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A NOTE ON THE ELASTICITY OF THE MARKETABLE SURPLUS OF A SUBSISTENCE CROP[1]

The behaviour of the marketed supply of food crops grown partly for home consumption is a matter of critical importance for a growing economy. For the rate of growth of the urban industrial sector depends on the availability of food from the rural, agricultural sector.

In this note we derive an expression for the elasticity of the marketable surplus of a single subsistence crop and examine the probable limits of this elasticity assuming ranges of the other relevant parameters plausible for the Indian economy. The peculiarity of this elasticity arises from the fact that the peasant is the producer as well as the consumer of the commodity produced and hence a change in price has a different effect on his income from what it would be if he were a pure consumer.

It is often said that even if the elasticity of the total output of a subsistence crop is positive it is possible that the elasticity of the marketed output may be negative. We shall investigate the conditions under which this might be true.

When more adequate data are available regarding the marketed supply the theory can be tested and improved.

II. NOTATION

We shall suppose that the subsistence crop is wheat and use the following notation :

Q = the quantity of wheat produced

C = the quantity of wheat consumed

M = the quantity of wheat marketed

$c = \frac{C}{Q}$ = the consumption ratio

$m = \frac{M}{Q}$ = the sale ratio

$r = \frac{Q}{M} = \frac{1}{m}$ = the reciprocal of the sale ratio

P = the relative price of wheat

Y = the total income of the peasants

e = the elasticity of the market supply with respect to P

d = the total elasticity of home consumption with respect to P

b = the elasticity of output with respect to P.

1. The author is extremely grateful to Professor A. C. Harberger of the University of Chicago for a very helpful discussion of the first draft of this note and to Dr. Dharm Narain and Dr. T. N. Srinivasan for their comments. The responsibility for the deficiencies of the note, if any, is entirely of the author.

III. A SIMPLE MODEL

Since the market supply[2] is :

$$M \equiv Q - C \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

it follows that

$$\frac{dM}{dP} = \frac{dQ}{dP} - \frac{dC}{dP}$$

or, in terms of elasticities,

$$e = rb + (r\text{-}1)d \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (2)$$

The ratio of output to market supply, r, is likely to be positive and range from 1 in the case of the purely commercial farmers who sell the entire crop to, say, 10 in the case of the subsistence farmers who sell only 10 per cent of it.

Let us consider the sign of e on the basis of equation (2). We can distinguish four cases.

(i) If b, the elasticity of output, is positive and d, the elasticity of home consumption is negative, e will be positive. .. .. (3-i)

(ii) If b is negative and d is positive, e will be negative. .. (3-ii)

(iii) If b and d are both negative, e will be positive so long as

$$r \mid b \mid < (r\text{-}1) \mid d \mid$$

$$\text{or} \quad \mid b \mid < c \mid d \mid \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (3\text{-iii})$$

where $c = \frac{r-1}{r}$ = the proportion of output consumed.

(iv) If b and d are both positive, e will be positive so long as

$$rb > (r\text{-}1)d$$

$$\text{or} \quad b > cd. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (3\text{-iv})$$

The first and the fourth cases seem to be the most interesting, for, whatever little empirical work has been done in India shows that the elasticity of the total output of a single subsistence crop with respect to its relative price, net of the

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2. We abstract, in this note, from disposals other than consumption and sale and use the words 'marketable surplus', 'market supply', 'marketed supply' and 'sale' synonymously.

effect of other variables, such as weather, is *positive* even though it may be as low as .1 or .2. Let us, therefore, examine these cases further. What we need now is a home consumption function. Let us specify this as :

$$\frac{dC}{C} = g\frac{dP}{P} + h\frac{dY}{Y} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

where g represents the elasticity of the substitution effect on consumption and h the elasticity of the income effect.

The next problem is to define the effect of an increase in the relative price of wheat on the total income Y.

If the peasant were a pure producer and the revenue from wheat formed a fraction k of his total income a 10 per cent increase in P would increase his income by 10k per cent. In symbols,

$$\frac{dY}{Y} = \frac{dP}{P} \cdot \frac{QP}{Y} = k\frac{dP}{P}$$

where $k = \frac{PQ}{Y}$.

If he were a pure consumer his income would fall :

$$\frac{dY}{Y} = \frac{dP}{P} \cdot \frac{PC}{Y}$$

where $\frac{PC}{Y}$ is the ratio of his expenditure on wheat to his total income.

Since he is a consumer as well as a producer the total change in his income would be

$$\frac{dY}{Y} = \frac{dP}{P}\left(\frac{PQ}{Y} - \frac{PC}{Y}\right)$$

$$= \frac{dP}{P} \cdot \frac{PM}{Y} \qquad (\text{because } M = Q - C)$$

$$= \frac{dP}{P} \cdot \frac{PQ}{Y} \cdot \frac{M}{Q}$$

$$= mk\frac{dP}{P} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Relations (1), (4) and (5) constitute our simple model.

From (4) and (5) we have :

$$\frac{dC}{C} = g\frac{dP}{P} + mkh\frac{dP}{P}$$

$$= (g + mkh)\frac{dP}{P}$$

so that $d = g + mkh$ .. .. (6)

Substituting (6) in (2) we have the result :

$$e = rb - (r\text{-}1)(g + mkh) \quad .. \quad .. \quad .. \quad .. \quad (7)$$

And we know from (3) that if b is positive, this (7) will be positive so long as either d is negative, or, if d is positive,

$$b > c(g + mkh) \quad .. \quad .. \quad .. \quad .. \quad .. \quad .. \quad (8)$$

Now d will be negative and hence e surely positive if g, the negative substitution effect is larger than mkh, the total positive income effect in (6).

Suppose, for example, that $b = .15$, $r = 3$, ($m = .33$ and $c = .66$), $g = -.3$, $k = .3$ and $h = .7$. Then, from (7) and (8), $d = -.23$ and $e = .91$.

The complicated case is the one in which d is positive ($mkh > |g|$). In this case we require condition (8) to be fulfilled for the market supply function to be well-behaved.[3]

We can also see from (7) that *ceteris paribus* e is an increasing function of b and $|g|$ and a decreasing function of k and h.[4]

In other words, other things being equal, the elasticity of market supply varies inversely as (1) the income elasticity of home consumption and (2) the proportion of wheat revenue to total income ; and it varies directly as (3) the elasticity of total output and (4) the absolute elasticity of the substitution effect on home consumption.

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3. This condition can be rewritten for any parameter.

$$m < \frac{b - cg}{ckh} \qquad (\text{or } c < \frac{b}{g + mkh}) \qquad (9)$$

$$h < \frac{b - cg}{cmk} \qquad (10)$$

$$k < \frac{b - cg}{cmh} \qquad (11)$$

$$|g| > \frac{b - cmkh}{c} \qquad (12)$$

4. $\frac{\partial e}{\partial b} > 0$, $\frac{\partial e}{\partial |g|} > 0$; $\frac{\partial e}{\partial k} < 0$; $\frac{\partial e}{\partial h} < 0$. The relation of e to m, however, is complicated, for $\frac{\partial e}{\partial m}$ is positive only if $m > \sqrt{\frac{|g| + b}{kh}}$.

Knowing the direction in which e is moved by the movement of each of the parameters, b, g, k and h, we can estimate the lower and upper limits of e by choosing two sets of values of these parameters such that they give us these limits. The available results of the empirical work that has been done show that the ranges of these parameters might be as shown in Table I. Combining these with three alternative values of m we get the estimates of e given in the Table.

TABLE I—CALCULATION OF PLAUSIBLE LIMITS OF e

Plausible Ranges of Parameters [5]	Values Relevant	
	For Min. e	For Max. e
b = .1 to .2	.1	.2
g = —.2 to —.4	—.2	—.4
h = .5 to .8	.8	.5
k = .1 to .7	.7	.1
m	0.1 or 0.5 or 0.9	
r (= 1/m)	10·0 or 2·0 or 1.1	

	m=.1	m=.5	m=.9
Min. e	2.30	.12	.08
Max. e	5.56	.78	.26
Min. e (g = 0)	.50	—.08	.06

5. The basis of the values used in the Table I may be briefly indicated.

The range of b is derived from the present writer's Ph.D. dissertation (Farm Supply Response in the Punjab (India-Pakistan)—A Case Study of Cotton, University of Chicago, 1961) on farm supply functions for the Punjab which has been one of the most important wheat regions of India. The elasticity of the acreage of wheat with respect to the relative price of wheat—relative to an index of the price of 10 alternative crops grown in the Punjab was there estimated to be .1 in the short run and .2 in the long run (in the Nerlovian sense). The elasticity of acreage is considered a good approximation to the elasticity of output, net of the effect of autonomous variations in the yield per acre and other factors. The range .1 to .2, therefore, seems to be plausible for the elasticity of supply of wheat.

The price elasticity of the demand for wheat for India was estimated to be —.35 (±.21) and the income elasticity to be .91 (±.41) by Mr. A. K. Chakravarty ("Analysis of the Demand for Wheat," Paper No. ICRNI/P. 1. 7/15.6, Second Indian Conference on Research in National Income, Delhi, 1960 (mimeographed) from a demand regression of the usual form : the logarithm of per capita wheat consumption (1924-25 to 1941-42) on the logarithm of the price of wheat deflated by the wholesale price index for all commodities and the logarithm of per capita income. Messrs. B. K. Barpujari and Kailash Chandra ("Consumer Demand for Important Commodities in the Third Five-Year Plan," Paper No. ICRNI/P. 1. 8/25.8, Second Indian Conference on Research in National Income, Delhi, 1960 (mimeographed)) estimated the price elasticity of the per capita physical consumption of cereals with respect to the wholesale price of cereals deflated by the all-India cost of living index to be —.19 and with respect to per capita disposable income deflated by the same index to be +.50 using all-India data for 1950-51 to 1957-58. Cross-section studies of National Sample Survey data during 1952-1956 also revealed the elasticity of the per capita consumption of cereals with respect to total consumer expenditure per capita to be .41 in the rural areas (A. K. Bisvas and D. K. Bose, "Consumption Projections of Selected Items over the Period of Third Five-Year Plan," Paper No. ICRNI/P. 16/16.7, *Ibid.*). On the basis of these estimates it seems reasonable to assume that the price elasticity of wheat consumption ranges from —.2 to —.4 and the income elasticity from .5 to .8.

It should be noted that in our model P is defined simply as the relative price of wheat whereas the estimates chosen relate to the elasticity of supply with respect to the price of wheat deflated by

An important outcome of the calculations shown in Table I is that e is never negative so long as the substitution effect is non-zero. If we regard the farmers whose income elasticity of the consumption of wheat is as high as .8 and whose wheat revenue forms as much as 70 per cent of income as "subsistence farmers" the elasticity of even their marketable surplus varies from 0.1 to 2.3. It is also clear that given plausible values of the other parameters ($g \neq 0$) the elasticity of the market supply varies inversely as the initial sale ratio. In other words, the elasticity is higher in the case of "subsistence" farmers who initially consume a high proportion of their wheat output than in the case of "commercial" farmers who consume a small part. This is the opposite of what is commonly supposed to be true in the current literature.

We can conclude, then, that the market supply function is likely to be perverse in the circumstances (3-ii) when the elasticity of output, b, itself is negative and the elasticity of consumption d is positive. But if b is positive, albeit small, the likelihood of a perverse market supply behaviour is extremely small ; it arises only if $g = 0$ and m is in the middle range, as in the last row of the Table.

The depletion of the market supplies of food crops due to crop failures is often misinterpreted as a reflection of a backward sloping market supply function. Thus the perversity of the weather is construed as the perversity of the peasant. Our analysis is a warning against such misinterpretations.

When adequate data about market supplies are available the parameters of properly specified and estimated market supply functions may reveal the backward sloping market supply function to be as rare as the backward sloping total output functions for individual crops.

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an index of the price of alternative crops and the elasticity of demand with respect to the price of wheat deflated by an index of wholesale prices or the cost of living index. Thus the empirical elasticities of supply and demand can only be supposed to be approximations to the elasticities with respect to the P of the model. Also, the empirical g is not the strict elasticity of substitution effect. But we have only used ranges in our argument.

It may also be noted that we have not lagged the price variable in the total output function though, strictly speaking, it should be lagged or be some weighted average of past prices approximating the expected price to which the farmer responds as a producer. If the price in the output function was defined as P_{t-1} and the price in the home consumption function as P_t, the marketable surplus would be a function of P_t as well as P_{t-1}.

This would, of course, be a more realistic market supply function than equation (7). But it would not significantly affect the general conclusions of this note nor the orders of magnitude of the elasticity of market supply derived on our alternative assumptions.

Family budget studies of wheat farmers in the Punjab show that the proportion of the wheat output consumed varies from 60 to 80 per cent. The sale ratio should, therefore, range from .2 to .4. These studies also show that the range of values of k, the ratio of wheat revenue to total income may vary from 10 to 70 per cent.

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