GRAIN-SUPPLY RESPONSE IN ETHIOPIA: AN ERROR-CORRECTION APPROACH

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Abstract

This paper quantifies the responsiveness of producers of teff, wheat, maize and sorghum to incentives using an error-correction model (ECM). It is found that planned supply of these crops is positively affected by own price, negatively by prices of substitute crops and variously by structural breaks related to policy changes and the occurrence of natural calamities. It has found significant long-run price elasticities for all crop types and insignificant short-run price elasticities for all crops but maize. Higher and significant long-run price elasticities as compared to lower and insignificant short-run price elasticities are attributable to various factors, namely structural constraints, the theory of supply and the conviction that farmers respond when they are certain that price changes are permanent. The paper concludes that farmers do respond to incentive changes. Thus attempts, which directly or indirectly tax agriculture with the belief that the sector is non-responsive to incentives, harm its growth and its contribution to growth in other sectors of the economy.

1. INTRODUCTION

Agriculture is the largest sector in the Ethiopian economy in terms of contribution to GDP (over 50%), foreign exchange earnings (over 90%) and employment creation (over 80%). The sector had been neglected until 1994 because growth was thought to be synonymous with industrialization. This view was justified by the belief that industry is the dynamic sector, while agriculture is static and unresponsive to incentives. This belief led to the taxing of agriculture by turning domestic terms of trade against agriculture. The consideration that agriculture is unresponsive implied that resources generated in agriculture could be transferred to other sectors of the economy without significantly affecting agricultural growth.

Efforts gradually to liberalize agriculture have been initiated since 1992. In addition, the age-long policy of industry-led growth was replaced by an agriculture-led growth strategy in 1994. The rationale behind these is the belief

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that the supply response of agriculture is high and that the continuation of the taxing of agriculture will have a multifaceted impact on the growth of the sector and other sectors of the economy through its functional role in the economy. The primary objective of this study is therefore to determine the responsiveness of Ethiopian farmers to incentive changes by estimating supply-response functions.

There are a number of studies that have attempted to estimate supply response of Ethiopian farmers using historical data. These include the World Bank (1987), Fernando (1992), Zerihun (1995) and Abebe (1998). These studies can be criticized on two grounds. Firstly, the modelling technique used. They applied Nerlovian Partial Adjustment models, which are considered weak for the following reasons. Firstly, their inability to give an adequate distinction between short- and long-run elasticities (McKay *et al*, 1998; Townsend, 1997). Secondly, it uses integrated series, which poses the danger of spurious regression (Granger & Newbold, 1974; Nelson & Plosser, 1982; Townsend, 1997). Thirdly, the assumption that production adjusts to a fixed target of supply, towards which actual supply adjusts, is considered unrealistic under dynamic conditions (Nerlove, 1979). Fourthly, there is empirical evidence that the dynamics of supply can be better described by Error-Correction Models (ECM) than Partial Adjustment Models (McKay *et al*, 1998; Hallam & Zanoli, 1993). In this study, an ECM is employed. This is believed to correct for major weaknesses in past studies.

The second, common weaknesses of past studies are that they used proxy variables to producer prices, they used a small number of observations in supply-response estimation, they made little or no attempt to take into account the effects of structural breaks on their price-elasticity estimates, and they used non-stationary data. These aspects cast doubt on the validity of these studies. In an attempt to solve these problems, a relatively larger number of observations were used, statistical properties of the data were studied and available variables which are thought to be good predictors of planned supply of teff, wheat, maize and sorghum, namely, real producer prices of own and substitute crops, rainfall, policy variables and others were collected from various sources. It is hypothesized in this study that the planned supply of teff, wheat, maize and sorghum are positively affected by own prices, negatively by prices of substitute goods and negatively or positively by changes in the price policy regimes depending on the nature of the changes.

2. THE DATA AND VARIABLES

The data set begins in 1966 and ends in 1994. It was obtained from the following sources: Food and Agriculture Organization's statistical database (FAO) and various issues of the Central Statistical Authority (CSA). The data were indexed at the 1990 prices and converted to logarithms in order easily to interpret coefficients of interest as elasticities. Several variables predict agricultural supply. Considering the problem with the quantification of some of these variables, long-run supply response is estimated using variables indicated in equation 1 below.

$$Y_t = \alpha_0 + \alpha_1 P_{1t} + \alpha_2 P_{2t} + \alpha_3 R_t + \alpha_4 T_t + \alpha_5 DTB_t + \alpha_6 D_t + \varepsilon_t \quad (1)$$

Where,

1. Y_t is the dependent variable representing area planted at time t. Area planted is preferred to output for the reason that the latter fails to reflect planned production decisions of farmers because of its susceptibility to weather variability.

2. P_{1t} represents a vector of own prices. It is calculated by dividing the nominal producer price of the crop in question by the GDP deflator. P_{1t} is expected to have a positive sign and it is interpreted as the long run price elasticity of supply.

3. P_{2t} is a vector for the real producer price of competing outputs. P_{2t} measures the opportunity cost of producing other crops. Wheat and teff compete for land. The same is true with sorghum and maize due to similarities in planting seasons. Therefore, wheat is considered a substitute to teff while maize is to sorghum and vice versa. The effects of changes in own prices on quantity supplied are represented by movements along the same supply curve, whereas changes in the producer prices of competing crops are expected to cause increase or decrease in supply (or shift in supply curve), depending on the direction of change in the price of the competing crop.

4. R_t is rainfall. An attempt was made to capture the effect of rainfall on the planned supply of teff and wheat by adding rainfall figures for the months of June, to September of three weather stations located in 'Bahir Dar', 'Debre Markos' and 'Debre Zeit'. For maize, rainfall data were collected from five weather stations, namely 'Bahir Dar', 'Debre Zeit',

'Debre Markos', 'Gore', 'Jima' and 'Combolcha'. For sorghum, data on rainfall were collected from 'Combolcha' and 'Gore' weather stations.

5. T_t stands for time trend. Historical data on infrastructural developments, expenditure on agricultural research and extension, applications of modern techniques like fertilizers and improved seed varieties on crop basis are hardly available. Therefore, these variables cannot be easily represented in the acreage supply-response equations directly and individually. Rather, an attempt is made to capture their effects collectively by introducing time-trend variables in the long-run equations of each crop.

6. DTB_t and D_t stand for structural breaks. These are in line with Newbold *et al* (2000) systematic method of identifying and also capturing the effects of exogenous variables on the parameter estimates. The inclusion of these variables in the regression equation has the advantage of salvaging the whole exercise from the celebrated 'Lucas critique' which states that Ordinary Least Square (OLS) estimates cannot be assumed to be independent of changes in the exogenous variables (Maddala, 1992). The method enables the analyst to detect and also evaluate exogenous variables, which, among others, could result from transitions to new policy regimes. This was achieved by examining series of residuals from the fitted models of long-run equations and by identifying cases where the absolute values of the residuals exceeded two standard deviations. Each break date (i.e. TB) identified in this way is represented by a pair of dummy variables (see equation 2). According to results obtained (Section 4.3), such events occurred in 1972, 1976, 1982, 1984, 1990, 1992 and 1993. The years 1972, 1982, 1984 and 1993 stand for years in which grain supply was affected by different-from-normal weather patterns. Except for the year 1982, the three represent years during which adverse drought situations occurred.

$$\left.\begin{array}{l} DTB_t = 1 \text{ if } t = TB\text{, and 0 otherwise} \\ D_t = 1 \text{ if } t > TB\text{, and 0 otherwise} \end{array}\right\} \qquad (2)$$

The remaining years, i.e. 1976, 1990 and 1992, may be associated with radical changes in the economic systems of the country. Socialism was announced the political and economic system of the country in 1975/76, a mixed economic system was introduced in 1990 and a free-market economic system in 1992. Socialism brought with it nationalization of land, agricultural collectivisation, a fixed pricing system of grain, forced grain delivery requirements to government parastatals, villagization and resettlement programmes. The change to a mixed economic system in 1990 lifted many of the constraints, which had adverse consequences on agriculture, namely agricultural collectivisation, fixed pricing, fixed quota delivery systems and checks on the free movement of grain. The change to a free market economic system in 1992 strengthened the reform process that was started in the 1990s by initiating macro-economic policy reforms.

3. METHODS

Co-integration and error-correction techniques are applied in this study. These techniques are believed to overcome the problem of spurious regressions and to give consistent and distinct estimates of long-run and short-run elasticities that satisfy the properties of the classical regression procedure. This is because all variables in an ECM are integrated of order zero, I (0). Spurious regression and inconsistent and indistinct short-run and long-run elasticity estimates are major problems exhibited by traditional Adaptive Expectation and Partial Adjustment models (Hallam & Zanoli, 1993; McKay *et al*, 1998). Co-integration and ECMs have been used in agricultural supply response analysis in other countries by a number of researchers, namely Townsend (1997), Schimmelpfennig *et al* (1996) and Townsend & Thirtle (1994).

One major use of the co-integration technique is to establish long-run equilibrium relationships between variables. However, two conditions must be met for co-integration to hold. First, individual variables should be integrated of the same order. Second, the linear combination of these variables must be integrated of an order one less than the original variables (Engle & Granger, 1987). In other words, if the variables under consideration are integrated of order one, or I (1), the error term from the co-integrating relationship should be integrated of order zero, I (0), implying that any drift between variables in the short run is temporary and that equilibrium holds in the long run.

If deviation from the long-run equilibrium path is bounded or co-integration is confirmed, Engle & Granger (1987) show that the variables can be represented in a dynamic error-correction framework. Therefore, in this paper, like similar studies elsewhere, supply response is modelled in two stages. First, a static co-integrating regression given by equation 1 is estimated for each crop and tests for co-integration are conducted. Second, if the null for no co-integration is rejected, the lagged residuals from the co-integrating regression are imposed as the error correction term in an error correction model. An example of an ECM model is shown below.

$$\Delta Y_t = \varphi_0 + \varphi_1 \Delta P_{1t} + \varphi_2 P_{2t} + \varphi_3 R_t + \varphi_5 \Delta DTB_t + \varphi_6 \Delta D_t$$
$$- \lambda(Y_t - \alpha_0 - \alpha_1 P_{1t} - \alpha_2 P_{2t} - \alpha_3 R_t - \alpha_4 T_t - \alpha_5 DTB_t - \alpha_6 D_t) + \upsilon_t \quad (3)$$

Where Δ represents first differencing, λ measures the extent of correction of errors by adjustment in Y_t. φ_1 measures the short-run effect on supply of a per cent change in own price (or short-run price elasticity of supply) while α_i measure the long-run price elasticities.

4. RESULTS AND DISCUSSIONS

4.1 Order of integration

The test for the order of integration is the first step in any co-integration analysis. If a series is integrated, it accumulates past effects. This means that perturbation to the series does not return to any particular mean value. Therefore, an integrated series is non-stationary. Order of integration of such a series is determined by the number of times that it must be differenced before it is actually made stationary. It follows that if two or more series are integrated of the same order then a linear relationship can be estimated. Examining the order of integration of this linear relationship is similar to testing for the null hypothesis that there is no co-integration against its alternative that there is co-integration. In this section, an attempt is made to determine the order of integration of the variables. This is followed by the test for co-integration in section 4.2.

Table 1 shows that all acreage variables are integrated of order 1 or I (1), both in the non-trended and trended models. Real producer prices of the crops under study are I (1) in the non-trended models, except the real producer price of sorghum which is I (0). But in the trended model, except for the producer price of wheat, all the other prices are I (0). Table 1 further shows that rainfall data on teff, wheat, maize and sorghum growing seasons of selected regions are stationary or are integrated of order one (I (1)).

Table 1: Unit root (DF) test statistics (H_0: 1 unit root)

Variable Name	DF Test with intercept	DF test with intercept & trend
Log area planted in teff	-1.90	-1.89
Δ Log area planted in teff	-7.49	-7.79
Log area planted in wheat	-1.71	-1.26
Δ Log area planted in wheat	-3.86	-3.81
Log area planted in maize	-1.94	-2.80
Δ Log area planted in maize	-5.30	-5.18
Log area planted in sorghum	-1.99	-2.60
Δ Log area planted in sorghum	-4.68	-4.48
Log area planted in barley	-3.13	-3.06
Δ Log area planted in barley	-5.41	-5.22
Log producer price teff	-2.24	-5.52
Δ Log real producer price teff	-4.32	-5.39
Log producer price wheat	-2.40	-4.45
Δ Log real producer price wheat	-3.20	-4.35
Log real producer price maize	-2.90	-5.24
Δ Log real producer price maize	-3.77	-5.13
Log real producer price sorghum	-3.04	-5.25
Δ Log real producer price sorghum	-3.89	-5.18
Log of teff and wheat growing season rain	-3.74	-4.35
Log of maize growing season rain	-3.22	-3.61
Log of sorghum growing season rain	-4.94	-4.92
Critical values, 95% confidence level	-2.98	-3.59

Note: Δ = first difference.

The inconclusive results with regard to producer prices were dealt by differencing the series. This is in line with literature that differencing, even though the true data generating process is stationary, has little consequence on the consistency of parameter estimates compared to working with levels while the true data-generating process is difference stationary (Maddala, 1992). What differencing does to data, which is already a stationary process, is to create a moving average error, and hence, inefficient estimates, which can be corrected by estimating the differenced equation using an OLS technique. But if data in levels are wrongly considered stationary and are modelled without being differenced, its likelihood of violating the assumptions of classical regression procedure is very high. This results from an over time increase in the variance of errors. Therefore, it is a widely accepted view that it is best, with most economic time series, to work with differenced data rather than data in levels (Plosser & Schwert, 1978). The consequence of differencing is loss of information on the long-run relationships among variables, which can be handled by estimating an ECM. With this in mind, all the I (1) and all others with inconclusive test results were differenced. Test results on DF tests on the differenced series for all variables are reported in Table 1. According to the results obtained, all are stationary processes, or I (0).

4.2 Co-integration

Test results for the order of integration of series in section 4.1 showed that some of the series are integrated of order one or I (1) while the remaining are I (0). The main objective of this section is to test for the stationarity of the linear relationship of these variables or to determine whether the variables are integrated of order zero, or in short, whether they are co-integrated. If co-integration is confirmed, a non-spurious long-run equilibrium relationship exists. When this is combined with ECM, whose variables are I (0), consistent estimates of both long-run and short-run elasticities is evident.

Two tests, one residual-based, proposed by Engle & Granger (1987) and the second reduced rank procedure of Johansen (1988), were employed to test for co-integration. The residual-based procedure is known as a single-equation approach. It assumes that the variables in the long-run equation are all I (1) and tests whether the error term in equation 1 is I (1) against the alternative that it is I (0). The Johansen reduced-rank approach, on the other hand, is a system approach in the sense that it tests for the existence of a more than one co-integrating relationship. In this study, the constant and the trend variables in the Johansen procedure applied were set unrestricted, meaning that they were not forced to lie in the co-integration space only. The two approaches are used in this study only to support evidence on the long-run equilibrium relationships among variables. Results are reported in Table 2. According to Table 2, both the residual-based and the Johansen test procedures indicate the existence of co-integrating relationships between planned supply and the variables that predict it. This is the first step in supply-response modelling.

Table 2: Co-integration tests

Equation	Variables	DF Test		Johansen Model	
		Without trend	With trend	Eigenvalue Test	Trace Test
Wheat	WHEATA, WHEATP, D72, D76, DTB82, D82, DTB92	-5.51 (-2.98)*	-5.45 (-3.59)*	1) 19.33 (22.26)* 2) 18.19 (16.28)**	43.94 (39.33)* 24.61 (23.83)*
Maize	MAIZEA, MAIZEP, SORGHUMP, DTB76, D84, D90, DTB93,	-4.75 (-2.98)*	-4.62 (-3.59)*	1) 44.08 (24.35)* 2) 27.87 (18.33)* 3) 12.17 (11.54)*	84.12 (39.33)* 40.03 (23.83)* 12.17 (11.54)*
Sorghum	SORGHUMA, SORGHUMP, MAIZEP, RAINFALL, D72, DTB90, D90, DTB93	-4.73 (-2.98)*	-4.62 (-3.59)*	1) 21.54 (22.26)	45.20 (39.33)* 23.66 (21.23)*
Teff	TEFFA, TEFFP, WHEATP, RAINFALL, DTB74, D74	-6.16 (-2.98)*	-6.02 (-3.59)*	1) 22.26 (22.26)**	41.78 (39.33)*

Note: Numbers in brackets are critical values; * = significant at 5%; ** = significant at 10%.

4.3 Error-correction model

After long-run relationships between cultivated area and the variables predicting it are confirmed, ECM is developed. Results are reported in Table 3. According to Hallam & Zanoli (1993), a high R^2 in the long-run regression equation is necessary to minimize the effect of small sample bias on the parameter estimates of the co-integrating regression, which may otherwise be carried over to the estimates of the error-correction model. The models are chosen on the basis of the following criteria: data coherence, parameter consistency with theory and goodness of fit. According to results from the short-run model (top of Table 3), planned supply of teff, wheat, maize and sorghum are affected positively by own prices but negatively by prices of substitute goods. Except for maize, whose price elasticity is 0.38, in the short run, both own prices and prices of substitutes of the other crops are insignificant. The insignificant price elasticities for the remaining crops can be attributed to infrastructural factors, namely, technological constraints, credit constraints, poor marketing situations, the existing land tenure system, lack of physical infrastructure and many more.

It has been also found that planned supply is significantly affected by policy changes, which resulted in the leftward or rightward shift of supply. The effect of these policy changes had a pronounced effect on planned supply in 1974, 1976, 1980, 1990 and 1992. Furthermore, planned supply is affected in the short-run by extreme weather changes, which occurred in 1972, 1982, 1984 and 1993. The years 1972, 1984 and 1993 represent severe drought situations, whereas 1982 represents a good harvest year. The error- correction terms in each equation have the required signs. However, the rate of adjustments towards the long-run equilibrium of each crop occurs, with almost 100% correction occurring in the current period. An investigation of this finding is left to other studies as it is beyond the scope of this study.

The long-run supply response model is given in the bottom half of Table 3. According to results obtained, own price and the introduction of socialism as the political and economic system of the country, represented by the break variables (i.e. DTB74 and D74), together account for 88% of the variation in planned teff supply. All variables in this equation have the expected signs. Supply of teff is positively affected by its own price, negatively by the price of its substitute (i.e. wheat), negatively by the introduction of socialist production relations and negatively by the time trend variable. Socialism was the political and economic system of the country between 1974 and 1990. Of these variables, own price, the constant term, DTB74 and DT74 respectively, are significant at the 15, 1, 5 and 1% levels. Table 3 further shows that a 10% increase in the producer price of teff caused a 2.8% expansion of cultivated area of teff.

Table 3: Restricted error-correction model results

Variables	Teff	Wheat	Maize	Sorghum
SHORT RUN				
Constant	-0.15 (-0.57)			-0.56 (-2.17)**
ΔP1	0.14 (0.90)	0.15 (1.15)	0.38 (2.72)**	0.09 (0.71)@
ΔP2	-0.09 (-0.63)	-0.23 (-1.57)	-0.47 (-3.47)**	-0.01 (-0.12)
R	0.08 (0.58)			0.27 (2.16)**
ΔD72		-0.12 (-4.25)***		-0.11 (-1.61)
ΔDTB74	-0.09 (-2.25)**			
ΔD74	-0.23 (-4.19)***			
ΔDTB76			-0.08 (-3.96)**	
ΔD76		-0.17 (-5.88)***		
ΔDTB82		0.12 (4.11)***		
ΔD82		0.13 (3.15)***		
ΔD84			0.12 (3.85)**	
ΔDTB90				-0.14 (-2.01)**
ΔD90			0.09 (3.27)**	-0.08 (-0.85)
ΔDTB92		-0.08(-3.65)**		-0.07 (-1.46)
ΔD92				
ΔDTB93			-0.15 (-7.32)	
ΔD93				
Error(-1)	-1.18 (-4.52)***	-1.12 (-4.60)***	-1.05 (-4.79)***	-1.11 (-3.50)**
Adjusted R^2	0.58	0.76	0.80	0.32
F	7.10	12.95	17.83	2.53
LONG RUN				
Constant	2.16 (7.49)***	2.22 (113.06)***	1.81 (197.71)***	1.63 (7.28)***
Time	-0.002 (-1.12)			0.005 (1.51)
P1	0.28 (1.53)	0.28 (1.83)	0.51 (2.87)	0.43 (1.41)
P2	-0.13 (-0.89)	-0.30 (-1.70)*	-0.63 (-3.85)**	-0.50 (-1.61)
R	0.06 (0.39)			0.26 (2.44)**
D72		-0.13 (-5.6)***		-0.19(-4.51)***
DTB74	-0.09 (-2.58)**			
D74	-0.19 (-7.97)***			
DTB76			-0.09 (-2.70)**	
D76		-0.15 (-5.6)***		
DTB82		0.11 (3.31)***		
D82		0.08 (4.48)***		
D84			0.11 (4.97)***	
DTB90				-0.21 (-3.19)**
D90			0.05 (2.53)**	-0.17 (-3.75)**
DTB92		-0.10 (-2.90)**		-0.12 (-2.05)**
DTB93			-0.14 (-4.10)***	
Adjusted R^2	0.88	0.92	0.82	0.78
F	33.0	45.9	2120	13.18

Note: Figures in brackets are t-ratios; P1 = is own price elasticity; P2 = cross price elasticity; R= rainfall; D followed by a date represents structural break in that date; DTB followed by a date represents time of break; @ indicates that price data are stationary on levels meaning not differenced; *** = significant at 1%; ** = significant at 5%; * = significant at 10%.

Own real producer price, real producer price of substitute, D76, DTB82, D82 and DTB92 together accounted for over 92% of the variation in the cultivated area of wheat. A cursory review of the equation for wheat shows that the variables have the expected signs except DTB92. The negative sign on DTB92 could be attributed to the changes in the political and economic systems of the country that allowed farmers to produce crops of their choice and to sell them at market-determined rates. Between 1975 and 1990, farmers used to be forced to produce and sell grain at fixed prices to satisfy fixed-grain quota delivery requirements imposed on them by the Agricultural Marketing Corporation (AMC). The negative sign could therefore be attributed to the diversification or change in the mix of production of crops by farmers. Similar incidences were witnessed in the mid-1980s when farmers attempted to evade flat grain quota delivery systems by changing their mix of production (Befekadu & Tesfaye, 1990). Many farmers were reported to have started producing oil crops to which the government responded by introducing fixed quota delivery systems and by imposing severe penalties on farmers who transgressed the fixed quota delivery policy. Grain collected used to be rationed at lower prices to urban consumers.

Table 4: Long- and short-run price elasticities

Equations	**Price elasticity coefficients**	
	Long-run	**Short-run**
Teff	0.28****	0.14
Wheat	0.28***	0.15
Maize	0.51***	0.38*
Sorghum	0.43****	0.09

Notes: * = significant at 1% level of significance; ** = significant at 5% level of significance;
*** = significant at 10% level of significance; **** = significant at 20% level of significance.

Planned supply of wheat is affected positively by own price, negatively by the price of the substitute (i.e. teff), negatively by D72 (i.e. the 1972 drought), negatively by DT76 (i.e. change in policy), positively by DTB82 and D82 (i.e. the 1982 good rain), and negatively by DTB92 (i.e. change of government). It is also shown that these variables are significant at the acceptable levels. Tables 3 and 4 further show that a 10% increase in the producer price of wheat and teff causes a 2.8% expansion and a 3% decrease in cultivated area of wheat. It is interesting to note that breaks, which represent adverse policy situations and natural calamities, shift supply of wheat by approximately 0.13 to the left.

Own price, price of substitutes (i.e. sorghum), DTB76, D84, D90 and DTB93, account for over 82% of the variation in the cultivated area of maize (Table 3). DTB76 and D90 captured the effects of the introduction of socialist policies between 1974 and 1978 on cultivated area of maize, while D90 captured the effect of the removal of many of the constraints that agriculture had been facing, with the exception of land, between 1974 and 1990. All the variables have the expected signs except D84. In addition, all are significant at the 1%

and 5% levels of significance. A 10% increase in the producer price of maize results in a 5.1% expansion in the cultivated area of maize (Table 4). A 10% increase in the price of its substitute, sorghum, causes a 6.3% decrease in the cultivated area of maize. A 10% increase in the magnitude of the occurrence of adverse situations emanating from a change of policies and drought on average cause a 1.1% shift in the supply function of teff to the left.

Own real producer prices, real producer prices of the substitutes (i.e. producer price of maize), rainfall, D72, DTB90, D90 and DTB92 together account for over 78% of the variation in the cultivated area of sorghum (Table 3). The variable D72 represents the 1972 drought, while DTB90, D90 and DTB92 capture the effects of the 1990 and 1992 change of policies. All the variables, except DTB90, D90 and DTB92, have the expected signs. With the exception of own producer prices and the producer price of the substitute crop, which are significant at the 15% and at the 20% levels respectively, the rest are significant at the 1% and 5% levels. This implies that a 10% increase in the real producer price of sorghum and maize causes a 4.3% expansion and a 5% contraction in the cultivated area of sorghum (Tables 3 and 4). The reasons for the negative signs of the 1990 and 1992 policy changes on the cultivated area of sorghum could be attributed to their effect on the transfer of resources from non-traded to traded goods by raising the domestic prices of tradables. Studies indicate that farmers in both predominantly cash-crop and non-cash-crop growing areas of the country have started increasingly utilizing their scarce resource, i.e. land, to the production of perennial crops such as coffee, t′ chat, and vegetables, such as potatoes and tomatoes, attracted higher prices (Zerihun, 1998; Tesfaye, 2002).

The following were some of the major policy changes that were introduced between 1974 and 1980, alone which could have bearing on the responsiveness of cultivated area of cereals to various changes. The effects of these policy changes on planned supply of the crops studied were captured by DTB74, D74, DTB76, D76, DTB90, D90, DTB92 and D92. Attempts are made in the following paragraphs to highlight possible reasons for these changes.

In 1974, land became the property of the state. This unified the age-old disparity in land ownership rights between the northern and the southern parts of the country. In the northern part of the country, in general, communal ownership of land was practised. But in the south, a free hold system was prevalent. In 1976, direct government control of prices and markets were introduced, which followed the establishment of the Agricultural Marketing Corporation (AMC), aimed at linking peasant farms to an urban rationing system. Peasant farmers started to be forced to sell their production quota at fixed prices to AMC. The quota was flat and had the objective of restricting the free-market exchange of grain. Later, the flat quota delivery system was replaced by a fixed quota delivery system in order to force farmers from evading grain quotas by changing their mix of production.

In 1976 and 1977, resettlement and villagization programmes were started. The former has the objective of resettling the unemployed and farmers from densely populated areas in the highlands to increase productivity through the use of under-utilized surplus lands and to provide land to those without it. Many new settlers reportedly abandoned their new homes and returned to their old villages for reasons such as dissociation from ways of life that they were used to and due to fear as their new homes were at the centre of political contention. With regard to the villagization programmes, according to Alemayehu (1990), the programme was executed with the intention to serve as a prelude to co-operativization. Like the resettlement programme, the benefit of villagization programme was political and social but not economic (Alemayehu, 1990).

In 1978, producer co-operatives (PC), guided by socialist ideology, were established. This had a goal of facilitating a transition to large-scale farm production in order to achieve the ultimate objective of the socialist state to extract as much resources as possible to finance growth in the non-agricultural sectors. In the same year, input pricing and marketing fell in the hands of government parastatals, namely the Agricultural Input Supply Corporation (AISCO) and the Ethiopian Seed Corporation (ESC). These corporations gave priority in terms of input delivery to producer cooperatives and state farms by marginalizing private peasant farms, which until 1990, accounted for over 90% of the cultivated land and production.

No significant addition to the changes mentioned above was introduced in the 1980s, except the formulation and implementation of the ten-year perspective plan. The plan vowed to speed up the establishment of producer co-operatives. It targeted to increase the number of producer cooperatives from 1,147 at the time, when the plan was implemented, to 15,344 by the end of the plan period. Except for the land policy, which remained unchanged to date, all the other policies that impacted on agriculture between 1974 and 1990 were reformed by the changes in 1990 and 1992 to the political and economic systems of the country.

5. CONCLUSIONS AND POLICY IMPLICATIONS

In this study, factors that explain long-run and short-run supply response of teff, wheat, maize and sorghum production are studied. It was found that planned supply of these crops is positively affected by own real producer prices and negatively by real producer prices of substitute goods. This occurred in both the short-run and in the long run. These findings rule out the applicability of perverse supply response in Ethiopian agriculture.

Except for maize, short-run price elasticities are not significant for the remaining crops. However, long-run price elasticities are positive and highly significant but inelastic. Long-run elasticities ranged between 0.05 to 0.51, which compared with estimates by Bond (1983) for other Sub-Saharan African countries, is very low. This could be attributed to the severity of structural constraints that Ethiopian farmers are facing. The finding that long-run price elasticities are positive and significant supports the expectation that farmers respond to incentive changes. In addition, the finding that long-run elasticities are positive, significant and greater than short-run elasticities may imply the following: that it takes time before farmers obtain information about price changes due to infrastructural problems, that farmers respond to price changes only when they are convinced that the changes are permanent, that some resources are fixed and take time before they can be mobilized.

Planned supply was also affected by structural breaks, which occurred in 1972, 1974, 1982, 1984, 1990, 1992 and 1993. In 1974, land became the property of the state and various other policy changes, which potentially affected agriculture but were in line with the socialist principles of production organization, were introduced. In 1990 and 1992, changes in policies from command-based to mixed-based and from mixed-based to market-based policies were introduced. The years 1972, 1982 and 1993 represent changes in weather patterns. Each structural break in its own time affected planned supply by causing an upward or downward shift in the supply curves, depending on their sign. The error correction coefficients indicate that the entire per cent of the adjustment towards long-run equilibrium for food crops is completed in one period. The amount is highly significant. We recommend follow-up studies to uncover the reasons behind these high error-correction coefficients.

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