] \tag{31}$$

$$\eta_{jg} = \eta_i + \eta_{ji} \left[\frac{\varepsilon_{ij}-\eta_{ij}}{\eta_i-\varepsilon_i}\right] \tag{32}$$

Applying the value of $\left({H_p}/{H_t^*}\right)$ to equation (24) is the same as applying $\left({H_p}/{S_iH_i}\right)$ and $\left({H_p}/{S_jH_j}\right)$ to Equations (26) and (28), so that Equation (24) can be written in any form:

$$S_i^* = \frac{1}{1-\left[\left(\frac{1}{\varepsilon_{ig}}\right)(\delta-1)\right]} \quad \text{for } 1< \delta < \varepsilon_j +1 \tag{33}$$

$$S_j^* = \frac{1}{1-\left[\left(\frac{1}{\varepsilon_{jg}}\right)(\delta-1)\right]} \quad \text{for } 1< \delta < \varepsilon_j +1 \tag{34}$$

S_i^* Shows the S_j^* optimum or optimum subsidy level. From equations (33) and (34), it is apparent that δ=1 and S_i^* = 1, therefore no intervention is needed. Still, on the contrary, if the government wishes intervention through subsidising, that will affect the optimum level influenced by supply and demand elasticity. S_i^* Equations (33) and (34) represent the optimum subsidy level given to commodities separately if a subsidy were given concurrently to the two.

3.2. Effect on Palm Cooking Oil and Quantities

The Equations from (7) up to (9) can be re-expressed in the ln form, becoming the following:

Palm cooking oil Demand Function:

$$lnX_i^d = \mu i \; lnH_i + \eta_{ij} lnH_i \tag{35}$$

Supply function:

$$lnX_i^s = \varepsilon_i lnS_i + \varepsilon_i lnH_i + \varepsilon_{ij} lnS_i + \varepsilon_{ij} lnH_j \tag{36}$$

Coconut cooking oil demand function:

$$lnX_j^d = \mu j \; lnH_j + \eta_{ji} lnH_j \tag{37}$$

Supply function:

$$lnX_j^s = \varepsilon_j lnS_j + \varepsilon_j lnH_i + \varepsilon_{ji} lnS_i + \varepsilon_{ji} lnH_i \tag{38}$$

From the Equations of (17), (18), (19) and (20), we can account for the palm cooking oil elasticity and quantities to subsidies in the following manner:

$$\frac{\partial \ln H_i}{\partial \ln S_i} = \frac{\varepsilon_i(\eta_j-\varepsilon_j)-\varepsilon_{ji}(\eta_{ij}-\varepsilon_{ij})}{(\eta_i-\varepsilon_i)-(\eta_j-\varepsilon_j)-(\eta_{ij}-\varepsilon_{ij})(\eta_{ji}-\varepsilon_{ji})} \tag{39}$$

$$\frac{\partial \ln H_i}{\partial \ln S_i} = \frac{(\varepsilon_j-\varepsilon_{ji})-(\varepsilon_i-\eta_{ji})}{(\eta_i-\varepsilon_i)-(\eta_j-\varepsilon_j)-(\eta_{ij}-\varepsilon_{ij})(\eta_{ji}-\varepsilon_{ji})} \tag{40}$$

$$\frac{\partial \ln H_i}{\partial \ln S_i} = \frac{\varepsilon_j(\eta_i-\varepsilon_i)-\varepsilon_{ij}(\eta_{ji}-\varepsilon_{ji})}{(\eta_j-\varepsilon_i)-(\eta_j-\varepsilon_j)-(\eta_{ij}-\varepsilon_{ij})(\eta_{ji}-\varepsilon_{ji})} \tag{41}$$

$$\frac{\partial \ln H_i}{\partial \ln S_i} = \frac{(\eta_i\varepsilon_{ij})-(\varepsilon_j\eta_{ji})}{(\eta_i-\varepsilon_i)-(\eta_j-\varepsilon_j)-(\eta_{ij}-\varepsilon_{ij})(\eta_{ji}-\varepsilon_{ji})} \tag{42}$$

$$\frac{\partial \ln X_i}{\partial \ln S_i} = \eta_i\left[\frac{\partial \ln H_i}{\partial \ln S_i}\right] + \eta_{ij}\left[\frac{\partial \ln H_i}{\partial \ln S_i}\right] \tag{43}$$

$$\frac{\partial \ln X_i}{\partial \ln S_i} = \eta_i\left[\frac{\partial \ln H_i}{\partial \ln S_i}\right] + \eta_{ji}\left[\frac{\partial \ln H_i}{\partial \ln S_i}\right] \tag{44}$$

The changing Impact of Si on the palm cooking oil, which is accepted by the producer (Si Hi), can be calculated by the following equations:

$$C_i = S_i H_i \tag{45}$$

$$\left[\frac{\partial C_i}{\partial S_i}\right] = S_i \left[\frac{\partial H_i}{\partial S_i}\right] + H_i \tag{46}$$

$$\left[\frac{\partial lnC_I}{\partial lnS_i}\right] = \left[S_i\left(\frac{\partial H_i}{\partial S_I}\right) + H_i\right]\left[\frac{1}{H_i}\right] = \left[\frac{\partial lnH_i}{\partial lnS_i}\right] + 1 \tag{47}$$

Equation (25) indicates that if the change of Si is equal to 1% and Hi; is reduced by 4%, the palm cooking oil accepted by the producer will increase by 6%.

3.3. Effect on Producer and Consumer Surplus

We can thus calculate the consumer surplus (ACS), producer surplus (APs) and the tax payable by the Taxpayer (AG) [16] through the following:

Government Expenditure on the commodity of palm cooking oil:

$$AS_i = (C_i + AC_j - H_i)(Xi + AX_j) \tag{48}$$

Government Expenditure for the commodity of coconut cooking oil:

$$AS_i = C_j + AC_j - H_j)(X_j + AX_j) \tag{49}$$

$$\Delta C_S = X_I \Delta\, H_I + X_J H_J - 0{,}5(X_I H_I + X_J H_i) \tag{50}$$

From total expenditures:

$$\Delta P_S = X_i \Delta\, H_i + X_J H_J - 0{,}5(X_I H_I + X_J H_i) \tag{51}$$

From total expenditures:

$$\Delta H_i = (H_{old} - H_{now});\ \Delta X_I = (X_{old} - X_{now}) \tag{52}$$

$$\Delta H_j = (H_{now} - H_{old});\ \Delta X_i = (X_{now} - X_{old}) \tag{53}$$

$$\Delta G = \left[X_i(C_I - H_i) + X_j(C_j - H_j)\right] \tag{54}$$

$$\Delta DW = -\Delta X_i(C_i - H_i) - \Delta X_j\left(C_j - H_j\right) + 0{,}5[\Delta X_i(\Delta C_i - \Delta H_i) + \Delta X_j\left(\Delta C_j - \Delta H_j\right)]$$

$$\Delta W = G\Delta C_S + \delta \Delta P_S + \Delta G \tag{55}$$

4. Results and Discussion

4.1. Optimal Subsidy Level

The calculation results indicate that the optimal subsidy level is 16% for palm oil and 26% for coconut oil, based on prevailing market prices. These findings suggest that if the government intends to set a base price as a price support mechanism and as a policy instrument for resource allocation aimed at maximising social welfare, then it is advisable to align the base price with these optimal subsidy rates. Doing so would help ensure the policy benefits are equitably distributed among farmers, consumers, and the broader community. The detailed results of the optimal subsidy calculation are presented in Table 1.

Table 1. Calculation Results on Optimal Subsidy Level

Scenarios	Optimal Subsidy Level	
	Palm Cooking Oil	Coconut Cooking Oil
Initial conditions	1.16	1.25
Scenario A	1.2	1.23
Scenario B	1.18	1.29
Scenario C	1.14	1.19
Scenario D	1.19	1.45

4.2. Impact Analysis on Market Equilibrium

The optimal subsidy rate corresponds to the most efficient market price level for palm cooking oil that maximises overall economic welfare. Determining this optimal rate involves adjusting subsidy levels to enhance social outcomes while minimising inefficiencies in the commodity market. When subsidies are provided to smallholder producers—at 16% for palm oil and 26% for coconut oil relative to current market prices—the equilibrium outcomes in both markets shift.

Table 2. Calculation Results on the Equilibrium of Palm Oil and Coconut Oil

Scenarios	Traded Quantity		Palm Oil		Coconut Oil	
	Palm Oil	Coconut Oil	Producer Price	Consumer Price	Producer Price	Consumer Price
Initial condition	0.1300	0.1000	0.8422	-0.9862	0.0138	-0.7730
Scenario A	0.1543	0.1209	0.8238	-0.9010	0.1000	-0.8629
Scenario B	0.1003	0.0786	0.8600	-0.8748	0.1252	-0.6856
Scenario C	0.2268	0.1424	0.8293	-0.9667	0.0700	-0.6698
Scenario D	0.0382	0.0378	0.8552	-0.9051	0.0949	-0.8955

As detailed in Table 2, the equilibrium price consumers receive for palm oil decreases to 0.9862, while the price received by producers increases to 0.8422. This results in a net increase of 0.1300 in the traded quantity of palm oil. In contrast, in the coconut oil market, consumer prices decline to 0.7730, producer receipts rise to 0.0138, and traded quantity increases by 0.1000.

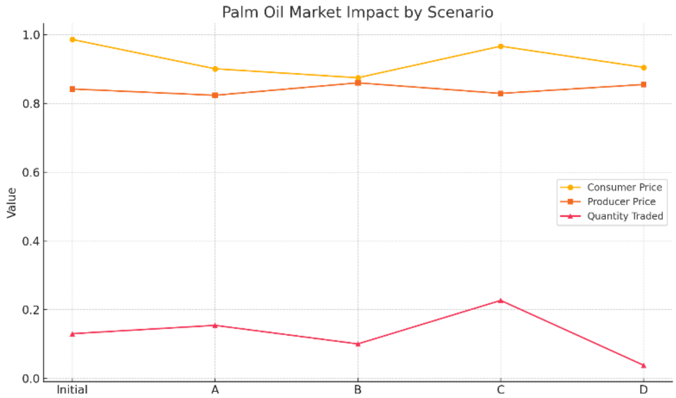

Fig 1. Palm Oil Market Impact by Scenario

The graph (Fig. 2) illustrates how government subsidies affect market equilibrium in the palm oil sector by analysing changes in consumer price, producer price, and traded quantity across five policy scenarios (Initial, A–D). Consumer Prices consistently decrease across all scenarios relative to the initial condition, reaching their lowest in Scenario B (0.8748). This reflects the intended policy outcome: subsidies effectively reduce end-user prices, increasing affordability. Producer Prices, while slightly fluctuating, remain relatively stable and show modest increases in scenarios B and D. These movements suggest that producers partially capture the subsidy benefit, thus maintaining or improving their revenue margin despite lower consumer prices. The convergence of consumer and producer prices indicates that the Policy moves the market closer to a quasi-equilibrium condition where both stakeholder groups experience gains. However, the spread between prices narrows most favorably in Scenario A, implying a more balanced subsidy transfer.

These findings suggest that implementing subsidies effectively stimulates market activity in the palm oil sector, while the effects on the coconut oil market are more modest. Overall, the intervention promotes greater trade volume in palm oil while potentially diminishing the relative competitiveness of coconut oil.

4.2. Impact Analysis on Market Equilibrium

Providing output price subsidies of 16% for palm oil and 26%, as detailed in Table 3, for coconut oil leads to an increase in consumer welfare by 0.0554 and producer (farmer) welfare by 0.0234. Meanwhile, the resulting deadweight loss borne by society due to policy-induced inefficiencies amounts to only 0.0279, or approximately 2.79% relative to the baseline condition. These surplus figures indicate that both consumers and producers benefit from the subsidy policy. This outcome is attributed to implementing subsidies based on optimal pricing designed to maximise overall societal welfare.

Table 3. Calculation Results on Impact of Consumer Surplus, Producer Surplus, Tax Paid, Deadweight Loss and Welfare

Scenarios	Consumer Surplus	Producer Surplus	Tax Paid	Deadweight Loss	Social Welfare
Initial condition	0,0554	0,0613	-0,0588	0,0279	0,0576
Scenario A	0,0696	0,0727	-0,0682	0,0017	0,0780
Scenario B	0,0265	0,0379	-0,1193	0,0745	0,0636
Scenario C	0,1537	0,0367	-0,2445	0,0758	0,0782
Scenario D	0,0081	0,0080	-0,0556	0,1805	0,0726

4.3. Sensitivity Analysis

This analysis uses the elasticity of demand and supply as a sensitivity variable. This is based on the consideration that the value of the elasticity is a determining factor in market palm cooking oil [20] [21] and [22]. There are 4 (four) scenarios created in this analysis:

Scenario A. The elasticity of palm oil and coconut oil rose 10% each

Increasing the elasticity of palm oil and coconut oil by 10% each will reduce the optimal subsidy level for palm oil from 16 % to 20 % and for coconut oil from 25 % to 23 %. The balance of the palm oil market has not shifted; consumers' palm cooking oil level has decreased, and the palm cooking oil received by farmers has been permanently reduced. Still, the percentage is relatively smaller than the initial condition. Traded palm oil has increased, but the rate is smaller than the initial condition. Whereas in the coconut oil market, where there is an increase in elasticity, the palm cooking oil received by consumers is the percentage that experienced a bit of decrease compared to initial conditions. Surplus levels received by consumers and farmers did not experience a shift, but occurred, slightly increasing the supply for farmers.

Scenario B. The elasticity of palm oil and coconut oil decreased by 10% each
Decreasing the elasticity of palm and coconut oil by 10% each will increase the optimal subsidy for palm oil from 16 % to 18 % and for coconut oil from 15.0% to 29 %. The balance of the palm oil market has shifted, and the palm cooking oil level received by consumers and the palm cooking oil received by farmers increased, where the increase was relatively greater than the initial conditions. In the coconut oil market, the palm cooking oil level received by consumers and the palm cooking oil received by farmers increased. However, the increase was relatively greater than the initial conditions. While the quantity of palm oil and oil traded coconut experienced a decrease compared to the initial condition. Welfare received by farmers with little experience declines from 0.9862 _ to 0.1115, while the loss to the Taxpayer is slightly increased from 0.0588 to 0.0605. This indicates a transfer from taxpayers and consumers to farmers.

Scenario C. The Elasticity of palm oil increases, and the Elasticity of coconut oil decreases by 10%
Increasing the elasticity of palm oil and decreasing the elasticity of coconut oil by 10% each will reduce the optimal subsidy level for palm oil from 16 % to 14 % and increase the optimal subsidy for coconut oil from 2.5 % to 19 %. The balance of the palm oil market has not shifted. The palm cooking oil level received by consumers decreased, and the palm cooking oil received by farmers continued to increase, although the percentage was relatively minor. Meanwhile, in the coconut oil market, there is a shift in the balance of consumer palm cooking oil, where after there is a decrease in the elasticity of coconut oil, the palm cooking oil received by consumers decreases. While the palm cooking oil level received by farmers and the quality of traded coconut oil did not change compared to the initial consumption, the percentage did increase slightly. The surplus received by consumers and farmers has not shifted, but there has been an increase in the surplus received by consumers. Losses on tax payments have increased.

Scenario D. The elasticity of palm oil decreased by 10%, and the elasticity of coconut oil increased by 10%.
Decreasing the elasticity of palm cooking oil and coconut oil's elasticity by 10% each will increase the optimal subsidy for palm oil from 16 % to 19 % and decrease from 25 % to 45 % for coconut oil. The balance of the palm oil market has not shifted. The level of palm cooking oil received by consumers and the palm cooking oil received by farmers decreased, whereas the decline was relatively minor. The percentage of traded palm oil has reduced compared to the initial conditions. There is no shift in the coconut oil market either. The palm cooking oil received by farmers is greater than in the previous situation. Meanwhile, the quantity of coconut oil traded experienced a smaller decline compared to the initial condition. Consumer welfare increases, but the surplus received by consumers increases relatively more slowly.

4.3. The Effect of Elasticity on Optimal Subsidies

If scenarios A, B, C and D are compared, the lower the elasticity of demand and supply, the higher the optimal subsidy level. In other words, the more inelastic the supply and demand for a commodity, the greater the difference between the optimal palm cooking oil and the market palm cooking oil. This implies that if the optimal palm cooking oil is used to improve people's welfare, then the market palm cooking oil for inelastic commodities such as agricultural commodities does not reflect the optimal palm cooking oil so that the market palm cooking oil of these commodities cannot be used as an instrument to improve people's welfare. Through trade [23]. Therefore, to improve people's welfare through agricultural commodities, the role of government guidance in pushing market palm cooking oil levels to optimal palm cooking oil is huge [24].
In contrast to agricultural commodities, industrial commodities have elastic demand and supply elasticities. Hence, the market price of palm cooking oil of these commodities is relatively able to reflect optimal palm cooking oil, and the prevailing palm cooking oil in the market is used to determine the level of social welfare through trade activities. Therefore, the government's intervention is not needed for industrial commodities with high elasticity.

5. Conclusion

This study concludes that the optimal subsidy levels for palm and coconut oil are 16% and 26%, respectively, based on elasticity-adjusted models that maximise social welfare. The welfare distribution shows producers tend to gain a larger surplus, although consumers benefit from lower market prices. Moreover, sensitivity analysis confirms a strong inverse relationship between elasticity and subsidy requirements: the more inelastic the supply and demand, the greater the subsidy needed to reach welfare-enhancing equilibrium.
In light of these findings, the following concrete policy recommendations are proposed:

1. Subsidy Calibration Based on Elasticity.
   The government should adopt a dynamic subsidy model that adjusts to updated elasticity values in the market. This ensures that subsidies are neither under- nor over-allocated, avoiding inefficiencies and unnecessary fiscal burdens.
2. Price Support Alignment with Optimal Levels.
   The base price or ceiling price set by the government should be aligned with the computed optimal price levels derived from subsidy simulations. This will help harmonise market signals and policy intentions.
3. Targeted Subsidy Distribution.
   Smallholder farmers and low-income consumers should be given priority through targeted mechanisms, such as e-voucher systems or cooperative-based subsidies, to prevent leakage and ensure that intended beneficiaries receive the support.
4. Elasticity Monitoring and Market Forecasting Tools.
   Institutionalise the use of forecasting models and elasticity tracking (e.g., rolling surveys, AI-driven demand modelling) to support evidence-based policy design and timely adjustments in subsidy rates.
5. Avoid Uniform Policy Across Commodities.
   Since palm oil and coconut oil demonstrate different elasticity profiles, subsidy policies should not be uniform. Differentiated subsidy schemes based on commodity-specific dynamics will yield better welfare outcomes.

In summary, a data-driven, elasticity-informed, and differentiated subsidy framework will allow the government to enhance the effectiveness of cooking oil subsidies, ensuring both affordability for consumers and viability for producers while minimising inefficiencies.

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