AN ANALYSIS OF VARIATIONS IN PRODUCTION AND PRICES OF POTATO

V. PUHAZHENDHI[1] AND C. RAMASAMY[2]

(Received : October, 1980)

SUMMARY

An attempt has been made to figure out the cyclical changes in the production and price series of Potato crop in Nilgiris district. In order to test the hypothesised length of cycle, fourier coefficients were computed. Fourier analysis attempted to compute the square of amplitude for each specified period by assuming several periods and correlogram helped to distinguish between different types of oscillatory series. The harmonic analysis revealed that the cycle of four year in production and six years in prices were not discernible and productions and price cycle did not persist in uniform manner. The variation in production and price of Potato in recent years were less due to the improvement in production and market system. Further the stability in price could be the solution which would lead to increase in farm investment and stabilisation of production.

Fluctuations in the prices and production of agricultural commodities observed through time are the result of a complex mixture of changes associated with seasonal, cyclical, trend and irregular factors. The most common regularity observed in agricultural prices is seasonal pattern of change. Normally, prices of storable commodities are lowest at harvest time and then rise as the season progresses, reaching a peak period to next harvest. Some of the agricultural commodities also exhibit cyclical behaviour in both production and prices. Prices and production cycles for agricultural commodities trend to vary in length in amplitude of fluctuations.

Economists have devoted substantial efforts to identify empirical regularities in prices and production behaviour of commodities. Mathematical techniques are available to describe the seasonal, cyclical, trend and irregular components of an economic time series.

---

1. Agricultural Economist, National Bank for Agriculture and Rural Development 2. Associate Professor, Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore.

These techniques attempt to decompose the observed series into its constituent parts. Unfortunately a variety of factors reduce the usefulness of such analysis. Reliable estimates of the future can be made only in so far as seasonal patterns, trends or cycles persist in uniform manner.

A clear understanding of cyclical changes in production and prices of agricultural commodities would help planners and policy makers to formulate agricultural development policies in right directions. The present paper intends to figure out cyclical changes in the production and price series of potato which is an important tubercrop. Specifically an attempt is made to measure the length of production and price cycles of the commodity in question.

SOURCE AND EXTENT OF DATA

The venue selected for the study is Nilgiris District because 67.32 per cent of total production of potato in Tamil Nadu State is concentrated here. Also Nilgiris district is one of the important potato producing districts in India. A study of fluctuations in production and prices usually require time series data. For the present analysis the data on production and wholesale prices of potato for the study area were collected for a period of 24 years from 1953-54 to 1976-77. The prices were deflated by the index of prices of major agricultural commodities, constructed for the purpose, to adjust them to changes in the general price level.

METHODOLOGICAL DEVELOPMENT

The cycle (C_t) is a movement of quasi-periodic oscillations around the trend. To test the existence of the cycles and measure their length, hormonic analysis were used for which a stationary time series with no trend is required.

Fourier Analysis :

In order to test the hypothesized length of cycle, fourier coefficients need to be computed. Given a time series x_1, x_2......with a period of length T, the stationary (free of trend) series Y_t is represented as,

$$Y_t = \frac{1}{2} A_o + \sum_{j=1}^{T/2} \left(A_j \cos \frac{360\ jt}{T} + B_j \text{ Sin} \frac{360\ jt}{T} \right)$$

*The data were collected from various issues of *Season and Crop Reports* published by Commissioner of Statistics, Government of Tamil Nadu, Madras.

where,

Y_t denotes the series

t denotes time, $t=1......N$

A_o, A_j and B_j are constants and are given by,

$$A_o=\sum_{t=1}^{N}\frac{X_t}{N}$$

$$A_j=\frac{2\left[\sum_{t=1}^{N}X_t\ \text{Cos}\left(\frac{360\,jt}{T}\right)\right]}{N}$$

$$B_j=\frac{2\left[\sum_{t=1}^{N}X_t\ \text{Sin}\left(\frac{360\,jt}{T}\right)\right]}{N}$$

The stationary series was obtained utilising

$$Y=\frac{\text{Actual value}-\text{Trend}}{\text{Trend}}\times 100$$

The trend value was calculated for production and price by using a second degree polynomial function.

The definition of stationary is as given by Granger [2].

It will be more convenient to group the data as shown below for investigating a given period, P, where mP is equal to N or the nearest integer below N.

x_1	x_2...............	x_p
x_{p+1}	x_{p+2}...............	x_{2p}
$x_{(m-1)p+1}$	$x_{(m-1)p+2}$...	x_{mp}
U_1	U_2...	U_p

sums

The periodic effects will be indicated by the column totals (U_j), if a term of period P is present in the series. But if the remaining element is random, the effect of summing m rows will be to reduce the relative contribution of that element to the column totals. Similar to that, if there exist other elements with different periods they will be out of phase in successive rows and tend to cancel out in the totals. Then if there are enough rows, the total (U_j) will reveal the periodic effect and will reduce any masking effects resulting from, oscillatory components of different periods, which would have prevented discernment of the periodic effect in the primary series. The Fourier coefficients A_p and B_p are obtained following chatfield [1] and given by

$$A_p = \frac{2\left[\sum_{j=1}^{P} U_j \operatorname{Cos}\left(\frac{360_j}{p}\right)\right]}{mp}$$

$$B_p = \frac{2\left[\sum_{j=1}^{P} U_j \operatorname{Sin}\left(\frac{360_j}{P}\right)\right]}{mp}$$

To obtain the square of the amplitude R_p^2 the Fourier coefficients A_p^2 and B_p^2 are added.

Periodogram Analysis :

"Hidden" periodicities are found out by periodogram analysis. The Fourier analysis helped to compute the square of amplitude for each specified period by assuming several periods. The significance of the amplitudes are tested by periodogram. The procedure of testing involves, first, to compute the square of the amplitude (R_p^2). If no periodic fluctuation are observed, the mean square amplitude for a random series without periodic fluctuation is given by, $R^2m = \frac{A\,\sigma^2}{N}$, where, σ^2 is the variance of the series x_t. Then k is calculated as follows :

$$k = \frac{R_p^2}{R_m^2}$$

The statistical significance of k is determined by applying one of the tests namely Schuster test, Walker test or Fisher test.

Correlogram Analysis :

The correlogram helps to distinguish between three types of oscillatory series namely moving averages, autoregressive schemes and harmonic terms as given by Soliman [4].

It is the array of the coefficients of serial correlation: $r_0(=1)$, $r_1, r_2 \ldots\ldots r_k$. It is computed as follows :

$$\frac{\frac{1}{N-k}\sum_{j-1}^{N-K}(x_i-\bar{x})\ (x_{i+k}-\bar{x})}{\frac{1}{N}\sum_{j=1}^{N}(x_i-\bar{x})^2}$$

where,

i denotes time $i=1, 2\ldots\ldots N$;

N refers to the number of observations; k indicates the order of the serial correlation; and x_i denotes the value of the variable in the i^{th} time period.

For a series generated by the moving average method, the correlogram will vanish after a certain order. In the case of series generated by the auto regressive method, the correlogram will oscillate and will not vanish, although its oscillation will dampen. For infinite cyclical series of harmonic terms, the correlogram is a harmonic with the period equal to that of original harmonic component; it will not vanish or be dampened as stated by Soliman [4].

Empirical Results

In the present analysis 4-year cycle model for production and 6 year cycle for price were hypothesised. However, an exact likeliness of this model is not expected with the actual data as there are many exogenous variables that effect potato production and distort the smooth theoretical relationships. The trend value was calculated for production and price by using a second degree polynomial function. The deviations of the actual series from the computed trend, expressed as percentages of the corresponding trend values, were considered as cycle measures. The values of trend and cycle are given in Appendix I and values of cycles are represented in Figure 1. An examination of the Figure I reveals that there were four complete cycles (from trough to trough) in production and six complete cycles in prices of potato in the past 24 years. The production cycle fluctuated about 45 and 30 per cent above and below the average. Theoretically, the price cycle is to be inverse of the production cycle, but this phenomenon is only partly exhibited in the actual data. This might be due to the influence of other factors which affect both production and price independently.

The price cycle fluctuates about 63 and 31 per cent above and below the average. The amplitude of the swings in the price cycle was larger than that of in production. As the potato can not be stored for a longer period, post-harvest glut and pre-harvest scarcity can explain greater amplitudes in price cycles.

It can be noted from the Figure 1 that the amplitude of swings seems to be decreasing both in production and price. In the early years, the production was subject to greater variations because of lesser control over incidence of pests and diseases, and other factors affecting production. Absence of organised marketing facilities, and more time lag in the communication of market information to the producers would have resulted in higher price swings in the early years. The introduction of improved technology in agriculture, and operation of Indo-German Nilgiris Development Project in the study district during the recent years would have introduced an element of stability which would have minimized the variations in the production. Similarly formation of and efficient running of Nilgiris Cooperative Marketing Society, improved transportation system, and other infrastructural development could have contributed to stabilize prices of potato smoothening the swings.

As indicated elsewhere, the existence and length of cycles were statistically tested using harmonic analysis. The details of calculation of fourier coefficients are presented in Appendices II and III for production and price respectively. The results of which are shown in Table 1 for production and prices.

The production of four years and price cycle of six years were not found to be significant at the 5 per cent level to Schuster test

TABLE 1

Fourier coefficients, amplitude squared, mean square amplitude and the ratio *k* for production (4 years) and price (6 years) cycles

Period	*Fourier coefficients*		*Amplitude Square* Rp^2	*Mean square Amplitude* Rm^2	*Ratio* $Rp^2/Rm^2=K$
	Ap	*Bp*			
Production (4 years)	4.2366	—2.0566	17.9488	47.25	0.3799
Price (6 years)	−4.6091	4.5933	21.2438	10.61	2.0022

(Schuster [3]). Hence it is not unlikely that the observed ratio for a a period of four years for production and six years for price could have occurred by chance. The Schuster test has not confirmed a cycle of four and six years for production and price respectively.

The computed serial correlation coefficients of the production and price series are presented in Table 2. The representative correlograms are shown in Figure 2 and Figure 3. As the correlogram vanishes after a certain order, the type of oscillatory series is moving averages type both for production and price series.

TABLE 2

Correlogram of Potato production and price series (trend free)

K	*Production rk*	*Price rk*	*k*	*Production rk*	*Price rk*
0	1.0000	1.0000	13	0.0262	0.1727
1	0.6290	0.1774	14	−0.0102	0.0085
2	0.1440	−0.0931	15	0.0500	0.0186
3	−0.2430	−0.2726	16	0.0991	0.0413
4	—0.3866	0.0023	17	0.0537	—0.0131
5	—0.4468	0.0833	18	—0.0285	—0.0235
6	—0.3712	0.2324	19	0.0041	0.0447
7	—0.0750	0.1415	20	—0.0055	0.0383
8	0.0346	—0.1463	21	0.0031	—0.0020
9	0.0207	—0.0365	22	0.0001	—0.0001
10	0.0032	—0.0831	23	0	0
11	0.0167	0.0720			
12	0.0876	0.0436			

The analysis revealed that regular cycles of a given length have not appeared both in production and prices The harmonic analysis revealed that the cycles of four years in production and six years in prices were not discernible. The production and price cycles did not persist in uniform manner. Eventhough regular cycles of the given length could not be measured, there were cycles of uneven length. The correlogram analysis showed that the series vanished in the later years.

Policy Implications

It can be concluded that the improvement in production and market system in recent years were able to lessen the variations in production and prices of potato. This indicates further scope for minimising the variations in production and price of potato with further technological development in production and improvement in marketing environment. The stability in prices could act as incentives, to the agricultural producers, which, in turn, would lead to increased farm investment and stabilization in production of agricultural commodities. Then, it is needless to say that specific policies to stabilise agricultural production (through stabilization of area and yield of potato) and prices should be designed and implemented, with an element of urgency.

REFERENCES

[1] Chatfield, C. (1975) : *The Analysis of Time Series Theory and Parctices;* p. 133. London, Chapman and Hall;

[2] Granger, G. (1968) : *Spectora Analysis of Economic Time Series: Princeton*, N.T. : Princeton University Press.

[3] Schuster, A. (1906) : The Periodogram and its optical Analogy; Proceedings of the Royal Society of London.

[4] Soliman, M.A. (1972) : Statistical Analysis of Cyclical Variations in the National Turkey Market; *Technical Bulletin*, 276, Deptt. of Agril. and Applied Economics, University of Mannesota,

APPENDIX I

Time series data for Potato Production and Price

Year	*Production (in quintals)*			*Price (Rs. per Quintal)*			
	Actual	*Trend**	*Cycle+*	*Actual*	*Deflated price*	*Trend***	*Cycle+*
1953-54	45.171	55 23	—18.21	31 81	25.69	19.07	34 71
54-55	43.971	54.05	—18.64	29.16	26.94	21.14	27.44
55-56	48.136	56 76	−15.20	26.51	23.11	23 05	0.26
56-57	57.673	52.41	10.03	31.81	26.39	24.80	6.41
57-58	53 464	51.95	2.90	31.81	28.79	26.39	9.09
58-59	65.835	51.73	27.25	38.96	32.29	27.82	16.07
59-60	75.260	51.75	45.42	36.17	27.93	31.85	−12 30
60-61	73.773	52.01	41.83	39.67	29.67	30.20	−1.75
61-62	57.121	52 51	8.77	44.64	32 45	31.15	4.17
62-63	44.979	53.25	−15.55	46.15	33 69	31 94	5 48
63-64	37.540	54.23	—30.77	41.53	25.68	32.57	−27.29
64-65	42.530	55.45	—23.30	47.90	30 59	33.04	−7.41
65-66	49.030	58.61	—16.35	46.20	24.36	33.50	—25.91
66-67	59.750	60.55	− 1.32	106.90	54.53	33.49	62.82
67-68	63.760	62.73	1.64	89.42	42.94	33.32	28.87
68-69	70.773	65.15	8.63	60.75	30.24	32·99	−8.34
69-70	59.200	67.81	−12.69	63.90	25.46	32.50	—21.66
70-71	61.280	70.71	—13.34	56.49	22.43	29.61	−24 25
71-72	80.501	73.85	9.00	62.93	23.98	31.04	−22.74
72-73	82.880	77.23	7.31	69.78	25.33	30.07	−15.76
73-74	85.242	80.85	5.42	102.14	37.08	28.94	28.12
74-75	79.974	84.71	—5.59	78.62	18.77	27.65	—32.12
75-76	89.784	88.71	1.20	61.44	18.86	26.20	—28.02
76-77	99.395	93.15	6.69	63.44	16.92	24.59	—31.19

* The trend value was estimated from a second degree polynomial function

+ Cycle= $\frac{\text{Actual value}-\text{Trend}}{\text{Trend}} \times 100$

**Price series was deflated by the index of the prices of major agricultural

APPENDIX II

Calculation of the Fourier coefficients (4 years) for Potato Production adjusted for trend

V_1	V_2	V_3	V_4
−10.06	−10.08	−8.63	5.26
1.51	14.10	23.57	21.76
4.61	− 8.28	−16.69	−12.92
−9.58	− 0.80	1.03	5.62
−8.61	− 9.43	6.65	5.65
4.39	− 4.74	1.07	6.24
−17.74	−19 23	6.94	31.61

$$A_p = \frac{2}{24}\left[\left(-17.74\frac{\text{Cos } 360}{4} - 19.23\ \frac{\text{Cos } 360\times 2}{4} + 6.94\frac{\text{Cos } 360\times 3}{4} + 31.61\ (\text{Cos } 360)\right)\right]$$

$$= 4.2366$$

$$B_p = \frac{2}{24}\left[\left(-17.74\ \frac{\text{Sin } 360}{4} - 19.23\ \frac{\text{Sin } 360\times 2}{4} + 6.94\ \frac{\text{Sin } 360\times 3}{4} + 31.61\ (\text{Sin } 360)\right)\right]$$

$$= -2.0566$$

APPENDIX III

Calculation of the Fourier coefficients (6 years) for Potato Prices adjusted for trend

V_1	V_2	V_3	V_4	V_5	V_6
6.62	5.80	0.06	1.59	2.40	4.47
−3.92	0.53	1.30	1.75	−6.89	−2.45
−9.14	21.04	9.62	−2.75	−7.04	−7.18
−7.06	− 4.74	8.14	−8.88	−7.35	−7.67
−13.50	22.63	19.12	−8.29	−18.88	−12.83

$$A_p = \frac{2}{24}\Bigg[\Bigg(-13.50\,\frac{\text{Cos } 360}{6} + 2.63\,\frac{\cos 360\times 2}{6}$$

$$+19.12\,\frac{\cos 360\times 3}{6} - 8.29\,\frac{\cos 360\times 4}{6} - 18.88\,\frac{\cos 360\times 5}{6}$$

$$-12.83 \cos 360\Bigg)\Bigg]$$

$$= -4.6091$$

$$B_p = \frac{2}{24}\Bigg[\Bigg(-13.50\,\frac{\sin 360}{6} + 22.63\,\frac{\sin 360\times 2}{6}$$

$$+19.1\,\frac{\sin 360\times 3}{6} - 8.29\,\frac{\sin 360\times 4}{6} - 18.88\,\frac{\sin 360\times 5}{6}$$

$$-12.83 \cos 360\Bigg)\Bigg]$$

$$= 4.5933$$