[*Jpn. J. Rural Econ.* Vol. 2, pp. 34-46, 2000]

# Fertilizer Subsidy Reform in the Indian Foodgrain Market: A Comparative Static Analysis with Respect to an Increase in Fertilizer Price

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## 1. Introduction

Government interventions in the Indian foodgrain market include (1) procurement-cum-public distribution system (PDS), (2) buffer stock management, (3) subsidies of inputs, and (4) public investment. Their purposes are to increase production and productivity, to ease uncertainty, and to protect the vulnerable class.

In the New Economic Policy implemented since 1991, these interventions have been reconsidered. The present economic reforms are being conducted under the conditionalities of the structural adjustment programs from the IMF and the World Bank. These reforms are directed towards achieving short term macroeconomic stability and improving medium to long term economic efficiency. The agricultural sector has an important role in this reform because agricultural subsidies are recognized as a factor in the expansion of government expenditure and fiscal deficit. And these subsidies are recognized as a factor contributing to the decrease and stagnation in public investment since the 1980s.

In 1991, the Rao Government tried to reduce fertilizer subsidies by raising the issue price of fertilizers. However, this reform has been quite limited. Nitrogenous fertilizers such as urea are still under price control, though non-nitrogenous fertilizers were de-controlled. Small farmers were temporarily excluded from this deregulation exercise. Also, the government gives subsidies for producing, importing, and using de-controlled phosphatic and potassic fertilizers like di-ammonium phosphate and muriate of potash. The maximum retail price of these fertilizers is fixed and the part of differences between the cost of production and retail price, and the cost of importation and retail price is subsidized. In early 90s, the fertilizer consumption pattern has actually changed. The ratio of consumption of nitrogenous fertilizer to that of de-controlled fertilizers has increased. In order to modify this biased consumption pattern and to mitigate the effects of devaluation in rupees to producers and importers, the above 'concession' subsidies for phosphatic and potassic fertilizers has recently been increased.

To the extent that welfare losers can resist, reforms may tend to progress slowly. Agricultural input subsidies bring divisible benefit to the rich and large farmers because they have good access to irrigation facilities and high yield varieties (HYVs). In this case, reducing these subsidies will have a negative impact on the welfare of the upper class. However, in India, the effects of these reductions may be different from the above under the present procurement system.

The food subsidy in procurement-cum-PDS /stock and the fertilizer subsidy are together known as an explicit subsidy. Under the present system of procurement, the reduction of the fertilizer subsidy may cause an increase in the food subsidy. If the government wishes to avoid this negative effect on the food subsidy, the issue price of foodgrain in the PDS may be increased. This means that the welfare of low-income class would be negatively effected.

This paper formalizes the Indian foodgrain market in a static equilibrium model and uses a comparative static approach to examine the effect of the increase in the fertilizer issue price. And the conclusions as described briefly above are derived.

## 2. Procurement system and subsidies

In this paper, we treat the procurement-cum-PDS and the fertilizer subsidy as interventions

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by government in the foodgrain market.[1]

The government procurement has the purpose of securing the buffer stock and the PDS. The central government agency, the Food Cooperation of India (FCI), purchases foodgrains in the developed foodgrain states, like Punjab and Haryana.[2] The FCI has also the role of distribution/transportation to the less developed foodgrain states. The private distribution of foodgrains between states was controlled for the administration of these interventions. However, this restriction of movement has recently been abolished. Despite this, the FCI still has an advantage in using railroad transportation. And the capacity in the road transportation is so low that there are still substantial barriers in private movement. Because of this, we assume that the foodgrain movement between states by private traders is controlled in the below formalization.

Forms of procurement are different between paddy (rice) and wheat. In wheat, the procurement occurs under farmers' voluntary sales. Farmers are able to bring their produce to the government purchase center under the minimum support price (MSP). In paddy, procurement is under levy. The FCI purchases the rice from the millers at a particular rate.

Government declares the MSP in every sowing season. This price basically follows a recommendation from the Commission of Agricultural Costs and Prices (CACP). The recommendation from the CACP is based on the average costs in states under procurement. In the marketing season, the FCI receives wheat and procures paddy. Then, the MSP in paddy is the procurement price.

The FCI procures part of the marketable surplus, then farmers can sell the residual in the open market. This means that farmers have a two-tier price, the MSP/procurement price and the open market price.

The foodgrains are procured for buffer stock and the PDS.[3] The FCI sometimes off-loads the excess foodgrains onto the open market. The issue prices in the PDS and the FCI's sales are usually lower than the economic cost of procurement (this includes procurement price and cost, storage cost, and other administration costs). This negative margin is covered from the central government expenditure and is food subsidy.[4]

Food and fertilizer subsidies are explicit subsidies because they are accounted for in government expenditure. In 1991 - 1992, the shares of the explicit subsidy in the central government revenue expenditure and in the GDP were 9.8 and 2.0%, respectively. The shares of food and fertilizer subsidy in the central government expenditure were 3.5 and 6.3%, respectively. In the 90s, as interest payments have increased, the weight of the subsidy in government expenditure has fallen. Food subsidy, however has increased. Each of food and fertilizer subsidy accounted for 4.1% of government expenditure in 1997-1998.[5]

Fertilizer subsidy is divided into two types. The one is for the fertilizer production plants as known as the retention price scheme, while the other is for issuing to the farmers. This paper analyzes only fertilizer subsidies for farmers.

There are other implicit input subsidies for credit, irrigation water, and electricity. The agricultural sector pays cheaper charges of these inputs than the non-agricultural sector. In addition, the recovery rate for these fees is low. The Government of India, especially the Ministry of Finance, stresses the need for a reduction in these agricultural subsidies as the non-merit subsidies. However, while the need of the food subsidy is recognized in the context of income distribution, more efficient administration in procurement-cum-PDS is required.[6]

1) Tyagi [15] is used as the main reference concerning the foodgrain market.
2) In some states, state agency also procures independently, we don't treat this state procurement.
3) The one of the problems in the PDS is that the beneficiaries are not properly targeted. Recently TPDS (targeted PDS) has been introduced.
4) Strictly speaking, this negative margin is known as "consumer subsidy." In addition to this, the food subsidy includes the costs for stock carried over. However in this paper, we do not explicitly differentiate between both.
5) Figures are derived from Government of India [6].
6) Government of India [5] is a useful reference.

## 3. The Model

In formalization below, home consumption of foodgrains in farms is ignored for simplicity. Output is then equal to marketable surplus.

**1) Wheat market**

As has been described, the FCI procures wheat by farmers' voluntary sales. Farmers have the alternative of supplying either to the open market or to the FCI depending on their prevailing prices. The open market price is equal to the MSP after the farmers' arbitrage supply behavior.[1] This means that the government should set the appropriate MSP in order to secure their required foodgrain. This MSP is the price that leads to equilibrium on the open market.

To begin the formalization of the model, it is assumed that government fixes the amount of procurement of wheat ($\bar{Q}$). The procurement price/MSP ($p_p$) is equal to the open market price ($p_o$), and it is the incentive price ($p$) to the farmers.

$$p \equiv p_p = p_o \tag{1}$$

This open market price is determined from the open market equilibrium condition.

$$y - \bar{Q} = D(p) \tag{2}$$

Where, $y$ is the production and $D(\cdot)$ is the demand function in the open market.

We assume that production is under the technology with two variable factors and a fixed factor, and it is described by the production function:

$$y = f(x_1, x_2; F) \tag{3}$$

Where, $x_1$ is the variable factor 1, $x_2$ is the variable factor 2, and $F$ is the fixed factor.

The cost function is derived.

$$C = C(\bar{w}_1, w_2, y; F, w_F) = C_v(\bar{w}_1, w_2, y) + FC \tag{4}$$

Factor 1 is under the full control of the government, and its price is $\bar{w}_1$. Variable factor 2's market is assumed as perfect. $w_2$ and $w_F$ are the prices of factor 2 and the fixed factor, respectively. $C_v(\cdot)$ is the variable cost function, and $FC$ is the fixed cost. By profit maximization, the supply schedule is,

$$p = \frac{\partial C}{\partial y} = \frac{\partial C_v}{\partial y}. \tag{5}$$

And the variable factor demand functions are derived from cost function.

$$x_1 = \frac{\partial C}{\partial \bar{w}_1} = \frac{\partial C_v}{\partial \bar{w}_1}, \quad x_2 = \frac{\partial C}{\partial \bar{w}_2} = \frac{\partial C_v}{\partial w_2} \tag{6}$$

The supply function of the variable factor 2 is assumed to be $k(w_2)$. Then the equilibrium in this factor market is then given by

$$x_2 = k(w_2) \tag{7}$$

In this market, government fixes the amount of procurement ($\bar{Q}$) and the issue price of factor 1 ($\bar{w}_1$). Farmers behave given these policy variables and fixed factor price ($w_F$). The output ($y$), the open market price/MSP ($p$), the demand for factor 1 ($x_1$), the demand for factors 2 ($x_2$), and the price of factor 2 ($w_2$) are then determined.

As described in previous section, however, the CACP recommends the MSP based on the average cost. In the above formalization, though not shown explicitly, it is not a contradiction. The ratio of the average variable cost to the marginal cost is constant under a homogenous production function. If the total variable cost does not vary with respect to total cost, the marginal cost or the incentive price is constant with respect to the average cost.[2]

**2) Paddy market**

A procurement of paddy is generally under levy by securing some rate from the millers. This does not mean that the open market price equals the procurement price. It is assumed that the millers show to farmers the weighted average price of the open market price and the procurement price. This pooling price is the incentive price for farmers. For purposes of simplicity, margins to millers are omitted from the analysis.

The production technology of paddy is also described as a function with two variable factors and a fixed factor.[3]

$$y = f(x_1, x_2; F) \tag{8}$$

Where the variables are defined as in the model of wheat.

The cost function is,

$$C = C(\bar{w}_1, w_2, y; F, w_F) = C_v(\bar{w}_1, w_2, y) + FC. \tag{9}$$

Definitions follow those defined previously.

Factor demand functions are

$$x_1 = \frac{\partial C}{\partial \bar{w}_1} = \frac{\partial C_v}{\partial \bar{w}_1}, \quad x_2 = \frac{\partial C}{\partial w_2} = \frac{\partial C_v}{\partial w_2}. \tag{10}$$

Government fixes the amount of procurement $\bar{Q}$, and procures the paddy in the ratio of output $\theta$.

$$\bar{Q} = \theta y \tag{11}$$

Procurement price $p_p$ is fixed by adding a particular margin to the average cost ($AC$).

$$p_p = \tau \cdot AC = \tau \frac{C}{y} \tag{12}$$

Where, $\tau$ is the markup rate.

Farmers can supply the ratio of the produc-

tion $(1-\theta)$ to the open market. The equilibrium in the open market is

$$(1-\theta)y=D(p_o). \tag{13}$$

Where, $D(\cdot)$ is the demand function in the open market and $p_o$ is the open market price.

Then, the incentive price $\bar{p}$ is

$$\bar{p}=(1-\theta)p_o+\theta p_p. \tag{14}$$

And, the supply schedule is

$$\bar{p}=\frac{\partial C}{\partial y}=\frac{\partial C_v}{\partial y}. \tag{15}$$

Factor 2 is assumed to be subjected to a perfectly competitive market. The supply function of the variable factor 2 is given as $k(w_2)$, and the equilibrium in this factor market is

$$x_2=k(w_2). \tag{16}$$

The policy variables are the amount of procurement $(\bar{Q})$, the issue price of factor 1 $(\bar{w}_1)$, and the markup rate $(\tau)$. Farmers respond to these variables and the fixed factor price $(w_F)$. Output $(y)$, open market price $(p_o)$, procurement price $(p_p)$, incentive price $(\bar{p})$, factor demand for factor 1 $(x_1)$, and factor demand for factor 2 $(x_2)$ and price of factor 2 $(w_2)$ are determined endogenously.

1) In actuality, in the beginning of the marketing season (every April) the wholesale price is equal to the MSP.
2) In practice, the MSP is about 1.2 times of the average cost in Punjab.
3) In this paper, the variables in paddy are not differentiated from those in wheat by using subscription.

## 4. Comparative Static Analysis of Fertilizer Subsidy Reduction

Using comparative static analysis, the effects of increase in the factor price of 1 are examined in both the wheat and paddy markets.

### 1) Wheat market

By taking the total differentials of equations (2), and (5)-(7), the below comparative static systems are derived. "$\hat{}$" means the rate of change in the concerned variable.

• Market equilibrium

$$\left(\frac{1}{1-\theta}\right)\hat{y}-\left(\frac{1}{1-\theta}\right)\hat{\bar{Q}}=\varepsilon\hat{p} \tag{17}$$

Where, $\theta$ is the ratio of the procurement to the production $(\theta=\bar{Q}/y)$, and $\varepsilon$ is the elasticity of demand with respect to price.

• Supply schedule

$$\hat{p}=\frac{1}{\eta_{yp}}\hat{y}+c(\eta_{1y}S_1\hat{\bar{w}}_1+\eta_{2y}S_2\hat{w}_2) \tag{18}$$

Where, $\eta_{yp}$ is the elasticity of supply with respect to price, and $c$ is the ratio of the variable cost to the value of output $(C_v/py)$.

• Factor demand

$$\hat{x}_1=-\sigma S_2\hat{\bar{w}}_1+\sigma S_2\hat{w}_2+\eta_{1y}\hat{y} \tag{19}$$

$$\hat{x}_2=\sigma S_1\hat{\bar{w}}-\sigma S_1\hat{w}_2+\eta_{2y}\hat{y} \tag{20}$$

Where, $\sigma$ is the elasticity of substitution between factor 1 and 2. $S_1$ and $S_2$ are the share of each factor in total variable cost, and they satisfy the condition $S_1+S_2=1$. And $\eta_{iy}(i=1,2)$ is the elasticity of the factor $i$'s demand with respect to output $\left(\eta_{iy}=\frac{\partial x_i/x_i}{\partial y/y}\right)$.

• Market equilibrium for factor 2

$$\hat{x}_2=\kappa\hat{w}_2 \tag{21}$$

Where, $\kappa$ is the elasticity of factor 2 supply.

In the above system, the effects of an increase in the issue price of factor 1 $(\bar{w}_1)$ on the endogenous variables can be found. However, the above system includes many parameters. So for simplicity, the production technology in the neighborhood of the equilibrium is described by the function homogenous of degree $\lambda(\lambda<1)$ in variable factors.[1]

Here, the effects on the endogenous variables (the elasticities with respect to the increase of the price of factor 1) are as follows:

$$\frac{\hat{p}}{\hat{\bar{w}}_1}=\frac{S_1\lambda(\kappa+\sigma)+\hat{\bar{Q}}\theta\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)} \tag{22}$$

$$\frac{\hat{y}}{\hat{\bar{w}}_1}=\frac{\lambda\{S_1\varepsilon(1-\theta)(\kappa+\sigma)+\hat{\bar{Q}}\theta(\kappa+S_1\sigma)\}}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)} \tag{23}$$

$$\frac{\hat{x}_1}{\hat{\bar{w}}_1}=\frac{-S_2\kappa\lambda\sigma+\varepsilon(1-\theta)[S_1\kappa+\{1+S_2\kappa(1-\lambda)\}\sigma]+\hat{\bar{Q}}\theta(\kappa+\sigma)}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)} \tag{24}$$

$$\frac{\hat{x}_2}{\widehat{w}_1}=\frac{\kappa[S_1\{\lambda\sigma+\varepsilon(1-\theta)(1-\sigma(1-\lambda))\}+\hat{\bar{Q}}\theta]}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)} \tag{25}$$

$$\frac{\hat{w}_2}{\widehat{w}_1}=\frac{S_1\{\lambda\sigma+\varepsilon(1-\theta)(1-\sigma(1-\lambda))\}+\hat{\bar{Q}}\theta}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)} \tag{26}$$

The sign conditions of the elasticities should be checked. First, assuming that government does not change the amount of procurement ($\hat{\bar{Q}}=0$) in the fertilizer subsidy reform. We assume that all the parameters except the price elasticity of demand are non-negative, and $0<(1-\theta)\leq 1$. Then, the sign conditions of elasticities are

$$\frac{\hat{p}}{\widehat{w}_1}>0,\ \frac{\hat{y}}{\widehat{w}_1}<0,\ \frac{\hat{x}_1}{\widehat{w}_1}<0.$$

However, the signs of the $\frac{\hat{x}_2}{\widehat{w}_1}$ and $\frac{\hat{w}_2}{\widehat{w}_1}$ are ambiguous, because they depend on the elasticity of substitution.

We should take notice of the effect on the procurement price/open market price in the context of a fiscal deficit. From above analysis, we confirm that the procurement price could increase if there is an increase in the fertilizer price. In the case where the amount of procurement is unchanged, there is an expansion in the difference between the procurement price and the foodgrain issue price, and the food subsidy is expected to increase.

Though government intends to reduce the fertilizer subsidy, the reform leads to this perverse result. If government wants to avoid this, the issue price in the PDS may be reconsidered. Assume the below.

$$\bar{Q}=D_p(p_i) \tag{27}$$

Where $D_p(\cdot)$ is the demand function in the PDS, and $p_i$ is the issue price of government foodgrain. Hence, by increasing the issue price in the PDS, government can reduce the amount of procurement.

The effects of the amount of procurement on the fertilizer price elasticities of endogenous variables, especially on the procurement price should be checked.

$$\frac{\partial(\hat{p}/\widehat{w}_1)}{\partial\hat{\bar{Q}}}>0,\ \frac{\partial(y/\widehat{w}_1)}{\partial\hat{\bar{Q}}}>0,\ \frac{\partial(\hat{x}_1/\widehat{w}_1)}{\partial\hat{\bar{Q}}}>0,$$

$$\frac{\partial(\hat{x}_2/\widehat{w}_1)}{\partial\hat{\bar{Q}}}>0,\ \frac{\partial(\hat{x}_2/\widehat{w}_1)}{\partial\hat{\bar{Q}}}>0$$

These show the existence of the Dantwala-Mellor effect which means increasing the procurement results in a production incentive to farmers.[2] If government increases the fertilizer price, the food subsidy can then be eliminated by reducing the amount of procurement. Needless to say, this harms the welfare of low-income class who can access to the PDS.

**2) Paddy market**

As well as in wheat market equilibrium, we can analyze the effects of the fertilizer price on the endogenous variables in paddy market equilibrium. However, the comparative static system in paddy is more complex than in wheat because the procurement price is explicitly based on the average cost under levy procurement.

- The supply schedule

$$\hat{\bar{p}}=\frac{1}{\eta_{y\bar{p}}}\hat{y}+\eta_{1y}cS_1\widehat{w}_1+\eta_{2y}cS_2\hat{w}_2 \tag{28}$$

- Procurement price

$$\hat{p}_p=\hat{\tau}+\nu(S_1\widehat{w}_1+S_2\hat{w}_2)+\left(\frac{1}{\gamma}-1\right)\hat{y} \tag{29}$$

Where $\gamma$ is the ratio of the total cost to the value of output($\gamma=\frac{C}{\bar{p}y}$), and $\nu$ is ratio of the total variable cost to total cost ($\nu=C_v/C$).

- Incentive price[3]

$$\hat{p}=(1-\theta\tau\gamma)\hat{p}_o+\theta\tau\gamma\hat{p}_p-\frac{\theta}{1-\theta}(1-\tau\gamma)\hat{\theta} \tag{30}$$

- The amount of procurement

$$\hat{\bar{Q}}=\hat{\theta}+\hat{y} \tag{31}$$

- The open market equilibrium

$$-\left(\frac{\theta}{1-\theta}\right)\hat{\theta}+\hat{y}=\varepsilon\hat{p}_o \tag{32}$$

The equations for the factor demand functions and the supply functions of factor 2 are followed as in the case of wheat market. Consequently they are omitted here.

As before, we assume that the production function is homogenous of degree $\lambda$ ($\lambda<1$) in variable factors in neighborhood of the equilibrium.[4]

The markup in the procurement price ($\tau$) is assumed to be constant, and the amount of procurement is assumed unchanged ($\hat{\bar{Q}}=0$).

Then, we can find the elasticities with respect to the fertilizer price in paddy market equilibrium as follows:

$$\frac{\hat{y}}{\hat{w}_1}=\frac{S_1\varepsilon(1-\theta)\lambda\nu(\kappa+\sigma)(1-\lambda\theta\tau)}{D} \tag{33}$$

$$\frac{\hat{x}_1}{\hat{w}_1}=\frac{-\lambda\sigma\kappa_2S_2(1+\varepsilon)(\nu-\lambda\theta\tau)+\varepsilon(1-\theta)[\lambda^2\sigma\kappa_2S_2\theta\tau+\{\sigma+\kappa_2(S_1+\sigma S_2)\}(1-\lambda\theta\tau)\nu]}{D} \tag{34}$$

$$\frac{\hat{x}_2}{\hat{w}_1}=\frac{\kappa_2S_1[\lambda\sigma(1+\varepsilon)(\nu-\lambda\theta\tau)+\varepsilon(1-\theta)\{-\lambda^2\sigma\theta\tau+(1-\sigma)(1-\lambda\theta\tau)\nu\}]}{D} \tag{35}$$

$$\frac{\hat{w}_2}{\hat{w}_1}=\frac{S_1[\lambda\sigma(1+\varepsilon)(\nu-\lambda\theta\tau)+\varepsilon(1-\theta)\{-\lambda^2\sigma\theta\tau+(1-\sigma)(1-\lambda\theta\tau)\nu\}]}{D}$$

$$\frac{\hat{p}_o}{\hat{w}_1}=\frac{\lambda S_1(\kappa_2+\sigma)(1-\lambda\theta\tau)\nu}{D} \tag{37}$$

$$\frac{\hat{\bar{p}}}{\hat{w}_1}=\frac{\lambda S_1(\kappa_2+\sigma)\{(1+\varepsilon)(\nu-\lambda\theta\tau)-\varepsilon(1-\theta)(\lambda\theta\tau+\nu(1-\lambda\theta\tau))\}}{D} \tag{38}$$

$$\frac{\hat{p}_p}{\hat{w}_1}=\frac{\lambda S_1(\kappa_2+\sigma)\{-\varepsilon(1-\theta)+(1+\varepsilon)(\nu-\lambda\theta\tau)\}\nu}{D} \tag{39}$$

$$\frac{\hat{\theta}}{\hat{w}_1}=\frac{-\varepsilon\{\lambda S_1(\kappa_2+\sigma)(1-\theta)(1-\lambda\theta\tau)\nu\}}{D} \tag{40}$$

Where,

$$\begin{aligned}D=&-\varepsilon S_1(1-\theta)(1-\lambda\theta\tau)\nu\\&+(\kappa_2+\sigma S_1)[(1+\varepsilon)\lambda(\nu-\lambda\theta\tau)-\varepsilon(1-\theta)\{\tau\lambda^2\theta+(1-\lambda\theta\tau)\nu\}]\end{aligned} \tag{41}$$

We should analyze about the sign conditions of the above elasticities. First, we confirm that the denominator of each is positive.

$$D>0$$

This is from the condition for the stability of the open market equilibrium.[5]
Then, the sign conditions are

$$\frac{\hat{y}}{\hat{w}_1}<0,\ \frac{\hat{x}_1}{\hat{w}_1}<0,\ \frac{\hat{p}_o}{\hat{w}_1}>0,\ \frac{\hat{\bar{p}}}{\hat{w}_1}>0,\ \frac{\hat{p}_p}{\hat{w}_1}>0,\ \frac{\hat{\theta}}{\hat{w}_1}>0.$$

The effects on demand and price of factor 2 are ambiguous because of the degree of substitution between variable factors.

The grounds for the above results are upon the values of parameters. These satisfy below. $0\leq\theta<1$, $0\leq\lambda\leq\nu\leq1$.[6] $\tau\geq1$, $0\leq S_1\leq1$, $0\leq S_2\leq1$, $S_1+S_2=1$, $\sigma\geq0$, $\kappa_2\geq0$. And $0\leq\nu-\lambda\theta\tau\leq1$.[7] Then, $0\leq1-\lambda\theta\tau$.

The price elasticity of demand is the most important indicator when evaluating the sign conditions. The signs of elasticities for output ($y$), open market price ($p_o$), share of the procurement in output ($\theta$), and demand of factor 1 ($x_1$) are not violated as long as the demand elasticity is non-positive. However, the sign of elasticity for demand of factor 1 is not easily found. Details of this calculation are shown in the appendix. The elasticities for procurement price ($p_p$) and the incentive price ($\bar{p}$) show the above sign under the less elastic demand ($-1\leq\varepsilon\leq0$). For more elastic demand ($\varepsilon<-1$), we cannot find easily the sign conditions. But under the actual values of the parameters, the sign conditions are as above. The details are also shown in the appendix.

We can confirm that as well as in the case of wheat, an increase in the fertilizer price results in the increase in the procurement price in paddy market. When the issue scheme in the PDS remains unchanged, this leads to the increase in the food subsidy.

In order to avoid this situation, government may reconsider the issue price in the PDS and reduce the amount of procurement. Here, only the effect of the procurement on the elasticity of procurement is shown.

$$\frac{\partial(\hat{\tilde{p}}/\hat{w}_1)}{\partial\hat{Q}} = \frac{\theta\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}\{\varepsilon(\nu-\lambda\tau)+(\nu-\lambda\theta\tau)\}}{D}$$

$$>0 \Leftrightarrow \varepsilon > -\frac{1}{1-p_p/p_o}$$

That is, reducing the procurement results in the decrease in the procurement price as far as the price elasticity of demand is in the above range. In reality, the difference between the open market price and the procurement price is not large,[8] and the above sign condition is violated only under quite elastic demand. We can confirm that the government is able to curtail the food subsidy by reducing the procurement based on the Dantwala-Mellor effect.

1) The simplifications are as follows: $\eta_{1y}=\eta_{2y}=\frac{1}{\lambda}$, $c=\frac{C_v}{py}=\lambda$, and $\eta_{yp}=\frac{\lambda}{1-\lambda}$. In addition, the framework of this paper is based on the existence of a fixed factor. The analysis focuses on the short-term effects of the fertilizer subsidy reform. In this sense, the present analysis is limited. In extending the present approach to long-term analysis, a consistency between the short-term technology and the long-term technology should be required. However, analyzing in short-term could be better in concerning that the government surveys the average costs of production in differentiating the variable factors and fixed factors, then fixes the policy variables such as the MSP, and individuals behave under these policy variables.

2) With respect to Dantwala-Mellor conjecture, refer to Dantwala [3], Mellor [9], Hayami, Subbarao, and Otsuka [8], Schiff [12], and Shuto [13].

3) From setting the procurement price (12),

$$\tilde{p}=(1-\theta)p_o+\theta p_p=(1-\theta)p_o+\theta\tau\frac{C}{y}.$$

Then,

$$\frac{(1-\theta)p_o}{\tilde{p}}=1-\theta\tau\frac{C}{\tilde{p}y}, \qquad \frac{\theta p_o}{\tilde{p}}=\theta\tau\frac{C}{\tilde{p}y},$$

Hence, (30) is derived.

4) $\eta_{1y}=\eta_{2y}=\frac{1}{\lambda}$, $\gamma=\frac{C}{\tilde{p}y}=\frac{C_v}{\tilde{p}y}\frac{C}{C_v}=\frac{\lambda}{\nu}$, and $\eta_{yp}=\frac{\lambda}{1-\lambda}$.

5) That is the condition that the excess demand decreases with respect to an increase in the open market price.

6) For $\frac{C}{\tilde{p}y}=\gamma=\frac{\lambda}{\nu}<1$.

7) $\nu=\lambda\theta\tau=\nu(1-\theta\tau\frac{\lambda}{\nu})=\nu(1-\theta\tau\gamma)=\nu\frac{(1-\theta)p_o}{\tilde{p}}$.

8) In Punjab, the wholesale price is hardly more than twice of the procurement price. We can refer that in CACP [2]

## 5. Effect on Producers' Welfare

As described, an increase in the fertilizer price results in a decrease in output, and increases in procurement price, open market price, and incentive price. This means that consumers in the open market may have welfare reduction. With respect to the welfare of the low-income earners who access to the PDS, whether they are harmed or not depends on the government's attitude toward a change in the food subsidy. Here, the effect on the welfare of producers is analyzed.

### 1) Producers' welfare and the procurement form

In the present paper, the producers' welfare is evaluated by the producer's surplus. The producer's surplus is derived by deducting total variable cost from output value. For simplicity, technology is described as a function homogenous of degree $\lambda$ in variable factors. Hence, the producer's surplus ($PS$) is

$$PS=py-C_v=py\left(1-\frac{C_v}{py}\right)=py(1-\lambda) \quad (42)$$

And its rate of change is

$$\widehat{PS}=(1-\lambda)(\hat{\tilde{p}}+\hat{y}). \quad (43)$$

In the case of procurement by farmers' voluntary sales, the change in the producer's surplus of the fertilizer price is

$$\frac{\widehat{PS}}{\hat{w}_1}=\frac{(1-\lambda)S_1\lambda(\kappa+\sigma)\{1+\varepsilon(1-\theta)\}}{-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma).} \quad (44)$$

On the other hand, under levy procurement,

$$\frac{\widehat{PS}}{\hat{w}_1}=\frac{(1-\lambda)S_1\lambda(\kappa+\sigma)\{(1+\varepsilon)(\nu-\lambda\theta\tau)-\varepsilon(1-\theta)\lambda\theta\tau\}}{D}$$

$$=\frac{(1-\lambda)S_1\lambda(\kappa+\sigma)}{D}\left\{1-\varepsilon\left(1+\theta\frac{p_p}{p_o}\right)\right\}\left\{\nu\frac{(1-\theta)p_o}{\tilde{p}}\right\}. \quad (45)$$

In the case of wheat, when fertilizer price is increased, whether the producers can gain depends on the price elasticity of demand and the share of the procurement to the output. And, in the case of paddy, that depends on not only them, but also the difference between the open market price and the procurement price. This critical condition for the effect on producer's welfare in the case of wheat is similar to that of paddy, for the open market price just equals the procurement price in the case of wheat. From the equation (44), we confirm that producers of wheat under procurement are able to gain their welfare with respect to an increase in the fertilizer price. For, under the situation that the FCI procures about 60-70% of their production in Punjab, this result is hardly violated unless the demand is quite elastic.

**2) Regional disparity in producers' welfare**

Recently, the moving restriction of foodgrain was reformed. However, there are still some substantial barriers to movement. Not only the difference in technology, but this situation, the welfare effect of the reform in states under procurement is different from those without procurement. States under procurement are the developed areas in foodgrain production where the irrigation facilities have been established early and high yield varieties (HYVs) have been well diffused. In this sense, states under no procurement are the less developed areas.

In the context of the availability of the irrigation facilities and HYVs, the subsidy to agricultural inputs may have different effects on the welfare between classes. This is known as government intervention with divisible benefits (Teranishi [14]). That is, when government subsidizes inputs, producers who can access to the irrigation facilities and HYVs well gain more than those who have less access to them. Using this logic, the reform of fertilizer subsidies may result in the easing of regional or class disparities. However, this is not appropriate under the Indian procurement system. As described, in the principles of the procurement system, an increase in the fertilizer price results in an increase in the procurement price through increasing costs. Especially in the case of wheat, producers' welfare under procurement may improve. Here, we should confirm whether the producers under procurement or no procurement could gain more. In other words, we should analyze whether regional/class disparity enlarges in increase in the fertilizer subsidy.

For simplicity, we assume that the parameters are same between the states. First, we confirm in the case of wheat. The elasticity of the producer's surplus without procurement is shown in equation (44), with $\theta=0$. In this case, whether the producers gain or not depends on only the price elasticity of demand, and then the producer could lose when confront with demands of elasticity less than $-1$. And for the comparison with that under procurement,

$$\frac{\partial(\widehat{PS}/\widehat{w}_1)}{\partial\theta}= \frac{-\varepsilon S_1(1-\lambda)\lambda(\kappa+\sigma)(S_2+\kappa+S_1\sigma)}{[-\varepsilon(1-\theta)\{S_2+(1-\lambda)(\kappa+S_1\sigma)\}+\lambda(\kappa+S_1\sigma)]^2} >0$$

Then, procurement can contribute positively to the gain of producers' welfare result from increase in the issue price of factor 1. On the other hand, in the case of paddy, because of the difference between the open market price and the procurement price, the relative gain in producers' welfare between the states is ambiguous.[1] In both cases, under the less elastic demand, procurement can bring about the more improvement of producers welfare from the increase in issue price of factor 1.

Thus, the reform of the fertilizer subsidy may enlarge the regional/class disparity. This is an opposition to the basic logic of divisible benefits in the agricultural input subsidy. In actuality, the government allowed the small farmers' subsidy to continue temporarily.[2]

**3) A numerical example**

In this section, a numerical example is shown in order to illustrate the above analysis. In addition to the endogenous variables and the producer's surplus, the elasticity of the food subsidy and the fertilizer subsidy are evaluated. In this example, the scheme of procurement is assumed unchanged.

Under the condition that the amount of procurement is constant, the change rate of the food subsidy ($SUB_{\text{food}}$) is

$$\widehat{SUB}_{\text{food}}=\begin{cases}\left(\dfrac{p}{p-p_i}\right)\hat{p} & \text{in wheat}\\ \left(\dfrac{p_p}{p_p-p_i}\right)\widehat{p_p} & \text{in paddy}\end{cases}$$

$p$ and $p_p$ are the procurement prices in the case of wheat and of paddy respectively, and pi is the issue price in the PDS. And, that of the fertilizer subsidy for farmers ($SUB_{fert}$)is

$$\widehat{SUB}_{fert} = -\frac{\bar{w}_1}{w_1^* - \bar{w}_1}\widehat{\bar{w}_1} + \hat{x}_1.$$

Where, $w_1^*$ is the shadow price of the fertilizer.

In the numerical example, parameter values need to be determined. Average costs in states under procurement are reported by CACP [2]. Since we cannot refer the average costs in the state under no procurement, then, we substitute the average costs in the state with the small procurement share. Punjab is used as the developed area in both of paddy and wheat, and Orissa in paddy and Madhya Pradesh in wheat are picked up as the less developed area, respectively. The costs of these states are shown in Table 1.

This numerical example uses simplified parameters. We pick up labor as the variable factor 2. Other factors are treated as fixed. It is assumed that the elasticity of substitution between the variable factors is 1,[3] and the factor 2 is supplied infinitely ($\kappa=\infty$). The parameters are shown in Table 2. And the values of the degree of homogeneity in the production function ($\lambda$) are from the supply elasticities estimated in a previous study (Gulati and Sharma [7]).[4]

The effects on variables under no procurement in both of paddy and wheat are evaluated by using the equations (22) - (26) with $\theta=0$. In order to calculate the change of food subsidy, we need the ratio of the procurement price to the backward margin, and set at a value of 3 for both paddy and wheat. This is the ratio of procurement price to consumer subsidy from "Economic Survey".[5] And in finding the change of fertilizer subsidy, we use a value of 2 for the ratio of the shadow price to the issue price. This shadow price is the decontrolled price of urea in 1991 estimated by the FAO (FAO [4]). Using selected values for price elasticity of demand raging from 0 to $-2$, values for the model's endogenous variables are determined. These results are shown in Table 3.

These results show that the open market price increases as the fertilizer price increases. This means that the consumers who access to the open market lose in the fertilizer subsidy reform. Also, the degree of the welfare loss is more under less elastic demand. Producers gain less under more elastic demand. However, in this numerical example, the welfare of producers with procurement could increase more

**Table 1. Cost of production in wheat**

| | Haryana | | Punjab | | Madhya Pradesh | | Rajasthan | | Uttar Pradesh | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995-96 | | 1995-96 | | 1995-96 | | 1994-95 | | 1990-91 | |
| | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) |
| Human labor | 2,410.71 | 0.18 | 2,480.58 | 0.17 | 1,614.99 | 0.18 | 2,835.66 | 0.25 | 1,211.24 | 0.17 |
| Bullock labor | 171.33 | 0.01 | 37.37 | 0.00 | 473.81 | 0.05 | 367.46 | 0.03 | 758.86 | 0.11 |
| Machine labor | 1,546.07 | 0.11 | 1,384.67 | 0.10 | 676.62 | 0.08 | 1,125.54 | 0.10 | 712.49 | 0.10 |
| Seeds | 590.14 | 0.04 | 500.57 | 0.03 | 614.91 | 0.07 | 673.64 | 0.06 | 396.6 | 0.06 |
| Fertilizers and manure | 1,869.24 | 0.14 | 2,164.03 | 0.15 | 826.67 | 0.09 | 778.87 | 0.07 | 679.41 | 0.09 |
| Fertilizers | 1,869.24 | 0.14 | 2,124.67 | 0.15 | 822.62 | 0.09 | 751.44 | 0.07 | 662.21 | 0.09 |
| Manure | | 0.00 | 39.36 | 0.00 | 4.05 | 0.00 | 27.43 | 0.00 | 17.2 | 0.00 |
| Insecticides | 70.57 | 0.01 | 314.32 | 0.02 | 0.38 | 0.00 | 11.74 | 0.00 | 1.95 | 0.00 |
| Irrigation charges | 749.97 | 0.05 | 341.87 | 0.02 | 823.27 | 0.09 | 1,020.4 | 0.09 | 617.07 | 0.09 |
| Interest on working capital | 179.22 | 0.01 | 195.83 | 0.01 | 125.53 | 0.01 | 140.06 | 0.01 | 113.07 | 0.02 |
| Miscellaneous | | 0.00 | 23.51 | 0.00 | 0.06 | 0.00 | | 0.00 | | 0.00 |
| Rental value of owned land | 4,965.61 | 0.36 | 3,947.29 | 0.28 | 2,681.73 | 0.31 | 2,559.08 | 0.22 | 1,685.61 | 0.24 |
| Rent paid for leased-in lard | 14.16 | 0.00 | 1,770.33 | 0.12 | | 0.00 | 604.79 | 0.05 | 37.17 | 0.01 |
| Lard revenue, cesses & taxes | | 0.00 | 3.21 | 0.00 | 6.11 | 0.00 | 12.05 | 0.00 | 10.27 | 0.00 |
| Depreciation on implements & farm buildings | 203.36 | 0.01 | 223.03 | 0.02 | 270.31 | 0.03 | 122.98 | 0.01 | 198.08 | 0.03 |
| Interest on fixed capital | 884.54 | 0.06 | 924.55 | 0.06 | 619.95 | 0.07 | 1,279.01 | 0.11 | 735.46 | 0.10 |
| Total cost | 13,654.93 | 1.00 | 14,311.17 | 1.00 | 8,734.34 | 1.00 | 11,531.08 | 1.00 | 7,157.28 | 1.00 |

**Table 1 (continued). Cost of production in paddy**

| | Haryana | | Punjab | | Madhya Pradesh | | Orissa | | Uttar Pradesh | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1994-95 | | 1994-95 | | 1994-95 | | 1994-95 | | 1994-95 | |
| | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) | (Rs./ha) | (share) |
| Human labor | 4,406.65 | 0.28 | 2,999.51 | 0.20 | 2,065.59 | 0.26 | 3,278.09 | 0.35 | 2,992.4 | 0.43 |
| Bullock labor | 96.29 | 0.01 | 51.78 | 0.00 | 1,161.39 | 0.15 | 846.34 | 0.09 | 1,110.63 | 0.16 |
| Machine labor | 1,158.27 | 0.07 | 1,053.54 | 0.07 | 172.62 | 0.02 | 91.18 | 0.01 | 28.4 | 0.00 |
| Seeds | 235.7 | 0.01 | 293.87 | 0.02 | 438.83 | 0.06 | 358.04 | 0.04 | 333.7 | 0.05 |
| Fertilizers and manure | 1,819.26 | 0.11 | 1,621.81 | 0.11 | 750.19 | 0.09 | 1,030.51 | 0.11 | 51.51 | 0.01 |
| Fertilizers | 1,819.26 | 0.11 | 1,581.19 | 0.10 | 590.57 | 0.07 | 645.22 | 0.07 | 15.34 | 0.00 |
| Manure | | 0.00 | 40.62 | 0.00 | 159.62 | 0.02 | 385.29 | 0.04 | 36.17 | 0.01 |
| Insecticides | 289.05 | 0.02 | 650.44 | 0.04 | 75.88 | 0.01 | 25.28 | 0.00 | 0.18 | 0.00 |
| Irrigation charges | 1,886.9 | 0.12 | 1,481.89 | 0.10 | 33.17 | 0.00 | 12.61 | 0.00 | 0.15 | 0.00 |
| Interest on working capital | 231.37 | 0.01 | 216.51 | 0.01 | 110.94 | 0.01 | 128 | 0.01 | 71.43 | 0.01 |
| Miscellaneous | | 0.00 | 0.23 | 0.00 | | 0.00 | | 0.00 | | 0.00 |
| Rental value of owned land | 4,633.9 | 0.29 | 5,104.96 | 0.33 | 2,195.23 | 0.28 | 2,276.76 | 0.24 | 1,299.85 | 0.19 |
| Rent paid for leased-in lard | 2.57 | 0.00 | 679.65 | 0.04 | | 0.00 | 661.27 | 0.07 | 383.94 | 0.06 |
| Lard revenue, cesses & taxes | | 0.00 | 3.15 | 0.00 | 2.96 | 0.00 | 11.18 | 0.00 | 17.93 | 0.00 |
| Depreciation on implements & farm buildings | 119.82 | 0.01 | 207.87 | 0.01 | 323.1 | 0.04 | 201.42 | 0.02 | 225.64 | 0.03 |
| Interest on fixed capital | 1,045.08 | 0.07 | 883.28 | 0.06 | 635.63 | 0.08 | 397.67 | 0.04 | 448.41 | 0.06 |
| Total cost | 15,924.86 | 1.00 | 15,248.49 | 1.00 | 7,965.53 | 1.00 | 9,318.35 | 1.00 | 6,964.2 | 1.00 |

Source: CACP [1].

**Table 2. Parameters for numerical example**

| | State with procurement | State with no procurement |
|---|---|---|
| Wheat | | |
| $S_1$ | 0.47 | 0.33 |
| $S_2$ | 0.53 | 0.67 |
| $\lambda$ | 0.10 | 0.30 |
| $\theta$ | 0.60 | — |
| Paddy | | |
| $S_1$ | 0.33 | 0.17 |
| $S_2$ | 0.67 | 0.83 |
| $\lambda$ | 0.20 | 0.36 |
| $\nu$ | 0.30 | — |
| $\theta$ | 0.70 | — |
| $\tau$ | 1.20 | — |

than with no procurement under the same elasticity of demand. Especially in wheat, producers in state with procurement may hardly lose in fertilizer subsidy reform.

The elasticity of procurement price should be noted. As analyzed in the above section, the increase in the fertilizer price leads to a hike in this price. This results in an expansion of the food subsidy. With respect to the effect on the fertilizer subsidy itself, there is approximately a 2% decrease for a 1% increase in the fertilizer price. On the other hand, the degree of the increase in the food subsidy depends on the degree of the elasticity of demand. However, under inelastic demand, the degree of adverse effect on the food subsidy is quite large, and the reduction of the fertilizer subsidy could be offset significantly. By referring to some previous studies, the values of price elasticity of demand are estimated to be from around $-0.5$ to around $-1.0$.[6]

Then, the offset effect by increase of food subsidy should be noted. Recently, the value of fertilizer subsidy has been almost at the same level as that of the food subsidy. And Pursell and Gulati [10] estimated that half of entire fertilizer subsidy went to the fertilizer industry and half went to farmers. In addition, because of decrease in fertilizer demand, the decrease in the subsidy for fertilizer industry should be accounted. For the reasons stated above, and under the assumption that the change rate of the fertilizer demand is as same as that of the fertilizer subsidy to industries, the degree of offset by increase in food subsidy to total fertilizer subsidy is as $\left[\dfrac{\widehat{SUB}_{\text{food}}}{(0.5\cdot\widehat{SUB}_{\text{fert}}+0.5\cdot\hat{x}_1)}\right]$. The present example shows that nearly 20% and more of the reduc-

**Table 3. Results of numerical example (elasticities for 1% change in fertilizer price)**

| | State with procurement | | | | | State with no procurement | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\varepsilon$ | | | | | $\varepsilon$ | | |
| | 0 | −0.5 | −1 | −1.5 | −2 | 0 | −0.5 | −1 | −1.5 | −2 |
| Wheat | | | | | | | | | | |
| $y$ | 0.00 | −0.03 | −0.04 | −0.04 | −0.05 | 0.00 | −0.08 | −0.10 | −0.11 | −0.12 |
| $p$ | 0.47 | 0.17 | 0.10 | 0.07 | 0.06 | 0.33 | 0.15 | 0.10 | 0.07 | 0.06 |
| $x_1$ | −0.53 | −0.87 | −0.94 | −0.97 | −0.99 | −0.67 | −0.92 | −1.00 | −1.04 | −1.06 |
| $x_2$ | 0.47 | 0.13 | 0.06 | 0.03 | 0.01 | 0.33 | 0.08 | 0.00 | −0.04 | −0.06 |
| $w_2$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $PS$ | 0.42 | 0.12 | 0.06 | 0.03 | 0.01 | 0.23 | 0.05 | 0.00 | −0.03 | −0.04 |
| $SUB_{food}$ | 1.41 | 0.50 | 0.31 | 0.22 | 0.17 | | | | | |
| $SUB_{fert}$ | −1.53 | −1.87 | −1.94 | −1.97 | −1.99 | −1.67 | −1.92 | −2.00 | −2.04 | −2.06 |
| Paddy | | | | | | | | | | |
| $y$ | 0.00 | −0.04 | −0.06 | −0.06 | −0.07 | 0.00 | −0.05 | −0.06 | −0.07 | −0.07 |
| $p_p$ | 0.10 | 0.08 | 0.07 | 0.07 | 0.06 | 0.17 | 0.09 | 0.06 | 0.05 | 0.04 |
| $p_o$ | 0.62 | 0.30 | 0.19 | 0.14 | 0.11 | | | | | |
| $p$ | 0.33 | 0.15 | 0.10 | 0.07 | 0.05 | | | | | |
| $x_1$ | −0.67 | −0.89 | −0.96 | −0.99 | −1.01 | −0.83 | −0.96 | −1.00 | −1.02 | −1.04 |
| $x_2$ | 0.33 | 0.11 | 0.04 | 0.01 | −0.01 | 0.17 | 0.05 | 0.00 | −0.02 | −0.04 |
| $w_2$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| $\theta$ | 0.00 | 0.04 | 0.06 | 0.06 | 0.07 | | | | | |
| $PS$ | 0.26 | 0.09 | 0.03 | 0.00 | −0.01 | 0.11 | 0.03 | 0.00 | −0.01 | −0.02 |
| $SUB_{food}$ | 0.30 | 0.23 | 0.21 | 0.20 | 0.19 | | | | | |
| $SUB_{fert}$ | −1.67 | −1.89 | −1.96 | −1.99 | −2.01 | −1.83 | −1.96 | −2.00 | −2.02 | −2.04 |

Source: calculation by author.

tion in the fertilizer subsidy may be offset by an increase in food subsidy within foodgrain market. This degree of offset effect should not be neglected.

1) The effect on $PS$ of paddy producers under no procurement is expressed as the equation (44) with $\theta=0$.
2) This measure was broken off just on about one year because that was not what was feasible.
3) Until here we discuss genarally, and we assume the prodcution function is Cobb-Douglas type for simplicity in this subsection.
4) In Gulati and Sharma [7] , they estimated the elasticity of supply in the short term as follows. Paddy in Punjab—0.25, Wheat in Punjab—0.12, CPaddy in Orissa—0.57, Wheat in Madhya Prades h—0.43. Estimation periods between state vary, but they are almost from the mid-60s to the mid-80s.
5) Government of India [6], Table 5.10.
6) For example, Swamy and Binswanger [11] and Binswanger, Quison, and Swamy [1] can be referred.

## 6. Conclusion

This paper, through formalizing the Indian foodgrain market in a static equilibrium model, the interrelation between the food subsidy and the fertilizer subsidy is expressed clearly. One of the characteristics of this model is the setting of the procurement price. There are some previous studies that treat the Indian foodgrain market with procurement. In these models, the procurement price is fixed as the issue price in the PDS. This model, however, shows the procurement price based on the average cost of the producers under procurement as it is actually determined. Then, we can introduce the difference between the procurement price and the issue price in the PDS, and show explicitly food subsidy in the model.

We analyzed the effects of an increase in the fertilizer issue price by the comparative static in the model. Briefly stated, an increase in the fertilizer price results in an increase in the procurement price by causing the average and the marginal costs to increase. This means the expansion of the food subsidy occurs through widening of the difference between the procurement price and the issue price of foodgrain under the assumption that the PDS scheme is remains unchanged. Our numerical example also shows that there is an adverse

effect on the food subsidy when the fertilizer subsidy is reduced, and the degree of offsetting is larger under more elastic demand.

Government procures only in state with developed foodgrain production and the procurement price can cover the average cost of production there. Because of this system, we can confirm that the producers in states under procurement hardly lose in the face of increases in the fertilizer price. This shows that fertilizer subsidy reform may enlarge the regional difference between states under procurement and states under no procurement.

Government interventions in the Indian foodgrain market are important in terms of reducing uncertainty and alleviating poverty. However, the problems in reform are from the interrelations between multiplex interventions. In the 90s, the issue price in the PDS has increased, and at the same time the poverty indicators have become worse. On the other hand, the procurement has increased. This increases the food subsidy. The FCI sometimes sells the stocks to the open market. Consistency cannot be confirmed there. India has faced the difficulties of partial reform under the frictions between welfare of classes/individuals and government fiscal deficit. The commitment of government for a consistency in reforms should be required.

The author is grateful for helpful comments by anonymous referees and the editorial board of *JJRE,* and Professors Natsuki Fujita, Yonosuke Hara, Koichi Fujita, Katsuhiro Saito, and Norikazu Kanada. And the author thank for assistance in translating and comments by Rodney Radcliffe Reid. A part of this work is supported from Grant-in-Aid for Encouragement of Young Scientists, Grant-in-Aid for Scientific Research of the Ministry of Education, Science, Sports and Culture. Needless to say, the errors and mistakes in this paper are attributed to the author's.

## Appendix

In the section 4, we reserve evaluation of the sign conditions of the elasticities of the 1's factor demand, the procurement and the incentive price with respect to the fertilizer price in levy procurement.

First, the negative sign of the elasticity of $x_1$ is shown by taking the differential of the equation (34) with respect to the elasticity of demand, $\varepsilon$.

$$\frac{\partial(\hat{x}_1/\hat{w}_1)}{\partial\varepsilon}=\frac{S_1(1-\theta)\lambda\nu(\kappa+\sigma)^2(\nu-\lambda\theta\tau)(1-\lambda\theta\tau)}{D^2}>0 \tag{46}$$

Under inelastic demand (ex. $\varepsilon=0$), we can get $\frac{\hat{x}_1}{\hat{w}_1}<0$, then for more elastic demand we can find the negative sign for the elasticity of 1's factor demand from the above differentiation.

For incentive and procurement prices, we cannot always get the positive sign conditions in any other parameters under more elastic demand. First, we check the sign of the elasticity of incentive price. This is shown below. We have expressed the elasticities by the technical parameters in main text. But here, these are shown by using the prices.

$$\text{sign}\left[\hat{\hat{p}}/\hat{w}_1\right]=\text{sign}[p_o+\varepsilon\theta\{p_o-p_p(2-\nu)\}]$$

Then,

1. In the case of $p_o-p_p(2-\nu)\leq 0$ for any $\varepsilon(\leq 0)$,

$$\frac{\hat{\hat{p}}}{\hat{w}_1}>0 \tag{47}$$

2. In the case of $p_o-p_p(2-\nu)>0$

$$\frac{\hat{\hat{p}}}{\hat{w}_1}>0 \Leftrightarrow \varepsilon>-\frac{1}{\theta\{1-(p_p/p_o)(2-\nu)\}} \tag{48}$$

In the second case, the elasticity of incentive price never shows the negative sign unless the demand is quite elastic. For example, we set the parameters as follows. In Punjab, the ratio of the wholesale price to the procurement price is less than 2. We set 0.5 on $p_p/p_o$. And the share of the procurement to the production is about 70%. The ratio of the variable cost to total cost ($\nu$) is

$$\varepsilon>-\frac{1}{0.7(1-0.5)}=-2.85 \tag{49}$$

That is, the positive sign condition in this case is violated under very elastic demands which are out of touch with reality.

For the procurement price, because of $\frac{\hat{p}_p}{\hat{w}_1}>\frac{\hat{\hat{p}}}{\hat{w}_1}$, under the situation $\frac{\hat{\hat{p}}}{\hat{w}_1}>0$, then, we can get $\frac{\hat{p}_p}{\hat{w}_1}>0$.

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(Received October 25, 1999; accepted February 14, 2000)