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(RESEARCH ARTICLE)

Soybean supply response model in sub-optimal land in Tanjab Timur district: Application of the meta response function

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Abstract

Soybean production in Jambi Province in the last decade tends to decline. This requires attention and assessment to find solutions to existing problems. The objective of study is to (1) evaluate the use of inputs and their effect on production, as well as investigate the ability of production factors, such as land and other factors to analyze supply responses; and (2) analyze soybean supply response variable to the components of input costs, gross revenue, and other variables, to produce a soybean supply response model in sub-optimal land types: Application of Meta-Response Functions. This research was done from April 2021 to June 2021 on peat land types (sub-optimal). Stratified random sampling is used based on land area. Appropriate qualitative and quantitative data analysis methods are used, calledthe Meta Response Function, which in their application are distinguished based on the research objectives, namely in the first objective using the Production Function Empirical Model, and in the second using the Meta-Response Model. The results showed that soybean farmers on peatland in the research area respond to changes in input use efficiently. Output supply is a response to soybean production. On input demand, many are sensitive to the use of labor, maintenance/harvesting labor. Theobtained production elasticity completes part of the data base needed to evaluate the policy implicationsof using alternative inputs from soybean supply and input demand.

Keywords: Soybean; Supply response; Production; Meta-Response model

1 Introduction

Sub-optimal land such as peatland has the potential to be used as agricultural land, considering its large area spread throughout Indonesia. More than 38 million hectares of sub- optimal land in the tropics, about 8.7 million ha (22.89%) is located in Jambi, most of which is still forest and only a small part has been cultivated as agricultural land. This fact clearly causes sub-optimal land to be quite potential for expansion of agricultural areas and at the same time it can also increase the production of agricultural crops, such as soybeans [1].

While soybean production has developed relatively poorly for the past five years, this condition may be rather difficult to occur in the future. Production developments obtained in the soybean sub-sector activities in Jambi are based on the New Order era (1986-1988) and the reform era (1989-2019) from the types of available land typologies. The varying results will illustrate the possibility of uncertainty and risk factors in soybean farming. Likewise, the economic crisis and the financial problems faced, have an impact on reducing the input subsidy program [2-3]. In this situation, agricultural policy experts seek to explore the issue of production supply and demand for inputs for soybean commodities. The findings of production supply problems such as changes in the use of production factors have been summed up in several papers [4]. However, studies of production supply and demand for inputs in relation to price variations are still few that examine it.

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It is known that the results of many agricultural production decisions are made on uncertain prices, production, the amount of inflation, as well as government programs in the agricultural sector. According to [5], decisions that are fundamental to production cannot be ignored from the influence of response management. [6] States that if the response component is omitted in the agricultural management model, then (1) the production response can be overestimated, (2) the results obtained can be over-specialized, and (3) the elasticity of the production response will result in a poor estimate.

Meanwhile the problem of measuring the response is a problem with both the farm level and the aggregation model, as well as more problems at the aggregation level. So the main problem in the production response analysis depends on the selection for inclusion in the analysis. Despite the considerable methodological problems, production response is an interesting consideration for policy makers as many basic farming programs are now being tested for efficiency, distributional impact and improved production [7-8].

The technology change literature in particular to eliminate transfer costs is associated with the shift from traditional technology to modern technology. One might argue that technological change is affected not only by input prices but also by transfer costs from adopting the old technology to the new one. [9] Revealed that long-term agricultural supply is positively determined by agricultural investment, where agricultural investment can be observed as a level of agricultural fixed costs. If the technology is exogenous, then the input is still considered as a supply variable.

Furthermore, [10] reduces fixed costs to two sources of investment. The first source of investment is from its own business investment which is endogenous in the long-term model. The second source of investment is community investment which is exogenous in the long term model. In this case we can review community investment from land management systems, research and development, as a factor accelerating the rate of technological change. The process of adoption of a new technology under uncertainty can be described as a biased analysis process [11]. Initially a farmer becomes concerned about the potential benefits of adopting a new technology, then he may begin to accumulate prior information about the new technology. Bias theory suggests that decision makers should have the capability to combine prior beliefs with current observations and subsequent beliefs. In the context of the biased learning process and technology adoption, [12] explained that the greater the difference between the actual mean results and the initial confidence. On the other hand, he also states that greater variability in the outcome distribution will slow the rate of adjustment of subjective beliefs about the true mean.

One way to empirically test the technology change hypothesis is through the assumption that new technology can be disaggregated from old technology. For example, in agriculture, it is reasonable to distinguish between the old technology of soybeans and the new technology. As stated by [13], the adoption of new technologies can be examined in two different ways. At the individual level, technology adoption can be seen as an individual decision process, starting with farmers who are just learning to use the new technology until the final adoption of the technology. In aggregation, the level of adoption of a new technology can be measured by the level of use of the new technology in a particular geographic area or population.

[14] has extensively studied the issue of technological change in the agricultural sector in Indonesia. He observed the change from the choice in the hybrid soybean and non-hybrid soybean agricultural sector. He found that hybrid soybeans gave a positive adoption response to price changes and a negative response to non-hybrid soybean prices. This finding also explains the absorption of negative soybean responses on non-hybrid soybean prices, but gives a positive response on hybrid soybean prices [15].

According to [16] that producers will change the use of seeds because of different fertilizer responses due to changes in the relative price of inputs such as fertilizer, to maximize profits in the meta-response model. By using the Meta-Response Model (MMR) used, [14] explains that the disclosure of farmer decisions is in uncertain conditions. MMR is expressed as an indirect production function in the form of an envelope associated with each change in the replacement technology variable. This MMR is used to estimate the production response model that was first used by Lau and Yotopoulus [17]. However, the use of benefit indicators for maximum function has been discussed in depth by Dillon and Anderson [18]. Besides that, other models from the profit model approach such as (a) static functions, (b) real variables used to proxy expected profits, and (c) actual profit models related to producer variations to see the use of various production factors and output values. MMR is useful for solving this response problem [14]. But this model needs to be revised in several ways, such as by including the expected utility variable.

Variations in the relative price of fertilizers will have an impact on the intensity of changes in the use of hybrid seeds with various fertilizer variations, as stated by [14], thus obtaining the maximum profit by using the meta-response model. The meta-response model in the form of an envelope consists of the use of inputs for all production factors used such as hybrid seeds, irrigation conditions and plant cultivation.

MMR uses assumptions such as the producer's utility will affect the maximum profit expectation by using constraints such as output prices, variable input prices, and variable inputs. Then the model can be formulated:

$$\text{Max } E[U(\pi)] = E[U\{P, f(X, T, \varepsilon) - cx\}] \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where: π is profit variable, p is production price, x is input variable, T is technological variable, and c is input variable price. If the assumptions $f'(.) > 0$ and $f''(.) < 0$ are used, and if the risk is in additional form [19], the set of input variables X^* that maximizes the expected utility of profit is:

$$X^* = d^*(P, C, T, \theta , \varepsilon) \ldots\ldots\ldots\ldots\ldots\ldots 2$$

where

θ = moment of production

If equation (2) is substituted for (1) indirect expected utility of profit, it can be derived as follows:

$$E[U(\pi^*)] = E[v^*(P, C, T, \theta, \varepsilon)] \ldots\ldots\ldots\ldots\ldots\ldots 3$$

In general, it is assumed that farmers form expectations variables beyond their control so that the choice of input occurs ex-ante to the realization of output, finally the product supply function is an ex-post supply function, because when production is first realized, the farmer's choice is only to sell at the market price [9].

Economic analysis enhances the confrontation of problems expressed through structural changes to the specifications and estimates of economic models. In the analysis of agricultural supply, important structural changes have reflected the impact of government programs on farms seeking to control production. As a result, the integration of changes in farming programs in crop supply response models has received attention in previous studies [16].

In the past two decades, the response to supply of soybean acreage has received attention from policy makers. This is because the government wants to review the effectiveness of the farming commodity program. Particular emphasis has been placed on empirical measures and analysis of the effects and impacts of government programs on farming. Likewise with price support programs and input subsidies.

So by considering the above problems in considering the production development program, it is considered necessary to further evaluate the above problems in order to find a good model for developing soybean production. Taking into account several targets for the development of the agricultural sector, such as to improve the welfare of farmers, this study will analyze the above problems, especially in analyzing the effectiveness of the soybean development program that has been carried out to find the response function of sub-optimal land soybean supply with the Meta Response Function approach.

2 Methods

The research was conducted in Tanjab Timur District because this District is one of the centers of peatland soybean production in Jambi Province. Determination of the location is done purposively with the consideration that the location is a soybean production center in Jambi Province which represents the agroecosystem, namely peatland. The research was conducted from April 2021 to June 2021.

The data collected in this study include primary data and secondary data. Primary data was obtained from direct interviews with farmers whose data was taken from a number of productions from the last planting season in 2020, while secondary data was obtained from literature studies by taking data from books, journals and scientific writings that have been recorded and published.

This research was conducted in Rantau Rasau Sub-District, Tanjab Timur District, and Jambi. In the implementation of this research, two villages will be chosen purposively with the consideration that these villages have the largest harvested area and soybean production, namely Rasau Jaya Village and Sungai Jeruk Village. From the source of the

Agricultural Extension Agency in Rantau Rasau District, it was found that the number of farmers in Rantau Jaya Village who cultivate soybean was 189 farmers, while farmers in Sungai Jeruk village were 82 people. So, the total population in the research village is 271 people. By using the Slovin formula, 55 samples were taken using stratified random sampling. From the results of the above calculation, the number of samples of farmers from two villages is obtained, namely in Rasau Jaya Village the number of samples of farmers is 38 samples and in Sungai Jeruk Village the number of samples of farmers is 17 samples.

This analytical method in its application is sorted based on the research objective, namely the Empirical Model of the Meta-Profit Function. In this study, the trans-log function for the empirical model of the profit function is used. In the profit model, essentially the same explanatory variables as the production function are used, except they are expressed on a per- hectare basis. The empirical model of the profit function can be written as the logarithmic form of the following Cobb-Douglas function:

The normalization of the profit function used in this study to determine the supply response of soybean farmers is expressed as:

$$Y=A\pi X\ \pi Z + u \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

bi cj j

The finite normalization of the profit function, derived from the production function (4), is explained by [20]:

$$\mathrm{Ln}\ \pi^* = \ln \alpha + \sum \beta I \ln Pi + \sum \mathcal{T} j \ln Zj + U \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

where: π^* is normalized profit variable, p1 is normalized fertilizer price, p2 is normalized pesticide price, x1 is maintenance labour wage, x2 is harvest labour wage, Z1 is land acreage variable, and Z2 is capital variable.

The estimation of the supply function with the selected sample is tested using the two- stage method. The Chi-squared value was used to test the hypothesis. The parameter estimates of the supply function obtained from this two-stage procedure are consistent [21]. It is known that the estimation parameters do not directly measure the effect of changing one unit of light variable to change the profitability of crop or variety production.

To obtain the optimal level of input variables, the Shephard-Hotelling lemma concept used in the case of the Cobb-Douglas finite profit function is as follows:

$$X_i^* = -\delta \pi^* / \delta P_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Equation (6) is rearranged and empirically estimated as:

$$(X_i^* P_i) / \pi^* = \beta_i + V_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

Where: Xi

Is quantity of input variables and Vt is error term.

Since the production function is assumed to be in the Cobb-Douglas form, the simultaneous solution of equation (7) and the profit function (4) completes the estimation of the elasticity of demand factor, Zellner's seemingly unrelated regression method, completes the efficiency parameters α, β, $\mathcal{T}$, ∑[21]. This model is estimated using Ordinary Least Squares to estimate the coefficient, R2, t-value, and Durbin Watson value.

3 Results

3.1 Estimation of Meta-Production Function

This study examines the supply response of soybean in the production function. Parameters of the expected production function using ordinary least squares. In order to test the significance of each parameter, the null hypothesis can be expressed as Ho: 1 = 2 = = n= 0

The estimation results of optimal crop production parameters show that the hypothesis 1= 2 = ... = n = 0 can be rejected. The estimated elasticity of the production function for soybean obtained that the adjusted R-squared for the OLS estimate is 0.862, and the F-statistic is 6.83, which is significantly larger than the F-table (3.12). This means that at least one of the parameters is not equal to zero. It can also be seen that the parameters of some explanatory variables are significantly different from zero.

3.2 Production Maximization

Lagrange multipliers were not significantly different from zero, as was the X^2 test (12.217), which is larger than X^2 table (9.49). So the hypothesis that soybean farmers on peatland in the study area maximized production cannot be rejected. For more information, it can be seen in the following table.

Table 1 Restriction Test on Parameter Production Function and Demand Factor Function

Restriction	Lagrange (λ)	Multiplier (t)	X^2 Statistics Test	Restriction
Fertilizer	0,382	(1,912)	0,598	
Pesticide	0,574	(1,983)	0,294	12,217
Maintenance	0,627	(3.319)	0,463	
Harvesting	1,018	(2.178)	1,127	

3.3 Elasticity of Output Supply and Input Demand

The estimated parameters of the production function and the elasticity of demand factors are shown in Table 2. The coefficients are correct in sign that, apart from maintenance, they are greater than zero.

Table 2 Estimation Combination of Normalizing the Production Function and Demand Factor

Variables	Estimation Restriction		Demand Factor Elasticity	
Constant Fertilizer Factor	493,027 -0,473**	(0,452)	-0,264**	(0,161)
Pesticide Factor	-0,438**	(0,427)	-0,232**	(0,174)
Maintenance Labor	-0,226	(0,332)	-0,211	(0,063)
Harvesting Labor	-0,318**	(0,309)	-0,271**	(0,173)
Land Acreage	0,371*	(0,370)		
Capital	0,398*	(0,395)		

3.4 Production Elasticity

Through the concept of duality, there is a correspondence between production and the production function. As a result, the implicit production elasticity can be derived from the production function. The production elasticity (bi' and cj') is derived from the parameters of the production function as follows:

$$Bi' = -\beta i \quad (1-\mu)^{-1} \text{ for variable input} \ldots\ldots 8$$

$$Cj' = \quad \tau j\,(1-\mu)^{-1} \text{ for fixed input} \ldots\ldots 9$$

Where:

$\mu = \Sigma\beta i$, and

βi dan τj are estimated from equation (7).

Indirect production elasticity (bi' and cj') and production elasticity which are estimated directly from the production function equation (4) are shown in Table 3.

Table 3 MLE of Production Function and Production Elasticity derived from Production Function

Variables	Unit	MLE Estimation		Indirect Estimation
Fertilizer Factor	Kg	0,473**	(0,174)	0,139
Pesticide Factor	Kg	0,438**	(0,198)	0,142
Maintenance Labour	Day	0,226	(0,078)	0,108
Harvesting Labour	Day	0,318**	(0,123)	0,143
Land Acreage	Ha	0,371*	(0,147)	0,169
Capital	IDR	0,398*	(0,182)	0,137

4 Discussion

An important condition for reducing the production function used is that the farmer maximizes the short term production. The validity of this assumption can be tested directly by testing whether the parameter is derived from the demand factor equation simultaneously [22]. If the parameter derived from these two equations is not significantly different, then the average sample farmer maximizes the short term production, given the availability of technology and resources. Since it is feasible to simultaneously estimate the production and demand factor equations to avoid the bias problem of the simultaneous equations, [11] used the P statistic to test the null hypothesis that ßi is not significantly different, if ßi is derived from two separate and combined sets of equations.

The elasticity of supply for peatland soybean taking into account the inputs used (estimated as ßi) is estimated to be close to one (0.978). The implication is that the sample farmers respond to changes in soybean inputs. For planning purposes, a 1% change in soybean input, ceteris paribus, will bring about a similar change (0.978%) in soybean supply from Tanjab Timur District.

Estimates suggest that a 10% increase in the workforce would lead to an approximately 5.44% increase in soybean supply consisting of a 2.26% increase due to crop maintenance, and a 3.18% increase due to an increase in labor used for harvesting. If the labor used increases, it is used for harvesting. If the labor force increases, adjustments in the labor used for maintenance may be part of the increased use of fertilizers.

The estimated elasticity of demand factor for fertilizers is 0.473, this means that 10% of fertilizer inputs increase, causing 4.73% of fertilizer use to increase in the short term. So with the existing production function, it will increase production by the same proportion. The elasticity of output by considering land inputs exceeds the temporary with capital. So the size of the farm will have an impact on production when compared to the increase in the intensity of farming capital.

Direct estimates (0.902) and indirect (0.838) which reduce the elasticity of production explain that decreasing returns to scale are depicted. The estimated production elasticity for land (0.371) is consistent with that reported by [23]. Production elasticity is slightly lower for pesticides than for fertilizers. This is not surprising because farmers are now growing locally high yielding varieties that are responsive to fertilizers, as well as resistant to some pesticides.

5 Conclusion

The production elasticity of peatland soybean farming was estimated using production function analysis for a sample of farmers in Rantau Rasau Sub-District, Tanjab Timur District that had applied good cultivation technology. It is assumed in this approach that is tested that farmers maximize short term production, with the availability of technology and fixed resources. The analysis showed that the average sample farmer maximizes production by considering the normal conditions of the variable input.

The analysis also explains that soybean farmers on peatland in the research area respond to changes in input use efficiently. Output supply is a response to soybean production. On input demand, many are sensitive to the use of labor, maintenance/harvesting personnel. The obtained production elasticity completes part of the data base needed to evaluate the policy implications of using alternative inputs from soybean supply and input demand.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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