ELASTICITY OF DEMAND FOR WHEAT IN INDIA.

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There exists some doubt as to the nature of demand for wheat in India. Some hold that being a staple article of food, its demand must be inelastic. But others point out that the commodity can hardly be regarded as a necessary article of food for the whole of India, as it enters principally into the dietary of people of two provinces, Punjab and the United Provinces, which contain only 20 per cent. of the total population of India. It is further pointed out that even in the two provinces named above, there is a large section of people who may be regarded as a kind of marginal consumers of wheat. This class, it is stated, depends on wheat when its price is low, but would at once turn to coarser grains like millets (*jowar, bajra* and *ragi*) when the price of wheat is comparatively high. Owing to this difference of opinion, it is of some interest to examine the question in the light of statistical evidence. In the present paper an attempt has been made to construct the statistical demand curve of wheat for India, and to derive from it the elasticity of demand for the commodity.

Statistical demand curves are based on records of prices at various times, and the quantities taken at those prices. But in order that the resulting curve might yield the true demand curve, it is necessary that certain fundamental conditions relating to the nature of the primary demand and supply functions should hold good. If we can postulate that the supply schedule moves during the period of study while the demand schedule remains constant or relatively so, the curve derived from statistical analysis might be regarded as approximating to the demand curve. In reality however, the demand schedule would hardly remain constant over a fairly long period of time owing to various disturbing factors, such as the growth of population, variation in the income of the people, fluctuation in the general price level, etc. But if we could allow for the effects of such disturbing factors or at least of the most important ones, by applying suitable corrections to the data or by other statistical devices, we might regard the demand schedule to be more or less constant ; and in that case it might be possible to obtain a fairly reliable idea of the demand curve.

Further, the demand and supply schedules are more or less independent in the case of agricultural commodities in general, for supply is usually a fixed quantity within each interval of time. For when a crop is once planted, its supply cannot ordinarily be varied. Farmers have no reservation price, and they have to dispose of their produce according to the existing demand schedule at that time. Particularly is this so for commodities like Indian wheat which cannot be stored by the farmers for any length of time. Owing to the chronic poverty of the Indian cultivators they are under pressure to sell their crops as soon as raised. Moreover the wheat crop is harvested in India just before the monsoon and the farmers do not venture to withhold supply from the market for fear of spoilage through the rains which set in just after the wheat harvest in India. In these circumstances, our effort to derive the demand curve from statistical analysis is likely to yield a good approximation to the true demand curve.

The necessary statistical data for the period 1893 to 1913 are tabulated in Table 1. The *raw* quantity series, shown in col. 2, represents the amount of wheat retained for domestic consumption in India, and the figures have been derived from the official records of production and net exports of wheat (including flour expressed in terms of grains[1]).

TABLE 1.—CONSUMPTION AND PRICE OF WHEAT IN INDIA

Year	Home retention of wheat in India (in million maunds[1])	Retail prices of wheat expressed in rupees per maund [1]	Weighted Index Numbers of gold prices in India [2]	Home retention of wheat adjusted to population (in million maunds [1])	Deflated retail prices of wheat in rupees per maund [1]	Index Numbers of retail prices of other food grains[3]	Corrected Index Numbers of retail prices of other food grains
1	2	3	4	5	6	7	8
1893	178·2	2·785	98	178·2	2·842	129	132
1894	187·8	2·295	84	187·6	2·732	115	137
1895	176·0	2·546	85	175·5	2·905	121	142
1896	143·8	3·356	98	143·2	3·424	155	158
1897	142·0	4·515	123	141·2	3·671	209	170
1898	168·6	3·142	104	167·4	3·021	138	133
1899	172·4	3·064	101	170·0	3·634	137	136
1900	145·6	3·865	119	144·1	3·248	195	164
1901	182·7	3·506	116	180·6	3·022	157	135
1902	150·4	3·110	106	147·8	2·934	141	133
1903	180·2	2·837	103	175·0	2·754	126	122
1904	202·0	2·692	100	196·0	2·692	116	116
1905	180·0	3·108	112	173·5	2·775	148	132
1906	210·4	3·401	132	201·6	2·577	183	139
1907	206·3	3·676	140	196·4	2·626	182	130
1908	163·8	4·969	149	155·0	3·335	232	156
1909	178·2	4·459	134	167·6	3·328	194	145
1910	226·3	3·721	125	211·5	2·977	168	134
1911	234·9	3·358	130	218·1	2·583	162	125
1912	222·4	3·735	145	205·2	2·576	192	133
1913	232·8	3·876	152	213·5	2·550	203	134

[1] One maund = 82 2/7 lbs.
[2] Base 1890–1894 = 100.
[3] Base 1873 = 100. The series has been reconstructed from data shown in summary Table III (page 3) of "*Index Numbers of Prices in India 1861–1926*".

[1] It has subsequently come to the notice of the writer that the figures are readily available (expressed in terms of million bushels) from Table V appended to the Bulletin (Vol. III, No. 8, July, 1927): *"India as a producer and exporter of Wheat"* published by the Food Research Institute, Stanford University, California.

TABLE 2. TREND-RATIOS OF UNADJUSTED AND ADJUSTED DATA.

Year	UNADJUSTED DATA: Quantity retained for consumption (in million maunds)	Retail price (in Rupees per maund)	Straight line trend of quantity series (col. 2)	Straight line trend of price series (col. 3)	Trend-ratios of: Quantity col. (2) / col. (4)	Trend-ratios of: Price col. (3) / col. (5)	ADJUSTED DATA: Quantity retained for consumption adjusted for growth in population	Retail price of wheat deflated by general Index Numbers	Straight line trend of quantity series (col. 8)	Straight line trend of price series (col. 9)	Trend-ratios of: Quantity col. (8) / col. (10)	Trend-ratios of: Price col. (9) / col. (11)
1	2	3	4	5	6	7	8	9	10	11	12	13
	C	P	T_c	T_p	c'	p'	c	p				
1893	178	2·785	153	2·880	1·163	·964	178	2·842	156	2·735	1·141	1·031
1894	188	2·295	156	2·943	1·205	·780	188	2·732	158	2·755	1·190	·992
1895	176	2·546	159	2·997	1·107	·850	175	2·995	161	2·776	1·087	1·079
1896	144	3·356	163	3·051	·883	1·100	143	3·424	163	2·796	·877	1·225
1897	142	4·515	166	3·103	·855	1·451	141	3·671	165	2·816	·855	1·304
1898	169	3·142	160	3·159	1·000	·995	167	3·021	167	2·826	1·000	1·063
1899	172	3·064	172	3·218	1·000	·954	171	3·074	170	2·837	1·006	1·082
1900	146	3·865	175	3·267	·834	1·183	144	3·248	172	2·877	·837	1.129
1901	183	3·506	179	3·321	1·022	1·056	181	3·022	174	2·897	1·040	1·043
1902	150	3·110	182	3·375	·824	·921	148	2·934	177	2·918	·836	1·005
1903	180	2·837	185	3·429	·973	·827	176	2·754	179	2·938	·983	·937
1904	202	2·692	188	3·483	1·074	·773	190	2·692	181	2·958	1·053	·910
1905	180	3·108	191	3·537	·942	·879	174	2·775	184	2·979	·946	·932
1906	210	3·401	195	3·591	1·077	·947	202	2·577	186	2·999	1·086	·859
1907	206	3·676	198	3·645	1.040	1·009	196	2·626	188	3·019	1·043	·870
1908	164	4·064	201	3·699	·816	1·343	155	3·385	190	3·039	·816	1·097
1909	178	4·450	204	3·753	·873	1·186	168	3·328	193	3·060	·870	1·088
1910	226	3·721	207	3·807	1·092	·977	212	2·977	195	3·080	1·087	·967
1911	235	3·358	211	3·861	1·114	·870	218	2·583	197	3·100	1·107	·833
1912	222	3·735	214	3·915	1·037	·954	205	2·576	200	3·121	1·025	·825
1913	233	3·876	217	3·969	1·074	·977	214	2·550	202	3·141	1·059	·812

The *unadjusted* price series (col. 3) relates to retail prices to which the consumers respond; and the figures—which represent the annual averages of retail prices of wheat over a good number of stations in India—have been extracted from the official Blue Book '*Index Numbers of Indian Prices, 1861-1928.*' In columns 5 and 6 are shown the *adjusted* quantity and price series. The quantity figures have been adjusted by allowing for the growth in population which in intercensal years has been estimated on the basis of a constant geometric rate of increase. The price statistics have been corrected by deflating them with the weighted index numbers of gold prices in India (Col. 4 of Table 1) quoted in Table VIII of the "*Index Number of Indian Prices*" already referred to. In the last two columns of the table are shown the *unadjusted* and *corrected* series of index numbers of retail prices of other food-grains in India—also derived from the above publication —the correction being made as in the case of wheat prices, that is with the help of the weighted index numbers of gold prices in India.

As consumers' demand seems to be predominantly a function of the level of prices, we shall employ the method of trend-ratios, in preference to the link-relative method, for the purpose of our investigation. Accordingly the trend-ratios of consumption and prices both for the unadjusted and adjusted series have been computed and are shown in Table 2.

The coefficient of correlation[2] between the trend-ratio of price (p') and of consumption (c') is found to be -0.698 ± 0.08, and is definitely significant. As both the variables are here affected by errors of estimate, it will be better to use the line of best fit[3] instead of the regression line.

By actual calculation we find the line of best fit to be

$$p' = 2.7584 - 1.7583\ (c') \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \quad (1)$$

where p' represents the trend-ratio of *unadjusted* price, and c' the trend-ratio of *unadjusted* consumption.

Equation (1) may therefore be regarded as an approximation to the demand curve in the ratio form. A simple transformation however enables us to express the relation in terms of the original variables. Writing $c' = C/T_c$, and $p' = P/T_p$ where C and P stand for unadjusted quantity and price data, and T_c and T_p for their respective trends, the equation reduces to

$$C = -0.5687\ (T_c/T_p)\ P + 1.5688\ (T_c) \qquad \ldots \qquad \ldots \quad (1.1)$$

which is in a very convenient form for estimating directly the amount of consumption

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2. The following constants for the *unadjusted* series were obtained by direct calculation with $n = 21$

$$\bar{p}' = 1.000 \qquad \bar{c}' = 1.000 \qquad r(p', c') = -0.683 \pm 0.08$$
$$s_p' = 0.1687 = s_2 \qquad s_c' = 0.1132 = s_1$$

3. The line of best fit which is obtained by making the sum of the normal *distances* to the line minimum, is defined by the equation

$$p' - \bar{p}' = m\ (c' - \bar{c}'),$$

where m is determined from the equation:—

$$m^2 + \left(\frac{s_1^2 - s_2^2}{s_1 s_2 r_{12}}\right).m - 1 = 0$$

where s_1^2 is the variance of c' (the independent variable) and s_2^2 the variance of p' (the dependent variable).

from price. For example, substituting the values of T_c and T_p for, say, 1911 from Table 2, the relationship for that year becomes

$$C = 331{\cdot}02 - 31{\cdot}08\ (P) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1{\cdot}2)$$

which shows that a rise or fall of one rupee per maund would have decreased or increased consumption by 31 million maunds in that year. The coefficient of elasticity η may be easily deduced from equation (1) above, and its values at certain selected levels are shown in Table 3.

TABLE 3. ELASTICITY OF DEMAND FOR WHEAT.

Consumption of Wheat as percentage of normal (trend-value)		Value of Coeff. of Elasticity of Demand
	$c' =$	$\eta =$
20% less than normal ...	0·8	−1·0
10% „ „	0·9	−0·7
Normal (trend-value) ...	1·0	−0·6
10% above normal ...	1·1	−0·4
20% „ „	1·2	−0·3

These results are in agreement with the general proposition that elasticity is *greater* for high price (or low consumption) than it is for low price (or high consumption).

The results obtained above should not however lead us to think that the case of variable elasticities at different levels has been proved in our present problem. Rather, the results were derived on that hypothesis, as the method of fitting employed carried with it that implication.[4]

Instead of drawing our scatter-diagram on the arithmetic scale, we may plot the trend-ratios on the geometric scale which is equivalent to plotting their logarithms on the arithmetic scale. That is, we can use $\log c'$ and $\log p'$ as the two variables instead of the trend-ratios c' and p' themselves. Doing this we obtain the following regression equation[5] :—

$$\log p' = -0{\cdot}0083 - 0{\cdot}0534 \log c' \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

The observed points together with the calculated values and the straight line (2) are shown graphically in Chart 1, and the relevant figures in the transformed scale (both observed and calculated) are given in columns 2, 3, and 5 of Table 4. There is no evidence of curved regression, and the fit by the logarithmic straight line (2) seems quite

[4] The point is analogous to that of fitting a trend line empirically to a series of data, and then claiming on the basis of computed trend values that the data follow that law, without demonstrating the statistical adequacy of the fit in a satisfactory manner. So far as the writer is aware, Prof. Ferger was the first to draw special attention to this point in his article "The Static and Dynamic in Statistical Demand Curves." *Quarterly Journal of Economics*, Vol. XLVII, No. 1, Nov., 1932 (pp. 50-53).

5. The statistical constants are :—

$\overline{(\log p')}$ = Mean value of ($\log p'$) = 0·005738

$\overline{(\log c')}$ = Mean value of ($\log c'$) = 0·002752

$s(\log p')$ = Standard Deviation of ($\log p'$) = 0·0694

$s(\log c')$ = Standard Deviation of ($\log c'$) = 0·0591

$r(\log p', \log c') = -0{\cdot}6884 \pm {\cdot}031$

good. As equation (1) is not a regression equation a direct comparison with (2) is not possible. But we can easily write down the regression equation corresponding to (1):—

$$p' = 2{\cdot}0253 - 1{\cdot}0253\,(c') \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1{\cdot}3)$$

or taking logarithms:—

$$\log p' = \log\,[2{\cdot}0853 - 1{\cdot}0253(c')] \qquad \ldots \quad \ldots \quad (1{\cdot}4)$$

For comparison the curved line (1.4), which corresponds to the regression line of p' on c', is also plotted in Chart 1 (relevant values are given in Col. 4 of Table 4). It will be seen that there is no appreciable difference between (2) and (1.4), and both give practically the same fit.[a]

TABLE 4. OBSERVED AND CALCULATED VALUES OF TREND-RATIOS OF UNADJUSTED PRICE AND CONSUMPTION.

Year	log c' = logarithm of trend-ratios of unadjusted consumption given in Table 2, Col. (6)	log p' = logarithm of trend-ratios of unadjusted price		
		Observed as given in Table 2, Col. (7)	Deduced from	
			Equation (1·4)	Equation (2·0)
(1)	(2)	(3)	(4)	(5)
1893	+ 0·0636	− 0·0159	− 0·0794	− 0·0708
94	+ ·0810	− ·1079	− ·1023	− ·0835
95	+ ·0441	− ·0706	− ·0505	− ·0304
96	− ·0540	+ ·0414	+ ·0192	+ ·0432
97	− ·0690	+ ·1626	+ ·0603	+ ·0368
98	−	− ·0072	−	− ·0083
99	−	− ·0203	−	− ·0083
1900	− ·0788	+ ·0730	+ ·0682	+ ·0069
01	+ ·0033	+ ·0237	− ·0099	− ·0173
02	− ·0941	− ·0337	+ ·0722	+ ·0710
03	− ·0119	− ·0823	+ ·0120	+ ·0030
04	+ ·0310	− ·1118	− ·0343	− ·0379
05	− ·0239	− ·0360	+ ·0233	+ ·0164
06	+ ·0372	− ·0237	− ·0337	− ·0390
07	+ ·0170	+ ·0039	− ·0182	− ·0243
08	− ·0883	+ ·1281	+ ·0732	+ ·0750
09	− ·0590	+ ·0718	+ ·0331	+ ·0170
1910	+ ·0382	− ·0101	− ·0430	− ·0447
11	+ ·0169	− ·0605	− ·0340	− ·0380
12	+ ·0158	− ·0203	− ·0168	− ·0283
1931	+ ·0310	− ·0101	− ·0343	− ·0379

[a] (This as judged by visual comparison — *Editor.*)

Thus on the evidence before us the assumption of constant elasticity (linear relation between log p' and log c') has as much claim in its support as that of varying elasticity (linear relation between p' and c'). The same conclusion is also reached by working with trend-ratios of adjusted data, although the correlation coefficient works out in that case to a slightly lower figure of $-0{\cdot}57 \pm 0{\cdot}10$ (with $n = 21$). We see therefore that the assumption of constant elasticity is equally justified within the range of our observations, and as this is a simpler hypothesis we shall adopt it in our subsequent analysis.

TABLE 5. OBSERVED AND CALCULATED VALUES OF ADJUSTED PRICE AND ADJUSTED CONSUMPTION

Year	c = Adjusted Consumption Table 2, Col. (8)	p = Adjusted Price		
		Observed Table 2, Col. (9)	Deduced from	
			Equation (3·1)	Equation (4·1)
(1)	(2)	(3)	(4)	(5)
1893	178	2·812	2·910	2·877
94	188	2·752	2·814	2·816
95	175	2·993	2·939	2·893
96	143	3·424	3·353	3·151
97	141	3·671	3·354	3·169
98	167	3·021	3·030	2·953
99	171	3·034	2·990	2·928
1900	144	3·218	3·339	3·143
01	181	3·022	2·884	2·861
02	153	2·934	3·283	3·110
03	176	2·734	2·934	2·803
04	196	2·692	2·735	2·763
05	174	2·775	2·960	2·909
06	202	2·577	2·686	2·733
07	196	2·626	2·732	2·763
08	155	3·335	3·185	3·010
09	168	3·828	3·028	2·951
1910	212	2·977	2·604	2·670
11	218	2·383	2·553	2·645
12	205	2·576	2·655	2·713
1913	214	2·330	2·588	2·660

In the case of constant elasticity type of demand, we may dispense with the trend-ratio method, and derive the demand curve directly from the logarithms of the original variables. Accordingly we take the logarithms of the *corrected* or *adjusted* data and find that the correlation coefficient[7] is of a very high order, $-0{\cdot}84 \pm {\cdot}04$ $(n=21)$. Under such circumstances, the usual regression lines would differ but little from the best-fitting line obtained on the assumption of possible errors in both the variables. We may therefore use the ordinary regression line of price on consumption as our demand curve. Its equation is given by

$$\log p = 1{\cdot}92258 - 0{\cdot}64805 \log (c) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Actual values of c and p are given in Columns 8 and 9 of Table 2. The above equation can also be expressed in terms of original variables p and c:—

$$p = 83{\cdot}072\,(c)^{-0.64805} \quad \ldots \quad \ldots \quad \ldots \quad (3{\cdot}1)$$

Observed and calculated values are given in Table 5, and the curve in the form of equation (3.1) is shown graphically in Chart 2. It will be noticed that the demand is elastic. As the coefficient of correlation is very high, we may, without serious error, use the reciprocal of the regression coefficient[8] as an approximate value of the coefficient of elasticity η. In this particular case we find $\eta = -1{\cdot}5$ from the regression line of price on consumption.[9].

So far we did not consider the effects of the level of prices of other food grains in our investigation. Including this as a second independent variable, and designating the logarithm of the corrected values of this factor (shown in the last column of Table 1) by f, we find the following equation[10] on the basis of linear relationship:—

$$\log p = 0{\cdot}38723 - 0{\cdot}41580 \log c + 0{\cdot}47372 \log f \quad \ldots \quad \ldots \quad (4)$$

with the coefficient of multiple correlation $R = 0{\cdot}89$. The coefficient of partial correlation r (log c, log p) works out at $-0{\cdot}64$ and the relation between the two on the basis of the average level of prices of other food-grains during the five-year period 1909-1913 is found to be

$$\log p = 1{\cdot}39488 - 0{\cdot}41580 \log c \quad \ldots \quad \ldots \quad \ldots \quad (4{\cdot}1)$$

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7. The statistical constants are:—

Mean value of $(\log p) = 0{\cdot}4657$
Mean value of $(\log c) = 2{\cdot}2181$
S. D. of $(\log p) = 0{\cdot}0447$
S. D. of $(\log c) = 0{\cdot}0577$
Coefficient of correlation $= r\,(\log p, \log c) = -0{\cdot}84 \pm 0{\cdot}04$

8 See M. Ezekiel: "The Assumptions implied in the Multiple Regression Equation," *Journal of the American Statistical Society*, Vol. XX. New Series No. 151, September, 1925, pp. 406-07.

9 The value of η is equal to $-1{\cdot}1$ when derived from the regression line of consumption on price; while its value works out at $-1{\cdot}4$ when it is derived from the line of best fit on the assumption of possible errors in both the variables.

10. Besides the constants given in footnote (7), we also have

Mean value of $(\log f) = 2{\cdot}1389$
S. D. of $(\log f) = 0{\cdot}0401$
$r(\log p, \log f) = +0{\cdot}80 \pm {\cdot}05$
$r(\log c, \log f) = -0{\cdot}71 \pm {\cdot}07$

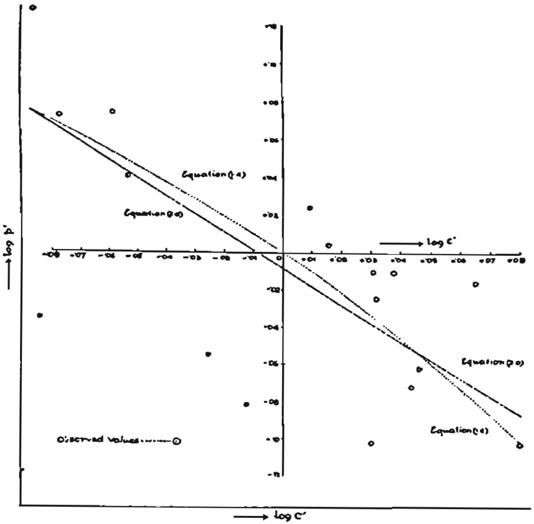

CHART 1. TREND-RATIOS OF UNADJUSTED PRICE AND CONSUMPTION (TABLE 4.)

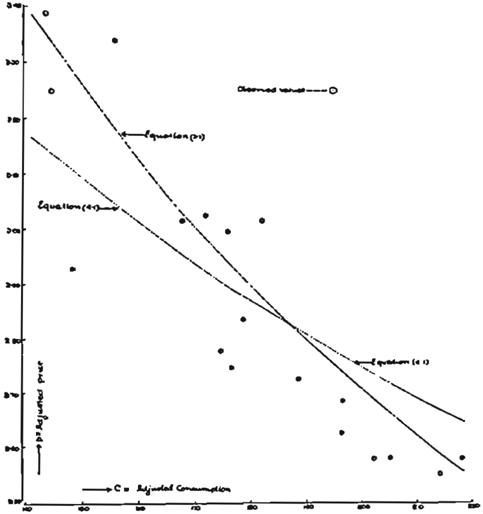

CHART 2. ADJUSTED PRICE AND ADJUSTED CONSUMPTION (TABLE 5.)

The observed and calculated values are given in Table 5, and are shown graphically in Chart 2. This equation gives a value of over 2 (numerically) for the coefficient of elasticity. But if we treat consumption (c) as the dependent variable and the other two factors (p and f) as the independent variables the relationship is given by the following equation.

$$\log c = 2{\cdot}9954 - 0{\cdot}9818 \log p - 0{\cdot}1350 \log f \ldots \qquad \ldots \qquad (5)$$

from which the value[11] of η works out at about $-1{\cdot}0$.

Discussion.

Using different equations we have obtained somewhat divergent values for the coefficient of elasticity. We should clearly choose that particular value which is derived from the demand curve that fits the data with the highest degree of precision[12]. Judged by this test, the assumption of constant elasticity seems to be more appropriate to our present case than that of varying or changing elasticity; and on this basis the value of the coefficient of elasticity of demand for wheat in India may be put approximately at $-1{\cdot}5$, *showing that the demand is elastic.* These conclusions of course refer to the period 1893 to 1913 covered by the present study. To what extent these results hold good during the post-war period will form the subject matter of a future study.

(Paper Received January, 1934.)

[11] Or, rather -2 approximately, on the assumption of possible errors in all the variables.

[12] See H. L. Moore: "Economic Cycles," p. 84. Also H. Schultz "Statistical Laws of Demand and Supply," p. 63.