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 the Tanjab Timur region has been on a downward trend for nearly a decade. 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 capacity 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 conducted in 2021 on peatland types (sub-optimal). Stratified random sampling is used for the land area. Appropriate qualitative and quantitative data analysis methods are used, called the Meta Response Function, which in their application is distinguished from 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. In terms of output supply, it responds to soybean production. In terms of input demand, many variables are sensitive to the use of labor, maintenance, and harvesting labor. Production elasticity completes the policy section of the database for analysis of the policy impact of applying alternative inputs on soybean supply and input demand.

***Keywords**: Soybean, supply response, production and Meta-Responsemodel.*

I. 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 sametime it can also increase the production of agricultural crops, such as soybeans [1].While soybean production has developed relatively poorly for the past ten 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 thereform 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 reducingthe input subsidyprogram [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 productionsupply 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 toprice variations are still few that examine it.

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 responsecomponentis 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 leveland 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 associatedwith 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 inputisstill considered as a supply variable.Furthermore, [10] reduces fixed costs to two sources of investment.

The first sourceof 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 inthe 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 canbe described as a biased analysisprocess [11]. Initially a farmer becomes concerned aboutthe 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 processand technology adoption, [12] explainedthat the greater the difference between the actual meanresults and the initial confidence. Onthe 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 theassumptionthat new technology can be disaggregated from old technology. For example, in agriculture, itis reasonable to distinguish between the old technology of soybeans and the new technology. As stated by [13], the adoption of new technologies can be examinedin two different ways. Atthe individual level, technology adoption can be seen as an individual decision process, startingwith farmers who are just learning to use the new technology until the final adoption of the technology.

In aggregation, the level of adoptionof a new technology can be measured by thelevel 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 givesa 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 maximizeprofits 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. MMRis expressed as an indirect production function in the form of an envelope associated witheach 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) staticfunctions, (b) real variables usedto proxy expected profits, and (c) actual profit models related to producer variations to see theuse of various production factors and output values.MMR is useful for solving this response problem [14]. But this model needs to be revisedin 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], thusobtaining the maximum profit by using the meta-response model. The meta-response modelinthe 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 profitexpectation by using constraints such as output prices, variable input prices, and variable inputs. Then the model can be formulated:

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

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 ifthe risk is in additional form [19], the set of input variables X* that maximizes the expected utility of profit is:

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

where θ is moment of production

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

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

In general, it is assumed that farmers form expectation variables beyond their controlso 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]. Economical 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. Consequently, the integration of changes in farming programs in crop supply response models has received attention in previous studies [16]. In the past decade, the response to supply of soybean acreage has received attention from policy makers. This factis 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. The same goes for price supportschemes and input subsidies.

So, the above problems are considered when considering the production developmentplan, and it is considered necessary to further evaluate the above problems in order to find a good model for the development of 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.

II. METHODS

The study was conducted in the Tanjab Timur district as it is one of the centers of soybean production in the peatlands of Jambi Province. The location was determined on purpose considering that it was the center of soybean production in Jambi province and isan agro-ecosystem, i.e., peatland. The study will be conducted in 2021. The data collectedin 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 studiesby 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, Jambi. In the implementation of this research, two villages will be chosen purposively withthe 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 the 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 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 method of analysis is classified according to the purpose of the research in its application, namely the empirical model of the meta-profit function. In this study, the translog 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 thatthey are expressed in units of hectare. 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:

$Y = a \square X_i^{b_i} \square Z_j^{c_j} + U$ 4

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

$\text{Ln}\ \square^{*} = \ln \square + \square\square_{I} \ln P_i + \square\square_{j} \ln Z_j + U$ 5

where: π^* is normalized profit variable, p_1 is normalized fertilizer price, p_2 is normalized pesticide price, x_1 is maintenance labour wage, x_2 is harvest labour wage, Z_1 is land acreagevariable, and Z_2 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 estimatesof the supply function obtained from this two-stage procedure are consistent [21]. It is knownthat 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 conceptused in the case of the Cobb-Douglas finite profit function is as follows:

$X_i^{*} = - \square\ \square^{*} / \square\ P_i$ 6

Equation (6) is rearranged and empirically estimated as:

$(X_i^{*} P_i) / \square^{*} = \square_i + V_t$ 7

Where: X_i^{*} is quantity of input variables and V_t 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 theefficiency parameters □, □, □, □ [21]. This model is estimated using OrdinaryLeast Squares toestimate the coefficient, R^2, t-value, and Durbin Watson value.

III. RESULTS AND DISCUSSION

4.1. Estimation of Meta-Production Function

This study examines the supply response of soybeans using the frontier production function. Ordinary least squares was used to estimate the parameters of the expected production function. In terms of testing the significance of each parameter, the term for thenull hypothesis can be expressed as Ho: 1=2==n=0. The expression finding of the best soybean production parameters showed that the hypothesis Ho: 1… n = 0 is acceptable. The estimation of the production function elasticity on soybean crop was obtained that theR-squared for the OLS estimation was 0.862, and the F-statistic was 6.83 which is significantly larger than the F-table (3.12). This fact has meaning that at least one of the parameters was not equal to zero. It could also be expressed that some explanatory variableparameters was significantly different from zero.

The best case to apply the production function is when the farmer maximizes production in the short run. The validity of the assumptions can be checked by checking whether the production function parameters are immediately and directly derived from the factor demand equation [22]. If the parameters of the production function derived from the simultaneous equations do not differ significantly, most farmers maximize the productionfunction given technology and resource availability in the short run. [11] evaluated the nullhypothesis that if ßi is derived separately from the two equations and the combined set, then it is not significantly different, using the P statistic.

4.2. Production Maximization

The Lagrange multipliers were not significantly different from zero, as was the X^2test(12.217), which is larger than X^2table (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 3. Restriction Test on Parameter Production Function and Demand Factor Function

Restriction	Lagrange (□)		Multiplier (t)	X^2 Statistics Test
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	

Research results expressed that a research samples do maximize the profit expectation and also considerations using point of uncertainty were not playing in majority in exploring the difference between farmers' applying of inputs in soybean production. Elasticity of Output Supply and Input Demand The estimated parameters of the production function and the elasticity of demand factorsare shown in Table 4. The coefficients are correct in indicating that, apart from maintenance,they are greater than zero.

Table 4. Estimation Combination of Normalizing the Production Function and Demand FactorElasticity

Variables	Estimation Restriction		Demand Factor Elasticity	
Constant	493,027			
Fertilizer Factor	-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)		

After accounting for the inputs used (estimated as ßi), the supply elasticity of peatland soybeans is close to unity (0.978). The implication is that the sample farmers respond to changes in soybean inputs. For planning purposes, ceteris paribus, a 1 percent change in soybean input would result in a similar change (0.978 percent) in soybean supply in the Tanjab-Timur region.It is estimated that a 10% increase in labor would increase soybean supply by about 5.44%, including a 2.26% increase in crop maintenance and a 3.18% increase in harvest labor.If the labor used increases, it is used for harvesting. Adjustments in the labor used for maintenance may be a part of the increased use of fertilizers.

The estimated elasticity of demand factor for fertilizers is 0.473. This fact 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. Theelasticity of output is achieved by taking into account that inputs temporarily exceed capital. The size of the farm will have an impact on production when compared to the increase in theintensity of farming capital. Consider that the output elasticity of land input does not exceed that of temporary capital. Consequently, the size of the farm has no effect on profit when compared to the increase in capital intensity of farming.

4.3. 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:

$Bi' = - \square i \ (1 - \square)^{-1}$ for variable input 8

$Cj' = \square j \ (1 - \square)^{-1}$ for fixed input..9

where □ is □□i, and □i dan □j are estimated from equation (7).

Indirect production elasticity (bi' and cj') and production elasticity which are estimateddirectly from the production function equation (4) are shown in Table 5.

Table 5.MLE of Production Function and Production Elasticity derived from ProductionFunction

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

From the above information, it can be seen that the estimated parameters show appropriate coefficients and the production elasticity is logical and reasonable. The closedanalogy of direct and indirect elastic production has some consequences. First, in terms of models, the original (production) and model double (profit) production models are expressed in equivalent terms. In contrast, the results of soybean supply responseelasticity and input demand elasticity published in Table 5 are convincing. Finally, the point of the deviance equation does not appear to be a problem when estimating the elasticity of reduction from the supply-production function as the final equation [3] is appropriate.Directly 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.

IV. CONCLUSION

The production elasticity of peatland soybean cultivation was estimated by analyzing the production function of a sample of farmers in the Tanjab Timur district applying best practice techniques. It is close to the assumed condition that examined respondents will increase production in the short run with respect to technology and fixedavailable inputs. The analysis showed that most respondents maximized production under the usual conditions of the input variables.The results then show whether soybean farmers on suboptimal land in their studyarea responded effectively to changes in inputs. In terms of output supply, it is responsiblefor soybean production. On the input demand side, some are sensitive to labor use, harvesting labor and maintenance labor. Findings of elastic production support part of a database exploring the impact of government policies on crop supply responses and inputdemand for alternative input use.

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