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# GOVERNMENT POLICY AND DYNAMIC SUPPLY RESPONSE - A STUDY OF THE COMPULSORY GRAIN DELIVERY SYSTEM\*\*

## *Abstract*

*The impact of government policy on the dynamics of agricultural supply in the 1980s is explored. Specifically, an intertemporal acreage allocation model that allows for the impact of compulsory grain delivery is developed. Subsequently, an estimable dynamic acreage demand equation is derived, and estimated for a crop using region-level data. Generalized method of moments (GMM) estimators for dynamic panel data models are used. The elasticity estimates thus obtained suggest that the demand for crop acreage (and hence the supply of crop output) responded negatively to the level of forced grain procurement, and positively to output price.*

## I. INTRODUCTION

In the 1980's Ethiopian farm households were subject to a system of compulsory grain delivery (CGD). Under this system, such households were required to sell a portion of their output to the government at fixed prices<sup>1</sup>. After meeting this obligation (commonly referred to as the 'quota') these producers were allowed to buy and sell farm output on the local 'open' or 'free' market. Generally such a system affects the welfare of producers. It may also affect their resource allocation decisions. The first objective of this paper is to investigate the impact of CGD on the production decisions of Ethiopian farm households. Accordingly, the paper can be viewed as a quantitative inquiry into an aspect of the recent economic history of Ethiopia.

In principle the impact of the compulsory delivery system can be modelled in different ways. That it is an implicit form of taxation (or rent) seems to be the common view<sup>2</sup>. Thus, identifying an equivalent form of explicit taxation facilitates the analysis. Accordingly, it is proposed that the 'quota' should be viewed as a proportional output tax implicitly imposed on farm households. One way of modelling this is to consider the 'quota' as a proportion of output. This is consistent with the most common criteria used in determining the level of a household's 'quota' obligation, namely<sup>3</sup>.

❖ the potential crop output of the household; and

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<sup>1</sup> The government agency responsible for administering the CGD was the Ethiopian Agricultural Marketing Corporation (EAMC).

<sup>2</sup> See Taffesse (1989), Franzel et al (1989), Azam (1992), Dercon (1994), Pickett (1991). This view is shared by those who analyzed the procurement system in general, as well as its specific applications - see Sah and Stiglitz (1992), Sah and Srinivasan (1987).

<sup>3</sup> To the extent that it was not based on a 'quota' schedule, the determination of 'quota' levels to be delivered by households was not uniform. Nevertheless, the most common practice was the imposition of relatively higher 'quota' on households with higher outputs [see Alemayehu (1987)]

- ❖ the wealth (or, more precisely, the overall income-generating capacity) of the household, measured by variables including size of land-holding, number of oxen and other livestock owned, and non-farm income.

In contrast, Azam (1992) identifies the 'quota' as an implicit lump sum tax, and proceeds to model its impact accordingly. This formulation excludes the possibility of the 'quota' system affecting the production decisions of farmers. It also does not accurately reflect the process of 'quota' allocation to peasant households. Moreover, this characterization has the added advantage of allowing the study of the impact of an agricultural price policy (i.e., CGD) in the content of supply response models. This is an important advantage, since the second objective of the paper is to assess the price responsiveness of farm households' crop supply in Ethiopia during the period of study. The possibility of jointly studying these effects is created by defining the average price of crops subject to CGD as follows:

$$P = \phi P^s + (1 - \phi)P^m$$

where:  $P$  = the weighted average price;  $P^s$  = the procurement (or EAMC) price;  $P^m$  = the 'free' or 'open' market price;  $\phi$  = the 'quota' as a proportion of the farm household's total output (or the rate of 'quota').

To achieve the objectives stated above, a simple dynamic farm household model is developed. The model is a variant of the linear rational expectations model [Sargent (1987), Hansen and Sargent (1980) as applied to agricultural supply response analysis [Ecksten (1984, 1985), Tegene, Huffman, and Miranowski (1988)]. The main innovation is the direct introduction and analysis of CGD in the framework. Furthermore, the decision problem of the farm household is explicitly placed in the agricultural household models framework in a very simple manner. On the basis of the model elasticities of acreage demand for crop cultivation are computed. Subsequently, an estimable acreage demand equation is derived, and estimated for a crop using region level data. The elasticity estimated thus obtained suggest that the demand for crop acreage (and hence the supply of crop output) responds negatively to the 'quota and positively to output price.

The rest of the paper is organized as follows. Section (5.2) presents a simple dynamic model of farm household production choices and the elasticities thereof. Section (5.3) describes the details of the empirical analysis including the data, econometric specification, estimation procedure, and estimation results. Section (5.4) concludes. The final section is an appendix detailing the procedure used for obtaining an explicit solution for the acreage decision rule, as well as some of the properties of the generalized method of moments (GMM) estimators employed.

## 2. A DYNAMIC MODEL OF FARM HOUSEHOLD PRODUCTION CHOICE

A simple dynamic model is presented in this section as a means of investigating the impact of CGD on the intertemporal production choices of the farm household<sup>4</sup>.

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<sup>4</sup> The model stated below is an adaptation of Eckstein (1985) considers the demand for acreage (in levels rather than shares) by farmers in the absence of forced crop procurement by the state. He also does not address the question of separability of production and consumption decisions.

## 2.1 Assumption and Characterization

1. Consider a representative infinitely-lived dynastic farm household which maximized its discounted expected intertemporal utility via its consumption, production, and saving choices<sup>5</sup>. This farm household is assumed to have a (common) one-period utility function,  $u(x_{i+j})$  which is linear, i.e.,

$$u(x_{i+j}) = \Theta_0 + \Theta_1 x_{i+j}; \Theta_0, \Theta_1 > 0, t, j = 0, 1, \dots \quad (1.1)$$

where  $u(x_{i+j})$  represents consumption in period  $i + j$ . In other words the household is deemed to be risk-neutral. In other words, the impact of the randomness of some variables on the choices farmers make is considered without modelling their behaviour towards risk. It is further assumed that the intertemporal utility function is additively separable, and that each period yield and price risk are realized before consumption decisions are taken. Under these circumstances, the farm household's production and consumption decisions are separable. Thus the farm household maximized its discounted expected utility by first maximizing its discounted expected profits, and subsequently choosing the level of consumption and/or savings subject to the corresponding budget constraint. This budget constraint has three components, savings from the previous period,  $s_{i+j-1}$ , the interest (or return accruing to those savings at a rate,  $r$  (which is assumed to remain constant over time), and current profits,  $\pi_{i+j}$ , i.e.,

$$x_{i+j} + s_{i+j} = (1 + r) s_{i+j-1} + \pi_{i+j}; t, j = 0, 1, \dots \quad (1.2)$$

Savings represent the cash-equivalent of different savings instruments available to the farm household, including cash, other financial assets, and grain storages.

2. Using its exogenously given total cultivable land,  $A_{i+j}$ , and subject to yield risk, the farm household is assumed to produce two (groups of) annual crops under a fixed-proportions technology of production<sup>6</sup>. This technology is represented by two production functions which are linear in acreage, stochastic, and involve a one-period lag between cultivation and harvest (harvest at  $t+j$  is a function of acreage at  $i+j-1$ )<sup>7</sup>. Formally<sup>8</sup>:

$$Q_{1,t+j} = y_1 A_{1,t+j-1} + \varepsilon_{1,t+j}; y_1 > 0, t, j = 0, 1, \dots \quad (1.3)$$

<sup>5</sup> The structure of our model is such that the conditions for exact aggregation are satisfied. Hence, the 'representative' household is equivalent to the 'average' household. In fact, Eckstein (1985) aggregates a closely related model over a (stable) population of farmers to characterize rational expectations equilibrium of the market for a crop.

<sup>6</sup> The size of the farm household's landholdings may vary over time, primarily due to land redistribution. But this is beyond the control of the household.

<sup>7</sup> Under the assumed fixed-coefficients technology, each crop is produced by using land and non-land factors in fixed proportions. The output of each crop, as well as the direct cost of its production, can thus be expressed as a function of the amount of acreage allocated to its cultivation. It is in this sense that (1.3) and (1.4) are production functions. See also Tegene, Huffman and Miranowski (1988).

<sup>8</sup> Crop 1 is identified as the crop subject to CGD while Crop 2 may be considered as free from CGD. However, even if both are subject to CGD the analysis below will not be affected.

$$Q_{2,t+j} = y_2 A_{2,t+j-1} + \varepsilon_{2,t+j}; y_2 > 0, t, j = 0, 1, \dots \quad (1.4)$$

$Q_{1,t+j}$  = output of crop  $i$  ( $i = 1, 2$ ) at time  $t + j$ ;  $A_{1,t+j}$  = the proportion of total acreage allocated to crop  $i$  at time  $t + j$ ;  $y_1$  and  $y_2$  are parameters;  $\varepsilon_{1,t+j}$  = exogenous shocks to production during  $t + j$  which have zero mean, constant variance, and are serially uncorrelated. In line with the fact that crop production involves biological gestation periods of some (sometimes considerable) length, the one-period lag in production captures the phenomenon that the farm household has to make acreage decisions in terms of its expectations about unknown future output prices. This introduces price risk into the decision problem of the farm household.

3. It is assumed that the direct cost of producing a crop is a function of acreage allocated to its production. This cost has two components distinguished by the period during which they are incurred (or known); costs known at the time of planting and costs known at the time of harvest. The latter is an attempt to capture the flexibility of input use after planting and up to and including harvest and the uncertainty of output given the lag in production. The focus here is on Crop 1. Given this focus it is assumed that there are additional adjustment-cost-like expenses related to Crop 1. To capture these costs as well as the direct costs it is assumed that a quadratic cost function is associated with that crop. This function takes the following specific form<sup>9</sup>:

$$C_{1,t+j} = (v_{1,t+j-1} + f_{1,t+j})A_{1,t+j-1} + \frac{b}{2}A_{1,t+j-1}^2 + dA_{1,t+j-1}A_{1,t+j-2}; b > 0; d < 0 \quad (1.5)$$

where:  $v_{1,t+j-1}$  and  $f_{1,t+j}$  are non-land costs of producing Crop 1 over the total available acreage at the time of cultivation ( $t+j-1$ ) and at the time of harvest ( $t+j$ ) respectively<sup>10</sup>. The term  $\frac{b}{2}A_{1,t+j-1}^2$  eventuates decreasing returns to scale in the long-run. Two contracting dynamic effects are captured by  $d$  [Eckstein (1985)]. The first is the tendency to rotate crops is successive cultivation of the same crop on a plot substantially reduces soil fertility and increases the cost of production. The second is the incentive to recultivate the crop planted last period if the cost of land preparation for that crop has been high and the current cost of production is lower as a result<sup>11</sup>. The sign of  $d$  is determined by which of these two dominate. If the first effect dominates, then  $d > 0$ , while  $d < 0$  if the second effect is dominant. For simplicity it is

<sup>9</sup> Although quadratic cost functions are commonly used, this specific form as applied to agricultural supply response analysis is due to Eckstein (1985). In this regard, Eckstein (1985) notes that a combination of the terms  $\frac{b}{2}A_{1,t+j-1}^2$  and  $dA_{1,t+j-1}A_{1,t+j-2}$  (with  $d < 0$ ) is equivalent to the standard adjustment cost formulation.

<sup>10</sup> More explicitly,  $v_i$  represents the total non-land costs that would be incurred during the cultivation period if total acreage is planted with crop  $i$  ( $i=1,2$ ), i.e:

$$v_i = (\text{non-land cultivation costs of crop } i \text{ per hectare}) \times A$$

where  $A$  is total available acreage. Similarly:

$$f_i = (\text{non-land harvest costs of crop } i \text{ per hectare}) \times A$$

<sup>11</sup> In other words, planting a crop different from the one cultivated last period involves costs higher than replanting with the same crop. In that sense, this tendency is induced by the presence of adjustment costs.

also assumed that a linear cost function of the following form is associated with Crop 2:

$$C_{2,t+j} = (v_{2,t+j-1} + f_{2,t+j})A_{2,t+j-1} \quad (1.6)$$

where:  $v_{2,t+j-1}$  and  $f_{2,t+j}$  are non land costs of producing crop 2 over the total available acreage at the time of cultivation ( $t+j-1$ ) and at the time of harvest ( $t+j$ ), respectively.

4. At the beginning of this paper it is argued that the 'quota' should be viewed as a proportional output tax implicitly imposed on farm households<sup>12</sup>. Accordingly, the impact of the 'quota' is analyzed by defining an average price in the following manner<sup>13</sup>:

$$P_1 = \phi_1 P_1^s + (1 - \phi_1) P_1^m$$

where  $P_1$  = the weighted average price of Crop 1;  $P_1^s$  = the procurement (or EAMC) price of Crop 1;  $P_1^m$  = the 'free' or 'open' market price of Crop 1;  $\phi_1$  = the 'quota' as a proportion of the farm household's total output of Crop 1 (or the rate of 'quota'). The average price defined this way represents the household's marginal value of a unit of output. It increases with  $P_1^s$  and  $P_1^m$ , and falls with  $\phi_1$ . Since  $P_1^s$  is less than  $P_1^m$ , and since,  $0 < \phi_1 < 1$ , the average price is less than the corresponding market price<sup>14</sup>. The valuation of the corresponding crop output at  $P_1$  thus captures the tax nature of the 'quota'. As will be clear shortly, however, using this expression for the average price in a dynamic setting is very cumbersome. In particular, it is difficult to accommodate within the linear-quadratic framework set out below. The main problem stems from its nonlinearity in the variables, such that it introduces higher-order moments in the otherwise linear solution (in first-order moments). Hence it is useful to adopt a linear alternative. To do so, a first-order Taylor approximation around the means of the three variables involved is adopted. Let  $x = [\phi_1 \ P_1^m \ P_1^s]$ , and representing the means,  $\bar{x} = [\bar{\phi}_1 \ \bar{P}_1^m \ \bar{P}_1^s]$ , such that:

1j

$$P_1(x) = \phi_1 P_1^s + (1 - \phi_1) P_1^m \\ \cong l'_0 + l_1 \phi_1 + l_2 P_1^m + l_3 P_1^s$$

where:

$$l'_0 = P_1(\bar{x}), \quad l_1 = \left( \frac{\partial P_1}{\partial \phi_1} \right)_{\bar{x}}, \quad l_2 = \left( \frac{\partial P_1}{\partial P_1^m} \right)_{\bar{x}}, \quad l_3 = \left( \frac{\partial P_1}{\partial P_1^s} \right)_{\bar{x}}$$

<sup>12</sup> The analysis below does not consider ways other than adjusting crop-mix that households may have devised to avoid delivering the quota or minimize its impact. Thus  $\phi_1$  has to be viewed as relating to the implicit output tax actually paid by farm households. In line with that the empirical analysis used actual procurement by the EAMC to compute .

<sup>13</sup> If Crop 2 is also subject to CGD, then the same procedure can be applied to define its average price. None of the results will be affected as a consequence. But, additional results pertaining to the effects of the 'quota' rate and market price of that crop will be obtained.

<sup>14</sup> There are anecdotes of some farm households buying crops to meet their 'quota' obligations. In such instances  $\phi_1 > 1$ , and thus,

$P_1 < P_1^s$ . Hence, the definition of the average price can accommodate these cases. However, these cases are not considered since they are unlikely to be typical.

The subscript  $\bar{x}$  indicates that the derivatives are evaluated at  $\bar{x}$ <sup>15</sup>. Observe also that  $\iota_1 < 0$ ;  $0 < \iota_2 < 1$ ; and  $0 < \iota_3 < 1$ . Thus the alternative expression possesses all the properties of the original. The fact that procurement prices changed very little over time (see section 3.1.3 below) is exploited to simplify the new expression further and obtain:

$$P_1 = \iota_0 + \iota_1 \phi_1 + \iota_2 P_1^m \quad (1.7)$$

where  $P_1 = \iota_0 + \iota_3 P_1^s$ .

Finally, the farm household is assumed to form expectations rationally. Following the most common characterization, rational expectations are identified as expectations which, in the context of specific models describing the behavior of the relevant variables, are equal to the mathematical expectations of those variables conditional on the information available at the time the forecasts are made<sup>16</sup>.

## 2.2 The Model

With the above assumptions, the farm household's problem can be characterized as maximizing its discounted intertemporal expected utility by choosing decision rules for consumption, savings, and acreage allocations under yield and price risk. These choices are made subject to the sequence of budget constraints, which is partly determined by the linear production technology, the exogenously given total household land-holding and the relevant information available to the household. The exogenously given initial level of savings,  $P_{t-1}$ , constitutes an additional constraint. The optimization problem can thus be summarized as follows<sup>17</sup>:

$$\max_{\{x_{t+j}, s_{t+j}, A_{t+j}\}} \lim_{T \rightarrow \infty} E = \left\{ \sum_{j=0}^T \beta^j (\ell_0 + \ell_1 x_{t+j}) \right\}; \quad t = 0, 1, \dots \quad (2.1)$$

subject to:

$$x_{t+j} + s_{t+j} = (1 + r)s_{t+j-1} + \pi_{t+j}; \quad t, j = 0, 1, \dots \quad (2.2)$$

$$Q_{1,t+j} = y_1 A_{1,t+j-1} + \varepsilon_{1,t+j}; \quad t, j = 0, 1, \dots \quad (2.3)$$

$$Q_{2,t+j} = y_2 A_{2,t+j-1} + \varepsilon_{2,t+j}; \quad t, j = 0, 1, \dots \quad (2.4)$$

<sup>15</sup> The partial derivative with respect to  $\phi_1$  captures only the direct impact of the 'quota' rate on the average price. The effect that may operate via  $P_1^m$  is introduced later.

<sup>16</sup> The nature and/or validity of rational expectations will not be considered any further. There is a huge literature concerning these issues. Among others, See Sargent (1987), Pesaran (1987), Cuthbertson and Taylor (1987), and Blanchard and Fisher (1989).

<sup>17</sup> Note that consumption is the numeraire, i.e., all prices are measured relative to an index of consumption goods' prices (say, for instance, a consumers' price index). This reflects the view that farm households consider relative prices in making their choices.

and  $s_{t-1}$  given, where:  $\pi_{t+j} \equiv (P_{1,t+j}Q_{1,t+j} - C_{1,t+j}) + (P_{2,t+j}Q_{2,t+j} - C_{2,t+j})$  = farm profits at time  $t + j$ ;  $\beta = (1 + r)^{-1}$  = the discount factor,  $r$  being the household's rat of time preference;  $P_{i,t+j}$  = average price (as defined above) of crop  $i$  household's information set at time  $t$ . In this regard, the information set is assumed to contain: current and past realizations of prices, costs, and production shocks; as well as the history of household production, consumption, and savings choices up to and including  $(t-1)$ . Note that  $0 < \beta < 1$ . The rest of the notation is as above.

First, consumption is factored out from (2.1) by using (2.2) to substitute for it. Then,  $\pi_{i+j}$  in (2.1) is expanded by using (2.3) - (2.4), (1.5) - (1.6) and (2.5) to respectively substitute for  $Q_{1,t+j}$ ,  $Q_{2,t+j}$ ,  $C_{1,t+j}$ ,  $C_{2,t+j}$ , and  $A_{2,t+j}$ . Correspondingly, the objective of the farming household can summarized as:

$$\max_{\{A_{1,t+j}, s_{t+j}\}} \lim_{T \rightarrow \infty} E_t = \sum_{j=0}^T \beta^j \{ \ell_0 + \ell_1 [ P_{1,t+j} y_1 - R_{1,t+j} - V_{1,t+j} ] \}$$

$$A_{1,t+j-1} - \frac{b}{2} A_{1,t+j-1}^2 - dA_{1,t+j-1} A_{1,t+j-2} + (P_{2,t+j} y_2 - v_{2,t+j-1} - f_{2,t+j}) + P_{1,t+j} \varepsilon_{1,t+j} + P_{2,t+j} \varepsilon_{2,t+j} + (1+r)s_{t+j-1} - s_{t+j} \} \quad (2.6)$$

subject to  $(A_{1,t-1}, s_{t-1})$  given.  $E_t$  represents  $E(. / - t)$ , while

$R_{1,t+j} \equiv (P_{2,t+j} y_2$ , and  $V_{1,t+j} \equiv (v_{2,t+j-1} + f_{1,t+j}) - (v_{2,t+j-1} + f_{2,t+j})$ ). The Sum of  $R_1$  and  $V_1$  captures the total (actual and opportunity) cost of producing Crop 1. Briefly, the farm household chooses a contingency plan  $\{A_{1,t+j} + \varepsilon_{1,t+j}\}$  to maximize its discounted expected intertemporal utility. Obviously  $x_{i+j}$  and  $A_{2,t+j}$  are obtained via (2.2) and (2.5), respectively.

Equation (2.6) represents a linear-quadratic optimization problem in discrete time. the corresponding first order conditions (including the transversality conditions) are obtained by differentiating the equation with respect to  $A_{1,t+j}$  and  $s_{t+j}$  ( $j=0,1,\dots,T$ )<sup>18</sup>. In this regard, note that  $A_{t+j}$  directly affects  $\pi_{t+j+1}$  and  $\pi_{t+j+2}$ , which in turn affect contemporaneous consumption and utility via the budget constraints. Similarly,  $s_{t+j}$  impacts on consumption and utility during  $(t + j)$  and  $(t + j + 1)$  through the corresponding budget constrains. After rearranging, the following Euler equations for  $j = 0, 1, \dots, T - 1$  are thus obtained:

$$E_t \{ \beta^{j+1} [ u'(x_{i,t+j+1}) (P_{1,t+j+1} y_1 - R_{1,t+j+1} - V_{1,t+j+1} - bA_{2,t+j} - dA_{2,t+j-1}) - \beta u'(x_{i,t+j+2}) dA_{1,t+j+1} ] \} = 0 \quad (2.7a)$$

$$- E_t \{ \beta^j [ u'(x_{i,t+j}) - \beta(1+r)u'(x_{1,t+j+1}) ] \} = 0 \quad (2.7b)$$

and for  $j = T$ , the transversality conditions:

<sup>18</sup> The relevant rule of differentiation is Leibniz's rule [whiteman (1983)].



$$\lim_{T \rightarrow \infty} E_t \{ \beta^{T+1} u'(x_{i+T+1}) (P_{1,t+T+1} y_1 - R_{1,t+T+1} - V_{1,t+T+1} - bA_{2,t+T} - dA_{1,t+T-1}) A_{1,t+T} \} = 0 \quad (2.8a)$$

$$\lim_{T \rightarrow \infty} E_t [ \beta^{T+1} u'(x_{i+Tj}) (1+r) s_{i+T} ] = 0 \quad (2.8b)$$

where  $u'(\cdot)$  represents the partial derivative of  $u(\cdot)$  with respect to  $x$ .

Two remarks about the first-order conditions. First, by the linearity of the one period utility function, the marginal utility of consumption over time is constant. By (1.1) it is equal to  $\Theta_1$ . Hence the  $u'(\cdot)$  terms drop out of all first order conditions. Second, they reveal that, under the specified circumstances, production and consumption decisions are separable. Combined with the production functions, (2.7a) and (2.8a) determine household production choices independent of consumption. Accordingly the production decision of the farm household can be separately considered via the first-order conditions relating to  $A_{1,t+j}$ . As a first step towards a solution the Euler equations are restated by applying the law of iterated conditional expectations to (2.7a) and rearranging<sup>19</sup>:

$$E_t \{ E_{t+j} (P_{1,t+j+1} y_1 - R_{1,t+j+1} - V_{1,t+j+1} - bA_{1,t+j} - dA_{1,t+j-1} - \beta dA_{1,t+j+1}) \} = 0$$

$$t = 0, 1, \dots$$

$$j = 0, 1, \dots, T-1$$

For these equations to hold for all realization of  $(P_{1,t+j+1}, R_{1,t+j+1}, V_{1,t+j+1})$  it is necessary that the term in parentheses is equal to zero. Therefore, after substituting for  $P_1$  from (1.7) above, the first-order conditions for the farm household's production problem can be stated as:

$$\beta E_{t+j} \left[ A_{1,t+j+1} + \frac{b}{d\beta} A_{1,t+j} + \frac{1}{\beta} A_{1,t+j-1} \right] = E_{t+j} \frac{1}{d} [(\iota_0 + \iota_1 \phi_{1,t+j-1} + \iota_2 P_{1,t+j+1}^m) y_1]$$

$$- E_{t+j} \frac{1}{d} [R_{1,t+j+1} - V_{1,t+j+1}] \quad (2.9)$$

for all  $j = 0, 1, \dots, T-1$ .

Equation (2.9) form a set of stochastic Euler equations. Since these equations are linear, it is possible to explicitly solve for the optimal decision rule if the additional assumption is made that the exogenous stochastic process  $\{P_{1,t+j+1}^m\}_{j=0}^{\infty}$ ,  $\{R_{1,t+j+1}\}_{j=0}^{\infty}$ , and  $\{V_{1,t+j+1}\}_{j=0}^{\infty}$  are of mean exponential order less than  $\frac{1}{\sqrt{\beta}}$  such that for some  $M > 0$ , and  $1 \leq q < \frac{1}{\sqrt{\beta}}$  [see Sargent (1987, 393); Hansen and Sargent (1980, 12)]:

<sup>19</sup> The law of iterated conditional expectations states that, for  $-t \subseteq -t+j$  (i.e., for a nondecreasing information set):

$$E(\cdot | -t) = E[E(\cdot | -t+j) | -t]$$

In the short-hand we use:

$$E_t(\cdot) = E_t[E_{t+j}(\cdot)]$$

$$\left| E_t(P_{1,t+j+1}^m) \right| < Mq^{t+j+1}; \quad \left| E_t(R_{1,t+j+1}) \right| < Mq^{t+j+1}; \quad \left| E_t(V_{1,t+j+1}) \right| < Mq^{t+j+1};$$

for all  $t$  and all  $j \geq 0$ <sup>20</sup>. The assumption (roughly) implies that  $E_{t+j}(P_{1,t+j+1}^m)$ ,  $E_{t+j}(R_{1,t+j+1})$ , and  $E_t(V_{1,t+j+1})$  will not grow faster than  $\beta^{(t+j+1)/2}$ ; [Epstein and Yatchew (1985, 238], or more formally, the two stochastic processes are bounded in the mean [Eckstein (1985, 206)]. This assumption is made to ensure that the solution satisfy the transversality condition.

With this assumption (2.9) can be solved for  $A_{1,t+j+1}$ , the solution being :<sup>21, 22</sup>

$$A_{1,t+j} = \lambda_1 A_{1,t+j-1} - \left( \frac{\lambda_1}{d} \right) \sum_{i=0}^{\infty} (\beta \lambda_1)^i E_{t+j} [y_1(t_0 + \iota_1 \phi_{1,t+j+1+i} + \iota_2 P_{1,t+j+1+i}^m) - R_{1,t+j+1+i} - V_{1,t+j+1+i}] \quad (2.10)$$

When  $\lambda_1$  is the smaller of the roots satisfying  $\frac{1}{\lambda_1} = -\frac{b}{d} - \beta \lambda_1$ .

Equation (2.10) represents the farm household's demand for land relating to Crop 1. It implies that his demand is a function of past allocation of acreage to Crop 1, expected output prices, expected rate of 'quota', and realized and expected non-land input and opportunity costs. Because the terms  $E_{t+j}(\phi_{1,t+j+1+i})$ ,  $E_{t+j}(R_{1,t+j})$ ,  $E_{t+j}(P_{1,t+j+1+i})$ ,  $E_{t+j}(R_{1,t+j+1+i})$  and  $E_t(V_{1,t+j+1+i})$

are present, that equation does not yet constitute a decision rule. To make it one, it is necessary to express those expectational variables as functions of elements of the current information set  $(-_{t+j})$ , i.e., as functions of variables known to the farm household at time  $t+j$ . This will be done in a later section. Nevertheless, as it stands, (5.14) can be used to compute acreage demand elasticities with respect to relevant variables.

### 2.3 Elasticities

One of the main objectives in this paper is to examine the impact of CGD on the intertemporal production choices of farm household under risk. The simple model presented above reduces this to analyzing the effect of CGD on the acreage allocation decisions of farm households. The obvious route, in this regard, is to identify the long-run and short-run elasticities of expected acreage with respect to changes in the expected rate of 'quota', using equation (2.10). The response of

<sup>20</sup> Since, by definition, it is bounded within the interval [0,1] there is no need to make the same assumption about  $\phi$ .

<sup>21</sup> The solution procedure used is described in the first section of this chapter's appendix.

<sup>22</sup> The solution stated as (2.10) displays the certainty equivalence property, i.e. the same solution would result if we had maximized the criteria formed by substituting

$[E_t(p_{1,t+j}), E_t(R_{1,t+j}), E_t(V_{1,t+j})]$  for  $[P_{1,t+j}, R_{1,t+j}, V_{1,t+j}]$  and dropping the expectations operator from outside the sum in the objective function (2.6). Also see Sargent (1987), and Hansen and Sargent (1980).

these allocations to prices can also be examined in a similar fashion. This section deals with the task<sup>23</sup>. Recall that Crop 1 is subject to CGD, the rate of ‘quota’ being 1. Also recall the definition of the average price of that crop as:

$$P_1 = t_0 + t_1\phi_1 + t_2P_1^m$$

Hence, the unconditional and conditional expectations of the average price can be respectively represented as<sup>24</sup>:

$$E(P_1) = t_0 + E t_1(\phi_1) + t_2 E(P_1^m)$$

$$E_{i+j}(P_{1,t+j+1+i}) = t_0 + t_1 E_{i+j}(\phi_{1,t+j+1+i}) + t_2 E_{i+j}(P_{1,t+j+1+i}^m) \quad (2.11a)$$

The previous equations express the argument that the expected rate of ‘quota’ as well as the expected output market price operate via the expected average price of Crop 1. As noted earlier a change in the quota rate has a direct, negative effect on  $P_1$ . That impact is captured by the negative parameter. That an average farm household is being considered implies that the ‘average’ quota rate may also influence the corresponding market price. The possible routes through which this effect may occur include: the income effect on farm households demand for goods (including Crop 1); the effect on the supply of Crop 1 in the rural market; the impact on the purchases of Crop 1 made by urban consumers/traders. A rise in the ‘quota’ rate reduces the income of farm households. It may thus lower their demand for Crop 1 if it is a normal good. It is also likely to induce a fall in that part of urban demand for Crop 1 which is met via direct purchases on the rural grain market. This is a consequence of the fact that a fraction of the amount of Crop 1 procured goes to urban consumers. On the other hand, a rise in the ‘quota’ rate leads to a decreased supply on the rural market. The first two tend to push the market prices downward, while the third exerts a pressure in the opposite direction. The ultimate effect on the market price of Crop 1 in the rural market is dependent on the relative strength of these contraction pressures.

In line with the observations in the previous paragraph, (2.11a) is differentiated with respect to the relevant expected 1, to derive the impact of the latter on the unconditional and conditional means of the average price of Crop 1, respectively:

$$\frac{\partial E(P_1)}{\partial E(\phi_1)} = t_1 + t_2 \frac{\partial E(P_1^m)}{\partial E(\phi_1)}$$

$$\frac{\partial E_{i+j}(P_{1,t+j+1+i})}{\partial E_{i+j}(\phi_{1,t+i+1+i})} = t_1 + t_2 \frac{\partial E(P_{1,t+j+1+i}^m)}{\partial E(\phi_{1,t+j+1+i})} \quad (2.11b)$$

<sup>23</sup> The discussion below focuses on acreage elasticities. Note, however, that the linear production functions can be used to translate the response of acreage demand in to that of output supply.

<sup>24</sup> It is possible to make  $t_0$ ,  $t_1$  and  $t_2$  time varying parameters to reflect the possibility of changes in the relative strength of the three determinants of  $PI$ . That route is not followed so as to keep the model as close to what can be estimated as possible.

The analogous expressions for the effect of  $P_1^m$  are:

$$\frac{\partial E(P_1)}{\partial E_{i+j}(P_1^m)} = \frac{\partial E_{t+j}(P_{1,t+j+1+i}^m)}{\partial E_{i+j}(P_{1,t+j+1+i}^m)} = \iota_2 \quad (2.11c)$$

Note that an expected rise in  $P_1^m$  always increases the expected average price ( $\iota_2 > 0$ ). In contrast, a rise in expected  $\phi_1$  generates two potentially counteracting effects. The direct effect is always negative since, given  $P_1^s$  and  $P_1^m$ , a higher 'quota' rate results a larger expected share of the lower  $P_1^s$  in the average price. The indirect effect, which operates via  $P_1^m$ , is ambiguous since the impact of  $\phi_1$  on  $P_1^m$  cannot be signed *a priori*. If the indirect effect is negative (or zero), then, an expected rise in the 'quota' rate leads to an expected fall in the average price of Crop 1. In contrast, if the indirect effect is positive, but the direct impact exceeds the induced change in absolute value, i.e.,

$$|\iota_1| > \iota_2 \frac{\partial E(P_1^m)}{\partial E(\phi_1)}$$

$$|\iota_1| > \iota_2 \frac{\partial E(P_{1,t+j+1+i}^m)}{\partial E(\phi_{1,t+j+1+i})}$$

Then, the net effect is an expected fall in the average price of Crop 1<sup>25</sup>.

### 2.3.1 Long-run elasticities

The long-run elasticities express the impact of expected changes in mean prices and the mean 'quota' rate on the farm household's mean acreage demand. Consider the effect of the 'quota' rate first. The long-run elasticity of expected acreage demand with respect to expected  $\phi_1$ ,  $\xi_{A,\phi}^L$ , is derived by first taking the unconditional expectation of (2.10), differentiating with respect to  $E(\phi_1)$  and making use of (2.11b), and weighting the result by the ratio of the unconditional means  $E(\phi_1)$  and  $E(A_1)$ <sup>26</sup>.

The final result is:

<sup>25</sup> Obviously, the two opposite effects may cancel each other out if they are equal.

<sup>26</sup> Take unconditional expectations of both sides of (2.10) and rearrange to obtain:

$$(1 - \lambda_1)E(A_1) = -\left(\frac{\lambda_1}{d}\right)E\left[y_1(\iota_{0+}\iota_1\phi_{1+}\iota_2\phi_2 + \iota_2P_1^m) - R_1 - V_1\right]\sum_{i=0}^{\infty}(\beta\lambda_1)^i$$

Given  $|\beta\lambda_1| < 1$ , it is also the case that:

$$\sum_{i=0}^{\infty}(\beta\lambda_1)^i = \frac{1}{(1 - \beta\lambda_1)}$$

such that:  $(1 - \lambda_1)E(A_1) = -\left[\frac{\lambda_1}{d(1 - \beta\lambda_1)}\right]E\left[y_1(\iota_{0+}\iota_1\phi_{1+}\iota_2\phi_2 + \iota_2P_1^m) - R_1 - V_1\right]$

$$\xi_{A,\phi}^L = \left[ \frac{\partial E(A_1) \partial E(P_1)}{\partial E(P_1) \partial E(\phi_1)} \right] \frac{E(\phi_1)}{E(A_1)} = - \left( \frac{\lambda_1 y_1}{d(1-\lambda_1)(1-\beta\lambda_1)} \right) \left[ t_1 + t_2 \frac{\partial E(P_1^m)}{\partial E(\phi_1)} \right] \frac{E(\phi_1)}{E(A_1)} \quad (2.12a)$$

The long-run elasticity of expected acreage demand with respect to expected market price of Crop 1,  $\xi_{A,P^m}^L$ , is derived in analogous manner:

$$\xi_{A,P^m}^L = \left[ \frac{\partial E(A_1) \partial E(P_1)}{\partial E(P_1) \partial E(P_1^m)} \right] \frac{E(P_1^m)}{E(A_1)} - \left( \frac{\lambda_1 y_1}{d(1-\lambda_1)(1-\beta\lambda_1)} \right) t_2 \frac{E(P_1^m)}{E(A_1)} \quad (2.12b)$$

The corresponding elasticity with respect to R1 is obtained in the same way:

$$\xi_{A,R}^L = \left[ \frac{\partial E(A_1) E(R_1)}{\partial E(R_1) E(A_1)} \right] = \left( \frac{\lambda_1 y_1}{d(1-\lambda_1)(1-\beta\lambda_1)} \right) t_2 \frac{E(R_1)}{E(A_1)} \quad (2.12c)$$

Recall that:  $0 < \beta < 1$ ;  $0 < |\lambda_1| < 1$ ;  $y_1$  is positive; and  $\lambda_1$  and  $d$  can be positive or negative. However, the latter two will have opposite signs since  $d > 0$  implies  $\lambda_1 < 0$ <sup>27</sup>. In addition, the nature of the CGD implies that  $0 < E(\phi_1) < 1$ ,  $t_1$  is negative, and  $0 < t_2 < 1$ . By making use of these features, the following can be inferred from (2.12a) and (2.12c)<sup>28</sup>.

1. The long-run 'quota' elasticity,  $\xi_{A,\phi}^L$ , is negative if both the direct and indirect effects of  $\phi_1$  are negative, or if: the latter, though positive, is less than the former in absolute value;

$$|t_1| > t_2 \frac{\partial E(P_1^m)}{\partial E(\phi_1)}$$

It implies that the imposition of or increase in the rate of, the 'quota' on Crop 1 reduces the acreage share of that crop in the long-run. The impact occurs via the average price,  $P_1$ . A rise in the mean rate of 'quota' decreases the mean  $P_1$ , and thereby makes Crop 1 less profitable. As a result the household lowers its mean acreage demand for the crop, provided that it is feasible to do so. The reduction is conditioned by production possibilities via  $b$ ,  $y_1$  -- and  $d$ , as well as household rate of time preference through  $\beta$ . If Crop 2 is also subject to 'quota', however, the choice between the two crops will be affected not only by production possibilities, but also

<sup>27</sup> That,  $\lambda_1 \lambda_2 = \frac{1}{\beta}$ , and  $0 < \beta < 1$ , implies,  $\lambda_1 \lambda_2 > 0$ , such that  $\lambda_1$  and  $\lambda_2$  have the same sign. Further, with  $b$  and  $\beta$  positive,

$\lambda_1 + \lambda_2 = \frac{b}{\beta d}$ , means that the sign of  $\lambda_1$  and  $\lambda_2$  depends on that of  $d$ . In short, if  $d > 0$ , then  $\lambda_1 + \lambda_2 = 0$ , and thus,

$\lambda_1 \lambda_2 < 0$ .

<sup>28</sup> Note that analogous results hold in the static case under certainty (see Taffesse (1999)).

by the relative magnitude of the ‘quota’ rates. Briefly, in the long-run, the system of forced grain procurement may reduce the production of the crops it directly affects, and may even lead to a fall in crop production as whole. On the other hand, the  $\xi_{A,\phi}^L$  is positive if:

$$|l_1| < l_2 \frac{\partial E(P_1^m)}{\partial E(\phi_1)}$$

In other words, a positive indirect effect more than compensates for the negative direct effect, such that mean  $P_1$  rises. This rise, in turn, provides that incentive for the household to increase its long-run acreage demand for Crop 1.

2. The long-run price elasticity,  $\xi_{A,P^m}^L$  is positive but lower than what it would have been in the absence of CGD. Indeed a one percent rise in Crop 1’s market price counts as a  $l_2$  percent (less than one percent) increase for the farm household’s acreage decisions. Thus, the system of compulsory grain delivery reduces the long-run price responsiveness of crop supply.
3. The long-run elasticity of acreage demand for Crop 1 production with respect to  $\xi_{A,R}^L$  is negative. A permanent rise in the revenue (per hectare) obtainable from the cultivation of Crop 2 creates the incentive for the household to switch into that crop, and out of Crop 1.

### 2.3.2. Short-run elasticities

The short-run elasticities capture the effect, on current acreage demand, of changes in expected prices and ‘quota’ rates,  $(i+1)$  periods hence. These elasticities are computed in the same way as their long-run counterparts, but directly using (2.10), with (2.11b) and (2.11c). For  $\phi_1$ ,  $P_1^m$  and  $R_1$  these elasticities, evaluated at the unconditional means of  $\phi_1$ ,  $P_1^m$ ,  $R_1$  and  $A_1$  are:

$$\begin{aligned} \xi_{A,\phi}^{i+1} &= \left[ \frac{\partial E_{t+j}(A_{t+j}) \partial E_{t+j}(P_{1,t+j+1+i})}{\partial E_{t+j}(P_{1,t+j+1+i}) \partial E_{t+j}(\phi_{1,t+j+1+i})} \right] \frac{E(\phi_1)}{E(A_1)} \\ &= - \left( \frac{\lambda_1 y_1}{d} \right) (\beta \lambda_1)^i \left[ l_1 + l_2 \frac{\partial E_{t+j}(P_{1,t+j+1+i}^m)}{\partial E_{t+j}(\phi_{1,t+j+1+i})} \right] \frac{E(\phi_1)}{E(A_1)} \end{aligned} \quad (2.13a)$$

$$\begin{aligned} \xi_{A,P^m}^{i+1} &= \left[ \frac{\partial E_{t+j}(A_{t+j}) \partial E_{t+j}(P_{1,t+j+1+i})}{\partial E_{t+j}(P_{1,t+j+1+i}) \partial E_{t+j}(P_{1,t+j+1+i}^m)} \right] \frac{E(P_1^m)}{E(A_1)} \\ &= - \left( \frac{\lambda_1 y_1}{d} \right) (\beta \lambda_1)^i l_2 \frac{E(P_1^m)}{E(A_1)} \end{aligned} \quad (2.13b)$$

$$\xi_{A,R}^{i+1} = \frac{\partial E_{t+j}(A_{t+j})}{\partial E_{t+j}(R_{1,t+j+1+i})} \frac{E(R_1)}{E(A_1)}$$

$$= -\left(\frac{\lambda_1}{d}\right)(\beta\lambda_1)^i \iota_2 \frac{E(P_1^m)}{E(A_1)} \quad (2.13b)$$

Again the aforementioned results concerning  $\lambda_1$ ,  $\beta$ ,  $d$ ,  $y_1$ ,  $\iota_1$  and  $\iota_2$  are used. In addition, note that, given the sign of  $d$ , the sign of  $(\beta\lambda_1)^i$ , depends on whether  $i$  is even or odd. Suppose the decline in land productivity is the dominant dynamic effect such that  $d$  is positive. Then  $\lambda_1$  and  $(\beta\lambda_1)^i$  are negative. Hence,  $(\beta\lambda_1)^i$  is negative (positive) with  $i$  odd (even). In contrast,  $d$  is negative if adjustment costs dominate dynamic behavior. Accordingly,  $\lambda_1$  and  $(\beta\lambda_1)^i$  are positive, such that ( ), is positive for all  $i$ . Hence:

$$\begin{aligned} (\beta\lambda_1)^i &< 0, \text{ if } (d > 0 \text{ and } i \text{ is odd}) \\ (\beta\lambda_1)^i &> 0, \text{ if } (d > 0 \text{ and } i \text{ is even}) \text{ or } (d < 0) \end{aligned}$$

Note also that  $(\beta\lambda_1)^i$ , approaches zero as  $i$  gets larger, implying the further into the future a period is the less important to current decisions it becomes. These features enable us to make the following observations concerning short-run elasticities on the basis of (2.13a) and (2.13c).

1. The short-run elasticity of acreage demand with respect to expected rate of 'quota' alternates sign with  $i$  if  $d > 0$ . It is, however, negative for all  $i$  provided that  $d < 0$ , and that the direct and indirect effects of  $\phi_1$  are both negative, or if: the later, though positive, is less than the former in absolute value:

$$|\iota_1| > \iota_2 \frac{\partial E(P_{1,t+j+1+i}^m)}{\partial E(\phi_{1,t+j+1+i})}$$

Furthermore, as the forecast period becomes longer (i.e., the higher  $i$  is), this elasticity gets closer to zero.

2. The short-run elasticity of acreage demand with respect to expected market price of Crop 1 alternates sign with  $i$  if  $d > 0$ . It is, however, positive for all  $i$  provided that  $d < 0$ . Like its long-run counterpart, this elasticity is lower than the level that would obtain in a CGD-free environment. In addition, the magnitude of this elasticity becomes smaller in absolute value as the forecast period gets longer.
3. The short-run elasticity of acreage demand with respect to  $R_1$  alternates sign with  $i$  if  $d > 0$ . It is however, negative for all  $i$  provided that  $d < 0$ . Like the other short-run acreage elasticities, this elasticity declines (in absolute value) towards zero as the forecast period gets longer.

Two examples illustrate some of these features. In both cases, assume that the effect of expected  $\phi_1$  on expected  $P_1$  is negative. First, suppose the farm household anticipates a rise in next (or harvest) period's 'quota' rate. In this case, where  $i=0$ , the short-run elasticity is negative, implying that the household responds by reducing the current acreage share of Crop 1. The household expects a lower return from

cultivating Crop 1 and accordingly reduces its current acreage allocation to that crop. In contrast, an expected increase in the harvest period's  $P_1^m$ , and thus a higher profit from Crop 1, will induce a higher acreage share for the crop. Second, suppose the household expects to rise two periods hence (i.e.,  $i=1$  or during  $t+j+2$ ). Consequently that period's expected return from Crop 1 falls. Further assume that  $d > 0$ . Then deteriorating soil fertility means that the household has to plant more (less) of Crop 1 during  $(t+j+1)$  depending on whether it has cultivated less (more) of that crop during the current period (i.e.  $t+j$ ). To counter the potential loss of revenue and simultaneously satisfy the need for crop rotation the household grows more of Crop 1. In short, current acreage demand for Crop 1 rises because lower expected profitability combines with the dynamic effect of declining land productivity to make that crop more attractive for current production. On the other hand, since it involves a potential gain in income, the converse will apply for an expected increase in Crop 1's market price that will obtain during  $(t+j+2)$ .

To summarize by decreasing the returns to farm households, CGD is likely to have reduced, directly as well as through lower own-price responsiveness, the long-run acreage share (and thus output supply) of the crops it affected. The corresponding short-run effects are more complicated in that they also depend on the pattern of the dynamic effects at work. Moreover, both of these effects are further complicated by the impact of the 'average' rate of 'quota' on market price – an impact which cannot be signed *a priori*. On the other hand, it is shown that acreage demand generally responds positively to a crop's own price and negatively to the revenue from competing crops.

### **3. Empirical Analysis**

#### **3.1 The Data**

The basic features of the data used are described in this section. The main sources of information are the publications of the Central Statistical Authority (CSA) and the Ethiopian Agricultural Marketing Agency (EMAC)<sup>29</sup>. The dataset thus compiled contains information on: acreage, output, and yield of major annual crops; producer prices of crops; and EAMC purchases and procurement prices.

Before moving on to considering other characteristics of the data, the following remarks about its spatial and temporal dimensions are deemed helpful.

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<sup>29</sup> As part of the grain market reforms, this agency has been reorganized and renamed the Ethiopian Grain Trade Enterprise (EGTE)



1. The unit of observation are administrative regions. Up to 1988 there were 14 administrative regions in the country. Of these, data is not available for two (Eritrea and Tigray). In 1988 a new administrative structure with thirty regions was introduced. Twenty-six of these are covered by the dataset used. In addition to Eritrea and Tigray, two new regions (Assab and Ogaden) are not covered by the reports available<sup>30</sup>. The twenty-six regions are aggregated into twelve to make the coverage compatible with that of the previous years<sup>31</sup>. Although inexact, this aggregation is not likely to involve substantial errors.
2. The data set covers the period from 1980/81 to 1989/90. There are a number of reasons for restricting the analysis to this period. First, although introduced in 1979, the centralized CGD system was not fully operational until 1981. This was particularly true of its impact on farm households. Second, the main source of consistent time-series data is the annual Agricultural Sample Survey of the CSA. This survey has began in 1980/81. Third, the CGD system was abolished in 1990. Fourth, a new government assumed power in 1991, and subsequently adopted a radically different administrative structure as well as an economic structural adjustment program. The first two facts mean that it is reasonable to start with 1980/81, whereas the last two imply that it is problematic to go beyond 1989/90.

### 3.1.1 Acreage allocation patterns

Table 3.1 reports the average regional acreage shares of cereals as a group and its five main constituents<sup>32</sup>. The first row of figures in that table confirm what has been observed before; cereals constitute by far the most important annual crop to farm households, accounting for more than 80 per cent of the total area planted with annual crops. The rest is cultivated with pulses and oil seeds. From among cereals, maize and Teff have the largest shares, respectively accounting for 25 percent and 23 per cent. The table also shows the considerable regional variation in land allocation among crops. For instance, Arssi and Bale farm households concentrate on growing barely and wheat, while those residing in Gojam and Gondor allocate more than half of cereal-cultivated land to barley and *Teff*. Such variation reflects differences in natural endowments, technological possibilities, tastes, and the historical processes which affect all of these regional and individual attributes. In the analysis below, this regional variation will be exploited jointly with the variation across time periods.

<sup>30</sup> Assab and Ogaden are not major crop producing areas. That they are not included for the years 1988/89 and 1989/90 is unlikely to materially affect compatibility with the data for the years before 1988.

<sup>31</sup> The aggregation involved the following. For 1988/89 and 1989/90:

Old	New
Arssi =	Arssi
Bale =	Bale
Gamo Gofa =	North Omo + South Omo
Gojam =	East Gojam + West Gojam + Metekel
Gondar =	North Gondor + South Gondor
Hararghe =	West Hararghe + East Hararghe + Dire Dawa
Illubabor =	Illubabor + Gambela
Keffa =	Keffa
Shewa =	East Shewa + North Shewa + South Shewa + West Shewa
Sidamo =	Sidamo + Borena
Wellega =	Wellega + Asosa
Wollo =	North Wollo + South Wollo

<sup>32</sup> Note that Producers' Cooperatives and State Farms are excluded, such that all figures relate to private peasant producers.

**Table 1: Mean Regional Acreage Shares (1981-90)**

Region	Cereals	Barley	Maize	Sorghum	Teff	Wheat
National	0.87 (0.06)	0.18 (0.13)	0.25 (0.18)	0.18 (0.16)	0.23 (0.13)	0.10 (0.10)
Arssi	0.83 (0.03)	0.37 (0.04)	0.11 (0.02)	0.05 (0.02)	0.10 (0.02)	0.34 (0.04)
Bale	0.89 (0.03)	0.43 (0.06)	0.12 (0.05)	0.01 (0.01)	0.08 (0.04)	0.25 (0.04)
Gamo Gofa	0.92 (0.04)	0.14 (0.03)	0.37 (0.12)	0.31 (0.07)	0.15 (0.08)	0.03 (0.02)
Gojam	0.81 (0.02)	0.21 (0.06)	0.13 (0.02)	0.05 (0.02)	0.43 (0.03)	0.08 (0.02)
Gondor	0.75 (0.02)	0.24 (0.07)	0.06 (0.02)	0.18 (0.04)	0.33 (0.04)	0.09 (0.03)
Hararghe	0.94 (0.02)	0.05 (0.02)	0.26 (0.08)	0.59 (0.08)	0.05 (0.01)	0.04 (0.01)
Illubabor	0.94 (0.02)	0.05 (0.01)	0.41 (0.03)	0.18 (0.03)	0.32 (0.02)	0.02 (0.01)
Kefa	0.90 (0.03)	0.06 (0.03)	0.41 (0.06)	0.19 (0.04)	0.26 (0.07)	0.04 (0.02)
Shewa	0.82 (0.02)	0.19 (0.04)	0.17 (0.03)	0.14 (0.03)	0.33 (0.03)	0.17 (0.02)
Sidamo	0.91 (0.02)	0.12 (0.04)	0.61 (0.10)	0.07 (0.03)	0.15 (0.05)	0.04 (0.02)
Wellega	0.87 (0.02)	0.07 (0.02)	0.33 (0.07)	0.15 (0.03)	0.36 (0.04)	0.02 (0.01)
Wollo	0.82 (0.04)	0.27 (0.09)	0.05 (0.02)	0.27 (0.08)	0.25 (0.04)	0.14 (0.02)

**NOTES:** Standard deviations in parentheses. Shares are computed from data compiled from CSA, Statistical Bulletin No. 56, No 74, No. 79 and No. 103. The share of cereals is out of total acreage cultivated with annual crops, while those of individual crops are out of total cereal acreage.

### 3.1.2 'Quota' rates

The available data regarding EAMC's procurement of crops from farm households can be grouped into two<sup>33</sup>. The first group consists of the annual domestic purchases of EAMC by crop (including the five major cereals) and source of supply (including merchants, and farm households via Peasant Association and Service Cooperatives). The second category is formed by the annual purchases of EAMC from farmers and merchants (together), by crop and administrative region. From the first set the share, at the national level, of farm households in the total domestic procurement of different crops by EAMC can be computed. The analogous share of merchants is similarly obtained. The relative shares of the two suppliers are then calculated, and the results are subsequently applied on the corresponding regional procurements from farmers and merchants so as to arrive at an estimate of the annual level of 'quota' by crop and administrative region. Finally, the ratio of the 'quota' level thus obtained to the corresponding regional output gives us the desired 'quota' rates. In short the next formula is used;

**Table 2: Mean Regional 'Quota' Rates (1981 - 90)**

Region	Barley	Maize	Sorghum	Teff	Wheat
National	0.02 (0.03)	0.02 (0.05)	0.02 (0.03)	0.03 (0.05)	0.15 (0.08)
Arssi	0.08 (0.05)	0.07 (0.15)	0.03 (0.03)	0.01 (0.01)	0.19 (0.08)
Bale	0.07 (0.07)	0.02 (0.02)	0.02 (0.02)	0.01 (0.03)	0.19 (0.11)
Gamo Gofa	0.00 (0.00)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.00)
Gojam	0.03 (0.02)	0.03 (0.02)	0.08 (0.05)	0.18 (0.06)	0.08 (0.03)
Gondor	0.01 (0.01)	0.01 (0.01)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)
Hararghe	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)	0.01 (0.02)	0.03 (0.07)
Illubabor	0.00 (0.01)	0.01 (0.01)	0.01 (0.02)	0.01 (0.01)	0.00 (0.01)
Kefa	0.02 (0.04)	0.01 (0.01)	0.01 (0.01)	0.00 (0.01)	0.01 (0.01)
Shewa	0.03 (0.02)	0.08 (0.04)	0.04 (0.03)	0.05 (0.01)	0.06 (0.03)
Sidamo	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.03 (0.03)	0.01 (0.01)
Wellega	0.01 (0.01)	0.03 (0.03)	0.02 (0.02)	0.03 (0.02)	0.04 (0.03)
Wollo	0.00 (0.00)	0.03 (0.04)	0.02 (0.01)	0.01 (0.01)	0.01 (0.01)

<sup>33</sup> All the information concerning the operation of the EAMC are compiled from EAMC (1987) and EGTE (1995).

Notes: Standard deviations in parentheses.

$$\phi_{ikt} = \frac{\left( \frac{{}_s F_{it}}{{}_s F_{it} + {}_s M_{it}} \right) X_{ikt}}{Q_{ikt}}$$

Where  $\phi_{ikt}$  is the rate of ‘quota’ applying to crop  $i$  and region  $k$  in year  $t$ ;  ${}_s F_{it}$  and  ${}_s M_{it}$  are, respectively, the (national share of farm households and merchants in EAMC’s total domestic procurement of crop  $i$  in year  $t$ ;  $X_{ikt}$  represents the total amount of crop  $i$  purchased by EAMC from the farmers and merchants of region  $k$  in year  $t$ ; and  $Q_{ikt}$  is the total output of crop  $i$  produced by the farm households of region  $k$  in year  $t$ . The rates calculated in this manner are to be viewed as the average rates of ‘quota’ which farm households of region  $k$  faced during year  $t$ .

At the national level, the average share of farm households in EAMC’s total domestic purchases range from 60 percent for maize to 76 percent for *Teff*. The corresponding ‘quota’ rates range from 2-5 percent see [Table 3.2](#)). However, there were substantial regional differences in ‘quota’ rates. The relevant rates for the five main cereals are summarized in [Table 3.3](#). The average regional ‘quota’ rate can be as low as zero for most crops (Gamo Gofa), and as high as 19 percent for wheat (Arssi and Bale). In this regard, the general pattern has been that higher regional output of a crop meant higher regional ‘quota’ level. The corresponding correlations are all positive, and are mostly large and significant (see [Table 3.3](#)). This pattern reflects the ‘quota’ determination process described above. It also provides some support to the argument that the ‘quota’ should be treated as an implicit proportional output tax<sup>34</sup>.

**Table 3: Correlations between Regional Crop Output and ‘Quota’ Level**

Year	Barley	Maize	Sorghum	Teff	Wheat
1980/81	0.60 (0.038)	0.77 (0.004)	0.59 (0.045)	0.63 (0.027)	0.70 (0.011)
1981/82	0.52 (0.083)	0.84 (0.001)	0.68 (0.016)	0.63 (0.029)	0.72 (0.008)
1982/83	0.49 (0.106)	0.36 (0.246)	0.58 (0.049)	0.79 (0.002)	0.60 (0.041)
1983/84	0.48 (0.113)	0.80 (0.002)	0.53 (0.075)	0.67 (0.016)	0.66 (0.018)
1984/85	0.90 (0.000)	0.77 (0.003)	0.20 (0.536)	0.84 (0.001)	0.92 (0.000)
1985/86	0.53 (0.076)	0.49 (0.102)	0.66 (0.019)	0.81 (0.001)	0.82 (0.001)
1986/87	0.59 (0.042)	0.81 (0.002)	0.80 (0.002)	0.75 (0.005)	0.77 (0.004)
1987/88	0.88 (0.000)	0.74 (0.006)	0.56 (0.059)	0.71 (0.010)	0.90 (0.000)
1988/89	0.81 (0.001)	0.86 (0.000)	0.39 (0.218)	0.70 (0.011)	0.86 (0.000)
1989/90	0.95 (0.000)	0.87 (0.000)	0.56 (0.057)	0.80 (0.002)	0.95 (0.000)

NOTES: Each entry is Pearson’s correlation coefficient between regional output and ‘quota’ level of the crop identified in the column, during the year identified in the row. Figures in parentheses are two-tailed significance levels.

<sup>34</sup> It does not however imply that these two variables are positively correlated overtime.

**Table 4: Mean Panterritorial Procurement Crop Prices (1981-90)**

<i>Barley</i>	<i>Maize</i>	<i>Sorghum</i>	<i>Teff</i>	<i>Wheat</i>
28.2 (1.93)	20.0 (1.83)	23.8 (1.34)	39.3 (2.21)	31.6 (0.97)

Notes: Computed from the information in EAMC (1987). Standard deviations in parentheses.

### 3.1.3 Crop Prices

Two sets of crop prices are relevant for the present analysis, namely, procurement Prices were administratively determined by the central government. They were also pan-territorial in that they apply to all parts of the country. Mean procurement prices for the five main cereals are reported in **Table 3.4**. As indicated by the low standard deviations, these prices did not change significantly in the 1980s. In fact they were raised only once for barley and wheat, and twice for the remaining three cereals during that period. Not only were the increases infrequent, they were also very modest, involving Birr 1 – Birr 4 per quintal<sup>35</sup>.

Market pieces, in contrast, refer to producers' prices obtained on the 'free' market. In this regard, the CSA collects monthly retail and producers prices in rural areas since 1981. The data thus collected are summarized as regional quarterly prices and are published<sup>36</sup>. Annual regional producers' prices of crops are computed as the simple mean of the corresponding quarterly prices<sup>37</sup>. **Table 3.5** reports the cereal prices calculated in this manner. First, these prices are considerably higher than the corresponding procurement prices. Second, substantial regional variation in crop prices can be observed. It is reasonable to expect that this variation reflects regional aspects of demand and supply including production patterns, supply shocks, and the degree of urbanization.

**Table 5: Mean Regional Market Crop Prices (1981-90)**

<i>Region</i>	<i>Cereals</i>	<i>Barley</i>	<i>Maize</i>	<i>Sorghum</i>	<i>Teff</i>	<i>Wheat</i>
National	54.5 (19.9)	54.4 (19.2)	47.6 (19.4)	52.6 (21.6)	74.8 (25.0)	65.4 (20.2)
Arssi	44.7 (13.1)	38.2 (11.4)	38.1 (12.0)	46.0 (12.6)	68.6 (18.6)	51.3 (14.7)
Bale	45.3 (14.4)	44.9 (14.6)	47.1 (17.0)	54.8 (18.4)	72.1 (23.2)	60.4 (18.8)
Gamo Gofa	47.1 (12.0)	47.9 (11.3)	40.9 (12.3)	42.4 (11.8)	75.1 (16.0)	70.3 (14.7)
Gojam	43.6 (11.6)	42.7 (13.4)	36.2 (9.9)	33.2 (9.6)	51.6 (13.9)	48.8 (13.8)
Gondor	55.3 (15.4)	50.9 (16.3)	45.2 (14.0)	51.8 (16.7)	65.0 (18.0)	57.6 (16.4)
Hararghe	70.9 (22.4)	70.8 (23.6)	63.3 (18.9)	73.4 (23.9)	96.1 (22.1)	79.0 (24.2)
Illubabor	54.8 (15.3)	61.8 (14.7)	47.2 (13.8)	48.5 (14.6)	75.7 (23.7)	66.9 (15.1)
Kefa	47.8 (15.5)	52.4 (17.3)	41.0 (16.2)	43.9 (12.1)	68.9 (19.6)	62.6 (17.7)
Shewa	66.0 (23.6)	59.7 (20.5)	51.3 (21.6)	59.8 (25.9)	84.1 (27.7)	75.8 (21.6)
Sidamo	50.2 (11.3)	56.0 (11.4)	45.4 (10.5)	53.4 (23.0)	74.3 (17.3)	67.5 (12.6)
Wellega	53.4 (13.1)	58.9 (15.2)	45.8 (12.4)	50.5 (13.5)	68.3(18.6)	67.9 (19.9)
Wollo	75.0 (33.9)	69.0 (28.9)	69.5 (36.8)	73.0 (34.0)	97.4 (42.1)	77.4 (28.8)

**NOTES:** Computed from the information in CSA (1985), CSA (1988a), CSA (1988b), CSA (1991a), CSA (1991b), CSA (1992). Standard deviations in parentheses.

<sup>35</sup> Unpublished EAMC document.

<sup>36</sup> For the year 1987/88 - 1989/90 the monthly prices themselves are reported.

<sup>37</sup> Ideally some weighting scheme is desirable to account for seasonality. In the absence of any information that can serve as a basis for devising such a scheme, the simple strategy is opted for.

### 3.2 Econometric Specification

In this section an explicit solution for the farm household's acreage demand decision rule is derived first. Then an estimable form of that rule is formulated. The formulation is a specific application of (2.10), *Teff* taking the place of Crop1<sup>38</sup>. *Teff* is a major cereal in terms acreage and output shares accounting, respectively, for 23 percent and 17 per cent. It is highly demanded as a good crop, particularly in urban areas. Partly as a consequence of this demand, it is the most commercialized food crop, consequence of this demand, it is the most commercialized food crop, constituting a major (for many parts of the country the major) source of cash income for farm households. For the same reason *Teff* has also been the main target of EAMC in its cereal procurement effort. On average, it accounted for 36 per cent of EAMC's annual cereal purchases from farm households. As a result, the imposition of the *Teff* 'quota' on farm households is likely to have had a very large impact on their cash income and, through it, their welfare. These reasons are behind the decision to make *Teff* the focus of the empirical analysis.

#### An explicit solution for the acreage decision rule

As noted earlier, equation (2.10) does not constitute a decision rule because the expectational terms  $E_{i+j}(\phi_{1,t+j+1+i})$ ,  $E_{i+j}(P_{1,t+j+1+i})$ ,  $E_{i+j}(R_{1,t+j+1+i})$  and  $E_{i+j}(V_{1,t+j+1+i})$  are present. To transform it into such a rule, it is necessary to express those expectational variables as functions of elements of the current information set ( $t+j$ ). One way of achieving this involves first postulating autoregressive processes for  $P_1^m$ ,  $\phi_1$ ,  $R_1$  and  $V_1$ , and then apply the Weiner-Kolmogorov prediction formula to solve for the expectational variables<sup>39</sup>. Towards that end, alternative specifications for these processes are explored using the available data.

A simple strategy is adopted for selecting from among alternative specifications. First, autoregressive models of the first- and second-order (*AR(1)* and *AR(2)*, respectively) are specified for  $P_1^m$  and  $\phi_1$ <sup>40 41</sup>. The model for  $P_1^m$  thus specified incorporate the possible impact that  $\phi_1$  may have. Second a combination of the Akaike Information Criteria (AIC) and tests for parameter significance is used to

<sup>38</sup> For the sake of notational economy, the subscript 1 is retained, but now used to identify variables relating to *Teff*.

<sup>39</sup> See Hansen and Sargent (1980) for further details.

<sup>40</sup> It is possible to postulate higher-order and/or vector autoregressive processes for  $P_{1t}$  and  $\phi_{1t}$ . Solutions analogous to (3.1a) below can still be obtained [see Hansen and Sargent (1980). Indeed, the ideal procedure is to postulate AR processes without specifying the order, and then empirically choose the appropriate lag length. Restricting the choice to AR (1) and AR (2) processes reflects data constraints. To that extent it is rather arbitrary.

<sup>41</sup> Data on  $V_j$  is unavailable. Consequently, it is excluded from this effort. However, we postulate that it is generated by an *AR(1)* process. The case of  $R_j$  is more complicated. It measures the revenue per hectare from all cereals and pulses other than *Teff*, and is computed as:

$$R_1 = \sum_{j=2}^J P_j y_j$$

where:  $P_j = \phi_j P_j^s + (1 - \phi_j) P_j^m$  = the average price of the crop  $j$ ;  $P_j^s$  = the procurement price of crop  $j$ ;  $P_1^m$  = the market

price of the crop  $j$ ;  $\phi_j$  = the rate of 'quota' on crop  $j$ . All attempts to consistently estimate an *AR(1)* and *AR(2)* processes describing  $R_j$  failed. It is possible to consider more complicated models. But the resulting acreage equation will be very problematic to implement using the data available. As a result, the assumption that the law of motion of  $R_j$  is *AR(1)* is maintained.

select the better specification. The details of this exercise are reported with the other results in section (3.4). At this juncture it suffices to report that the following specifications are selected in this manner.

$$P_{1t}^m, \theta_1 P_{1,t-1}^m + \theta_2 \phi_{1,t-1} + \theta_3 \phi_{1,t-2} + u_t^p; |\theta_1| < 1 \quad (3.1a)$$

$$\phi_{1t} = \gamma \phi_{1,t-1} + u_t^\phi; |\gamma| < 1 \quad (3.1b)$$

Moreover let us assume that the stochastic variables  $R_{1t}$  and  $V_{1t}$  are generated by the following  $AR(1)$  processes:

$$R_{1t} = \alpha R_{1,t-1} + u_t^R; |\alpha| < 1 \quad (3.1c)$$

$$V_{1t} = \rho V_{1,t-1} + u_t^V; |\rho| < 1 \quad (3.1d)$$

where  $u_t^p$ ,  $u_t^\phi$ ,  $u_t^R$  and  $u_t^V$  are zero-mean, constant-variance, and serially uncorrelated random variables<sup>42</sup>. Two remarks have to be made at this point. First, the farm household is assumed to derive its decisions rules taking the price, cost, and 'quota' rate stochastic processes as given. In other words, it operates according to the belief that its actions do not affect these processes. Second, recall that the specific AR processes for  $P_{1t}^m$  and  $\phi_{1t}$  are selected via a simple procedure involving estimation and testing. This procedure is legitimate only under rational expectations. The reason is that, under rational expectations, the models used by the farm household to form expectations about random variables are identical to the actual laws of motion of those variables [Epstein and Yatchew (1985)].

Now turning to the task of solving for the farm household's acreage decision rule, being by restating (2.10) for  $j=0$ , to simplify notation:

$$A_{1t} = \lambda_1 A_{1,t-1} - \left( \frac{\lambda_1}{d} \right) \sum P_{1t}^m, \theta_1 P_{1,t-1}^m + \theta_2 \phi_{1,t-1} + \theta_3 \phi_{1,t-2} + u_t^p; |\theta_1| < 1$$

Also define  $W_t = \text{-----}$ , where ' represents the matrix transpose operation. Then, following Hansen and Sargent (1980), state:

Furthermore, by defining = ----, and combining (3.1a) and (3.1b) the law of motion of can be rewritten as

<sup>42</sup> These variables are defined as:

$$u_t^p = P_{1t}^m - E_{t-1}(P_{1t}^m), \quad u_t^\phi = \phi_{1t} - E_{t-1}(\phi_{1t}), \quad u_t^R = R_{1t} - E_{t-1}(R_{1t}), \quad u_t^V = V_{1t} - E_{t-1}(V_{1t})$$

such that:

$$E_{t-1}(u_t^p) = 0, \quad E_{t-1}(u_t^\phi) = 0, \quad E_{t-1}(u_t^R) = 0, \quad E_{t-1}(u_t^V) = 0$$

I is (2X2) identity matrix, and L is the lag operator with, L----- Similarly rearranging using the lag operator it follows that:

=====

where:  $y(L) = 1 - yL$ ;  $a(L) = (1 - aL)$ ; and  $p(L) = (1 - pL)$ . Note also that the assumption that ----- ensure the existence of moving average representations for  $W_t$ , ----- and ---. Finally note that the Wiener-Kolmogorov prediction formula provided by Hansen and Sargent (1980) explicitly solves for ----. This it has to be slightly modified in order to solve for -----. This is done by exploiting the following equality:

-----

Where----. Substituting for ----- from ht Hansen Sargent version provides the desired formula. This modified version of the WienerKolmogorov prediction formula is applied to obtain:

----

Substituting these in (2.10a)', and rearranging results in:

Under the above assumptions, (3.3) represents a closed form solution for the decision rule for  $A_{1t}$ . It expresses the optimal acreage allocation rule of the farm household as a function of acreage allocated last period, current output price, current and once-lagged 'quota' rate, and current actual and opportunity costs of cultivating Crop 1. All of these variables are elements of the current information set of the household. Note also that  $w_3$  and  $w_4$  jointly capture the direct and indirect effects of the 'quota' rate described in section 2.3).

#### Econometric specification

As it stands equation (3.3) is nonstochastic. All right-hand-side variables are elements of the farm household's information set at  $t$  (or  $-t$ ). It can be made stochastic by the introduction random disturbances. Towards that end, first take expectations of (3.3), while exploiting the fact that all right-hand-side variables are elements of  $-t$ . Then add  $(A_{1t} - E(A_{1t}))$  to the resulting equation to obtain:

Where  $\epsilon_{it}$ . Note that  $\epsilon_{it}$  may represent random errors of optimization/forecasting as well as errors in data (Hansen and Sargent (1980), and Epstein and Yatchew (1985)). Moreover, ---

On the other hand, data on  $V1t$  is not available. In the process a stochastic relation estimable with available data is obtained. In equation (3.4)  $\epsilon_{it}$  represents shocks to non-land costs of producing Teff and other cereals. It can also be used as a means of including random errors of optimization and errors in data (Epstein and Yatchew (1985)). This equation is directly estimated as the underlying model are neither exploited nor their validity established empirically. However, primary objective of estimating acreage elasticities can be achieved using the unrestricted version. Next, a brief account of how these elasticities are computed.

Moreover, data on  $V1t$  is not available. A solution to both is provided by the Koyck transformation. Applying the Koyck Transformation,  $(A1t)$  and using  $(\epsilon_{it})$ , leads to :

In the process a stochastic relation estimable with available data is obtained. In equation (3.5)  $\epsilon_{it}$  represents shocks to non-land costs of producing teff and other cereals. It can also be used as a means of including random errors of optimization and errors in data (Epstein and Yatchew (1985))., This equation is directly estimated as the unrestricted the structural parameters. Thus, the restrictions implied by the underlying model are neither exploited nor their validity established empirically. However the primary objective of estimating acreage elasticities can be achieved using the unrestricted version. Next, a brief discussion of how these elasticities are computed.

The long-run elasticity of expected acreage demand with respect to mean  $\bar{R}$ , is derived by first taking the unconditional expectation of (3.5), differentiating with respect to  $\bar{R}$ , and weighting the result by the ratio of the unconditional means  $\bar{R}$  and  $\bar{A}$ . The result is:

The long-run elasticity of expected acreage demand with respect to mean  $\bar{R}$  and mean  $R1$  are obtained similarly:



The corresponding short-run elasticities, -----, and ----- are computed in an analogous fashion. All are evaluated at the unconditional means of acreage shares, prices, and the rate of 'quota' associated with Teff, and appear as:

**Estimation Procedure**

The models for ----- are estimated using available data on the relevant variables. As noted above the data set employed is composed of region-level information over ten years. To exploit this panel dimension, the equations are restated in the appropriate form by introducing regional effects. The resulting Teff acreage demand can be written as:

Where:  $I (i=1, \dots, N)$  identifies regions;  $y_{it}$ -----  
 Unobserved region-specific effects; and

To ensure stationarity, it is also assumed that, ----- . Similarly, the following for the Teff prices equation and the Teff 'quota' rate equation are respectively obtained:

Where :----- . Again, the subscript  $I$  indexes regions. Note that:

Represent the "fixed effects" decomposition of the disturbance terms commonly adopted in panel data models, with ----- representing white noise,.

Equations (3.8) – (3.10) form a set of dynamic panel data models. This each has to be estimated using estimation techniques applicable to such models. Recently a variety of estimators have been developed for the parameters of these models (Anderson and Hsiao (1982), Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1995). From among alternatives, a specific variant of the linear Generalized Method of Moments (GMM) estimator is chosen, namely, the system estimator proposed by Blundell and Bond (1995). This estimator is based on the estimation of the first-difference equations and the levels equations and the levels equations together as a system. In this process, lagged levels of  $(y, x)$  are used as instruments for the equations in first difference, while lagged differences are used as instruments for the equations in levels. To distinguish between them, this estimator and the usual GMM estimator based on the equations in first differences, are referred to as the GMM (II) estimator and the GMM (I) estimator, respectively<sup>43</sup>.

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<sup>43</sup> Further details regarding the two estimators are provided in the appendix.

The estimation results are reported in Tables 3.1-3.3. To highlight the advantages derived from using the GMM (II) estimator, results relating to some of the alternatives are also presented. The GMM(I) and GMM(II) estimates are reported for all equations. Two more estimates for the Teff acreage demand equation are also reported. The first is obtained by applying OLS directly to the pooled data (i.e., ignoring regional effects). The results included in the column of Table 3.3 identified as OLS. The second is derived by applying the Within-groups estimator. To accommodate regional effects, this estimator uses the data transformed by subtracting the appropriate time-means of the relevant variables. The resultant estimates are reported under the heading 'Within' in Table 3.3

In addition to the estimates themselves, a number of test statistics are reported.

1. The first pair relate to the Wald tests of the joint significance of the regressors and the time-dummies, respectively. One is a test of the null hypothesis that the estimated coefficients of the regressors in an equation are all zero. Under the null the test statistic is asymptotically distributed  $\chi^2_p$ , where the degrees of freedom  $p$  is equal to the number of regressors. This statistic is reported as  $\chi^2$ -Regressors. The other relates to the null hypothesis that the coefficients of the time dummies are jointly zero. It is asymptotically distributed  $\chi^2_q$  under the null, where  $q$  is equal to the number of time-dummies. This statistic is reported as  $\chi^2$ -Time dummies.
2. The second pair of reported test statistics is associated with testing the absence of first-order and second-order serial correlation in the residuals. Because, the first-differenced residual is an (MA(1) process, first-order serial correlation is to be expected. On the other hand, if the original residuals are serially independent, there will be no second-order autocorrelation in the residuals of the equations in first differences. Thus, not rejecting the null of no second-order serial correlation in the first-difference residuals implies either no serial correlation in the errors in levels or the residuals in levels follow a random walk. The former is necessary for the consistency of the GMM estimators, while the latter will make both OLS and GMM estimates of the first-difference equation consistent. Which of the two possibilities (no serial correlation in the errors in levels or the residuals in levels follow a random walk) apply may be determined by the test for first-order serial correlation in the differenced residuals. In this regard, Arellano and Bond (1991) developed test statistics for first-order and second-order serial correlation based on the residuals from the equations in first-differences. Under the respective nulls these tests are distributed asymptotically as standard normal. The tests are reported as  $m_1$  and  $m_2$ .
3. The Sargan test of the overidentifying (moment) restrictions is the third test reported. It is based on the two-step estimated so the model in first-differences. Under the null of optimal instruments, the Sargan test-statistic is asymptotically distributed  $\chi^2_r$  with as many degrees of the freedom as overidentifying restrictions. In the tables of results, this statistic is reported as  $\chi^2$ -sargan test.
4. Finally, the Akaike Information Criteria (AIC) is reported for the market price and the 'quota' rate equations. It is computed as:

Where: RSS is the residual sum of squares, and K represents the number of regressors.

### Results

This section presents the main empirical findings. These findings are summarized in Tables 3.1-3.4. Before considering other results, let us remark on the merits of the two main estimators employed. Overall, the GMM(II) estimator performed better than its GMM(I) counterpart. The efficiency gains due to the former are substantial. All standard errors (except one) are lower compared to those associated with the GMM(I) estimator. Accordingly, the discussion of results, including the comparison between the AR(1) and AR(2) models for the Teff market price and the Teff 'quota' rate, refer to the corresponding GMM(II) estimator.

1. The main results pertaining to the market price of Teff are reported in Table 3.1. First the AR(1) and AR(2) specifications for the market price of teff are compared on the basis of the respective GMM(II) estimates. The AR(1) model is superior in that: the coefficient of  $\alpha_1$  is not significantly different from zero.

Parameter	AR(1)		AR(2)	
	GMM(I)	GMM(II)	GMM(I)	GMM(II)

NOTES: Standard errors in parentheses, and degrees of freedom in square brackets. All standard errors are consistent in the presence of general heteroskedasticity. The Sargen test statistic corresponding to GMM(I) is not reported, because it is not well-determined. (\*),(-----) represents significance at 1 per cent, and 10 per cent, respectively.

From zero; the AR(2) model induces second-order serial correlation in the errors, which can be viewed as a sign of misspecification; and the AIC is smaller for the AR(1) model. Second, the estimate of the coefficient of  $\alpha_1$  in the preferred AR(1) process shows that the process is stable  $|\alpha_1| < 1$ . Third, the coefficient  $\alpha_1$  is positive but insignificant, while that of  $\alpha_2$  is negative and significant. It suggests that temporary or short-run changes in the 'quota' rate do not affect the market price of

Teff. In contrast, permanent or long-run changes in --- reduce the market price of Teff.

2. Table 3.2 summarized the results relating to the law of motion of the Teff 'quota' rate. First, GMM(II) estimates favour the AR(1) specification. Apart from generating an insignificant coefficient of ----- the AR(2) model leads to second-order autocorrelation in the errors. Second, the estimate of ----- ) indicate the stability of the AR(1) process.
3. Estimates of the parameters of the Teff acreage equation are reported in Table 3.3. They correspond to the OLS, within-groups, GMM(I) and GMM(II) estimators. The first three of these are included for comparison purposes. GMM(II) estimates are the preferred estimates. Observe that the estimates of ----- satisfy the stationary conditions for an AR(2) process.

Finally, the long-run and the short-run elasticities of acreage demand for Teff production are computed using the equations (3.6) and (3.7) together with the GMM(II) parameter estimates in Table 3.3 The results are reported in Table 3.4. All the elasticities are evaluated at the sample menas of the relevant variables.

1. The long-run elasticity of Teff acreage demand with respect to the 'quota' rate is negative but relatively small. That it is negative is consistent with the

Table 7. One-step GMM Estimates of the Teff 'Quota' Rate Equations

Parameter	AR(1)		AR(2)	
	GMM(I)	GMM(II)	GMM(I)	GMM(II)

NOTES: Standard errors in parentheses, and degree of freedom in square brackets. All standard errors are consistent in the presence of general heteroskedasticity.----- represent significance at 1 per cent, 5 per cent, and 10 per cent, respectively.

Table 8: One-step GMM Estimates of the Teff Acreage Demand Equation

Parameter	OLS	Within	GMM(1)	GMM(II)

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Notes:: Standard errors in parentheses, and degrees of freedom in square brackets. All standard errors are consistent in the presence of general heteroskedasticity. The Sargan test statistic corresponding to GMM(I) and GMM(II) is not reported, because it is not well-determined.----- represent significance at 1 per cent, 5 per cent, and 10 per cent, respectively.

Table 9: Elasticities of Teff Acreage Demand

Long-run		Short-run	

Prediction of the theoretical model set out earlier in this paper. It suggests that the long-run acreage demand for Teff cultivation has been reduced by the institution and expansion of the CGD. The reduction appears to have been relatively small. In contrast, the associated short-run elasticity is positive, but very small. Observe, however, that the coefficients of ----- in the Teff acreage equation is insignificant. The latter suggests that the 'quota' rate did not affect short-run acreage decisions of farm households.

2. The long-run and short run elasticities of acreage demand for Teff production with respect to the market price of Teff are positive. The signs of these elasticities conform with those of their theoretical counterparts. As would be expected, the long-run price elasticity is greater than the short-run one. In addition, the levels of the two elasticities are somewhat lower relative to those obtained by other studies. This is particularly true of the long-run elasticity. This relatively low own-price responsiveness may be partly explained by the presence of CGD, which is an outcome predicted by the theoretical model.

4. Consistent with the prediction of the theoretical model, the long-run and short-run elasticities of Teff acreage demand with respect to revenue from other annual crops are negative. Again, the short-run elasticity is smaller (in absolute value) than the corresponding long-run elasticity is smaller (in absolute value) than the corresponding long-run elasticity. In fact, permanent changes in the revenue from other crops induce the strongest response from long-run acreage demand for Teff cultivation. This is due to the fact that such changes represent a favorable shift in the profitability profile of, not a single alternative crop, but, most likely, a number of other annual crops. As a result the farm household affords a greater degree of flexibility in its acreage reallocation decision.

To summarize, the demand for teff acreage responds positively to the market price of teff, and negatively to the revenue obtainable from other cereals and pulses. In addition, the long-run demand for teff acreage is negatively affected by the 'quota' rate imposed on that crop.

#### 4. Conclusion

This paper set out to investigate the impact of compulsory grain delivery (CGD) and crop prices on the production choices of farm households in Ethiopia. For that purpose, a simple dynamic agricultural household model is developed under rational expectations and risk neutrality. In that model the effect of CGD is introduced via a weighted average price of crops. This price is approximated as a linear combination of the relevant 'quota' rate, crop procurement price, and crop, and the revenue from alternative crops. It is demonstrated that, in general, these elasticities depend on the technology of production, the cost of adjusting acreage allocations, the pattern of dynamic productivity effects, and household time preference. More specifically, it is shown that the long-run and current acreage allocations to a crop respond positively to that crop's market price, and negatively to the corresponding 'quota' rate and the revenue from competing crops.

Subsequently, an estimable dynamic acreage demand equation is derived by explicitly solving for the farm household's acreage allocation decision rule. This equation is then estimated for Teff – a major crop produced by Ethiopian farm households using region-level data. Recently developed techniques for estimating dynamic panel data models are employed for that purpose. The resulting estimates of elasticities of acreage demand for Teff production are consistent with the predictions of theoretical model.

The empirical evidence suggests that CGD is likely to have reduced the long-run acreage share (and thus the long-run supply) of the crops to which it applied to. It is likely to have done so by directly and indirectly (through lower market prices) reducing farm households' returns from these crops. It should also be noted that CGD may have affected crop supply in ways other than acreage reallocations. For instance, the lower crop profitability induced by CGD may adversely affect the farm households to reduce their dependence on crop cultivation and seek alternative income sources, such as animal husbandry. These possibilities, viable or otherwise, cannot be explicitly captured by the simple model employed in this paper. Nevertheless, on the basis of that model and the related empirical results, it is possible to conclude that the policy of compulsory grain delivery is unlikely to have been beneficial to the growth of crop production.

The empirical results also imply that acreage demand for the cultivation of a crop rises with the crop's price, and falls with revenue obtained from competing crops. In other words, the empirical evidence supports a normal supply response to prices furthermore, a comparison with elasticities reports by other studies indicate that the output price elasticities of acreage demand may have been somewhat lower in Ethiopia during the 1980's. It appears that this is in part explained by CGD.

