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**THEORETICAL EXAMINATION OF THE CONDITIONS OF BEST
MANAGEMENT PRACTICES ADOPTION AND EASING TRADE
DISTORTION FOR SUGAR**

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Theoretical Examination of the Conditions of Best Management Practices Adoption and the Easing of Trade Distortion for Sugar

Abstract

In this study it is examined to see that if the government subsidy compensating for the additional cost of adopting best management practices (BMP) is equal to marginal net benefit, will farmers then try to adopt BMP at every level of TRQ and FMA without exhibiting concerns over the form of their production function and, also, will this then imply an ability on the part of the government to lighten importing and market restrictions on sugar.

Introduction

Domestic sugarcane farmers are faced with two major issues, the environmental concerns of the public and the trade distortion that is extant in the sugar market. To address the public's concerns for the environment will require a more conservational way of producing sugarcane. For example, public concerns over water quality have grown significantly in recent years and has focused increasingly on agriculture as a potential source of surface and groundwater quality problems (Caswell et al., 2001). Use of inorganic fertilizer has increased fourfold and that of agricultural pesticides threefold in the past two decades (Luc et al., 2004). Nitrate is the most commonly detected agricultural chemical in water supplies. However, several herbicides have also been documented in groundwater and surface water with increasing frequency (U.S. Department of Interior). Louisiana is no exception to these findings and concerns. Based on a recent Louisiana costs and returns of sugarcane report, most sugarcane farmers use nitrogen and herbicides heavily. This heavy usage generates substantial water quality

concerns. Many of these contaminants, including nitrates, phosphorus, coliform bacteria and pesticides, are believed to emanate from agricultural production (Luc et al., 2004).

Secondly, U.S. free trade policies push the federal government to ease or eliminate trade restrictions for the domestic sugar market. Since the world price of sugar is lower than domestic price, reducing trade restrictions would cause domestic sugar prices to fall. The majority of sugarcane farmers would, in turn, suffer economic hardship due to lower sugar prices. The two main elements of the U.S. sugar policy are the price support loan program and the tariff-rate quota (TRQ) import policy. The loan program for sugar supports the minimum price of domestic sugar. This guarantees minimum incomes to farmers who produce sugarcane with high marginal costs. The goal of implementing TRQ policy is to ensure an adequate supply of sugar in the domestic market at reasonable prices for both consumers and producers. U.S. commitments affect the level and allocation of the TRQ of sugar owing to the U.S.'s supporting argument for open market in the international trade negotiation.

Another key program provision for sugar is a flexible marketing allotment (FMA). Flexible marketing allotments are determined by subtracting the sum of 1.5 million short tons raw value (STRV) and carry-in stocks of sugar (including Commodity Credit Corporation (CCC) inventory), from USDA estimates of sugar consumption and a reasonable range of carryover stocks at the end of the crop year. Flexible marketing allotments are likely to provide more effective price support throughout the marketing year. When allotments are in effect, processors who have expanded marketing in excess of the rate of growth in domestic sugar demand will have to postpone the sale of some

sugar. Producers will either store it at their own expense or sell it for uses other than domestic food use.

The objective of this study is to estimate the economic cost of sugarcane farming in the light of these two issues. Recent federal policies dealing with environmental conservation emphasize voluntary, rather than mandatory, controls. Design and implementation of control measures have typically been left to state and local officials (Teague, Mapp, and Bernardo, 1995). Central to the development of a local voluntary strategy to reduce contaminants of environmental resources from crop production is the identification of the appropriate management practices to minimize leaching and run-off of contaminants into surface and groundwater resources (Luc et al., 2004). These practices, often referred to as “best management practices” or “BMP” are typically developed to reduce run-off and/or leaching from the three principal sources of contamination: nutrients (mainly nitrogen and phosphorus), pesticides (herbicides and insecticides), and sediment (Luc, et al., 2004). In fact, there has been general concern on the part of researchers and policy-makers about the seemingly low and various adoption rates of many best management practices aimed at improving environmental quality. For example, a survey of Louisiana dairy farmers showed that 25 percent of the dairy farms had a stream and/or river running through their farm land. Luc, et al. (2004) introduced similar low adoption rates for soil testing and variable-rate application in Wisconsin, Iowa, and Illinois.

One possible explanation for farmers’ reluctance to adopt these practices is that they are uncertain of the impact on farm profitability (Luc, et al., 2004). Several factors may contribute to farmers’ perceptions that an “income drag” may occur following the

adoption of a particular BMP. First, many of the BMP's (e.g., incorporation or split application of nutrients and pesticides) require additional machinery operations, which may lead to increased production costs. Second, several herbicide BMP's require the use of substitute herbicides that have limited efficacy information available (leading to increased risk) and are more expensive than the original chemical they replace (Luc, et al., 2004).

Furthermore, recent policy developments in the trade distortion of sugar warrant a new analysis of the sugar market. The U.S. will soon be forced to reform their sugar programs toward a more open market system. This will affect domestic sugarcane farmers because of internal market changes and international commitments which had already been made under NAFTA, the Everything-But-Arms (EBA) agreement, and minimum-market access commitments made under the Uruguay Round of the World Trade Organization (WTO). Further commitments are being negotiated under the Free Trade Agreement of Americas (FTAA), with the latter only exacerbating pressures for reform.

Related to these two emerging issues, this study is intended to analyze a market condition that guarantees not only domestic sugarcane farmers' economic benefits, but also environmental quality, especially water quality improved by adopting BMP. In order to do this, this study assumes that BMP is a mandatory policy, so that all sugarcane producers adopt BMP to produce sugarcane. Under this condition, the study will estimate the optimal market condition where sugarcane can be produced in a more environmentally conscious way.

Mathematical Approach

Marginal cost would provide a useful way to compare the costs between Non-BMP that is used as a counterpart of BMP and BMP. Let us assume that m_i is a marginal cost of Non-BMP. Since each individual farmer, i , has a different level of marginal cost, the marginal cost of an individual farmer might be formulated as follows;

$$(1) B_i = m_i + \alpha_i$$

where α_i is an additional cost of adopting BMP. Now, we can then estimate an average marginal cost for all farmers as the following;

$$(2) \bar{B} = \frac{1}{N} \sum_{i=1}^n m_i + \alpha_i = \bar{m} + \bar{\alpha}$$

where, \bar{B} is an average marginal cost of BMP, \bar{m} is an average marginal cost of NMP, and $\bar{\alpha}$ is the average additional cost of adopting BMP. Total costs of BMP adopted by an individual farmer, i , would be formulated as the following;

$$(3) TC_{BMP}^i = (m_i + \alpha_i)Q_i$$

where TC_{BMP}^i is the total cost of an individual farmer, i , adopting BMP and Q_i is the amount of production of sugar. Total cost of all BMP sugarcane farmers would be formulated by the sum of the total cost of the individual BMP farmer as the following;

$$(4) TC_{BMP} = \sum_{i=1}^n TC_{BMP}^i$$

According to the traditional theory of production economics, an individual farmer will try to produce their crop(s) up to the point where profit is maximized. The profit maximizing condition of production is varied by market conditions with which the farmer is faced. Considering the emerging market situations as discussed in the previous section, this study assumes that the supply of sugar is a function of BMP, TRQ, and MA (Market

Allotment) representing the emerging market condition and other variables which must affect the domestic sugar production. Let us assume the supply function of sugar is as follows;

$$(5) Q_i = a_0 + a_1 B_i^{b_1} + a_2 T^{b_2} + a_3 A_i^{b_3} + a_4 B_i T + a_5 B_i A_i + a_6 T A_i + a_7 B_i T A_i + \varepsilon_i$$

where, Q_i is the amount of sugar supplied by an individual producer, i , B is the adopting rate of BMP, T is the amount of imported of sugar, A_i is the amount of market allotment assigned to each producer, and ε_i is representing other variables affecting sugar supply.

Federal policy arranges a loan rate for sugar as a price floor that guarantees minimum market price to support a sugarcane farmer's income. The current loan rate is 18 cents per pound for sugarcane. A producer whose marginal cost, m_i , is higher than the loan rate will exit the industry since m_i is a shut-down point. As a result, the loan rate should be greater than the marginal cost. So, the loan rate can be expressed as the following;

$$(6) L = m_i + \gamma_i \text{ or (6-b) } L = \bar{m} + \bar{\gamma}$$

where, L is loan rate, γ_i is difference between the loan rate and the marginal cost of a individual producer, and $\bar{\gamma}$ is difference between the loan rate and the average marginal cost of all producers. γ_i and $\bar{\gamma}$ must be positive for a current producing producer.

Sugar producers can adopt either the loan rate or market price as their actual price. If the market price is below the loan rate, the producers turn over the product to CCC to offset the loan. And therefore market price would be greater than or equal to the loan rate. So, market price can be formulated as the following;

$$(7) P = m_i + \rho_i \text{ or (7-b) } P = \bar{m} + \bar{\rho}$$

where, P is market price, ρ_i is the difference between market price and the marginal cost of an individual producer, and $\bar{\rho}$ is the difference between market price and the average marginal cost of all the producers. In addition, market price would be expressed as $P = L$ if the real market price is below the loan rate, or $P > L$ if above the loan rate. We note that $\rho_i \geq \gamma_i$ and $\bar{\rho} \geq \bar{\gamma}$ since if the real market price is below the loan rate, the farmer would then turn over his product to offset the loan to the CCC .

Another factor we must consider to estimate a market condition affecting sugarcane producer's revenue, is the government program for environmental conservation. According to recent farm policies, a farmer following federal rules protecting environmental quality, such as reducing chemical use, can get government support for the additional cost incurred by adopting a more conservationally approach in order to reduce environmental damage in the course of normal crop production. Current conservation programs are voluntary and cost sharing. BMP is one way to reduce environmental damage. Therefore, those farmers adopting BMP can be compensated with government support for the additional cost for adopting the BMP, which, in turn, affect the farmer's total profit. The amount of government support for BMP farmers can be formulated as follows;

$$(8) GS_i = (1 - S)\alpha_i Q_i$$

where, GS_i is the amount of government support for an individual BMP farmer, S is the rate of cost share from the government. If the government compensates 100% of the cost of adopting BMP, then S is 1. otherwise it will be $0 \leq S < 1$. Furthermore, the government compensates only the cost of adopting BMP, α_i .

Now, the net profit equation can be estimated by subtracting the total cost from the total revenue as following;

$$\begin{aligned}
 (9) \quad NR_{BMP}^i &= TR_{BMP}^i - TC_{BMP}^i \\
 &= (P \cdot Q_i + GS_i) - (m_i + \alpha_i)Q_i \\
 &= (m_i + \rho_i)Q_i + (1 - S)\alpha_i Q_i - (m_i + \alpha_i)Q_i \\
 &= (\rho_i - \alpha_i S)Q_i \\
 &= (\rho_i - \alpha_i S) \times (a_0 + a_1 B_i^{b_1} + a_2 T^{b_2} + a_3 A_i^{b_3} + a_4 B_i T + a_5 B_i A_i + a_6 T A_i + a_7 B_i T A_i + \varepsilon_i)
 \end{aligned}$$

By using equation (9) and imposing Lagrangean first order conditions, we can estimate the optimal level of BMP, TRQ, and MA to maximize profit for each individual sugarcane farmer.

Theoretical Results

To solve equation (9) in terms of BMP, TRQ, and MA, we set up a maximizing condition as follows:

$$\begin{aligned}
 (10) \quad \underset{B, T, A}{Max} L &= (\rho_i - \alpha_i S)(a_0 + a_1 B_i^{b_1} + a_2 T^{b_2} + a_3 A_i^{b_3} + a_4 B_i T + a_5 B_i A_i + a_6 T A_i + a_7 B_i T A_i) \\
 & \quad s.t \quad B_i \geq 0, T \geq 0, A_i \geq 0
 \end{aligned}$$

Now, we use the first order condition to solve the optimal condition, B^* , T^* , and A^* .

$$(11) \quad \frac{\partial L}{\partial B_i} = (\rho_i - \alpha_i S)(a_1 b_1 B_i^{b_1-1} + a_4 T + a_5 A_i + a_7 T A_i) = 0$$

$$(12) \quad \frac{\partial L}{\partial T} = (\rho_i - \alpha_i S)(a_2 b_2 T^{b_2-1} + a_4 B_i + a_6 A_i + a_7 B_i A_i) = 0$$

$$(13) \quad \frac{\partial L}{\partial A_i} = (\rho_i - \alpha_i S)(a_3 b_3 A_i^{b_3-1} + a_5 B_i + a_6 T + a_7 B_i T) = 0$$

We note that if the marginal net benefit (ρ_i) is equal to the government subsidy compensating for the additional cost of adopting BMP, then every level of BMP, TRQ,

and MA will be the optimal solution to maximize the net return of each individual farmer. However, if the government subsidy is less than the marginal net benefit, we should then solve the three equations to decide optimal levels of BMP, TRQ, and MA that maximize net revenue. As this study initially assumed, the farmer must adopt BMP since BMP is mandatory. So, in the three equations, we know that $B_i = 1$. We can now simplify the equations as follows;

$$(11) \ a_1 b_1 + a_4 T + a_5 A_i + a_7 T A_i = 0$$

$$(12) \ a_2 b_2 + a_4 B_i + a_6 A_i + a_7 B_i A_i = 0$$

$$(13) \ a_3 b_3 + a_5 B_i + a_6 T + a_7 B_i T = 0$$

By using these three new equations, we get the relation between T and A as follows;

$$(14) \ A_i = \frac{-a_2 b_2 T^{b_2-1} - a_4}{a_6 + a_7}$$

To solve the equation in terms of T and A , we put the equation (14) into the equation (11).

$$(15) \ a_4 a_6 T - a_5 a_2 b_2 T^{b_2-1} - a_7 a_2 b_2 T^{b_2} + a_1 b_1 a_6 + a_1 b_1 a_7 - a_5 a_4 = 0$$

We note that the optimal T^* will depend on the form of the production function. If we assume that the production function (Q) has a linear relationship with T , then b_2 will be 1.

Under this assumption, we get the value of T^* as follows;

$$(16.1) \ T^* = \frac{a_2(a_4 + a_5)}{a_4 a_6 - a_2 a_7}$$

We note that when $b_2 = 1$ in the initial production function, a_2 is equal to a_4 . As a result, the value of the coefficient a_6 should be greater than a_7 in order to satisfy the property of non-negativity. Now, we get the optimal value of A_i^* as follows;

$$(17.1) A_i^* = \frac{-2a_2}{a_6 + a_7} \quad \text{or} \quad \frac{-2a_4}{a_6 + a_7}$$

We note that since the increase in sugar imports decreases domestic production, a_2 should be less than zero, and as a result of this relationship, the initial maximizing constraint is satisfied.

If the production function (Q) is a quadratic function of T , instead of linear form, b_2 will then be 2. Under the quadratic assumption, we get the optimal value of T^* and A_i^* from the following;

$$(16.2) T^* = \frac{a_4 a_6 - 2a_5 a_2}{4a_2 a_7} + K$$

$$(17.2) A_i^* = \frac{2a_5 a_2 - a_4 a_6 - 2a_4 a_7}{2a_7(a_6 + a_7)} + K$$

where $K = \{(2a_5 a_2 - a_4 a_6)^2 - 8a_2 a_7(a_5 a_4 - a_1 a_6 - 2a_1 a_7)\}^{\frac{1}{2}}$

Conclusions

If the government subsidy, for compensating for the additional costs of adopting BMP, is equal to the marginal net benefit (ρ_i), then farmers will adopt BMP at every level of TRQ and MA without exhibiting undue concerns as to the form of their production function. It implies that if the government guarantees the marginal net benefit for farmers adopting BMP, import and market restrictions of sugar can be lightened. However, if the government subsidy is greater than the marginal net benefit, (ρ_i), or the government subsidy is less than the marginal benefit, the optimal solution depends upon each farmer's production function. It also implies that farmers who have a high marginal cost in their production function will be reluctant to adopt BMP, because adoption of BMP would

come at the price of increased cost.. Furthermore, with higher marginal costs to those farmers adopting BMP, BMP farmers will require more strict regulation against foreign imports in order to guarantee high domestic price supports to compensate them for their higher initial cost coming from BMP adoption, which, in turn, causes increased difficulty for the federal government in the realm of international policy.

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