IS INCREASED INSTABILITY IN CEREAL PRODUCTION IN ETHIOPIA CAUSED BY POLICY CHANGES?

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1. Introduction

Cereals include teff, barley, maize, sorghum, oats, millet and wheat. In Ethiopia, cereals make up 85% and 90% of the total cultivated area and total production of field crops respectively and for over 90% of modern input consumption (CSA, 2000; MEDaC, 1999). Cereal production has shown significant growth with an annual growth rate of 3% between 1960 and 2000. This was, however, accompanied by a more than proportionate increase in the standard deviation of production. The standard deviation of production of cereals as measured by the coefficient of variation (CV) around trend rose from 2% between 1960 and 1975 to 10% between 1974 and 1990 and to 13% between 1989 and 2000. These percentages are indicative of increased instability in cereal production. Instabilities in cereal production causes increased market and price instabilities and hence food insecurity.

Studies of production instability hypothesize that variability increases with higher use of inputs, expansion of areas planted, weather variability and incentives. It was assumed in this study that the effect of short-term fluctuations in input use, weather and other factors which impact production variation in the short-term could be captured by yield (i.e. output per hectare). On the other hand, the effect of factors that could be considered long-term sources of production instability is assumed to be captured by fluctuation in areas cultivated (Hazell, 1988, 1985 and 1984).

Hazell's (1988, 1985 and 1984), a pioneer in the study of production instabilities in cereals, computed fluctuations in cereal production directly by detrending the variables in question without studying the time series properties of the variables. What makes this study different is that an attempt was made to apply time series econometric techniques in order to better understand the time series properties of the variables. Econometric theory recommends that least square detrending, to compute year-to-year fluctuations in cereal production, gives better result only when a variable is confirmed to be a trend stationary process (Beveridge, et al., 1981; Chan, et al., 1977). If a variable is found to be a difference stationary process, differencing instead of detrending is the appropriate technique to compute year-to-year fluctuations in a time series variable.

The objective of this study is to study the extent of instability in cereal production and to investigate whether this has something to do with the recent change in the economic policy of the country.

2. Methods

To measure the extent of change in cereal production between periods, data on cereal production, area and yield were collected from the FAO statistical database and the data obtained were divided into two time periods, namely, 1975 to 1989 and 1990 to 2000. The time period 1975 to 1989, hereafter referred to as the 1st period, corresponds to the time when socialism was the political and economic system of the country. On the other hand, the time period 1990 to 2000, hereafter referred to as the 2nd period, corresponds to the time when markets were allowed to govern resource allocation in the country.

Attempts were made to study production instability in two stages. In stage one, the extent of instability in cereal production was analyzed by computing the following statistics, namely average production, coefficient of variation (CV), and the probability of a 5% shortfall below the trend line. The CVs were computed based on results on the fitted trend lines of polynomials of different order. Two deterministic trend lines were fitted for each crop making the total number of equations estimated equal to 14. The probabilities were computed by denoting that detrended production in year t is $\hat{a}_t = \bar{a} + e_t$ (where $\bar{a}$ is the period mean and e_t is the deviation from the mean). The probability of a shortfall of 5 per cent or more below trend is derived from $\Pr\{0.95\ \bar{a} \geq \bar{a} + e_t\} = \Pr\{-0.05\ \bar{a}/\sigma_e \geq e_t/\sigma_e\}$. σ_e is the standard deviation of e_t. Assuming that e_t is approximately normally distributed, the desired probability can be obtained from tables for the cumulative normal distribution (Hazell, 1985).

In the second stage, changes in the average and variance of cereal production were decomposed to compute sources of production instability. Year-to-year fluctuations in areas sown and yields were computed as follows. First, to decide on whether year-to year fluctuations should be computed by detrending or differencing the time series data, the classes of non-stationary process to which the variables under consideration belong were determined *a priori* (See Chan et al., 1977 for the consequences of inappropriately differencing or detrending a time series variable).

The class of non-stationary process to which a variable belongs is conventionally tested by applying the Augmented Dickey-Fuller (ADF) procedure. However, this procedure assumes that the data under consideration is free from significant influence of structural breaks (see Perron 1989 for the consequences of applying conventional ADF on a data characterized by structural breaks). This was tested by applying a recursive analysis using the Dickey-Fuller regression to the full time series and none of the breaks was found to be significant. Next, ADF was applied to test for unit root in the series which gave that the data on area sown and yield for each crop are difference stationary processes. Estimates of the differenced production functions for each crop were computed from the products of the differenced area and yield series. Finally, changes in the average and variance of total cereal production were decomposed into four and ten parts respectively with the assistance of a computer program that was developed using a Matlab program. The model used to decompose change in average production was found from Hazell (1984). Table 1 below shows the constituent parts of change in the variance of cereal production (See Hazell, 1984).

Table 1: Components of change in production covariances

Sources of Change	Component of Change
Δ in mean yields	$\bar{A}_{1i}\,\Delta\tilde{Y}_j\,cov\,(y_{1i}, A_{1i}) + \bar{A}_{1j}\,\Delta\tilde{Y}_i\,cov\,(y_{1j}, A_{1i}) + [\tilde{Y}_{1i}\Delta\tilde{Y}_j + \tilde{Y}_{1j}\Delta\tilde{Y}_i + \Delta\tilde{Y}_i\Delta\tilde{Y}_j]\,cov\,(A_{1i}, A_{1j})$
Δ mean areas	$\tilde{Y}_{1i}\Delta\bar{A}_j\,cov(A_{1i}, Y_{1i}) + \tilde{Y}_{1j}\,\Delta\bar{A}_I\,cov(y_{1i}, A_{1j}) + [\bar{A}_{1i}\Delta\bar{A}_j + \bar{A}_{1j}\,\Delta\bar{A}_j + \Delta\bar{A}_j\,\Delta\bar{A}_i]\,cov\,(y_{1i}, y_{1j})$
Δ in yield variance & covariance	$\bar{A}_{j\,i}\;\bar{A}_{jj}\Delta cov\,(y_i, y_j)$
Δ in area-variance covariance.	$\tilde{Y}_{1i}\,\tilde{Y}_{1j}\Delta cov\,(A_i, A_j)$
Δ in area-yield covariance.	$\tilde{Y}_{1j}\,\bar{A}_{ji}\Delta cov(A_j, Y_i) + \tilde{Y}_{1i}\,\bar{A}_{ij}\,\Delta cov\,(y_j, A_i) - [cov\,(A_{1j}, y_{1i}) + \Delta cov(y_i, A_i)]\Delta cov(A_j, Y_j) - cov\,(A_{1j}, y_{1j})\,\Delta cov(A_i, y_i)$
Interaction b/n Δ in mean yield and mean areas	$[\Delta\bar{A}_i\Delta\tilde{Y}_j\,cov\,(y_{1i}, A_{1i}) + \Delta\,\tilde{Y}_i\,\Delta\,\bar{A}_j\,cov\,(A_{1I}, y_{1j})]$
Interaction b/n Δ in mean areas and yield variances	$[\bar{A}_{1i}\Delta\,\bar{A}_j + \bar{A}_{1j}\Delta\,\bar{A}_I + \Delta\,\bar{A}_i\Delta\,\bar{A}_j]\,\Delta cov\,(y_i, y_j)$
Interaction b/n Δ in mean yields and area variances	$[\tilde{Y}_{1i}\Delta\,\tilde{Y}_j + \tilde{Y}_{1j}\Delta\,\tilde{Y}_I + \Delta\,\tilde{Y}_i\,\Delta\,\tilde{Y}_I]\,\Delta cov\,(A_i, A_j)$
Interaction b/n Δ in mean areas and yields and Δ in area-yield covariance.	$[\tilde{Y}_{1j}\Delta\,\bar{A}_j + \bar{A}_{1i}\Delta\,\tilde{Y}_j\,\Delta\,\bar{A}_i\Delta\,\tilde{Y}_I]\,\Delta cov\,(y_i, A_j) + [\tilde{Y}_{1I}\,\Delta\,\bar{A}_j + \bar{A}_{1j}\Delta\,\tilde{Y}_I + \Delta\,\tilde{Y}_i\Delta\,\bar{A}_j]\,\Delta cov\,(A_i, yj)$
Δ in residual	$\Delta cov\,(A_i y_I, A_j Y_j)$ – sum of the other components

$\tilde{Y}$ and $\bar{A}$ are mean values of yield and area respectively, Δ is change.

3. Results and Discussion

In an attempt to measure the extent of instability in cereal production and its effect on food security, coefficients of variation of cereals production and the probabilities that it may fall by 5 per cent or more below the trend each year were compared. These are discussed in the paragraphs that follow.

According to Table 2, teff ranks first, followed by sorghum and wheat in terms of share from total production, whereas in terms of share from total areas sown, teff is still ranked first, while maize and barley take second and third positions respectively. Table 2 further shows that average cereal production increased by

13% between the 1st and the 2nd periods. Teff accounted for 67% of the total increase, wheat for 47%, sorghum for 17%, and millet and oats for the rest.

Table 2: Changes in the Variability of Cereal Production between 1975-1990 & 1990-2000

Crop Type	Average Production			Coefficient of variation (%)			Probability of 5% shortfall below trend	
	1st Period	2nd Period	% Δ	1st P	2nd P	% Δ	1st P	2nd P
Wheat	675	982	45	12	8	-33	70	80
Barley	843	823	-2	8	10	25	77	79
Maize	1164	921	-21	31	19	-39	69	86
Oats	31	51	65	37	30	-19	74	75
Millet	194	222	14	17	33	94	69	78
Sorghum	1000	1111	11	21	17	-19	76	79
Teff	1093	1531	40	7	13	86	74	77
Cereal Total	4996	5644	13	10	13	30	72	80

The CV of total cereal production rose from 10% to 13%, an increase of 30%. This may be attributed most to a higher increase in the CV of teff from 7% to 13% (Table 2). Table 2 further shows that the probabilities that cereal production may fall by 5 percent or more below the trend each year is higher in the 2nd period both individually and as a group. The probabilities increased from 72% to 81% for total cereal production. These results imply that instability in cereal production in general is high and this is increasingly making the country food insecure.

What causes higher CV? Does it have anything to do with instabilities in yields or cultivated land or both? Increased instability in yield and/or area could be caused by a host of factors mentionable in this regard are changes in agricultural policies and the frequent occurrence of natural calamities, namely drought, flood and war. The paragraphs that follow investigate the potential effects of changes in agricultural policies in the second period on production instability.

Agricultural policy is a broad concept. It includes output policy, input policy, land policy, research policy, and many others. Grain output and input policies of the country were different during the two periods. In the first period, these policies were in line with a command-based system of economic policy thus a fixed grain output and input pricing system was introduced and grain output and input marketing were respectively regulated by government parastatals, namely the Agricultural Marketing Corporation (AMC) and the Agricultural Input Supply Corporation (AISCO). In the second period, grain output and input policies of the country were changed to a free-market-based system. The change liberalized the grain output and input marketing system of the country. Various researchers have found that the changes improved the performance of the grain and input markets by increasing the number of grain traders in the grain market and by causing spatial integration of grain markets (Asfaw & Jayne, 1998). In the input market, six private fertilizer marketing agencies and one new improved seed distributor were introduced. The question that remains to be answered is whether these changes in policies are responsible for increased instability in cereal production. This is discussed in the next paragraph.

A study of the extent to which farmers respond to the above policy changes by changing land allocated to crop production and/or by applying modern technologies in production is crucial to the understanding of sources of increased instability in cereal production. Data indicate that the links necessary for these policies to be translated into sizable changes in production are at their early stages of development. This could be attributed to a host of factors, namely lack of infrastructure, under developed institutions and a non-conducive land policy. These are said to have contributed towards the domination of cereal production by small-scale farmers, who produce cereals primarily for home consumption but not for sale. A good example showing the presence of acute shortage of infrastructural facilities is the statistics that close to 75 percent of the farmers are more than half days walks from all-weather roads (Wolday, 2001). Examples of institutional constraints directly affecting farmers' response to incentive changes are the prevalence of an under developed credit market and a poor agricultural research and extension. The former has limited the availability of credit to farmers and hence the application of modern agricultural inputs in production (Mulat et al., 1998) while the latter has resulted in the use of modern inputs only by the limited number of farmers. Currently, improved seeds and chemical fertilizers are applied by only 2% and 25% of farmers (MEDaC, 1998). In addition to infrastructural and institutional constraints, farmers' response to policy change is hampered by the state ownership of land which has resulted in a decrease in holding size as a result of land redistribution and put a limit on the use of area expansion as a source of production increase. According to data from the Central Statistical Authority (CSA), presently, over 63 percent of farm households hold less than one hectare. An increasing amount of land is being withdrawn from cultivation due to land degradation, and the demand for additional land for cultivation is being met by extending cultivation to areas previously designated as permanent pasture and forests (Alemu, 2002).

Therefore given that the effect of the change in agricultural policy on production is minimum due to the subsistence nature of production and the existence of various structural constraints, it can be proved that instability in cereal production is the result of natural factors such as drought. Production was affected by favorable/unfavorable drought situations four times during the second period. This can be supported by the finding that fluctuations in rainfall from the long-term average are increasing (Webb et al., 1992) and by the report that "Ethiopia can expect dry conditions for agriculture in perhaps three years out of very ten" (Befekadu & Berehanu, 2000). A further analysis, widely known as a variance decomposition procedure was applied to determine sources of increased instability in cereal production.

3.1. Decomposition of Changes in Average Production

Table 3 shows the results from the decomposition of the change in average cereal production. Millet (56%), maize (32%) and sorghum (16%) account for the majority of the change in the average cereal production (table 3).

Table 3: Component of Change in the Average Production of Cereals; 1975-1989 and 1990-2000

Crops	Change in mean yields	Change in mean area	Change in Area-Yield Covariance	Interaction between Changes in Mean Yields and Mean Areas	Contribution to Change in Average Production of Total Cereals
	%				
Barley	-8.1	-13.1	4.6	22.7	6.1
Maize	19.7	-1.2	11.4	2.4	32.2
Teff	-19.6	-1.4	14.0	11.9	4.9
Millet	-3.3	26.2	20.3	12.3	55.5
Wheat	-0.6	-8.1	-5.7	1.1	-13.4
Oats	4.0	2.8	-12.0	3.8	-1.5
Sorghum	5.1	-0.2	23.5	-12.2	16.1
Total	-2.8	4.9	56.0	41.9	100.0

Of the four parts, which constitute change in average production, increase in area-yield covariance accounts for 56% of the increase in the total cereal production.

3.2. Decomposition of Changes in the Variance of Production

Table 4 shows the results from the decomposition of the change in the variance of cereal production. Wheat (68%), sorghum (62%), and barley (30%) account for almost all the increase in the variance in total cereal production.

Table 4: Components of Change in the Variance of Total Cereal Production; 1975-1989 to 1990-2000

Crops	Change in yield variance & covariance	Change in area variance covariance	Change in Area-Yield Covariance	Change in mean yield	Change in mean area	Change in interact-ion terms	Change in Residuals	Row sum
	%							
Barley	-0.6	-23	36	22	1	-17	12	30
Maize	0.3	65	192	25	4	-176	-162	-51
Teff	1.7	-6	-474	57	0	-38	471	11
Millet	-0.2	-41	91	75	-1	-73	-30	20
Wheat	0.5	1	552	66	0	-82	-469	68
Oats	1.7	-12	-49	146	0	-133	5	-40
Sorghum	-0.1	95	-265	-31	4	-50	309	62
Total	3.2	80	83	360	7	-569	136	100

Of the ten component parts, which constitute the total increase in the variance of cereal production, change in mean yield (360%) accounts for the majority of the instability in cereal production. This could be attributed to a larger extent to instability in weather conditions. This is because modern input use is limited to limited number of farmers. This may be evidenced by the limited contribution that agricultural research and extension have made in respect of the availability of improved seed varieties and extended use of chemical fertilizers which are limited to 2% and 25% of farmers respectively. This may be supported by the findings by CIMMYT that yield variability is caused much by climatic factors, since the adoption of new technology is likely to cause greater stability rather than instability in yields over years (CIMMYT, 1989).

4. Conclusion

Increased instabilities in cereal production in Ethiopia have been caused by instabilities in yield. Increase instability in yield in turn is predominantly caused by weather variability than the change to a favorable policy environment and improvement in the technique of production. This is because production is at a subsistence level and the links necessary for favorable policy changes to be translated into sizable changes in production are at their early stage of development. The responsiveness of cereal producers to policy changes is affected by lack of infrastructure, underdeveloped institutions and the non-conducive land policy. Increased instability in cereal production as a result of favorable or unfavorable weather conditions is directly reflected in increased market and price instabilities and therefore on the welfare of farmers. Increasing the agricultural research and extension capabilities of the country in order to improve the supply of new drought resistant crop varieties can mitigate these because cereals grown by using new technologies have lower coefficients of variation than cereals grown by means of traditional technologies.

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