THE SUPPLY RESPONSIVENESS OF PEASANT AGRICULTURE IN ETHIOPIA: SOME MACROECONOMETRIC RESULTS FROM CEREALS PRODUCTION

Abebe Haile Gabriel*

ABSTRACT

In view of the strategic role that 'food supply' plays in economic development, this paper sets out to estimate the supply responsiveness of peasant agriculture, particularly cereals production, to price levels. A time series data on area cultivated, yield as well as price and other relevant variables are used. Cultivated area was taken as a response variable while effects of own-price, cross-price, factor (input) availability and costs, and yield expectations are considered as explanatory variables. A log-linear dynamic response equation is specified in which ad hoc specifications of supply response including partial adjustment and expectations formation are integrated. Results indicate that cereals, which are the single most important source of food supply in Ethiopia, are found to be inelastic to prices either in their aggregates or considered individually. On the other hand, relatively larger responses (which are also elastic for maize and sorghum) with respect to the movement of real exchange rate were observed perhaps suggesting that food imports have been competing more with cereals that mainly make up the poors' consumption bundle.

1. INTRODUCTION

With market orthodoxy gaining wide currency, the role of market signals in influencing the behaviour of economic agents has been highly stressed and spoken of perhaps too freely. Since the past sluggish agricultural performance in the poor countries is ascribed mainly to the distortion or absence of such signals, 'market liberalisation' has become the primary catchword in influential policy discussions and practices. The bottom-line of such an argument is that peasants, like any other 'economic men' are behaving rationally by responding to market forces; and since they are presumed to be at the price-receiving end of the agricultural product market transactions, they would expand production and increase sales as their erstwhile unfavourable terms of

* Assistant Professor, Ethiopian Civil Service College. The final version of this article was submitted in July 2000.

trade which resulted from suppressed markets are improved when markets are allowed to function 'freely'.

There has been much controversy around the issue of whether or not peasant agriculture is responsive to prices. Several researchers attempted to measure the supply responsiveness of agricultural production; however much of the emphasis has been on cash crops rather than on food crops. Although Ethiopia has been a late-comer to the SAPs, it has put the set of economic reforms in place that accompany the SAPs, with the exception, so far, of land privatisation. On the other hand, a comprehensive analysis of supply response of peasant production is lacking in. This paper attempts to make a modest contribution in addressing the problem.

The main thrust of the paper is to grapple with the issue of whether or not peasant agriculture (particularly cereals production) has been responsive to prices. The analysis focuses on macro level figures (both aggregate and individual cereals. The paper is organised into two sections: first the conceptual and methodological issues related to modelling peasant supply response are presented to be followed by a presentation of the supply response estimates for cereals production in Ethiopia. Finally a summary of the main points is provided.

2. PEASANT SUPPLY BEHAVIOUR AND THE SUPPLY RESPONSE MODEL

2.1. What is to Model? Choice of the Response Variable

Peasant supply response measures the degree to which level of production and/or marketed surplus changes in response to stimuli provided by changes in some important variables, mainly prices. In essence, it seeks to explain the behavioural changes of producers with respect to the production, consumption, and exchange decision of a certain product or set of products due to changes in economic incentives. Rational price sensitivity on the part of peasants would presuppose desirable responses to changes in prices. Conversely, insensitive producer behaviour is construed as insignificant or absence of output responsiveness despite notable changes in prices. Therefore, arguments surrounding the question that 'how much of a given product or set of products should be produced in response to changes in economic incentives' are predicated upon certain predetermined perceptions regarding the objective functions of the producer and that of the behaviour of markets. The analysis of supply response heavily draws from the neo-classical economics tradition of optimisation problem in which the supply behaviour of the 'firm' is often extended and metaphorically equated with the peasant 'farm'; while at the same time rural markets are deemed, with some qualifications, to assume resemblance of the features exhibited by the 'competitive markets'.

Strictly speaking, the primary concern of agricultural supply response is about marketed surplus, which varies with levels of production, or consumption, or both. For example, marketed surplus might directly vary with production (if consumption is maintained constant). On the other hand, marketed surplus might not necessarily fall even if production falls (it might even rise at the expense of consumption hence varying inversely with production). The available theory suggests that price elasticity of marketable surplus can be estimated directly through the construction of a string of structural functions involving marketed surplus, consumption, production, and prices after which a reduced form could be derived; or indirectly by deriving it from functions of total production and household consumption (Medani 1975; Behrman 1968; Hassel 1975). This requires that detailed data be available on production, household consumption and price levels. In the Ethiopian context, however, such kind of data is simply unavailable rendering estimation of marketed surplus response quite difficult if not impossible. When they are available, estimates of marketed surplus assume a fixed proportion of total production in which case no difference could be observed between changes in the two. In view of the strong dependence of the level of marketed surplus on total production (especially at a very low level of household consumption), the behaviour of total production might approximate peasant supply response behaviour. Therefore, total production is considered as a basis for modelling supply response.

What supply response seeks to measure would be producers' intentions in response to changes in certain key explanatory variables. But plans or intentions are not tangible and cannot be measured directly; nor could they be attained or materialised in fullness of magnitude. So, in practice actual performances are considered as their proxies in which output is regressed on a set of explanatory variables using econometric models whose functional forms would be specified taking into account both *a priori* theoretical considerations as well as specific circumstances. Then, the estimated coefficients (parameters) would become the basis upon which elasticities are to be derived.

The difficulty associated with not only measuring producers' intentions but also the conceivable disparity between intentions and actual performances has led analysts to dwell more on cultivated area rather than actual production as an appropriate index of dependent variable with which peasants' responsiveness could be modelled and estimated. This is underpinned by the fact that there is a very low degree to which peasants could exercise control over certain variables affecting production. Since producers' decision behaviour could be approximated by the amount of effort they are willing to put into (or withdraw from) the production process, size of area worked could be a better proxy to producers' intentions rather than actual output whose volume could be influenced by factors which lie beyond peasant's control. In other words, the type and amount of crop that the peasant intends to produce may better be estimated by the area allocated (and worked) to such a crop rather than the actual harvest. This is because the area actually cultivated with a particular crop is, to a much greater degree than actual output, under farmers' control and thus presumably a much better index of expected output in response to economic incentives such as prices. This is further supported by the evidence that cultivated area and expected output are strongly correlated on the one hand, and actual output is usually subject to the changes due to factors that are uncontrollable to farmers on the other hand (Behrman 1968; Nowshirvani 1962; Singh and Rao 1973).

The relationship between output and cultivated area of a given crop might be discerned by looking at the relationship between their respective elasticities. By definition, output of crop *i* at time *t* (Q_{it}) is a product of its cultivated area (A_{it}) and yield per unit area (Y_{it}):

$$Q_{it} = \sum A_{it} Y_{it} \qquad [1]$$

The impact of changes in a certain variable, say price (P) on output can be perceived from three possible points of views: it might induce changes in A, or in Y, or in both A and Y. Under ideal circumstances, i.e., if desired output (Q^D) would not differ from actual output (i.e., $Q^D = Q$, therefore no partial adjustment), and if data were permitting, the impact of price changes on output could be directly measured by taking Q as a dependent variable. In actual practice, however, divergences between expected and actual output are of a higher order of magnitude, and reliable data are often wanting (it is much easier to accurately measure area than output). If that is the case, then other possibilities ought to be sought to capture the different routes through which the stimulus could get into the system and bring about the perceived behavioural response, if any. In the context of poor countries, where technological stagnation characterises peasant production, yield is supposed to mostly remain insensitive to price incentives. Expressing A and Y as functions of P, i.e., $A = g(P)$, and $Y = h(P)$, it can be shown that price elasticity of output, ξ_{QP} is the sum of the price elasticity of cultivated area ξ_{AP}, and price elasticity of yield ξ_{YP}. Given equation [1], a complete differentiation of Q with respect to P gives:

$$\frac{dQ}{dP} = Y.\frac{dA}{dP} + A.\frac{dY}{dP}$$

Multiplying both sides of the equation by (P/Q), and substituting ($A \times Y$) for Q on the right hand side of the resulting equation, we get:

$$\frac{dQ}{dP}.\frac{P}{Q} = \frac{dA}{dP}.\frac{P}{A} + \frac{dY}{dP}.\frac{P}{Y}$$

Which is nothing but:

$$\xi_{QP} = \xi_{AP} + \xi_{YP} \qquad [2]$$

It can be assumed that ξ_{YP} is insignificant for cases where yield per unit area has been relatively independent of price changes and that producers exercise high degree of control over cultivated area so that actual cultivated area equals desired cultivated area, A^e (i.e., $A=A^e$), then ξ_{QP} would become equivalent to ξ_{AP}. That is, the noticeable way in which output could respond to changes in prices would be through changes in cultivated area (i.e., if $\xi_{YP} \approx 0$, then $\xi_{QP} \equiv \xi_{AP}$). If ξ_{YP} were not significantly different from zero, then ξ_{AP} would better approximate ξ_{QP}. Therefore, elasticities calculated from models in which cultivated area is the dependent variable probably better approximate the desired elasticities of planned output for agriculture, *ceteris paribus*, than actual output.

Nevertheless, it is important to note that the use of cultivated area as a dependent variable has certain limitations. Some of these would include that, first land is but one of the many factors of production required for production to take place. Due to the possibility of factor substitutability, a decision to allocate a certain area of land to the production of a specific crop may result in a wide range of planned outputs[1]. A possible way-out would be to employ an index of all inputs to be devoted to the crop. But, contrary to land, which is committed to a specific crop, most of the inputs utilisation can be altered throughout the production cycle in response to factors, which lie beyond peasants' control.

Secondly, land itself is often far from a homogenous factor of production. If land is sufficiently heterogeneous in quality and if other inputs constrain production, a situation is conceivable in which a farmer might decide to increase the planned output of a specific crop by devoting less, but better land to that crop.

The third problem is associated with absolute and relative scarcity of cultivable land. That is, the supply of cultivated area is not indefinitely elastic. This is particularly important where the size of cultivated land per household is very small on the one hand, and where food crops predominate it on the other. In other words, whether or not there exists an excess capacity with which to sufficiently expand area under a crop or group of crops in response to changes in relative prices is too important an aspect to ignore. Scarcity of land constrains peasants from increasing cultivated area when prices are increased. Alternative possibilities would include land reallocation and redistributing effort in favour of the crop whose relative profitability has increased; or raising yield per unit area through technological improvement; or expanding cultivated area through entering land markets; or some combinations of these. However, most of these (with the exception probably of reallocation) would significantly depend not only on the existence and functioning of rural factor markets, but also on capacities of peasant households to muster enough resources which would enable them to lay claim on those factors.

2.2. The Supply Response Model

A number of alternative approaches to estimation of elasticities of supply response are available both at the structural and reduced form levels (see Sadoulet and de Janvry 1995:84-86). The former concerns estimation of the structure of production functions and derivation of the supply response from it with the help of such analytical tools as production function estimation, linear programming, profit function approach, and complete structural models. The latter, on the other hand, involves a direct estimation of supply response of which the ad hoc specifications of supply response including partial adjustment and expectations formation is an integral component. This paper adopts the latter approach in which the relationship between output supply as a dependent variable and prices and a number of shifters as a set of explanatory variables could be directly modelled using time series data. This is partly because the microeconometric approach is relatively more data demanding which is not available as well as more stringent on assumptions of the behaviour of markets (e.g., wage labour is assumed rather than family labour). In addition, the latter approach permits some comparative evaluation with actual empirical estimates reported elsewhere. However, this is not to claim that the latter approach is without problems. Some of its drawbacks would come precisely from its comparative minimal theoretical and data demands.

Following Nerlovian (1958, 1979) traditions, with specific functional forms to be determined based on *a priori* theoretical considerations and particular circumstances, the general supply response model can be presented as:

$$Q_t^D = \alpha_1 + \alpha_2 P^E_t + \sum \alpha_3 X_{it}, \varepsilon_t \qquad [3]$$

Where, Q^D is desired level of output; P^E is a vector of expected level of prices, and X represents the set of non-price factors; α_i's are parameters with α_2 being the long-run coefficient (elasticity), and ε_t accounts for unobserved random factors with zero expected value. The Nerlovian models are constructed to handle two dynamic processes: adaptive expectations and partial adjustments.

$$Q_t - Q_{t-1} = \delta(Q^D_t - Q_{t-1}) + v_t \qquad 0 \leq \delta \leq 1 \qquad [4]$$

Where δ is the *partial adjustment coefficient* and v_t is a random term. Specification of a model that explains how price expectations[2] are formed based on differences between actual and past prices assumes:

$$P_t^E - P^E_{t-1} = \gamma(P_{t-1} - P^E_{t-1}) + w_t, \qquad 0 \leq \gamma \leq 1 \quad \text{or}$$

$$P_t^E = \gamma P_{t-1} + (1-\gamma) P^E_{t-1} + w_t \qquad [5]$$

Where γ is *adaptive expectations coefficient* and w_t is a random term. However, if we assume that peasants make their planting decisions based on their knowledge about prices that prevailed immediately the preceding period (i.e., inelastic expectations) then,

$$P_t^E = P^E_{t-1} \qquad [6]$$

Then substituting equations [3] and [6] into [4] would eliminate the unobservable variable (Q^D_t) to yield a structure that describes dynamically a supply response model for which parameter estimates can be obtained using either maximum likelihood procedure or least squares technique on an equation of the reduced form (Askari and Cummings 1976:32-33; Sadoulet and de Janvry 1995:87) such that:

$$\begin{aligned} Q_t - Q_{t-1} &= \delta(\alpha_1 + \alpha_2 P_{t-1} + \Sigma\alpha_{3i}X_{it} + \varepsilon_t - Q_{t-1}) + v_t, \quad 0 \leq \delta \leq 1 \\ &= \delta\alpha_1 + \delta\alpha_2 P_{t-1} + \Sigma\delta\alpha_{3i}X_{it} - \delta Q_{t-1} + \delta\varepsilon_t + v_t \\ Q_t &= \beta_1 + \beta_2 P_{t-1} + \Sigma\beta_{3i}X_{it} + \beta_4 Q_{t-1} + \mu_t \end{aligned} \qquad [7]$$

where, $\beta_1 = \alpha_1\delta$; $\beta_2 = \alpha_2\delta$; $\beta_3 = \alpha_3\delta$; $\beta_4 = 1-\delta$; and $\mu_t = \delta\varepsilon_t + v_t$

Hence, $\alpha_1 = \beta_1/\delta$; $\alpha_2 = \beta_2/\delta$; $\delta = 1-\beta_4$; etc.

Short-run and long-run elasticities could then be derived from these relations as follows. In the linear form of the equation, short-run and long-run price elasticities are given respectively by $\beta_2 \times (P/Q)$ and $(\beta_2/\delta) \times (P/Q)$ where P and Q are mean values of prices and output respectively. In the log-linear form of the equation, β_2 and (β_2/δ) would directly measure short-run and long-run price elasticities respectively (see, Askari & Cummings 1976; Behrman 1968; Sharma 1992; Sadoulet and de Janvry 1995).

3. SUPPLY RESPONSE ESTIMATION FOR CEREAL PRODUCTION IN ETHIOPIA

3.1. The Data

Area cultivated under cereals and yield of cereals per unit of area cultivated were found from reports of Central Statistical Authority and that of the National Bank of Ethiopia. The latter contains corrected versions of output data for the discrepancies of measurement between the periods of pre-1979 and after. Cereal price index was obtained from CSA reports and used to estimate aggregate cereals price after deflating it by the non-food general consumer price index. This is the only available price information that could be useable. However, Addis Ababa's grain market price is consequential to price determination in the regions (see, EHRS 1986). Fertiliser quantity and price is obtained from reports of the Agricultural Inputs Supply Corporation. Fisher's ideal quantity and price indexes were computed as proxies to the 'true' index since the latter lies somewhere in between the Laspeyres (which overestimates the increase and understates the decrease in the true index) and Paasche Indexes (which does the opposite). Nominal fertiliser prices are deflated by the general consumer price index to derive weighted fertiliser price index. Rainfall data were assembled by averaging the annual levels for 18 stations that could be available.

For individual crops, average producer prices were obtained from CSA reports and used after adjusting them by the non-food components of the national rural consumer price index (191/82=100). Nominal official exchange rate is multiplied by the ratio of US wholesale price index to Ethiopia's GDP deflator to derive real exchange rate.[3]

3.2. The Response Variable: Trends of Cultivated Area, Yield and Production

It is important to inquire whether or not the relationship between production and area cultivated could satisfy the foregoing discussion; that is, how could the problem of choice of dependent variable be resolved in the Ethiopian context? In order to identify the contributions of area and yield to changes in output, a distinction has to be made between area elasticity of output and yield elasticity of output, which are quite different from price elasticities. For instance, in cases where inelastic supply of land prevails, variation in output would result mainly from changes in yield; and it does not require a price elastic yield response for this to come about. Yield may vary due to changes in technology, weather, and other factors even though it is price inelastic. In fact, this has been the case in the Ethiopian condition where, notwithstanding fluctuations in cultivated area, the major source of fluctuation in cereals production has been yield rather than area. Between the years 1973 to 1995, cereals production, cultivated area and yield have on average grown at rates of 3.33%, 0.82%, and 2.56% per annum respectively (Table 1). Such an association can also be seen from Figure 1.

Table 1. Average per Annum Growth Rates of Area, Yield and Output of Cereals (1973-95)

	Cereals	Teff	Wheat	Barley	Maize	Sorghum	Total[§]
Area	0.82	1.66	1.39	0.56	3.14	3.43	1.34
Yield	2.56	2.26	3.32	2.02	5.19	6.31	2.74
Output	3.33	3.79	3.63	1.29	7.96	10.44	3.63

[§]includes cereals, pulses and oilseeds. Source: CSA, various reports.

Figure 1a. Growth Rates of Cultivated Area, Output and Yield of Cereals (1974/75-1995/96)

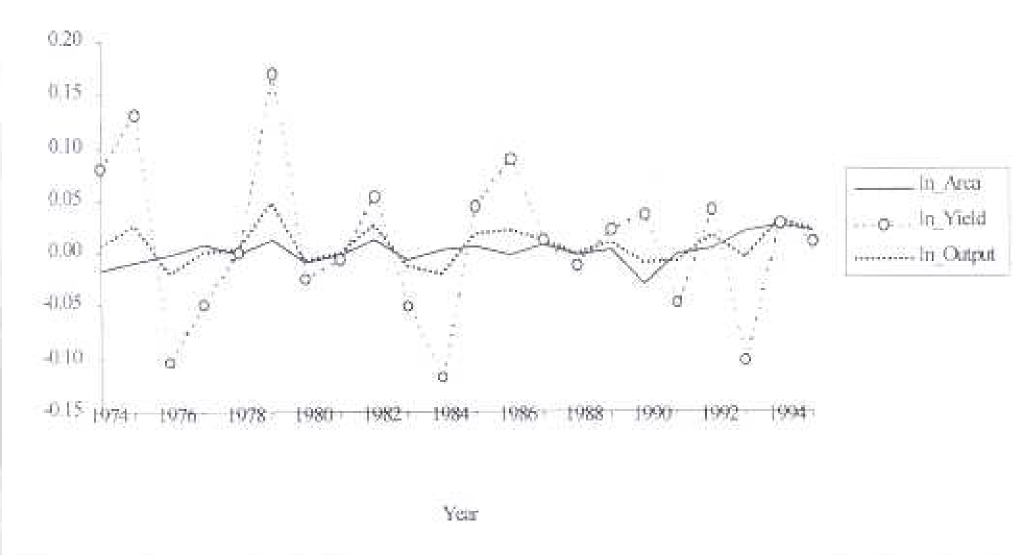


Figure 1b. Growth Rates of Cultivated Area and Output of Cereals (1974/75-1995/96)

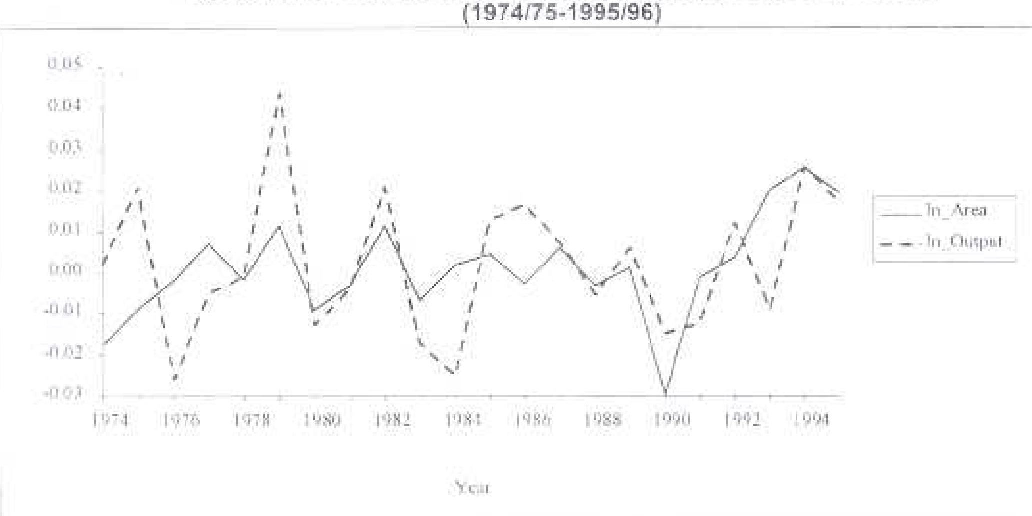
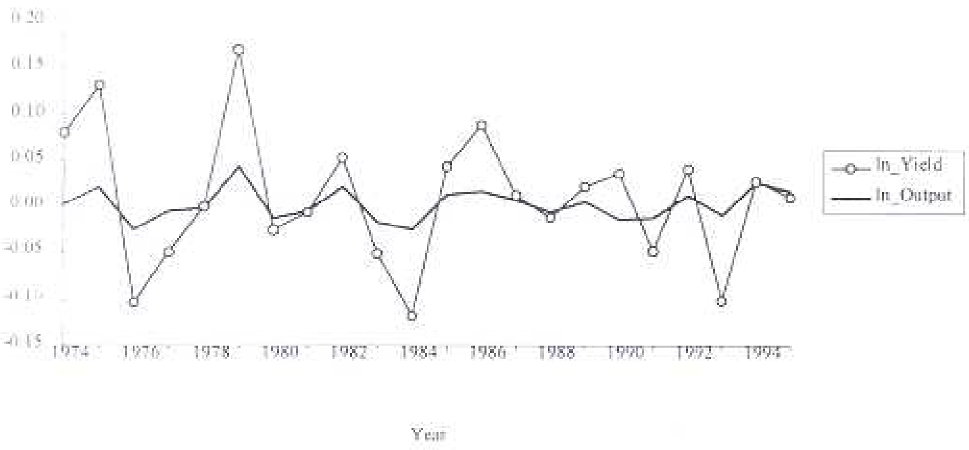
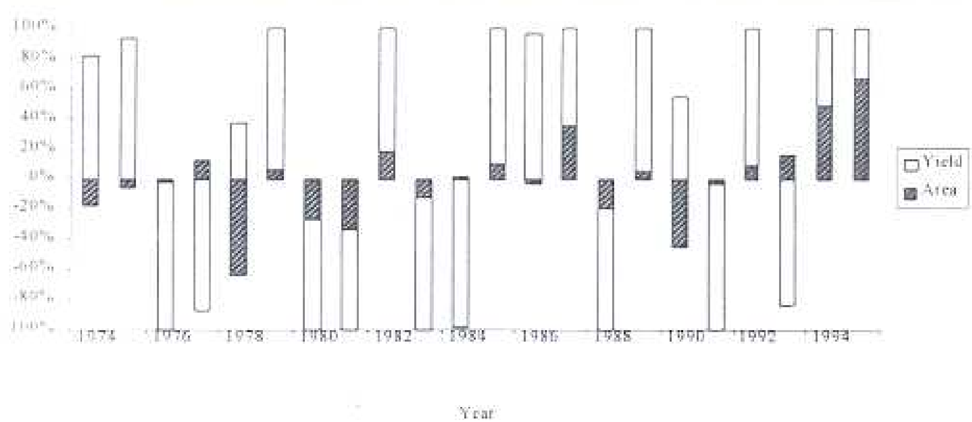


Figure 1c. Growth Rates of Output and Yield of Cereals (1974/75-1995/96)



While fluctuation of output is more salient, that of area was not that expressive (Figures 1a & 1b). In contrast, not only does yield fluctuate notably but also its pattern tends to correspond fairly to that of output (Figures 1a and 1c). Indeed, the correlation between output and yield is stronger (0.65) than that between output and area (0.55). The respective contribution of yield and area growth rates to that of output is shown in Figure (1d).

Figure 1d. Contribution of Area and Yield Growth Rates to Output Growth Rate



As could be seen from Figure (1d) with the exception of two years (1978/79 when cultivated area significantly declined and 1995/96 when it expanded) the contribution of yield growth to output growth has been by far more conspicuous than area growth. Hence, the scenario at hand would seem to be one of a relatively less flexible supply of cultivated area of land coupled with marked yield fluctuation determining level of production. Therefore, in such circumstances, it will be useful not only to model the area response behaviour but also inquire into the sources of observed yield fluctuations. To do so would be advantageous because it enables one to disentangle the area response behaviour (which is mainly a function of expectations) from the yield response behaviour (which is mainly a function of interactions and interplay of uncontrollable factors which would reduce yield, and peasants' efforts and capacities (or the lack of them) in counteracting them).

Yield response is usually perceived to be a function of technological change (trend variable) or an index of natural conditions (such as rainfall) or risk variables (Behrman 1968; Burton 1992:35), or sometimes treated as an exogenous variable in the equations to estimate the area response (Rajagopalan 1967; Parikh 1971, quoted in Weichang 1995:128). This is because of the assumption that yield response is too vulnerable to changes in weather conditions[4] and technological improvement, and is too weak to be identified econometrically (Weichang, ibid.).

The Ethiopian experience would reveal that marked yield fluctuations have strongly been associated with changes in weather conditions. Total amount of seasonal rainfall together with its length is the main yield determinant. Ethiopia's climate is predominantly bi-modal, with seasonality and variation in rainfall rather than temperature being the limiting factors, and about 85-95% of the food crop production in the country depends on precipitation that occurs during the main season. Late arrival of rains or its stoppage shortly before plant maturity would result in substantial crop failure. The distribution of rainfall during the season is also important since crops need different amount of water during different stages of their growth cycle. An important characteristic of Ethiopia's rainfall is that it exhibits high variability in time and space. Annual rainfall averages range from between 500 and 1500 mm. Although both shortages as well as excess rainfall are equally detrimental to cereals production, the Ethiopian experience reveals that it is the shortage rather than the excess which had adverse impacts. Weather data show rather conclusively that the lower the annual total rainfall, the greater the degree of variability.

Several severe drought years have been recorded in recent years (1973-1975, 1983-86, and 1993-94) in which one could notice a sharp fall in yield and output of cereals. Assigning a dummy (1 for these years, and 0 otherwise) and regressing yield of cereals on this binary variable would show that the impact of weather on yield has been significant. On the other hand, yield was found to be uncorrelated with prices (with insignificant coefficients and/or with wrong signs). A notable vulnerability of yield to changes in weather would imply that aggregate output would also be quite vulnerable to such changes. Therefore, much of the source of yield, hence output, fluctuation could clearly be explained by changes in weather conditions. This would leave us with cultivated area as a proxy with which to estimate peasant supply response to prices.

3.2. Explanatory Variables

The first set of explanatory variables to be considered in supply response analysis is the price level. Depending on the type of price-elasticity to be estimated, the price variable could enter in different ways, either in groups or separately, into supply response models. These include (a) own-price effect, (b) cross-price effect, and (c) relative price effect, etc. Each of these would involve dissimilar interpretation. For example, own-price elasticity measures the responsiveness of output to changes in its own price; cross-price elasticity estimates the responsiveness of a given output, say *X*, to changes in the prices of a competing output, say *Y*; and relative price elasticity measures the responsiveness of output to changes in relative prices of the output vis-à-vis that of the inputs used. Therefore, rational behaviour on the part of producer presupposes that the coefficient of own-price and that of relative prices (if favourable) in the supply model would assume a positive sign, while that of the cross-price a negative (if substitute). The presumption is that peasants positively respond to own-price and favourable relative price changes, and inversely to cross-price (if substitute) changes.

The second group which are classified as non-price factors might include a wide array of explanatory variables such as technology, rural labour force, excess capacity in terms of availability of resources (e.g. land), infrastructural development, pervious level of production, policy changes, index of availability of non-agricultural consumer goods in rural areas, etc. This requires that data be available on each of these variables. In reality however, only a fraction of these information would be available rendering the use of their proxies inevitable.

In this paper, the following effects are considered as important explanatory variables for area response (a) own-price effects, (b) cross-price effects, (c) factor (input) availability and costs effects, and (d) yield expectations.

Own-Price Effects

At an aggregate level, cereals' own-price is estimated by taking the retail cereal price index and deflating it by the non-food consumer price index to arrive at an estimate of real cereal price index. For individual cereals, the availability of average producer prices for major cereals and national rural consumer price index covering the years 1981/82-1994/95 permitted the derivation of real producer prices through deflating the former by the non-food rural consumer price index. It is expected that the coefficient of this variable would take a positive sign.

Cross-Price Effects

For cereals as a whole, the nearest competitive crops in production are cash crops such as coffee, t'chat, oilseeds and/or pulses. It is also known that these (perhaps with the exception of pulses) constitute the major export crops. The other competitive items would include food imports. It is expected that the movement of real exchange rate would capture the substitution effects both in production and consumption (between traded and non-traded goods such as cash crops and food crops or between food imports and domestic production). Since the impact of changes in real exchange rate would be a mixed one for exportable cash crops and food imports, it will be difficult to make an apriori assumption about the sign that its coefficient would assume. For example, it might assume a negative sign as the real exchange rate appreciates leading to an improvement in the competitiveness of export crops (making exports cheaper abroad); but the same movement would make food imports more expensive domestically, hence improving the competitiveness of domestic food production vis-à-vis food imports. The net effect could be determined by the relative changes in the competitiveness of food *vis-à-vis* cash crop production and the flexibility with which substitution could be made possible.

Factor (inputs) Availability and Costs

Since early 1970s, the most important purchased input used by peasants has been chemical fertilisers. The volume of fertiliser import as well as its use by peasants has been steadily increasing over the period despite the fact that even at present the rate of application remains to be one of the lowest by many standards. Most of the available fertiliser is also used for cereal production. Improved varieties of wheat, teff, maize, and sorghum have also been introduced since long time ago, but still their application has been restricted to certain limited areas and few peasants within these areas.

The volume index of chemical fertilisers (DAP and Urea) distributed to peasants is considered as a proxy to the availability of purchased inputs. In order to combine its profitability impact, the fertiliser volume index is multiplied by its price index and then divided by the value of output (price index times volume of output). Two alternative ways of measuring the quantity and price indexes of fertiliser were evaluated: (a) taking the simple sum of DAP and Urea for volume index and weighted price of fertiliser as derived from the respective quantity shares and prices of DAP and Urea for price index; and (b) constructing a quantity and price index in such a way that changes in both variables are taken into account. However, no significant difference was observed between parameter estimates obtained by using either (a) or (b) to measure the variables; therefore, option (a) was considered in the estimation equation. It is expected that as the availability of fertiliser per unit cost improves, peasants would expand the area under cereals (as opposed to other crops, e.g., pulses, which do require less chemical fertilisation).

Yield Expectations

It is hypothesised that one of the factors that would influence peasants' decisions with respect to the amount of area they intend to cultivate is the yield level that they expect from planting the crop in question. Several ways of estimating yield expectations are available[5]. Two alternative ways of capturing the potential effects of expected yield (y^e) are evaluated here: (i) expected yield estimated as a function of rainfall deviation and time trend such that:

$$y^e = d_0 + d_1\overline{R} + d_2t + d_3t^2 + u_{4t} \qquad [8]$$

where $\overline{R}$ measures the difference between annual rainfall in time *t* and the average rainfall over the period; and (ii) taking the previous yield level as a proxy to y^e assuming that peasants decisions as to the size of area they intend to allocate to a particular crop (or groups of crops) depends on the previous yield levels achieved. It is expected that the coefficient of this variable would turn positive such that cultivated area varies directly with expected yield.

3.3. Estimates of Aggregate Cereals Area Response

Several variants of specifications of the basic model were tried after which the following log-linear dynamic area response equation gave better results.

$$\log A_t = \beta_1 + \beta_2\log OP_{t-1} + \beta_3\log RER_t + \beta_4\log FERT_t + \beta_5\log Y^e_t + \beta_6\log A_{t-1} + e \qquad [9]$$

where *OP*, *RER*, *FERT* and Y^e are respectively own-price, real exchange rate, fertiliser quantity and expected yield. The results of the regression are reported in Table (2).

The regression results show that the coefficients of all the explanatory variables in the model with the exception of expected yield[6] were highly significant and have positive signs. That is, cultivated area of cereals varies directly with output price, real exchange rate, fertiliser availability per unit of cost, and past level of cultivated area. As these variables increase, cultivated area tends to increase; and conversely, as the variables decline, cereals cultivated area tends to fall. This makes economic sense because producers tend to expand area as cereals price rise and vice versa. The impact of the real exchange rate is that producers tend to expand cultivated area of cereals as it appreciates (improving its competitiveness) and vice versa which is understandable in view of the fact that the country is a net importer of food. It seems that the competitiveness between domestic food production *vis-à-vis* food imports was more important than that between food and cash crop production. Similarly, the availability of fertiliser input per unit of cost tends to raise cultivated area under cereals.

Table 2. Regression Results of Aggregate Cereals Area Equation (1974/75-1995/96)

Variable	Coefficient	t-Statistic
Constant	1.9142	1.1096
$log(OP_{t-1})$	0.3181*	2.6813
$log(RER)$	0.3058*	2.9029
$log(FERT)$	0.0675*	2.7326
$log(Y^{*})$	-0.2118	-0.5550
$log(A_{t-1})$	0.5346*	3.1024
R-squared	0.74	
Adjusted R-squared	0.66	
F-statistic	9.3017	
Prob(F-statistic)	0.0003	
Durbin's h-statistic	-1.98[§]	

*significant at less than 0.05 probability level.
[§]No serial autocorrelation at 0.05 probability level

Based on these estimates, short-run and long-run price elasticities of area response for aggregate cereals would be 0.32 and 0.68 respectively[7]. This implies that a 10% increase in cereal prices would lead to a 3.2% and 6.8% expansion of cultivated area of cereals in the short-run and long-run respectively. Supply elasticity due to movements in real exchange rate is somewhat comparable to own-price effect (0.31 in the short-run and 0.66 in the long-run). On the other hand, the impact of fertiliser availability per unit of cost is quite weak (0.07 and 0.15 respectively). In general, at an aggregate level, it could be shown that the supply responsiveness of cereals cultivated area has been fairly inelastic.

However, working with such an aggregate data, as total cereals which encompass a number of crops each with its specific characteristics, has its own inherent problems. This is because the price responsiveness of one cereal might behave differently from another, as for example an elastic response of one crop running parallel to an inelastic response of another; in which case averaging would only become unusable. Secondly, 'cereal price index' as a proxy would measure the price of each crop weighted by their respective quantities where the assumption is that such a proxy might reflect the movement of the average price for all cereals. In practice, the signal that this figure might throw would be different for each crop. For this reason, disaggregation of supply response into each cereal crop is imperative to which we now turn.

3.4. Estimates of Individual Crops Area Responses

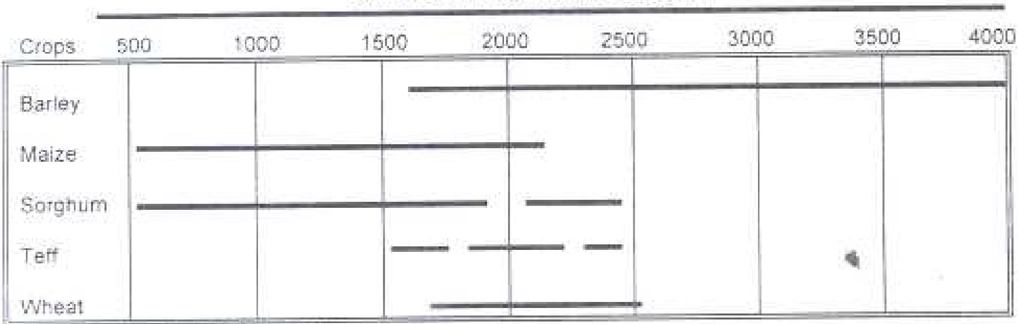
As we move from modelling supply response of aggregate cereals to that of individual cereals, certain adjustments would become inevitable. This is because there are some advantages that are associated with working with disaggregated data. First, it is more meaningful to talk about the price of an individual crop (say wheat) than a composite price index of a group of cereals. Nominal producer prices of each crop are deflated by the non-food rural consumer price index to estimate the real producer prices making it possible for real producer prices of each crop to enter into the model. Secondly, it is also easier to introduce the cross price effects of potential substitutes since differences in relative price movements have impacts on peasant production, consumption and exchange decisions.

On the other hand, there are some shortcomings to be dealt with. First, data on individual crops is harder to obtain and derive than for aggregate cereals. For example, price data (producer prices, rural consumer price index) is available only after 1981/82, information on actual fertiliser distribution and rate of application by crops is unavailable; data on the amount of precipitation and its distribution for each crop is hard to come by, etc. This problem of data unavailability would diminish the number of years to be considered from 22 to only 14 (i.e., from 1981/82 to 1994/95 only) with the effect that regression estimates would be less conclusive[8]. However, from the aggregate cereals response equations one could get an impression that expected yield was not a significant variable. For individual cereals, like in the aggregate response equation, previous yield levels as proxies to expected yield are found to be negatively but weakly correlated with respective areas (-0.08, -0.14, -0.16, -0.32, and -0.43 respectively for maize, sorghum, teff, wheat and barley) suggesting that it could perhaps be dropped from the estimation equations. Similarly, since the quantity of fertiliser actually applied to each crop cannot be known the omission of the aggregate volume of fertiliser from the estimation equations would not affect the result significantly. Besides, aggregate cereals area was found to be quite inelastic to fertiliser availability per unit cost.

Two indicators are provided below in order to determine whether or not inter-crop competition for land, therefore inter-crop cross-price effects are important. The first is the alititudinal range within which different crops are cultivated in Ethiopia (Table 3), while the second has to do with correlation matrix among the cultivated areas of different crops (Table 4).

For example, in the altitudinal range below 1500 meters maize and sorghum are the only crops grown. Similarly in the range of above 2500 meters only barley is to be grown. Between 1700 and 2300 meters, barley, teff, and wheat are the important crops. It could also be seen that all crops tend to overlap at around 1700-2200 meters above sea level. From such a rough distributional sketch one would be tempted to think that barley seems to compete with wheat and teff; maize with sorghum, teff and wheat; sorghum with maize and teff; teff with all crops; and wheat with teff, maize and barley. However a correlation matrix would suggest that such a competition among the different crops within the respective alititudinal ranges has been an exception rather than the rule.

Table 3. Alititudinal Range of Some Cereals
Altitude in Meters Above Sea-level



Source: Westphal, 1975, pp. 84

Table 4. Correlation Matrix of Area Cultivated of Individual Cereals (1981/82-1995/96)

	Teff	Barley	Wheat	Maize	Sorghum
Teff	1.000				
Barley	-0.026	1.000			
Wheat	0.700	0.472	1.000		
Maize	0.511	0.382	0.421	1.000	
Sorghum	0.631	0.472	0.888	0.473	1.000

As could be seen from Table (4) all the correlation coefficients but one (barley with teff) were positive implying that movement of area cultivated for all crops tends to move in the same direction. This can be further corroborated with evidences from the correlation matrix between cultivated area and lagged cross-price levels. Considering those cross-prices with negative signs, correlations were found to be (a) -0.01 for sorghum area and maize price; (b) -0.01, -0.05, -0.12 between teff area and prices of wheat, sorghum and maize respectively; and (c) -0.03, -0.10, and -0.30 between maize area and prices of wheat, barley, and sorghum respectively. On the other hand, wheat area was positively but weakly correlated with prices of all cereals. These would indicate that the correlations are too weak to be reckoned with thus making inter-crop cross-price effects less important in supply response estimates.

Therefore, only three variables are considered, namely own-rice, real exchange rate, and lagged cultivated area (this might help minimise errors of estimation; i.e., due to small number of years included in the time series). Area cultivated is expected to vary directly with own-price changes. The inclusion of real exchange rate in the estimation equation is intended to evaluate the relative competitiveness of each cereal *vis-à-vis* the observed pattern in the aggregate response. The equation is estimated thus:

$$\log A_t = \beta_{i1} + \beta_{i2}\log OP_{it-1} + \beta_{i3}\log RER_t + \beta_{i4}\log A_{t-1} + e_t \qquad [10]$$

The regression results are reported in Table 5 in which it could be shown that (a) own-prices have the expected signs in their coefficients in all equations, but only in two cases (wheat and teff) were they significant; (b) the coefficient of real exchange rate is also positive in all equations and significant in all but one (barley); (c) in likewise, previous level of cultivated area has positive coefficients in all equations and is significant except in teff equation.

Table 5. Regression Results for Individual Cereals Area Response Equations

Regressors	Barley	Maize	Sorghum	Teff	Wheat
Constant	1.975 (0.997)	2.132 (1.359)	1.718 (1.479)	1.916 (0.802)	2.544* (1.821)
log(OP$_{t-1}$)	0.157 (0.717)	0.1587 (0.990)	0.108 (0.744)	0.236** (1.814)	0.227 * (2.503)
log(RER)	0.207 (0.992)	0.460* (2.783)	0.823* (4.171)	0.286** (2.006)	0.359 * (3.008)
log(A$_{t-1}$)	0.589* (2.381)	0.555* (2.742)	0.571* (3.201)	0.574 (1.651)	0.436 ** (2.014)*
R^2	0.41	0.59	0.80	0.71	0.75
Adjusted R^2	0.23	0.47	0.73	0.63	0.68
F-statistic	2.299	4.864	12.904	8.319	9.999
Prob (F-stat)	0.1390	0.0245	0.0009	0.0045	0.0024
Durbin's h-statistic	0.627§	-0.99§	-2.61	not defined§§	-0.64§

Numbers in parenthesis show t-values.
*Significant at less than 0.05 probability level; **significant at less than 0.10 probability level.
§No serial autocorrelation at 0.05 probability level.
§§Durbin's h-statistic could not be calculated due to negative square roots. However, Breusch-Godfrey Serial Correlation LM (Lagrange multiplier) test shows the absence of serial autocorrelation.

Table 6. Short-run and Long-run Elasticity Estimates for Individual Cereals

ξ with respect to	Barley		Maize		Sorghum		Teff		Wheat	
	short-run	long-run	short-run	long-run	short-run	long-run	short-run	long-run	short-run	long-run
Own-Price	0.16	0.38	0.16	0.36	0.11	0.25	0.24	0.55	0.23	0.40
RER	0.21	0.51	0.46	1.03	0.82	1.92	0.29	0.67	0.36	0.64
δ		0.411		0.444		0.428		0.426		0.564

On the basis of these results both short-run and long-run elasticity estimates are summarised in Table (6) from which the following observations could be made: (i) Notwithstanding the non-significance of the own-price coefficients of barley, maize and sorghum, it could be generalised that both short-run and long-run price responses are fairly inelastic. Even for the 'superior' crops (teff and wheat) where price coefficients have been significant, price elasticities seem to be somewhat better but still low in absolute terms. A 10 percent increase in the price of teff and wheat would respectively lead to an expansion of cropped area by 2.4 and 2.3 percent in the short-run and by 5.5 and 4.0 percent in the long-run. (ii) Individual own-price elasticity estimates seem to be somewhat lower than aggregate cereals elasticities. However, sufficient care should be exercised in comparing these estimates due to discrepancies of the price data used between aggregate cereals and individual crops; and (iii) Responses with respect to the movement of real exchange rate are not only larger than own-price responses for all crops but also elastic for maize and sorghum in the long-run perhaps suggesting that food-aid has been competing more with crops which mainly make up the poors' consumption bundle than the 'superior' crops.

3.5. Result Comparison with Estimates from Other Similar Studies

Bond (1983) estimated output elasticities[9] for various crops in several countries of sub-Saharan Africa, and reported that price elasticities range from 0.1 to 0.5 in the short-run and from 0.6 to 1.8 in the long-run, and that aggregate supply elasticity in seven of the nine countries examined was not statistically significant. Comparable figures for the same set of crops in other LDCs would include: in India for the period 1951-64 short-run elasticities of food grains varied from -0.06 to 0.42; while for wheat (1950-67) it was 0.10 and 0.13 respectively in the short-run and long-run. Short-run and long-run elasticities for wheat in Kenya (1950-69) and Egypt (1953-72) were respectively 0.31 and 0.65 and, 0.91 and 0.44. Elasticities for barley in India (1960-69) ranged between 0.11 to 0.13 in the short-run and from 0.14 and 0.16 in the long-run. Short-run and long-run elasticities for maize in Kenya (1950-69), Egypt (1953-72), and Sudan (1951-65) were respectively 0.95 and 2.43, 0.04 and 0.09 and 1.09 and 1.09. Similar estimates for sorghum for India (1947-65) ranged between 0.02 to 0.20 in the short-run, while for Sudan (1951-65) it was estimated to be 0.31 (short-run) and 0.59 (long-run) (see Scandizzo and Bruce 1980, quoted in Sadoulet and de Janvry 1995:91).

A limited number of studies were conducted to study the supply response of Ethiopia's agriculture. The study by the World Bank in the mid-1980s reported that aggregate short-run and long-run elasticity for Ethiopia's agriculture were 0.24 and 0.558 respectively. The same study estimated, using Nerlovian dynamic model, responses for cereals as well as for some individual crops such as teff and barley. The short- and long-run elasticity estimates respectively were 0.147 and 0.264 for cereals, 0.027 and 0.080 for teff, and 0.219 and 0.318 for barley. Compared to the present study, these estimates are lower for aggregate cereals as well as for teff and higher for barley both in the short- and long-run. Given certain drawbacks[10] in the World Bank's study with respect to the number of years covered (only less than six years), the price data used, and the modelling approach employed (modelling output directly), such a divergence in estimates is to be expected. Fernando (1992 quoted in Zerihun 1995), used quarterly data on crops like teff, maize, sorghum, barley, and wheat, and regressed output only on producer prices and reported that Ethiopian peasants responded positively to price incentives. Zerihun (1995) studied, using Nerlovian partial adjustment model, the supply response of total agriculture as well as individual crops for 12 years covering 1981/2 to 1992/3. In addition to producer price, dummies for weather and policy change, time trend and lagged production level have entered into supply equation. Output index was directly taken as dependent variable. However, non-significance of the price coefficients shunned from undertaking elasticity computations. It was reported that, in a nutshell, parameter estimates like weather and previous period production level have the expected signs, and explain about 99 percent of the variation in agricultural production.

The present approach differs from the above studies in several ways. Methodologically, output response is disaggregated into its constituent elements. That is area response (which is mainly a function of expectations) was separated from yield response (which is largely a function of uncontrollable variables) whereby the former could be the basis upon which peasant responses to prices are to be estimated. Second, cross-price effects as well as input availability per unit of cost have been included in the set of explanatory variables. Third, the time covered for aggregate cereals is by far longer than the above studies.

4. CONCLUSION

This paper set out to estimate the supply responsiveness of peasant agriculture, particularly cereals production, to price levels. A time series data on area cultivated, yield per hectare as well as price levels and other relevant variables are used. Cultivated area was taken as a response variable while effects of own-price, cross-price, factor (input) availability and costs, and yield expectations are considered as explanatory variables. Supply responses are estimated at aggregate cereals level as well as for individual cereals. A log-linear dynamic response equation is specified in which ad hoc specifications of supply response including partial adjustment and expectations formation are integrated.

Results suggest that, notwithstanding some limitations with respect to the quality of data used, both short-run and long-run peasant supply responses were inelastic to prices. This is also true when cereals are considered in their aggregates or treated individually; however comparison between aggregate and individual responses should be made with the necessary precaution since there are differences in the number of years considered as well as in the type of prices used to measure them. Responsiveness varies with crop types but not that important. Even where elasticity coefficients were significant (e.g., teff and wheat), it is low in absolute terms. On the other hand, relatively larger responses were observed with respect to the movement of real exchange rate. These responses are also elastic for maize and sorghum in the long-run, perhaps suggesting that food imports have been competing more with domestic cereal production, particularly those making up of the poors' consumption basket.

Such a result would perhaps hint that the primary motive behind peasant production of food crops might transcend into extra-market considerations which include food security, risk aversion, patterns of accessing and use of resources, etc., which would fairly be understood by a careful investigation of several aspects including the historical evolution and the characteristics of the whole farming and agrarian systems in which linking it with historical entitlement issues is a crucial step. Peasants might be *willing* but *unable* to increase supply, and questions as to why would peasants are willing to produce more of a particular crop, and how would they be able to do so should be the leading issues in addressing problems of food supply.

Estimation of peasant supply responsiveness hinges on certain assumptions regarding the way in which the characteristics and operation of markets in terms of providing sufficient space for flexibility and in shaping the behaviour of producers in making production, consumption and exchange decisions. Such assumptions are very strong in the light of depressed and imperfect land markets that prevail in many rural areas. Indefinite expansion of the frontier of cultivated area through the operation of land markets seems to be unrealisable. Reallocation might be feasible, but then one would be forced to stick to the assumption that peasant households intend to specialise production and purchase other crops that are necessary for household consumption - an assumption that is also rather hard to justify in view of the available evidence. Even though specialisation in some crops could be perceived, there is a maximum limit beyond which it cannot be pushed further due to the fact that households do allocate their land for various products (cereals, pulses, oilseeds, vegetables, pasture, etc.). The validity of this assumption much depends on how far it comes to terms with household's overriding objective functions. Numerous factors, which are beyond the reach of control of peasants, would render it impossible to cultivate a particular crop in all plots as the latter vary in terms of soil properties, etc. Therefore, supply response has a lot to do with not only output prices but also with the quantity, quality, and the way of organisation of efforts (inputs, management, etc.) as well as the way uncontrollable factors influence these efforts and the outcomes. Often such considerations are considered as a black box in supply response analyses. While reiterating the inelastic nature of peasant supply response to prices, it has to be stressed that the importance of the non-price factors in determining supply behaviour cannot be overemphasised. At the same time, that supply response has been price inelastic does not mean that price is not an important factor at all. It is important to realise that both price and non-price factors should be seen as complementary rather than as substitutes in production organisation, particularly for peasant agriculture.

NOTES

[1] If only one fixed coefficient activity were available for a given crop and if the only effective constraint on production of that crop was the amount of land available, then (until some of the constraints became effective) the amount of land devoted to that crop would be an excellent index of the planned production of the crop. In the agriculture of the real world, however, innumerable activities are available (or, alternatively) substantial substitution between factors is possible (see, Behrman 1968).

[2] In a formulation that represents a learning process, farmers adjust their expectations as a fraction γ of the magnitude of the mistake they made in the previous period, that is, of the difference between the actual price and expected price in t-1 (see, Sadoulet and de Janvry 1995:87).

[3] This is a bilateral real exchange rate. Multilateral real exchange rate (considering all trading partners) would be much more appropriate to use. However, taking into consideration the fact that the USA has been historically a major trade partner on the one hand and due to the fact that birr is pegged to the US$ on the other, the resulting bilateral real exchange rate would not significantly deviate from the multilateral one.

[4] Drought affects up to 80% of the total crop area in the tropics. Even minor droughts can have great impact, especially in the humid tropics since soils are often rather poor and have limited water storage capacity. In the sub-humid and semi-arid tropics serious droughts occur often (ranging from 1:2 to 1:5 years) (see, Beets 1990).

[5] See, for example, Behrman (1968), Cuddihy (1980 quoted in Sadoulet & de Janvry 1995).

[6] Previous yield level did not improve the regression estimates any better than that obtained from equation (10). For this reason the yield variable that entered the area response equation is expected yield.

[7] The partial adjustment coefficient, $\delta = 0.4654$.

[8] One of the most serious problems would be that there would be too small degrees of freedom to work with.

[9] Bond used output per capita as dependent variable. It is obvious that, unless population is uncorrelated with output, the coefficient obtained is based on estimate of the elasticity parameter. The fact that both output and population increased overtime meant that a positive correlation between them resulted in a downward bias in the elasticity estimate (see, Schiff 1997).

[10] The WB ascribed the weaknesses of its study to non-availability of time series data on producer prices (for individual crops) and aggregate price index (for overall agriculture). Individual crop elasticity estimates were approximated using price indices, obtained after Addis Ababa price index was deflated by Addis Ababa cereal price index. In the case of overall agriculture, producer price was proxied by Addis Ababa food price index. Observation of less than six years was used for analysis.

REFERENCES

Askari, H., and J.T. Cummings (1976). ***Agricultural Supply Response: A Survey of the Econometric Evidence***. New York: NY: Praeger.

Beets, W.C. (1990). ***Raising and Sustaining Productivity of Smallholder Farming Systems in the Tropics: A Handbook of Sustainable Agricultural Development.*** AgBe Publishing. Alkmaar, Holland.

Behrman, J. 1968. 'Supply Response in Underdeveloped Agriculture: A Case Study of Four Major Annual Crops', in Thailand, 1937-1963. in Jonston, J., et al (eds.). *Contributions to Economic Analysis.*, 55. Amsterdam: North Holland.

Bond, M.A. (1983) 'Agricultural Responses to Prices in Sub-Saharan African Countries'. ***IMF Staff Papers***, 30.

Burton, M. (1992). ***An Agricultural Policy Model for the UK.*** Avebury.

CSA (1993) 'Report on Cropland Utilisation: Agricultural Sample Survey, 1988/89'. ***Statistical Bulletin*** 118. Addis Ababa, Ethiopia.

Eicher, C.K. and J.M. Staatz (1984). ***Agricultural Development in the Third World***. Baltimore: The John Hopkins University Press.

Hassel, W. (1975) 'The Price and Income Elasticities of Home consumption and Marketed Surplus of Foodgrains', ***American Journal of Agricultural Economics***, 57(1): (111-115).

Krishna, R. (1962) 'A Note on the Elasticity of the Marketable Surplus of a Subsistence Crop'. ***Indian Journal of Agricultural Economics***, part 3.

Lundahl, M. (1990). ***Incentives and Agriculture in East Africa***. Routledge.

Medani, A.I. (1975) 'Elasticity of the Marketable Surplus of a Subsistence Crop at Various Stages of Development', ***Economic Development and Cultural Change***, V, 23: 421-29.

Nerlove, M. (1979) 'The Dynamic of Supply: Retrospect and Prospect', ***American Journal of Agricultural Economics***, V, 64.

Nerlove, M. (1958). ***The Dynamics of Supply: Estimation of Farmers Response to Price.*** Baltimore: Johns Hopkins University Press.

Nowshirvani, V. (1962). Agricultural Supply in India: Some Theoretical and Empirical Studies. A PhD thesis, Massachusetts Institute of Technology.

Platteau, J.P. 1994. Sub-Saharan Africa as a Special Case: The Crucial role of (infra) Structural Constraints. A Paper presented at the Rural Development Studies Seminar, Institute of Social Studies, The Hague: The Netherlands.

Platteau, J.P. (1995). 'Famine Prevention in Africa', in Dreze, J. and Sen A. (eds.) ***The Political Economy of Hunger: selected essays.*** WIDER.

Rao, J.M. (1989) 'Agricultural supply response: A survey', ***Agricultural Economics***, V. 3.

Sadoulet E. and de Janvry, A. (1995). ***Quantitative Development Policy Analysis.*** Baltimore: The Johns Hopkins University Press.

Sharma, K.L. (1992) 'Aggregate Farm Supply Response in Kenya', ***Eastern Africa Economic Review***, 8(2).

Singh, R. D. and Rao, D. (1973) 'Regional Analysis of Supply-Price Relationship of Major Foodgrains in Uttar Predesh', ***Indian Journal of Economics***, V, 53.

Weichang, D. (1995). ***Agricultural Marketed Surplus Response in China.*** Aldershot: Avebury.

World Bank (1987). Ethiopia: An Export Action Program, Division EA2NE, Report No. 6432-ET, Washington DC: World Bank.

Zerihun Gudeta (1996). The Supply Response of Agriculture and Individual Crops in Ethiopia. MSc. thesis, Addis Ababa University, Addis Ababa.