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Vol XXVIII  
No. 2

ISSN 0019-5014

APRIL-  
MARCH  
1973

# INDIAN JOURNAL OF AGRICULTURAL ECONOMICS



INDIAN SOCIETY OF  
AGRICULTURAL ECONOMICS,  
BOMBAY

## PRICE SERIES CORRELATION AS A MEASURE OF MARKET INTEGRATION

Price series correlations are convenient measures of market integration since the only required data are prices, and these are more readily available than cost data relevant to evaluating inter-market price differentials. Studies of Indian agricultural markets have used this approach and found quite high correlation coefficients; in Punjab, for instance, both Cummings and Lele found correlation coefficients of about 0.90 for wheat.<sup>1</sup> It will be shown below that these high  $r$ 's reflect an upward bias due to methodology. It will also be suggested that even if markets are well integrated, correlation measures of their price series will not necessarily be high.

The studies cited above are based on raw price series. But time-series correlations should be restricted to residuals remaining after the trend and seasonal components have been removed.<sup>2</sup> These components reflect generally pervasive influences throughout an agricultural region. The trend due to rising demand occasioned by population increase, for instance, is apt to affect all parts of a region; change in supply during the year reflects in part a common climatic pattern. All price series in a region would be affected by such influences even if each market within the region was independent of others. If the trend components of the different series were isolated, they would be found to have perfect correlation,  $r = 1.0$ , an element therefore tending to boost correlation coefficients based on raw series; the same would be true for seasonal components.<sup>3</sup>

Cummings' eight-year collection of monthly wheat prices in eight Punjab markets and Delhi was reworked to eliminate trend and seasonal influences, first, by arranging the data into twelve monthly series for each town—thereby eliminating the seasonal element—, and, second, by obtaining the residuals from

1. Ralph W. Cummings, Jr.: *Pricing Efficiency in the Indian Wheat Market*, Impex, New Delhi, 1967, pp. 186, 190; data for Punjab markets are part of the comprehensive study of inter-relations between major Indian markets. Uma J. Lele: *Working of Grain Markets in Selected States of India, 1955-56 to 1964-65*, Department of Agricultural Economics, Cornell University, Ithaca, New York, December, 1968, p. 53, analyzed weekly wheat prices for five Punjab market towns and Delhi. Zaibun Y. Jasadwalla: *Marketing Efficiency in Indian Agriculture*, Allied Publishers, Bombay, 1966, pp. 106-108, found  $r = 0.90$  for groundnut prices at Bombay and Madras, using monthly prices, 1953-60; between terminal and upcountry markets  $r$  was lower, 0.60 for Bombay-Rajkot, and 0.62 for Madras-Coimbatore. Muhammad Osman Farruk: *The Structure and Performance of the Rice Marketing System in East Pakistan*, Department of Agricultural Economics, Cornell University, Ithaca, New York, June, 1970, pp. 80-85, studied three major terminal markets and two different groups of secondary markets, with daily data for a one-year period, and found  $r$ 's of about 0.90 between secondary markets, 0.86 between terminal and secondary markets, and 0.80 between terminal markets. In all these studies the correlation approach is only one aspect of the analysis of spatial and temporal differences in costs and prices. Perhaps the earliest correlation study was that of I.D. Mahendru: *Some Factors Affecting the Price of Wheat in the Punjab*, Board of Economic Inquiry Publication No. 49, Punjab Government, 1937, p. 66, based on fortnightly prices for six months at four important markets, for which the coefficients ranged from 0.43 to 0.86.

2. Frederick E. Croxton and Dudley J. Cowden: *Applied General Statistics*, Second edition, Prentice Hall, New York, 1955, pp. 562, 568, 578.

3. Actually, the trend rates of price increase varied from a high of Re. 0.82/year at Barnala (average of the twelve monthly trend rates) to a low of Re. 0.17 at Jullundur, but regardless of the rates, the linear trends would show perfect correlation.

linear trends fitted to each of these given-month series.<sup>4</sup> The nine detrended series for each month were then correlated; the results are shown in Table I. The overall average for all months was  $r = 0.68$ ; there was no difference between the average of correlation coefficients for Delhi and each other market, or for the average of the other markets with one another, excluding Delhi.

TABLE I—AVERAGE CORRELATION COEFFICIENT ( $r$ ) FOR GIVEN MONTHS BETWEEN EIGHT PUNJAB MARKET TOWNS AND DELHI FOR THE YEARS 1956 TO 1964

Month				Nine markets, including Delhi	Delhi and each of eight markets	Eight markets, excluding Delhi
April	..	..	..	0.68	0.68	0.68
May	..	..	..	0.42	0.34	0.46
June	..	..	..	0.44	0.40	0.45
July	..	..	..	0.50	0.45	0.51
August	..	..	..	0.71	0.76	0.69
September	..	..	..	0.30	0.36	0.28
October	..	..	..	0.56	0.55	0.56
November	..	..	..	0.80	0.85	0.78
December	..	..	..	0.95	0.95	0.93
January	..	..	..	0.95	0.97	0.95
February	..	..	..	0.88	0.91	0.87
March	..	..	..	0.94	0.96	0.94
Average	..	..	..	0.68	0.68	0.68

Source : Computed from residuals of trends fitted to prices in Cummings : *op. cit.*, pp. 168-171. These wholesale prices collected from Agricultural Prices in India, Directorate of Economics and Statistics, Government of India, are for the grade most commonly sold in each market. The eight towns and their 1960-61 wheat arrivals, in quintals, are : Moga (334,423), Ludhiana (323,853), Patiala (231,158), Abohar (147,202), Karnal (81,440), Bhatinda (71,595), Jullundur (23,688), and Barnala (not available). Two changes were made in Cummings' data to correct apparently typographical errors : Moga April, 1958 from Rs. 87.15 to Rs. 37.15, and Ludhiana September, 1961 from Rs. 69.01 to Rs. 39.01.

The bulk of market disposals, however, is made in the harvest months, April to July,<sup>5</sup> and in that period the average correlation coefficient is even lower. For the most relevant part of the year the average correlation coefficient is only about half as large as has been reported.

4. The size of the residuals relative to trend price is indicated below.  
Averages of Residuals (R) from Price Trends, and Average Price (P) for Eight Punjab Towns and Delhi, 1956-64

Month	April	May	June	July	August	September	October	November	December	January	February	March
R	2.90	1.58	1.28	1.24	1.77	1.24	1.42	2.56	4.01	4.94	6.05	3.61
P	40.48	38.27	38.47	40.22	40.31	40.09	41.50	42.68	44.61	46.14	46.73	44.38
R/P	7.2%	4.1%	3.3%	3.1%	4.4%	3.1%	3.4%	6.0%	9.0%	10.7%	13.0%	8.1%

5. June market disposals constituted about 35 per cent of the annual total at the five wheat markets in Lele's study, May disposals about 25 per cent, July 9 per cent and April 3 per cent; Lele: *op. cit.*, p. 39.

Reasons are not difficult to find to explain why the correlation coefficient is at the moderate level obtained above rather than the extremely high level previously reported. If reported prices in all markets were at perfectly competitive equilibrium levels, then the difference in prices between places would correspond to difference in shipment and marketing costs,<sup>6</sup> and the series would be perfectly correlated, subject to an important qualification discussed below. But wholesale prices in Punjab are determined by auction of separate lots on the market floor,<sup>7</sup> and price therefore is not necessarily that which satisfies all local suppliers, nor all interested non-resident merchants. With knowledge assumed available in perfect competition, some buyers will be attracted to buy in markets where prices are relatively low, either for their own distribution to sellers at closer level to consumers, or to sell in arbitrage at other wholesale markets.<sup>8</sup> In Punjab, however, this would require knowledge on the part of marginal traders of at least 86 markets classified as important for wheat, and perhaps even the remainder of the 232 wholesale markets registered in 1963 for produce assembling.<sup>9</sup> Even if there were sufficient knowledge of conditions in the various markets to make marginal shifts in demand and supply attractive, non-resident buyers would also need reliable local merchant representation and transportation efficient enough to take advantage of price differentials. Perfectly competitive conditions are found to a considerable extent, but it does not seem likely that they exist to the extent indicated by the order of 0.90 correlation coefficients.

An important qualification, in any case, is that even if markets are well integrated, correlation coefficients may not be high because these markets are not simply supply centres but also centres of importance for local consumption. In this circumstance it is possible for equilibrium price to be anywhere between a low which just makes it worthwhile to export grain from the local centre and a high which just makes it worthwhile to import grain from other markets. Unless markets have consistently large supply relative to demand, making them exporters, or the opposite, making them importers, price series correlation coefficients will be lower than otherwise, despite the integration which occurs at prices outside the export-import price range. For the period of mid-1950's to mid-1960's, in the Punjab markets referred to above, according to the Lele and Cummings studies,<sup>10</sup> this range was about plus or minus 10 per cent of central market price, a considerable range within which price could fluctuate even with perfectly competitive integrated markets.

6. Price differences between Delhi and Punjab markets were found by both Lele and Cummings to be generally smaller than the costs of transfer, but in many instances local price was higher than Delhi price.

7. Walter C. Neale, Harpal Singh, and Jai Pal Singh, "Kurali Market: A Report on the Economic Geography of Marketing in Northern Punjab," *Economic Development and Cultural Change*, Vol. XIII, No. 2, January, 1965.

8. Cummings: *op. cit.*, p. 63, reported that purchases in the Khanna market for consignment sale elsewhere, arbitrage transactions, constituted about 10 per cent of total sales in that market in 1959-60 and 1960-61, and 20 per cent in 1961-62 and 1962-63, but in 1963-64 there were apparently no purchases for that purpose.

9. Directory of Wholesale Agricultural Produce Assembling Markets in India, Directorate of Marketing and Inspection, Government of India, Nagpur, 1965, pp. 153-170, 235.

10. Lele: *op. cit.*, p. 60; Cummings: *op. cit.*, p. 74.

Considering the imperfections of competition and the possible range of local market price fluctuation which could still be consistent with integrated markets, it is not implausible that the overall correlation coefficient for the group of markets could be much lower than has been indicated in some studies.

GEORGE BLYN\*

## DEMAND FOR IRRIGATION : A CASE STUDY OF GOVERNMENT TUBE-WELLS IN UTTAR PRADESH

### SCOPE OF THE STUDY

The purpose in this short paper is to present some estimates of elasticity of demand for irrigation water with respect to four variables, namely, (1) price of farm output, (2) price of irrigation water, (3) normal rainfall, and (4) deviation from normal rainfall. A single-equation linear model has been employed to the time-series data in respect of State tube-wells in Uttar Pradesh. The study provides a basis for important policy implications which are spelt out towards the end of the paper.

### THE DATA

The basic data about the level of utilization of tube-wells are obtained from the Office of the Chief Engineer, Irrigation Department, Uttar Pradesh. Another useful source has been the administration report of the Irrigation Department, U.P.<sup>1</sup> Instead of using the all-India statistics of wholesale prices of agricultural commodities, the index numbers of wholesale prices of agricultural commodities compiled by the Office of the Director of Economics and Statistics, Uttar Pradesh, have been used to represent farm prices received by U.P. farmers drawing water from State tube-wells. Other sources of data are listed at appropriate places in the text. The measurement of the irrigation rate for tube-well water needs three observations. First, it is an effective rate, in the sense that any rebate or surcharge on basic rate is fully taken into account. Second, only the basic rates for electricity-driven tube-wells could be considered. Third, till September, 1967 tube-well water in U.P. was sold under one-part tariff based on volume of water alone. Thereafter, a two-part but optional tariff has come into force. This, however, does not affect our results because our time-series analysis is confined to 1946-67 during which period strictly volumetric basis of rate fixation prevailed. In point of fact, it is this volumetric basis of irrigation rates, unlike the crop basis of rates prevailing in most major and minor irrigation works, that makes it possible to undertake a study concerning demand for irrigation water.

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1. Published annually under the title Irrigation Administration Report of Uttar Pradesh by the Superintendent, Printing and Stationery, Uttar Pradesh, Allahabad.