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SUPPLY RESPONSE OF SUGAR CANE IN INDONESIA

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The paper investigates the supply response of sugar cane using an extended Nerlovian model. The analysis is separated into sugar mills and farmers' responses. Output response is decomposed into area response and yield response.

An important finding shows farmers to be responsive to price while millers are not. The insignificant results on sugar mills indicate that when they are under strict control, and are no longer profit maximizing, the Nerlovian supply response does not apply.

1. Introduction

This paper attempts to quantify the determinants of sugar cane supply to sugar mills in Indonesia. The current policy on sugar production in Indonesia encourages greater participation of farmers in cane growing. Before 1975, planting and processing of sugar cane were done solely by sugar mills. It will be useful to find out the responsiveness of cane growers, e.g., farmers or sugar mills to price incentives.

2. The Institutional Setting

To understand the production side of the Indonesian sugar industry, it is necessary to describe the institutional setting and look at the role of two economic agents, the sugar mills and farmers, and the government in influencing the decision of the agents.

Before 1975, sugar mills were a producing agent, managing their own plantations on rented land and processing cane into centrifugal

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sugar.[1] In the post-1975 period, sugar mills in Java mainly served as millers and managed a relatively small area. At present, mill-owned plantations account for only one-fifth of the total area of cane milled by sugar mills.

Farmers can be divided into two groups: the traditional cane growers and those under the intensification program. Traditional growers have been growing cane for a long time, mostly on unirrigated land in a few regions. They are mostly self-financed and their produce are milled only by a few sugar mills. The traditional cane grower has a choice between processing his cane into centrifugal sugar or traditional sugar *(gula merah)*. On the other hand, farmers under the intensification program are mostly those who used to lease their land to the mills in the pre-1975 period; at present they have become cane growers on their own land under the supervision of sugar mills and with the help of loans from the government banks. Farmers under the intensification program are compelled to send their cane to the mills to assure mills of a steady supply of cane.

The government plays an important role in influencing the sugar industry, owning 54 out of 59 mills (state enterprise and semi-government owned). On financing, the government invests in the sugar mills and finances them through credit for working capital. In marketing, the government through BULOG, is sole buyer, importer and distributor of centrifugal sugar. Aside from these roles, the government fixes annually the producer price known as *provenue* price. Four government agencies implement these tasks, namely: the Ministry of Agriculture for production; Ministry of Finance for pricing and financing the government investment on sugar and control; Bank Bumi Daya for financing of sugar mills and Bank Rakyat Indonesia for credit financing to small farmers under the intensification program; and BULOG which is assigned as sole importer and distributor and as of 1981 as sole buyer for domestic sugar. Aside from these agencies, there is a newly-founded Board — the "Dewan Gula Indonesia" — which is assigned for production expansion.

[1] Most of the sugar mills do not have enough land. Neither do they rent on long-term basis (more than one harvest). In addition, they are allowed to rent irrigated land from farmers for one harvest period under a three-year turnover compulsory leasing system. In 1975 through Presidential Instruction No. 9/1975, government encouraged greater participation of small farmers by not compelling them to lease their irrigated land, but instead requiring them to grow cane to be sent to the sugar mills under a production sharing system. Under this policy, farmers receive subsidized credit from Bank Rakyat Indonesia (the government bank) for planting cane and cost of living loans during the period that they have no income from cane production.

3. Review of Empirical Studies on Supply Response

The supply response model, specifically the area response model, has been used widely for studying agricultural supply functions. Since output is a product of area harvested and yield, output response can be decomposed into area response and yield response.[2] The reason for using the area response lies in the fact that agricultural output is determined by natural as well as economic factors, and if the yield response is small, the area response is an appropriate estimate (at least a lower bound) of supply output response (Scandizo and Bruce, 1980).

Perennial crops may be distinguished from food crops because of: (1) the long gestation period between initial input and first output, (2) an extended period of output flowing from the initial production or investment decision, and (3) eventually, a gradual deterioration (usually) of the productivity capacity of plants (French and Mathews, 1971). In the case of cane, either new planting or growing the ratoon and uprooting annually after the first cutting is possible. Some properties of tree crops are common.

The empirical model used in this study is drawn from Nerlove's supply response analysis. The application of Nerlove's supply response for sugar cane has been done in India by Nowshirvani (1962), Krishna (1963) and several other authors; in the Philippines by Askari (1973) and Ilag (1970); and in Indonesia, by Gunawan (1977). Nowshirvani pioneered the work on the supply response of sugar, basically employing the Nerlovian model by including longer price lagged variables to capture the nature of cane as an annual perennial crop. Nowshirvani's findings indicated farmers did respond to the sum of two consecutive lagged prices. On the other hand, Krishna also applied the basic Nerlovian partial adjustment model, but treated one-year and two-year lagged prices (P_{t-1} and P_{t-2}) separately as independent variables and found this useful since farmers responded differently. The study done by Ilag in the Philippines employed the simple one-year lag of sugar price, wage rate and rice price as competitive crop prices. Since the Philippines is an exporting country with the U.S. as the main market for her sugar exports, Ilag considered the U.S. quota as an explanatory variable. Askari's

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[2] Given output $Q = AY$, it is possible to decompose $\frac{\partial Q}{\partial P} \cdot \frac{P}{Q} = \frac{\partial A}{\partial P} \cdot \frac{P}{A} + \frac{\partial Y}{\partial P} \cdot \frac{P}{Y}$. Hence, total output elasticity with respect to price can be decomposed into area and yield elasticities with respect to price. See Pan A. Yotopoulos and Nugent (1970).

study for the Philippines found that the basic Nerlovian expectation equation did not yield satisfactory results. He suggested that expected normal price is equal to one-year lagged price plus the price change from two-year lagged period.

The findings of Gunawan (1977) for Indonesia showed that farmers did not respond to price since the coefficient was not significant. On the other hand, the sugar mills did respond to wholesale price negatively, and the coefficient was statistically significant. The negative response of sugar mills could be due to the definition of the price variable. Sugar mills were not paid the wholesale price, but instead received the *provenue*[3] price which does not necessarily increase with an increase in the wholesale price.

Most of the studies done so far have been more concerned with the area response; this is presumably due to the assumption that farmers' yield response to price is marginal. The only exception is Ilag's study (Philippines) which found a very high response, indicating that the elasticity with respect to wholesale price is greater than one. This finding therefore supports the need to estimate yield response, especially for cane, as annual perennial crops.

4. The Model, Data and Estimation

Given the two different types of cane planting, it seems reasonable to separate the analysis into sugar mills' and farmers' responses. The distinction is not only in the ownership, but also in the technology used, the type of land utilized, and prices faced by sugar mills and farmers during the period under study.

4.1 *Sugar Mill's Area Response*

Sugar mills in Indonesia are mostly state-owned enterprises whose production activities have been restricted by several regulations. Land allocation used to be regulated by the three-year turnover system (one cane-growing period every three years) and from 1967 to 1975, the rent level was fixed by the government. Furthermore, the output must be sold at government purchase price.

Although cane is a perennial crop, the sugar mills cannot take advantage of growing a ratoon crop, because they must return the

[3]The term *provenue* is defined as the price (amount) received by sugar mills as a producer's price. Before 1969 it was calculated from the ex-mill price (price at which the mill sells to wholesalers) after deducting taxes, funds and bags' costs. After 1969, *provenue* was fixed annually, and the ex-mill price was also fixed based on *provenue* plus fees.

rented land to the farmers after the first cutting. They can only practice the ratoon system on their own lands which account for less than one-fifth of the total land area planted by the sugar mills; these lands are used for factory complexes, experiments and growing cuttings.

In Indonesia where sugar mills face only the government-fixed price and where their plantations are on rented land, numerous institutional factors prevent the desired area response from being realized. To adjust to their desired response, sugar mills require time because the lease contract can not be changed once the terms have been set and the contract signed. The lease contract for the coming year's harvest is usually signed during the end of the wet season (between January and March) and the planting takes place after the wet season crops' harvest. Given this situation, the partial adjustment model is therefore an appropriate basis for constructing the model.

Sugar mills do not practice the ratoon system, and face a single-harvest expectation. Hence, based on the standard partial adjustment model which assumes expected normal price to be equal to last year's price, the area response for sugar mills can be constructed in the following equation:

$$(1) \qquad ASM_t = a_0 + a_1 PS_{t-1} \partial_2 PC_{t-1} + a_3 ASM_{t-1} + e_t$$

where :

ASM : area harvested under sugar mills plantation

PS : price of sugar (*provenue* price deflated by cost of living index excluding rice)

PC : price of competitive crops (weighted average of rice, corn and cassava deflated by the same deflator as price of sugar

t : time (year)

e : error term[4]

Equation (1) states that the current area of sugar cane harvested depends on the lagged prices of sugar *(provenue)* and competitive crops, and on a one-year lag of the area. The expected sign of a_1 and a_3 is positive, while that of a_2 is negative.

Since the recorded data are on area harvested, not on area planted, data on the former must be used, and it must be assumed

[4] The weighting factors calculated are based on the composition of value output of these three crops in Java during 1960-1981. The average shares are: rice = 0.62, corn = 0.15 and cassava = 0.23.

that area harvested is equal to area planted. When dealing with data on the harvested area, it is held that the decision to plant was made in the previous year. The information used in making the decision to produce is based on the year when planting takes place. Since the government announces the new *provenue* price at the harvest season, and planting starts 2-3 months after harvest, the one-year lag in price is considerably appropriate. The price of substitute crops, while not directly affecting the area planted or harvested, affects the decision of farmers on whether or not to lease their land. The price of substitute crops can also be interpreted as a proxy for the opportunity cost for the farmer of leasing their land to sugar mills.

As an alternative to the one-year lagged sugar price, the current *provenue* price is also tested. Since sugar mills prepare annual budgets, and therefore estimate their cost of production for the coming milling year, and because of their direct tie-up with the Ministry of Agriculture which fixes *provenue* price, it is reasonable to assume that sugar mills have an idea about the *provenue* price in the coming milling year. This is the basis for hypothesizing a relationship between current *provenue* price and area harvested.

To grasp the effect of a change in government policy, an intercept dummy variable that captures the effect of the intensification program is introduced. Since the intensification program changed the rent system, we can expect a negative effect of this policy on area harvested of sugar mill-owned plantations.

The weather factor is not included in the area response since the sugar mills can not cancel the lease contract at the end of the wet season once they sign it; this factor can only possibly delay planting. Furthermore a study on Indonesia has shown that rainfall did not significantly affect the area harvested (Gunawan, 1977).

4.2 *Farmers' Area Response*

Small farmers have more choices in planting, harvesting, and selling their cane or sugar than the sugar mills. Many factors affect their decision to plant and to harvest. As in the case of sugar mills, the reported data are only on area harvested of farmers' cane milled at the sugar mills, which accounted for only 30-60 per cent of total area harvested by farmers. Farmers can send their produce to the mills to be processed under output sharing, or sell them in cane form, or have the cane processed traditionally as *gula merah*.[5] Since farm-

[5] *Gula merah* is brown sugar which is processed traditionally and formed inside a coconut shell. It is similar to *panocha* in the Philippines.

ers practice the ratoon system in cane planting, one must therefore take into account that sugar cane is a perennial crop.

In constructing the model, two decisions should be considered: the decision to plant or grow ratoon and the decision to harvest based on information between the two periods. Farmers, especially free farmers, are free to sell their output, using the retail price as a proxy for the highest price level they could get.

To capture the nature of perennial crops in the standard Nerlovian partial adjustment model, price lags for two consecutive years will be included. The partial adjustment model of an extended Krishna's form of price expectation will be tested.

Using lagged prices of two consecutive years and current price, the farmers' area response of sugar cane sent to the mills can be written in the following form:

$$(2)\quad ASF_t = b_o + b_1 PSG_t + b_2 PSC_{t-1} + b_3 PSC_{t-2} + b_4 ASF_{t-1} + e_t$$

where :
ASF : area harvested of farmers' cane sent to the sugar mills
PSG : price of sugar relative to *gula merah* (retail levels)
PSC : price of sugar relative to food crops (retail levels)

and the rest as in the previous equation. Equation (2) expresses the area harvested as a function of current price of sugar relative to *gula merah*, one- and two-year lagged prices of sugar relative to the prices of food crops, and lagged area. The variable *PSG* reflects the decision of farmers to either send their harvest to the mills to be processed into sugar or process the cane traditionally into *gula merah*. Therefore, the expected sign of b_1 is positive since a higher sugar price relative to *gula merah* will encourage farmers to send their cane to the mills.

Both the one- and two-year lagged *PSCs* reflect the opportunity cost of farmers to grow cane as compared to food crops. For this purpose, food crops are measured in terms of the weighted average of the prices of rice, corn and cassava.[6] In this case, it is expected that a high price of sugar relative to food crops will positively affect area planted to cane, such that the expected sign of b_2 and b_3 is also positive. The inclusion of two consecutive lagged prices is to capture the nature of cane as a perennial crop where ratooning is possible and cane-growing takes more than a year. In

[6] The weighing factors are the same as in the footnote to equation (1).

Java, free farmers usually plant cane on unirrigated land (*tegal* and *sawah*) which has a different planting season. For *tegal* land, planting is done at the beginning or the end of the wet season i.e., between October and April (Djojosuwardho, 1981). With this schedule, they get second priority in milling, so their cane is milled early or late in the milling period when the sugar mills are not in the peak of their own cane processing.

To capture the effect of government policies during the period under study, two dummy variables are introduced: *first*, a dummy variable to capture the effect of the intensification program where 1976-1981 = 1, otherwise = 0; and *second*, a dummy to capture the effect of a change in marketing system where 1971-1981 (marketing under BULOG) = 1, otherwise = 0. Under the BULOG era, market price is stable. We can therefore expect a smaller price differential between harvest and off-harvest seasons, i.e., for a given annual average price, there could be different price levels during a certain period (planting), and this could have an effect on response.

4.3 *Yield Response Function*

Although some authors have neglected the yield function because its response is typically small, this study explores the yield function in explaining the declining yield. Yield is basically determined by natural factors and influenced by technology and prices of inputs.

The efforts of sugar mills or farmers to change yield as a result of changes in output and input prices are made on cane already planted. When farmers decide to plant they consider input prices, but the decision to put in greater effort and more money on the standing crops depends on expenses relative to expected returns. Current costs are known to farmers or planters during the growing period, but the price of their output is subject to uncertainty. The only information made available during the growing period is the price already fixed by the government. Therefore the ratio between input and output prices available during the growing season will affect the yield. The input prices are represented by two main inputs, namely: wages and the price of fertilizer relative to the price of sugar. We are asked to use two different price ratios, namely: wage to sugar price, and fertilizer to sugar price.

Variety is also considered an important determinant of yield. We expect the composition of the standing varieties to affect the yield. The problem is how to measure this variable properly as there

are many varieties introduced and rejected. To some extent, the weighted average of potential productivity at experimental field as a proxy for sugar cane varieties is considered appropriate.

Aside from these factors, natural factors such as weather heavily affect agricultural crops like cane. One measure of the weather variable that is commonly used is rainfall. Rainfall affects yield in two different ways. During the growing period, rainfall positively affects the cane output by increasing the number of tons of cane. Better water content in the soil during the growing period helps make the plants healthier, especially during the critical months of the driest period, July-December (BP3G-Pasuruan, 1977). In the three-month period at the start of the harvest season, higher rainfall will negatively affect the yield by reducing the sucrose content (Djojosuwardho, 1981). In view of this, the effects of rainfall during these two periods are distinguished.

Soil type and quality also determines yield, but this study was not able to obtain quantitative information on the composition of the land used. Land available for agriculture is fixed and most probably decreases as tracts of crop fields are converted to buildings and settlements. The additional land devoted to cane, given other factors, is expected to diminish in quality. We expect total area devoted to cane to have a negative effect on yield.

Based on the discussion above, the yield response functions are constructed in the following form:

$$(3)\quad YSM_t = c_o + C_1 RFA_t + c_2 RFA_{t-1} + c_3 RWS_{t-1} + c_4 RFS_{t-1} + c_5 SGV_{t-1} + c_6 AST_{t-1} + V_t$$

where :

YSM	: yield of sugar mill-owned cane
RFA	: monthly average rainfall
RWS	: ratio between wages and sugar price
RFS	: ratio between fertilizer price and sugar price
SGV	: sugar cane varieties
AST	: total area devoted to cane
V	: error term.

The only difference between estimating equations for farmers and mills lies in the use of SGV as an explanatory variable. Usually, farmers get their cuttings from sugar mills and the only record available is that on the sugar mill-owned plantations; it is plausible to

think that farmers will use the new variety only after a one-year lag. Therefore the variable *SGV* will have a two-year lag.

As an alternative measure to the variable to capture the effect of technological change *(SGV)*, the extraction rate *(ER)* is introduced. This measure reflects both the productivity of varieties and the quality of mills since the extraction rate depends on variety of cane, age of cane at harvest, the moisture content, and the milling facilities.

4.4 *Data and Estimation Procedures*

In estimating area response and yield response functions, time-series data covering the period 1960-1981 are used. Data on area, yield and variety composition are obtained from the Indonesian Sugar Experiment Station (BP3G) in Pasuruan, which provides more reliable figures because it has a strong tie-up with sugar mills. The data on prices, rainfall and wages are obtained from the publications of the Central Bureau of Statistics (CBS), Bank of Indonesia, and BULOG (National Food Authority).

The specification and measurement of variables are as follows:

ASM = Area harvested of sugar mill-owned plantation; expressed in hectare per year of milling year.

ASF = Area harvested of farmers' cane which are sent to the mill to be processed (either through output sharing, or purchased in cane form); measured in terms of hectares per milling year.

PS = Price of sugar, measured in Rupiah/100 kg; deflated by cost of living index excluding rice with base year 1970 = 100. The deflator is defined as

$$NRI = \frac{COL_t - W_{rt}P_{rt}}{1 - W_{rt}} \times 100,$$ where COL_t, W_{rt} and P_{rt} are cost of living, weight and price index of rice respectively, and *NRI* is the Non-Rice Index. Two kinds of prices will be used in this study namely: *provenue* price and retail price. The retail price is that recorded at the urban market (Jakarta).

PC = Price of competitive crops; measured using weighted average of three commodities, namely: rice, corn and cassava. All prices were obtained at retail level in the rural markets of Java and Madura, and are therefore closest to producer prices. The weighting factors are culculated based on the composition of the average value of production of the three commodities in Java during 1960-1980. The weight obtained was 62 per cent for rice, 23 per cent for cassava and 15 per cent for corn; all prices were deflated by *NRI*.

PSG = Price ratio of sugar to *gula merah*, both at retail and market prices in Jakarta.

PSC = Price ratio of sugar to food crops, at retail level.

RWS = Ratio of wages to sugar price. Weekly wages of labor on estates are used since these are the only available series covering sugar plantations.

RFS = Ratio of fertilizer price to sugar. The fertilizer price for 1960-1970 was calculated based on import price plus 50 per cent cost of distribution, while that for 1971-1981 was based on market price (usually the same as the government's fixed price).

RFA = Rainfall, measured as average monthly rainfall from two cities: Surabaya and Semarang. This is the only available series, and since sugar mills are concentrated around these two big provinces, we consider it an appropriate proxy for the whole area. *RFA* is separated into two periods: one-year lag and current period. The one-year lag was calculated for 12 months of April to March during which planting and growing activities usually take place. The current period is the monthly average during the eight months of April to November as milling season. Rainfall is measured in millimeter/month.

SGV = Sugar cane varieties, measured as weighted average of productivity which takes the yield at experiment station as a measure of potential productivity, and the composition of varieties planted by sugar mills being used as weighting factors. This variable can be formulated as

$$SGV = \sum_{t=1}^{k} a_{it} \cdot Y_i^*$$

/here a_{it} is the percentage of variety i planted at year , and Y_i^* is potential yield obtained by variety i at experiment tation. The varieties included are eight types of main varieties ex- ensively introduced and with high potential yield.[7]

The area response model uses lagged dependent variable as one xplanatory variable, and is estimated from time-series data; pre- umably therefore, the serial correlation problem exists. The estima- ion is done under SAS (Statistical Analysis System) Package Pro- ram using GLM (General Linear Models) procedure.[8] To correct erial correlation the yield response function is estimated using Autoregressive Method. The AUTOREG model is similar to the Cochrane Orcutt procedure and is equivalent to generalized least quares estimates with appropriate weights.[9]

5. Estimation Results

5.1 *Sugar Mills*

The estimated regression equations for the sugar mills' area res- onse function are presented in Table 1. In all equations estimated, wo variables which always appear as statistically significant are the agged area harvested, and the dummy for the intensification pro- ram. As expected, the coefficients on lagged area all have a posi- ive value of less than one. On the other hand, the dummy variable hows that during the intensification program (1976-1981), the area

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[7]These varieties are POJ 3016, POJ 3067, POJ 2978, POJ 2961, PS 8, PS 30, PS 35 and PS 41.

[8]The computational method consists of *first* solving normal equation $X'X\beta = X'Y$ using a modified sweep routine that produces a generalized (G2) nverse $(X'X)$ and a solution $\beta = (X'X)^{-} X'Y$. *Then* for each effect in the model, matrix L is computed such that the rows of L are each linear combination of the rows of $X'X$. Test of hypothesis $L\beta = O$ are made by first computing $S\ (L\beta = O) = (L\beta)'\ (L(X'X)^{-}L')^{-1}(L\beta)$, then the F statistics are computed using he error mean square. See SAS user's guide 1979 edition, SAS Institute Inc., North Carolina, pp. 237-263.

[9]The estimation procedure is as follows: Let $Y_t = X_1\beta + U_t$, where $u_t = {}_t - a_1\ U_{t-1} - a_2U_{t-2} \ldots - a_qU_{t-q}$. First, the OLS is applied to compute the oefficient of autocorrelation. The Yule-Walker equations are solved to obtain stimates of the autoregressive parameter and a preliminary estimate of a. Using utocorrelation coefficients, the data are transformed into $Z_t = X_i + \Sigma\ a_i\ X_{t-i}$. Then the parameters and variances of β are estimated using transformed data.

Table 1 — Estimated Regression Equation of Sugar Mills' Area Response Function

Dependent Variable: Area harvested of cane owned by sugar mills (hectares)

	Selection 1	Selection 2*	Selection 3**	Selection 4*	Selection 5	Selection 6
1. Intercept	8,951	8,902	8,303	7,459	8,473	3,066
	(0.810)	(0.770)	(0.580)	(0.690)	(9.860)	(0.260)
2. PS_t	—	—	—	−0.277	−0.070	—
				(−0.330)	(−0.080)	
3. PS_{t-1}	0.128	0.121	10.906	—	—	—
	(0.130)	(0.130)	(0.290)			
4. PC_{t-1}	−0.291	−0.122	—	−0.606	—	—
	(−0.130)	(−0.100)		(−0.510)		
5. Lagged Area	0.899	0.898	0.892	0.976	0.904	0.941
	(5.900)[1]	(5.930)[1]	(6.160)[1]	(7.370)[1]	(6,360)[1]	(5.600)[1]
6. Dummy Intensification	−9,952	−9,922	−10,022	−10,692	−9,680	—
	(−2.890)[1]	(−2.830)[1]	(−3.170)[1]	(−3.440)[1]	(−3.230)[1]	
R^2	0.756	0.756	0.757	0.821	0.756	0.611
$\bar{R}^2$	0.699	0.699	0.716	0.791	0.715	0.592
F	13.17	13.16	18.65	14.29	18.55	31.40
Durbin-h#	−1.341	−1.313	−1.201	−1.251	−1.233	−1.722

*Competitive crop represented by rice price.

**PS_{t-1} measured in terms of relative price to PC_{t-1};

t-statistics in parentheses, [1]significant at 1 per cent, [2]significant at 5 per cent and [3]significant at 10 per cent level of significance.

#Durbin-h is used to test for the serial correlation with the lagged dependent variable. All estimated equations appear to accept the null hypothesis on the z-test at 5 per cent level, that is, there is no serial correlation.

vested by sugar mill-owned plantations decreased. This was ected since during the period under the intensification program 976-1981), the land rent on irrigated land was reduced gradually, reasing the land allocated for leasing; the reduction was com- ted by 1981. On the average, this policy decreased the area nted by sugar mills by about 10,000 hectares as indicated by the gative coefficients of regression on the dummy variable for inten- cation.

Regarding the role of price as an explanatory variable, the find- gs showed that the sugar mills did not respond to the *provenue* ce. The insignificance of price in the area response function could due to the nature of sugar mills which probably ceased to be pro- maximizing agents; instead, they just maintain a certain level of oduction as targeted or planned by the Ministry of Agriculture. was also found that price of competitive crops did not affect the ea as the regression coefficient was statistically not different from ro; however, the sign as expected was negative. Competing crops l not affect the decision to plant or to harvest; they only reflected e opportunity cost to the farmers of leasing land to the sugar mills.

2 *Farmers*

The estimated regression equation of farmers' area response as esented in Table 2 shows that all fitted regression lines have F- tistics which are significantly different from zero at a high level 1 per cent.

Selections A1 and A2 are estimated for free farmers using two nsecutive lagged prices, current price, lagged area, and intercept mmies for intensification and marketing as the explanatory varia- es. In Selection A1, the price ratio of sugar to *gula merah* has a sitive sign and is statistically significant at the one per cent level. ne one-year lagged price of sugar relative food to crops appears with negative sign, but is statistically insignificant, while two-year lagged ice has a positive sign and is also not significant. Lagged area pectedly has a positive sign with a value of less than one and is tistically significant at a very high level of one per cent. The dum- es for intensification and marketing appear with positive signs, but e statistically insignificant.

Selection 2 which excluded dummy variables for intensification ogram and marketing under BULOG yielded a better result than lection A1. In Selection A2, PSG_t appears with a positive sign and statistically significant at the one per cent level. PSC_{t-1} has the same

Table 2 — Estimated Regression Equation of Farmers' Area Response Function

Dependent Variable: ASF (Area harvested of farmers' cane sent to sugar mills; in ha.)

		A. Free Farmers		B. All Farmers	
		A 1	A 2	B 1	B 2
1.	Intercept	−1,693 (−0.300)	−4,629 (−1.100)	−6,497 (−1.030)	−8,706 (−1.710)
2.	PSG_t	37.746 (3.080)[1]	37.659 (3.700)[1]	67.550 (3.420)[1]	67.620 (3.460)[1]
3.	PSC_{t-1}	−2.472 (−1.110)	2.735 (0.140)	−12.068 (−0.450)	−5.740 (−0.230)
4.	PSC_{t-2}	27.792 (1.170)	36.717 (1.830)[3]	22.355 (0.980)	31.315 (1.250)
5.	Lagged Area	0.515 (3.160)[1]	0.571 (4.030)[1]	0.808 (10.280)[1]	0.800 (10.730)[1]
6.	D-Intensification	343 (0.110)	—	20,644 (5.440)[1]	22,570 (6.050)[1]
7.	D-Marketing	2,209 (0.670)	—	3,719 (0.840)	—
	R^2	0.813	0.804	0.988	0.988
	$\bar{R}^2$	0.727	0.758	0.992	0.984
	F	10.890	17.430	199.590	266.530
	Durbin-h[a]	0.572	0.951	−0.459	−0.268

t-statistics in parentheses; [1]significant at 1 per cent, [2]significant at 5 per cent and [3]significant at 10 per cent level of significance.

[a]Durbin-h statistics indicate that there are no serial correlation.

positive sign but is statistically insignificant, while PSC_{t-2} yields a positive sign and is statistically significant at the 10 per cent level. Lagged area yielded a positive sign of less than one which is statistically significant, but it is slightly greater than that obtained in election A1.

These findings show that current price ratio of sugar to *gula nerah* has a strong influence on area harvested of farmers' cane. This is not surprising for the free farmers who have more flexible choices for their harvest. On the other hand, one- and two-year lagged prices of sugar relative to food crops do not have a strong effect compared to the relative price of sugar to *gula merah*. It was also found that the two-year lagged price has more influence than a one-year lag, the reason being that free farmers usually grow cane on unirrigated land where planting takes place at the end of year *t-2* or at the first quarter of year *t-1*. This finding is similar to Krishna's (1977) finding for India and Pakistan that as planting begins in March but preparation for planting starts earlier (December-March), a two-year lagged price has a stronger effect on area.

Selections B1 and B2 are estimated for all farmers including those under the intensification program in 1976-1981. Results of the Chow-test indicated that the parameters obtained from A and B differ from one another. In general, the estimated regression equations for all farmers performed a better $\bar{R}^2$. Three variables that appear statistically significant in both selections are: relative price of sugar to *gula merah*, lagged area, and dummy for intensification program.

Selection B2 is better than B1. In selection B2, the price of sugar relative to *gula merah* appears statistically significant at the one per cent level and has a bigger value compared to the coefficient obtained from free farmers. The relative prices of sugar to food crops for one- and two-year lags appear statistically insignificant, and have a negative and a positive sign, respectively. Although both are statistically insignificant, the two-year lagged relative price of sugar to *gula merah* has a better t-statistic than a one-year lag. The insignificant effect of PSC (relative price of sugar to food crops) could be due to the compulsory nature of the program.

The coefficient of lagged area for all farmers has a positive sign and is less than one, as expected, and the size of this coefficient is greater than that of free farmers. This means that the intensification program slows down adjustment to the desired responses,[10] under-

[10] The coefficient of regression on lagged area is $a_i = (1 - \gamma)$; therefore higher a_1 implies lower γ. Since γ is a measure of the adjustment process, lower γ means that the adjustment to the desired response will take a longer period.

standably so since farmers under the intensification program are partly under compulsion. The intensification dummy to capture the effect of the intensification program always appears highly significant and the coefficient is found to be greater than the effect of the intensification program in the reduction of sugar mill-owned area (see Table 1).

To sum up, farmers respond to both price at planting period (sugar/food crops) and price at harvest (sugar/*gula merah*). The effect of lagged area is greater for all farmers than for free farmers only; this is partly because of the compulsion and partly because of the larger area under ratoon system. The change in marketing system under BULOG does not affect farmers' area responses. The intensification program tends to slow down the adjustment to desired response. Finally, the intensification program increases the area of farmers cane, and the increase is double the decrease in the area formally operated by the sugar mills.

5.3 *The Elasticity of Area Response*

One of the purposes of estimating the supply response function is to measure the responsiveness of area harvested. One measure of the responsiveness is the price elasticities presented in Table 3.

Table 3 — Estimated Elasticities at Mean and 1976-1981 of Area Harvested of Farmers' Cane with Respect to Price#

No.	Definition of Price	Year Lagged	At Mean Short Run	At Mean Long* Run	1976-1981 Short Run	1976-1981 Long* Run
A.1	Sugar/*gula merah*	Current	0.269	0.627	0.312	0.729
A.2	Sugar/food crops	One-year	0.016	0.037	0.007	0.016
A.3	Sugar/food crops	Two-year	0.402	0.937	0.299	0.698
B.1	Sugar/*gula merah*	Current	0.249	1.245	0.166	0.832
B.2	Sugar/food crops	One-year	—0.033	—0.166	—0.014	—0.071
B.3	Sugar/food crops	Two-year	0.177	0.885	0.076	0.378

#The estimation is based on equations A2 and B2 of Table 15. A for free farmers and B for all farmers (including those in the area under the intensification program).

*The long-run elasticities were calculated by dividing the short-run coefficient with the coefficient of adjustment. The coefficients of adjustment obtained from Table 16 are 0.429 for free farmers and 0.200 for all farmers.

Table 3 indicates that short-run farmers' area elasticities with
ject to prices are less than unity, and therefore considerably
astic. Calculations of the elasticities for 1976-1981 indicate
; these elasticities are lower than those at the mean, except
sugar/*gula merah* which yielded a higher value for free farm-
As indicated by A.1, it appears that even though free farmers
respond to the price ratio of sugar to *gula merah*, the coeffi-
its are inelastic, meaning that the possibility of substitution
ween cane sent to the sugar mills and that processed traditional-
nto *gula merah* is limited. The reason for the inelastic response
ld be the limited capacity of the traditional processing indus-
, as well as, the limited market for *gula merah* as compared to
ar. With the inclusion of the area under the intensification pro-
m for 1976-81 (period under program), as indicated by B.1 which
maller than A.1 for short run, and as a result of slow adjustment,
long-run farmers' area response to price of sugar/*gula merah*
ame elastic. This finding is reasonable since it is only the free
ners who have choices while the intensification program farmers
st send their cane to the mills.

The relative price between sugar and food crops lagged for two
rs appears with a positive sign and the elasticities at mean are
02 for free farmers and 0.177 for all farmers. As indicated by A.3
l B.3, the long-run elasticities are sharply different as a result of
ferent estimated coefficients of adjustment for the free farmers
l all farmers. The long-run estimate for free farmers is 0.937 while
t for all farmers is 0.885. The response of all farmers to a one-year
ged price is negative but insignificant, and the elasticities are close
zero.

In the short run, at mean, the response of free farmers' is higher
n all farmers', and for the period under the intensification pro-
m (1976-1981), free farmers become more responsive compared
all farmers. One important finding of the elasticity estimates is
it during 1976-1981 which represents the period near the comple-
n of the intensification program, the response seemed to be less
rtly due to the compulsion of the program. For free farmers, the
cision to plant is reflected in their response to two-year lagged
ce. This is usually done early in the rainy season (which is the
ter part of the year, two calendar years before). The long-run elas-
ities both appear to be inelastic as shown by A.3 and B.3 in
ble 4; this indicates that farmers' response is not considerably
stic. Therefore government pricing policy can affect the deci-
n of farmers to grow cane, but the role of price in increasing
oduction is only limited.

Table 4 — Estimated Regression Equation of Sugar Mill Yield Response*

Dependent Variable: Yield of sugar mill owned cane (100 kg./ha.)

		Selection 1		Selection 2		Selection 3	
		OLS	AUTOREG	OLS	AUTOREG	OLS	AUTOREG
1.	Intercept	608.956	562.236	− 64.693	− 54.253	100.032	111.051
		(2.102)[2]	(1.890)[2]	(−1.768)[2]	(−1.369)	(8.140)[1]	(8.709)[1]
2.	RFA_t	0.004	−0.006	0.084	0.078	−0.012	−0.0268
		(0.071)	(−0.115)	(1.885)[3]	(1.710)	(−0.190)	(−0.503)
3.	RFA_{t-1}	0.187	0.142	−0.070	−0.045	0.186	0.131
		(2.678)[2]	(2.389)[2]	(−0.587)	(−0.697)	(2.497)[2]	(2.144)[2]
4	SGV_t	−3.461	−3.095	—	—	—	—
		(−1.758)	(−1.519)				
5.	ERS_t	—	—	16.728	15.929	—	—
				(4.617)[1]	(4.182)[1]		
6.	RWS_{t-1}	0.616	−0.507	−0.637	−0.568	−0.431	−0.350
		(−2.395)[1]	(−1.856)[3]	(−3.719)[1]	(−3.060)[1]	(−1.021)	(−1.320)
7.	RFS_{t-1}	0.065	0.048	0.098	0.085	0.057	0.036
		(1.237)	(0.901)	(2.546)[2]	(2.139)[2]	(1.021)	(0.652)
8.	AST_t	−0.0008	−0.0007	−0.00007	−0.00008	−0.0003	−0.0003
		(−2.761)[2]	(−2.525)[2]	(−0.856)	(−0.984)	(−3.668)[1]	(−3.257)[1]
	F	4.480	3.960	11.513	3.043	4.209	3.895
	$\bar{R}^2$	0.642	0.613	0.822	0.549	0.568	0.549
	R^2	0.499	0.458	0.750	0.368	0.433	0.408
	DW	1.220	—	1.338	—	1.126	—

t-statistics in parentheses; [1]significant at 1 per cent, [2]significant at 5 per cent and [3]significant at 10 per cent level of significance.
*The dummy variable to capture the effect of intensification program had been tried and found insignificant.

1 *Sugar Mills' Yield Response Function*

The estimated yield response function of sugar mills is present- in Table 4. The Durbin-Watson statistics obtained from OLS indi- :e the presence of serial correlation. To correct serial correlation, JTOREG is used, and the results obtained from both methods are)orted in Table 4.

Selection 1 was estimated using the original model. Results re- ıled that except for *SGV* and *RFS*, all the signs of the regression efficients were as expected. The explanatory variables which appear .tistically significant at the 5 per cent level are: one-year lagged nfall and total area devoted to cane. The *SGV* yielded a negative)ugh insignificant result; this is seen to be related to the lower ality of land and lower treatment in the field. Though the varieties ınted have higher potential productivity, they do not result in high)ductivity when planted on lower quality of land. The wage-sugar .ce ratio negatively affects the yield but is only statistically signi- ant at the 10 per cent level. When wage is high relative to sugar price, gar mills tend to reduce their expenses on inputs by lowering pro- ctivity. On the other hand, the fertilizer-sugar price ratio yields a sitive but insignificant sign. This might be because fertilizer price had en subsidized at a fixed rate from 1971 to 1980. Or this might be e to the small share of fertilizers to total expenses (8-10 per cent total planting cost) relative to wages and land rent expenses. Also, ere is a biological limitation to increased use of fertilizers which o affects sucrose content. The total area devoted to cane appears nificant and negative. This implies that marginal land is of lower ality, and supports the hypothesis that as sugar mills and farmers pand the area, they use lower quality land.

Selection 2 was estimated using *ERS* (extraction rate) as a easure of variety changes instead of *SGV*; the results do not appear perior to Selection 1. The *ERS* positively affects the yield; it is sta- tically significant at the 1 per cent level. From selection 2, it pears that *RWS* still gives the same effect as in Selection 1 and elds a statistically significant coefficient. Although the *RFS* yields better t-statistic and level of significance, the sign is contrary to pectations.

In selection 3, two variables which appear as significant deter- nants of sugar mills' yield are one-year lagged rainfall and tota ea devoted to cane.

The important finding from the sugar mill's yield function is at one-year lagged rainfall, the wage-sugar price ratio (one-year

lagged) and total area devoted to cane are the main determinants of yield. This seems to support the hypothesis that sugar mills expand their area on lower quality land. Sugar mills respond to the wage-price ratio by improving yield, although the response is quite inelastic.[11]

5.5 *Farmers' Yield Response Function*

As in the case of sugar mills, the farmers' yield function obtained from the OLS method suffered from a serial correlation problem; therefore the AUTOREG method was employed. Among the three selections presented in Table 5, Selection 2 is statistically superior.

From Selection 2, two variables which performed contrary to expectations are the fertilizer-sugar price ratio and total area devoted to cane. The current average rainfall has a positive sign, but is statistically significant only at the 10 per cent level. This result could be due to the fact that farmers' cane mostly occupies unirrigated land, and in the dry season (April-October), there is a need for enough water to sustain cane growth. Therefore the higher the amount of rainfall during this dry period, the higher the yield. The effect of average rainfall from the previous year is found to be insignificant; this could be because cane planting in unirrigated lands takes place during the rainy season. Therefore rainfall is not an important factor during the growing period.

The extraction rate is statistically significant and has an important positive effect, since it has an elastic effect on yield. The elasticity of the extraction rate on yield at mean is 1.57, which means that an increase of 1 per cent in the extraction rate will bring about an improvement in yield by one and a half per cent.

The wage-sugar price ratio has a negative sign that is statistically insignificant. This may be explained by the nature of farmers' cane-growing which is done on a small scale and which utilizes family labor. There is a substitution between hired labor and family labor, and wages become a less important determinant of the yield variation. The fertilizer price relative to sugar has the same positive sign as in the case of sugar mills and is also statistically insignificant. During the seventies, fertilizer price relative to sugar dropped, but fertilizer use can not expand without limit and its contribution

[11] The estimates of yield elasticity with respect to RWS_{t-1} at mean was found to be —0.135, and is therefore considerably inelastic. The elasticity of yield with respect to total area is —0.90.

Dependent Variable: Yield of Farmers' cane milled at sugar mills (100 kg/ha.)

		Selection 1		Selection 2		Selection 3	
		OLS	AUTOREG	OLS	AUTOREG	OLS	AUTOREG
1.	Intercept	−127.519	−89.917	−45.818	−50.294	44.041	45.520
		(−0.440)	(−0.297)	(−1.448)	(−2.047)[2]	(4.145)[1]	(4.007)[1]
2.	RFA_t	−0.051	−0.0490	0.069	0.082	−0.044	−0.042
		(−0.942)	(−0.886)	(1.199)	(1.907)[3]	(−0.832)	(−0.816)
3.	RFA_{t-1}	0.055	0.054	0.022	−0.008	0.064	0.061
		(0.827	(0.832)	(0.040)	(0.192)	(−0.998)	(1.005)
4.	SGV_{t-1}	1.184	0.936	—	—	—	—
		(0.592)	(0.440)				
5.	ERF_t	—	—	8.810	9.190	—	—
				(2.953)[1]	(4.303)[1]		
6.	RWS_{t-1}	0.004	0.002	−0.320	−0.199	−0.124	−0.094
		(0.012)	(0.007)	(−1.695)	(−1.043)	(−0.577)	(−0.402)
7.	RFS_{t-1}	−0.009	−0.018	0.045	0.0193	0.008	−0.005
		(−0.163)	(−0.291)	(1.089)	(0.519)	(0.165)	(−0.107)
8.	AST_t	0.0002	0.00017	0.00016	0.00016	0.00006	0.00008
		(0.807)	(0.630)	(2.348)[2]	(1.978)[3]	(0.854)	(0.647)
	F	0.099	0.851	2.767	5.513	1.064	1.033
	R^2	0.267	0.254	0.525	0.688	0.250	0.244
	$\bar{R}^2$	−0.027	−0.044	0.336	0.563	0.015	0.008
	DW	1.504	—	0.890	—	1.459	—

t-statistics in parentheses; [1] significant at 1 per cent, [2] significant at 5 per cent and [3] significant at 10 per cent level of significance.

in total planting cost is relatively small. This might explain why this factor became a less important determinant of yield.

Surprisingly, the effect of total area devoted to cane on yield is positive and statistically significant. In terms of responsiveness, as measured by the elasticity of the coefficient, it is very inelastic since its elasticity at the mean is only 0.30.[12] The explanation for this finding is that historically, farmers' cane used to be planted on un-irrigated land which is still available with lesser competition to food crops compared to irrigated land. Throughout the period under study, farmers' cane did not experience any significant movement in yield trend, while area devoted to cane experienced a significant increase of about 150 per cent.

The yield function for all farmers which includes farmers under the intensification program for 1976-1981 is presented in Table 6. These equations which were also tested using the Chow-test are shown to be significantly different from free farmers' yield response presented in Table 5. As in the case of free farmers, from the AUTO-REG method, only selection 2 (using the extraction rate as a measure of sugar cane variety) is found to be statistically fit. The current and last year's average monthly rainfall have a positive and a negative sign, respectively, contradicting expectations, but none is statistically significant.

The extraction rate yields a positive sign which is statistically significant at the one per cent level. In terms of responsiveness, the yield's elasticity with respect to the extraction rate is 1.08 (close to unity). This is below the free farmers' yield responsiveness, and could arise from the fact that the area under the intensification program not only has a lower extraction rate but also a lower productivity of cane. The elasticity for the period 1976-1981 is found to be less than unity (0.89), confirming that the declining yield during this period is due more to declining productivity of cane rather than the extraction rate.

The total area devoted to cane yields a positive sign that is statistically significant. The reason is that the inclusion of the areas under the intensification program has pushed farmers' yield higher, because the intensification program occupied irrigated areas which are of better quality land. In terms of responsiveness, the elasticity of yield at mean with respect to total area is only 0.04, which is negligible.

[12] Elasticity estimated for the last six years (1976-1981) is found to be 0.41, which is much greater than elasticity at the mean, but is still inelastic.

(Including Area under Intensification Program)

Dependent Variable: Yield of farmers' cane milled at sugar mills (100 kg/ha.)

		Selection 1		Selection 2		Selection 3	
		OLS	AUTOREG	OLS	AUTOREG	OLS	AUTOREG
1.	Intercept	158.791	209.268	−27.498	−21.527	33.086	41.646
		(0.599)	(0.797)	(−1.294)	(−1.013)	(3.952)[1]	(4.081)[1]
2.	RFA_t	−0.066	−0.062	0.018	0.019	−0.071	−0.071
		(−1.325)	(−1.322)	(0.449)	(0.474)	(−1.497)	(−1.618)
3.	RFA_{t-1}	0.021	0.018	−0.024	−0.036	0.016	0.009
		(0.359)	(0.341)	(−0.647)	(−0.971)	(0.278)	(0.183)
4.	SGV_{t-1}	−0.833	−1.161	—	—	—	—
		(−0.456)	(−0.638)				
5.	ERI_t	—	—	6.823	6.621	—	—
				(3.542)[1]	(3.437)[1]		
6.	RWS_{t-1}	−0.256	−0.239	−0.320	−0.199	−0.166	−0.120
		(−0.910)	(−0.830)	(−1.806)[3]	(−1.123)	(−0.850)	(−0.565)
7.	RFS_{t-1}	0.029	0.013	0.045	0.013	0.017	−0.004
		(0.558)	(0.237)	(1.312)	(0.379)	(0.388)	(−0.094)
8.	AST_t	0.00015	0.00009	0.00027	0.00020	0.00025	0.0002
		(0.656)	(0.410)	(4.558)[1]	(3.376)[1]	(3.890)[1]	(3.064)[1]
	F	4.078	2.785	2.752	6.032	5.105	0.815
	R^2	0.620	0.527	0.524	0.707	0.615	0.203
	$\bar{R}^2$	0.468	0.338	0.334	0.590	0.494	−0.046
	DW	1.164	—	0.941	—	1.201	—

t-statistics in parentheses; [1] significant at 1 per cent, [2] significant at 5 per cent, and [3] significant at 10 per cent level of significance.

*The introduction of a dummy variable to capture the effect of the intensification program resulted in a positive sign but is statistically insignificant.

The farmers' yield function estimation raises two important points. First, whether the area is owned by free farmers or included in the intensification program, the extraction rate seems to be an important determinant of yield; however, it is less elastic in the case of areas under the intensification program. This is possibly due to declining cane productivity per hectare of land, and it is also the main cause of declining yield during the intensification program. Second, even though the total area devoted to cane appears to have a positive effect, it is only slightly greater than zero, in terms of elasticity coefficients.

6. Concluding Notes

We have investigated empirically the supply response of sugar cane using an extended Nerlovian model. It was found useful in explaining the behavior of farmers in harvesting, when the assumption of profit maximizing agent is fulfilled. The insignificant results for sugar mills indicated that when they are under strict control, and are no longer profit maximizing, the Nerlovian supply response does not apply.

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