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Determinants of corn acreage response model underprice policy program

Edison Edison *

Department of Agribusiness, Faculty of Agriculture, University of Jambi, Indonesia.

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Abstract

The main objective of this research is to analyze the impact of several agricultural investments on corn production. The increasing trend in corn production in Jambi during the study years (1990-2022) is due to large increases in government improvement policy programs, such as price supports and input subsidy programs. Variations in area, yield, and output are also influenced by the prices of output and inputs such as fertilizer. The greater effectiveness of price support policies and input subsidy policies depends on the higher magnitude of the significant coefficients of these two variables. The first policy implication of the findings of this research is that price support policies are more effective and efficient in increasing areas. The influence of government support on corn prices is very important in analyzing the area response. Due to the role of government support on prices in the new environment, it has received much attention in policy implementation. When price support and the impact of market phenomena vary according to market conditions, price expectation measurement methods that analyze regional responses are used. This fact presumes that the impact of changes in government policy due to similar programs of territorial control and price supports is a likely form of future policy. A support and funding evaluation method was developed and tested to see the impact of changes in government programs. The results show that when price supports are far below expected market prices, the effect of cuts is negligible, and price support programs have only a small impact on acreage decisions. Alternatively, when price levels are favorable, the impact of cuts is greater, and the resulting impact on acreage decisions is greater.

Keywords: Supply response; Corn; Production; Price policy program

1 Introduction

In the current period of regional autonomy (decentralization), regional governments are trying to find and use regional potential to increase regional income. Like other regions in Indonesia, the main source of income for people in Jambi is from the agricultural sector, such as corn farming, which is one of the current business strategies because it can increase farmers' income. Jambi Province, which is one of the corn producing regions in Indonesia, shows an increase in corn production from year to year, this fact is due to the availability of infrastructure and production facilities for farmers [1-2].

Production developments that, although effective in recent years, may be relatively difficult to repeat in the future [3-4]. This fact is due to the economic crisis and financial difficulties that have resulted in reduced subsidies for these activities. Under these conditions, several agricultural policy experts are interested in observing the response to supply and demand for inputs in corn farming. Estimates of supply responses, such as changes in input usage, have been reported in several studies [5-6]. However, very few have examined the response of input supply and demand in relation to price changes.

* Corresponding author: Edison Edison

In Jambi Province, as elsewhere, many agricultural production and investment decisions are taken under the promotion of commodity prices, crop yields, and government policies in the agricultural sector [1-2]. The government has maintained input subsidies (such as fertilizer) and price support policies to increase agricultural production. This policy is very controversial. To deploy these policies, it is critical to understand farmers' responses to economic stimuli such as production factor prices and non-factor prices.

Farmers' responses to changes in the price of certain products are aimed at many conditions, which include the application of resources, especially land and family labor, crop selection and techniques, outdoor labor opportunities, product prices, and the availability of income ventilation, as well as farmer conditions and risk attitude untoward. Furthermore, according to [3-4], it is also emphasized that in every business activity in the agricultural or agribusiness sector, businesses are always faced with risk and intimate situations.

Farmers' responses to price changes are useful for policy purposes. If farmers respond to positive price movements, corn supplies will be affected by rising prices. The effectiveness and cost of alternative pricing policies depend on the size and significance of the expected response. Knowledge of the impact of other variables on production responses is important for policymakers. Important variables, including input prices, technological changes, farm management, risks, and financial constraints, must be considered in studying production responses to make this research more realistic and useful [7-8].

The response role of agricultural production has received much attention in recent empirical studies. Neoclassical theory on the model of farmer production behavior in its application with maximum profits has been tested and accepted in the literature [9]. According to [10], it has been shown theoretically that this increase results in a decrease in optimal production prices ranging from farming to competition.

Despite the many problems in the estimation, the production response has a better reference value for policymakers in examining the efficiency, distributional impact, and yield increase of the basic agricultural program in Jambi Province. The main considerations for examining production responses are that (a) production decisions are made based on ex ante expectations and (b) many producers are risk averse, at least when their income is limited.

If there is risk in the production process or in the prices of inputs and outputs, agents are assumed to behave as if they maximize the utility of expected profit. Depending on the risk agent's preferences, marginal expectations of inputs may not balance with price factors. If an agent rejects and risks production risks, its discretion will depend on how the risk enters the production function and whether its input will slightly increase the risk or reduce the risk.

Agricultural production processes are generally characterized by continuous decisions due to the time lag between input allocation and output realization. In terms of corn production in Jambi Province, experienced farmers tend to determine which crops to plant based on the availability of prices and developments in weather information and insecticide infestations in the local area. Finally, farmers will determine the levels of input variables such as labor and fertilizer. If the constraints are irrational, farmers are likely to change their decisions at each stage, depending on changes in the information.

When all inputs are applied, not many farmers are able to work to control the production process. Output levels are then determined by a number of exogenous factors such as rainfall, drought, insecticide and pesticide attacks, plant diseases, and other factors that can affect agricultural production. This lack of control makes it difficult to assess the ex-ante supply function, because factual outcomes can only be observed as an ex-post assessment of the supply function.

From the above information, the subject matter can then be withdrawn as follows: can the supply response of farmers to input prices, output prices, government programs in farming, the price of fertilizer, pesticide price, area harvested, and other exogenous variables be explained? From the issue and the problems above, the research objectives can be drawn: "assessing the supply response of farmers to input prices, output prices, government programs in corn farming, the price of fertilizer, pesticide price, area harvested, and other exogenous variables."

2 Material and Methods

There is a long tradition of broadcasting aggregate and farm-level risk supply responses in time-lagged production models [11]. However, measuring the expected rate of return and supply response to risk in a routing program is a problem for modelers. The optimal solution obtained from the correct architectural model will be of great guarantee for research and policy analysis.

With regard to selecting an appropriate model, this section presents a theoretical framework for land supply response decisions and their impact on government agricultural programs. The basic model adopted for production risk analysis is the regional response model, which is used to analyze production delays and their effectiveness on price support and the effectiveness of input program subsidies. Although agricultural production is viewed as a single product or multi-product production decision [12], this model does not include risk. In this section, a theoretical formulation of production decisions in skin conditions is presented using a single product approach (since we only focus on corn).

Let the general statement of the acreage decision model be:

$$A = f(\Phi, \pi, \lambda, \theta), \quad (1)$$

where: Φ is farmers gross revenue per hectare; π is profits; λ is risk; θ is policy farm program, and the farmers' objective under risk was to maximise the expected utility function defined as follows:

$$\text{Max } E\{U(\pi)\} = E\{U[X, \theta, T).\ A - C.\ X.\ A - F]\} \quad (2)$$

where: π is profits; X is input per hectare used; θ is policy farm program; T is *proxy* for technological change; A is acreage harvested; C is input prices; F is fixed cost of production.

The gross revenue per hectare can be denoted as Φ = (X, θ, T) A. If the assumption that f'(.) is 0 is imposed as the first order condition for a maximum, the solution will come up with the following equations:

$$A^* = A(\Phi, C, \theta, T) \quad (3)$$

$$X^* = X(\Phi, C, \theta, T) \quad (4)$$

Let the stochastic gross revenue was $\Phi_i = \Phi_i^* + \lambda$ .... (5)

where: Φ_i^* is farmers' expected revenue per hectare; and λ is risk associated with crop.

Then the acreage response and input demand equations are :

$$A^* = A(\Phi^*, \lambda, C, \theta, T) \quad (6)$$

$$X^* = X(\Phi^*, \lambda, C, \theta, T) \quad (7)$$

Upon the substitution of (3 – 7) back to (2), the indirect expected utility function can be derived as follows:

$$V(\Phi^*, \lambda, C, \theta, T) = E\{U[X^*, \theta, T).A^* - C.\ X^*.\ A - F]\} \quad (8)$$

The indirect utility function V(Φ*, λ, C, θ, T) is continuous and differentiable (Φ*, λ, C). However, according to [13], homogeneity and symmetry conditions were violated under risk and risk aversion.

The study was conducted in Jambi Province as the region is one of the corn producing areas in Indonesia. The study was conducted in 2023. The study was conducted using the survey method, and the data were collected from secondary data. The data used in this study are from 1990 to 2022 for Jambi Province. Data from 1990 to 2022 are used to capture different periods of economic crises, including high, medium, and low levels of economic crises.

3 The Acreage Response Functional Form

The acreage response equation is

$$A_t = \alpha_0 + \alpha_1 \Phi_t + \alpha_2\lambda_t + \alpha_3 C_t + \alpha_4 \theta_t + \varepsilon_t \quad (9)$$

where: A_t is acreage per hectare in year t; Φ_t is expected gross return in year t; λ_t is expected risk in year t; C_t is input prices in year t; θ_t is government farm program in year t; α_0 is intercept; α_1 - α_4 are parameters; ε_t is error term, the variables in equation (9) were defined as follows :

a) The Gross Return Variable (Φ_t)

$$\Phi_t = \Sigma P_t.Y_t.A_t \quad (10)$$

where: Φ_t is expected gross return in year t; P_t is output price in year t; Y_t is yield per hectare in year t; A_t is acreage per hectare in year t.

(b) Farmers' Expected Gross Return [$E(\Phi_t)$]

$$E(\Phi_t) = \alpha_1 \Phi_{(t-1)} + \ldots + \alpha_p \Phi_{(t-p)} + \beta_1 \varepsilon_{(t-1)} + \ldots + \beta_q \varepsilon_{(t-q)} \quad (11)$$

where: $\Phi_{(t-1)}$ is gross return per hectare in year (t-p), which is an auto-regressive (AR) component; $\varepsilon_{(t-q)}$ is error term of lagged q year, which is a moving average (MA) component.

(c) Risk Variable (λ_t)

$$\lambda_t = [\Phi_t - E(\Phi_t)]^2 \quad (12)$$

(d) Farmers' Expected Risk Variable [$E(\lambda_t)$]

$$E(\lambda_t) = \alpha_1 \lambda_{(t-1)} + \ldots + \alpha_r \lambda_{(t-r)} + \beta_1 U_{(t-1)} + \ldots + \beta_s \varepsilon_{(t-s)} \quad (13)$$

where: $\lambda_{(t-r)}$ is the risk variable in year (t-r), which is an AR component; $\varepsilon_{(t-s)}$ is *error term* of risk associated with production lagged s years, which is MA compenent.

In time series analysis, it is important to test the stationary of data. Non-stationary of the time series data has a substantial influence on the final estimated results. According to [14], if time series data are not stationary, any shock, even an unexpected policy shock, will cause a permanent response, and the series will not return to the pre shock level without an equal shock in the opposite direction. In contrast, a stationary time series contains only transitory responses.

The null hypothesis that crop acreage process is a unit root process was tested against the alternative hypothesis that acreage process is stationary around a linear trend. In other tests of this hypothesis, the equation was defined as follows

$$\delta(A_t) = \beta_0 + \beta_1 T + \beta_2 A_{t-1} + \beta_3 \delta(A_{t-1}) + \varepsilon_t \quad (14)$$

where: $\delta(A_t)$ is the difference acreage between year t and year(t-1); T is linear time trend; A_{t-1} is acreage in year t-1; ε_t is the *error term;* β_0 is *intercept;* $\beta_1 - \beta_3$ are parameters.

The null hypothesis, in terms of estimated coefficients of equation (12), can be expressed as follows:

$$H_0: \beta_1 = \beta_2 = \beta_3 = 0$$

If H_0 is not rejected, then the crop acreage process is a unit root process. Moreover, supply response consists of acreage and yield equations for corn. These equations are specified linearly, and estimated by seemingly unrelated regression. Partial adjustment is assumed, and thus lagged acreage is included in the model. The acreage equations are:

$$A_t = f(P^*_{t-1}, A_{t-1}, \theta_t, T, \Phi_t) \quad (15)$$

where: A_t is acreage harvested in year t; P^*_{t-1} is effective farm price deflated by index the variable cost of production in year t-1; θ_t is a variable representing the impact of input subsidy and price support program at year t; T is linear time trend; Φ_t is the risk variable in year t

The equation for the estimated area under risk was estimated using ordinary least squares. The Durbin-Watson value is used to test the hypothesis. These results will be used to see how much risk has an impact on acreage planted and about the structural elasticity of acreage harvested with respect to risk.

4 Results and Discussion

The main objective of this research is to analyze the supply response to farmers' decision rules regarding risks and government policy programs. The expected utility gain function is used to estimate the hypothesized parameters. This function relies on risk variables and government program policies to determine the best decisions and risk-effective strategies. The main functions used for risk analysis are the lagging production function, and the effectiveness of government programs.

4.1 Estimation of Lagged Production Function

This study investigated the acreage supply response in existing risk in lagged production function. The parameters of the crop acreage under risk were estimated by the ordinary least squares. In order to test the significance of each parameter, the null hypothesis can be expressed as $H_0 : \beta_1 = \beta_2 = \ldots = \beta_n = 0$. The results of estimated parameters of acreage response under risk were listed in Table 2. The Durbin Watson analysis showed that the hypothesis that $\beta_1 = \beta_2 = \ldots = \beta_n = .0$ can be rejected. This implies that at least one of the parameters is not equal to zero.

The acreage response was specified linearly and estimated in two steps. First, farmers' expected gross revenue per hectare and risk variables were identified. Second, the estimated results were used to predict expected gross revenue per hectare and risk. The expected gross revenue variables were specified as an autoregressive-moving average process of Φt. The result of ARMA (3,3) was expressed as follows:

$$E(\Phi_t) = \Phi_t{}^* = 36.2 + 0{,}67\ \Phi_{t-1} + 0.13\Phi_{t-2} + 0.24\Phi_{t-3} - 0.18\epsilon_{t-1} - 0.05\epsilon_{t-2} - 0.27\epsilon_{t-3} \ldots (16)$$

The expected risk variables (λ) were specified as an autoregressive-moving average process of $(\Phi_t - \Phi_t{}^*)^2$. The result of ARMA (3,3) can be expressed as follows:

$$\lambda = 24.6 - 0{,}37\ \lambda_{t-1} + 0.29\ \lambda_{t-2} + 0.42\ \lambda_{t-3} - 0.06\ U_{t-1} + 0.9\ U_{t-2} - 3.2\ U_{t-3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

Moreover, it suggests from empirical results that economic time series are rarely stationary, and thus there is no reason that their associated error will be stationary. In order to estimate a unit root (stationary) for the acreage response process, the Dickey-Fuller test was used to check the hypothesis that $H_0: \beta_1 = \beta_2 = \ldots = \beta_n = .0$. The results can be seen in Table 1.

Table 1 Dickey-Fuller Test for Acreage Response

	Results
F-test	61.702
Critical Value	6.19
Judgement	reject H_0
Implication	no unit root

These results indicated that corn data has no unit roots. So the data for these variables were not different before the acreage response was estimated. After the acreage response equation was specified, the estimated parameters can be seen in Table 2. From Table 2., the positive parameter on the expected gross revenue, $\Phi_t{}^*$, was significant at the 5% significance level. This indicated that as farmers' expected revenue for soybeans increases, the corn acreage will increase.

Table 2 Estimations of Acreage Corn Under Lags

Items	**Parameters**	**Standard Error**
Intercept	-8.029	
Φ_t *	0.0034***	0.0007
λ	-0.0029**	0.0009
C_1	0.0023	0.0067
C_2	0.0034	0.0021
θ_1	0.0569*	0.0402

Θ_2	0.0429**	0.0227
T	0.0038	0.0792
R^2	0.8257	
D.W.	2.7169	

where: Φ_t* is expected gross revenue; λ is expected risk; C_1 is fertiliser price; C_2 is pesticide; θ_1 is price support program; θ_2 is input subsidy; T is linear time trend; R^2 is adjusted R^2; D.W. is Durbin-Watson statistics.

The parameter on the risk variable, λ, was greater than zero, although it is not significant at the 1% significance level. This indicated that farmers are risk averse, and as the risk associated with gross revenue increased, the acreage curve would shift to the left. The parameter of support price programs, θ_1, was greater than zero, although it was significant at the 10% significance level. This indicated that the support price program has caused any distortions in acreage decisions by shifting the corn acreage response curve to the right.

4.2 The Impact of Fertiliser and Pesticide Use on Corn Yields

In order to test the trade distorting effect of fertiliser and pesticide subsidy program, it is necessary to analyse the impact of fertiliser and pesticide used on corn yields since this program already showed a positive impact on increasing yield and encouraged to use high yield varieties that need more fertiliser and pesticide used per hectare in previous year and time trend, and assumed to be linear in its equations:

$$Y_t = \beta_0 + \beta_1 \tau_{t-1} + \beta 2 \Phi_{t-1} + \beta_3 T + \epsilon_t \text{ .... } (18)$$

where: Y_t is corn crop yield in year t; τ_{t-1} is fertiliser used per hectare in year t-1; Φ_{t-1} is pesticide used per hectare in year t-1; T is time trend variable; β_0 is intercept; $\beta_1 - \beta_3$ are parameters; ϵ_t is error term.

The OLS method was used to estimate the corn yield parameters. The estimated equation was as follows:

$$\delta(A_t) = 403.7 + 0.057\,T + 0.318\,A_{t-1} + 1.034\,\delta\,(A_{t-1}) \text{ ………………… } (19)$$

$$(48.3) \quad (0.031) \quad (0.116) \qquad (0.237)$$

$$\text{D.W.} = 0.5867 \qquad R^2 = 0.8503$$

From the equation above, fertiliser and pesticide used per hectare had a positive influence on corn yield since its parameter was positive and significant at the 5 percent significance level. This indicated that more fertiliser and pesticides used showed more corn yield. And the parameter on time trend variable was significantly different from zero at the 1 percent significance level. It indicated that technical change has a significant impact on corn yield.

Input subsidy programs encourage farmers to use more fertilizers and pesticides, thereby increasing yields. Because, through the use of fertilizers, the total corn yield is the product of the planted area. Therefore, the impact of the input subsidy program will be to encourage farmers to increase production and shift the output supply curve to the right. Therefore, input subsidy programs cause the output supply curve to shift to the right, thus creating trade distortions.

5 Conclusions

In this study, interpreted and empirical models related to response supply conditions are reviewed. This study presents a framework for analyzing risky supply response decisions. The importance of considering risk in a corn crop framework is illustrated by conducting area model simulations at various levels of corn price support. Simulation models are used for the effectiveness of government programs. And finally, to see the impact of risk on supply response. First, a lagged production function is postulated for the empirical estimation of the expectations variable. The parameter estimation results show that risk variables play an important role for farmers in making decisions. The research results also show that farmers are reluctant to take risks. Therefore, government policies must take into account risk management and dynamic considerations. Finally, for the effectiveness of this policy, especially in government agricultural programs, the risk variable will again have an influence and impact on the final results. For example, eliminating risk will increase acreage, which means the supply curve will shift to the right.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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