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RESEARCH NOTES

THE IMPACT OF TARIFF PROTECTION ON SUGARCANE ACREAGE IN INDIA—1921-1940: A CASE STUDY OF ACREAGE RESPONSE IN THE UNITED PROVINCES*

Objective

This paper examines the effect of tariff protection to the Indian sugar industry in the 1930s on acreage under sugarcane. Acreage movement observed a cyclical pattern after the introduction of protection in 1931. It will be shown that these movements were a function of sugarcane prices. Since the object of protection was to maintain or increase sugarcane prices to the cultivator, it is argued that protection itself contributed to acreage instability during this period.

The Background

Tariff protection was extended to the Indian sugar manufacturing industry in 1931 as an indirect form of assistance to cultivators of sugarcane, at a time of acute agricultural depression. During the 1920s India was a net importer of white sugar. Between 1920-21 and 1930-31, an annual average of 2.61 million acres were cultivated under cane—mostly in the United Provinces (U.P.). The bulk of the sugarcane output was however converted into raw sugar (*gur*) for rural consumption. The white sugar manufacturing industry operated on a very small scale; by 1930-31 only 29 factories existed, producing 120,000 tons of sugar.

The object of protection was to stimulate the growth of the manufacturing sector so as to increase profitable outlets for the sugarcane crop, at a time when prices of most agricultural commodities were declining. To achieve this, a prohibitive tariff of Rs. 7-4 annas per cwt. was levied in 1931, which, supplemented by a 25 per cent revenue surcharge, represented an *ad valorem* rate of 190 per cent on imported sugar. The factory sector responded immediately to this stimulus, such that by 1939-40 the number of factories had risen to 140 (with a heavy concentration in the U.P.), whereas by 1937-38 imports of sugar had almost disappeared. Acreage under sugarcane expanded dramatically to as high as 4.22 million acres by 1936-37. Sugarcane crushed in factories increased from 1.78 million tons in 1931-32 to 11.69 million tons by 1936-37. Sugar produced from this cane increased from 0.16 million tons to 1.11 million tons during this period.

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To ensure that sugarcane cultivators received the benefits of protection to the white sugar industry, the Provincial Governments of U.P. and Bihar introduced minimum price fixation in 1934. Cane prices were linked to the price of sugar and the extraction percentage,[1] and bore no relation to either the cost of cultivation of the crop or prices of alternative crops.

The acreage under sugarcane in India rose continuously until 1936-37. It then collapsed, falling to nearly its pre-protection level. Cyclical fluctuations followed, creating problems for the industry. In peak years growers were seen to have burned large areas of crop, or left cane standing in the fields, and the authorities had to rally round with cash relief.[2] Conversely, in trough years there was an acute scarcity of cane and factories had difficulty in obtaining supplies. The President of the Indian Tariff Board felt that the benefits of protection were being undermined by this instability, stating: "We seem to be getting into a vicious circle in regard to cane. In some years there is over-production and the grower gets nothing for his cane and the next year the factories don't get sufficient cane at an economic price. From that point of view it is very desirable to stabilise the amount of cultivation."[3]

These acreage cycles appear to have carried well into the post-Independence period and have become a chronic feature of the Indian sugar industry.[4]

Against this background we take a closer, and quantitative, look at the instability of acreage under cane during the inter-war years. The analysis will, for convenience, be restricted to the U.P. Sugar and sugarcane production in the U.P. dominated aggregate Indian output throughout the inter-war years, and the shape of the acreage curve for the U.P. closely corresponds to the all-India curve.

The Problem

It would be incorrect to say that acreage under cane in India in pre-protection years was free from fluctuations. But fluctuations prior to 1931 tended to be smaller and irregular. After protection, they became regular and more

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1. By means of a formula: $C = \frac{S \times P}{200}$;
where C = minimum price per maund of cane, S = price per maund of sugar, P = average percentage of extraction. The object was to give cultivators a share of factory profits; the underlying principle being that the price of cane should represent half the selling price of the sugar manufactured from it.

See Evidence of the Government of Bihar; Report of the Indian Tariff Board on the Sugar Industry, 1939, Evidence, Vol. IIIA, p. 67.

2. Review of the Sugar Industry of India, October 31, 1941, p. 23 (Supplement to the *Indian Trade Journal*, December 21, 1944).

3. President's statement during the course of oral evidence; Indian Tariff Board, 1938, Evidence, Vol. IV, p. 232.

4. See Report of the Committee on Rehabilitation and Modernisation of Sugar Factories in India, Government of India, 1965, Parts I and II, p. 9; Report on the Cost Structure of the Indian Sugar Industry and the Fair Price for Sugar, Indian Tariff Commission, Bombay, 1969, Chapter 3, especially pp. 13-14, including Table 3.1; and P. C. Joshi, "The Sugar Cycle: A Diagnosis, *Sankhya*, Series B, Vol. 35, Part 4, December, 1973, pp. 427-450.

systematic; their periodicity moreover lengthened to an approximate four-year cycle.

The instability of acreage before and after 1931 can be compared statistically. The coefficient of variation for all-India acreage under cane for the 11 years, 1920-31, works out to *0.0693*, which is noticeably lower than an estimated *0.1342* for the subsequent 11 years, 1931-42.

Next we test for equality of variances between the two periods. We test the null hypothesis (H_0) that $\sigma_I^2 = \sigma_{II}^2$ (I = pre-protection period; II = post-protection period), against the alternative (H_1) that $\sigma_{II}^2 > \sigma_I^2$. The test statistic is :

$$\frac{\hat{\sigma}_{II}^2}{\hat{\sigma}_I^2}, \text{ where } \hat{\sigma}_I^2 = \frac{\sum_{j=1}^{n} (y_{ij}-\bar{y})^2}{(N_1-1)} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad 1=I, II$$

The estimated F-ratio works out to 6.7. The critical value of F (10, 10 d.f's) for a one-tailed test is 2.98 with 95 per cent confidence. We therefore reject H_0 in favour of H_1, and conclude that in the post-tariff period, acreage fluctuations about the mean were *significantly* greater than in the pre-tariff period.

The question is whether there was a causal relationship between protection and acreage instability, and if so, in what way.

Protection was intended to provide growers with a profitable market for their cane, so that the acreage under cane would be maintained, if not increased, during a period of economic depression. Implicit in this logic was the expectation that cultivators' acreage decisions would be determined by *prices* of cane relative to other crops. We therefore examine the influence of prices on acreage movements before and after protection.

The influence of price movements on acreage was suggested at the time, by the Central Agricultural Marketing Department,[5] among others. The Department stated that prices of *gur*, and in factory areas, of cane, were the real determining factor. Farmers consistently over-reacted to price movements, and the resultant imbalances in supply and demand equilibrium induced further price movements. A cobweb cycle was therefore suggested—though not proved—with a duration of 3 to 5 years. It was not explained, however, why the cane crop, with a gestation period of about one year, should generate a cycle of such a periodicity.

5. Report on the Marketing of Sugar in India and Burma, Marketing Series No. 39, Delhi, 943, pp. 10-11.

Similarly, the Agricultural Department, Bihar, was apparently convinced that acreage movements in Bihar were influenced by prices—especially for gate-cane to the factories.[6]

The argument that cultivators in poor economies are responsive to price movements is substantiatd by numerous studies, including Dharm Narain,[7] Raj Krishna,[8] Kamala Devi and Rajagopalan,[9] Sinha, Sinha and Thakurta[10] Y. Satyanarayana,[11] and Dayanatha Jha.[12] However, as Lipton discusses,[13] there is a variety of peasant motivations; and a sensitivity to price tempered by a subjective notion of the supposed value or 'superiority' of one crop over another (as suggested by Gupta and Majid[14]) could equally fall within the definition of rational behaviour.

Two possible alternatives can be considered: (*i*) that peasants were sensitive to actual *movements* in prices, in making their acreage decisions; (*ii*) that they were influenced more by the level of prices than by their exact movements, *i.e.*, in a situation where protection accompanied by minimum price fixation and increasing yields per acre had made cane a highly profitable crop during a period of general depression, minor variations in price would not necessarily affect the profitability of cane vis-a-vis competing crops.

It would be relevant to state that there was no significant increase in price fluctuations after protection. Testing for equality of variances between the pre-and post-tariff periods, produces an estimated F-ratio of 1.289 against the critical value of F (9, 9 d.f's of 3.2 at the 5 per cent level).

The Hypothesis

It is postulated that cultivators were influenced by both *gur* and sugarcane prices (relative to other crops). The *gur* sector accounted for the greater part of sugarcane acreage and output in the U.P., and since the cultivator converted cane into *gur* himself, the price of *gur* was the price actually received by him. However, the factory sector was not unimportant. In areas of

6. See Annual Reports of the Agricultural Department, Bihar, 1939-40, Patna, 1943, p. 55 and 1936-37, Patna, 1938, pp. 42-43.

7. Dharm Narain: The Impact of Price Movements on Areas under Selected Crops in India, 1900-1939, Cambridge Univesity Press, London, 1965.

8. Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region," *The Economic Journal*, Vol. LXXIII, No. 291, September, 1963, pp. 477-487.

9. P. Kamala Devi and R. Rajagopalan, "Price and Acreage Response (A Case Study of Groundnut Crop in North Arcot District)," *Indian Journal of Agricultural Economics*, Vol. XX, No. 1, January-March, 1965, pp. 31-35.

10. A. R. Sinha, H. C. Sinha and J. C. Guha Thakurta, "Indian Cultivators' Response to Prices," *Sankhya*, Vol. I, Parts 2-3, May, 1934, pp. 155-165.

11. Y. Satyanarayana, "Factors Affecting Acreage under Sugarcane in India," *Indian Journal of Agricultural Economics*, Vol. XXII, No. 2, April-June, 1967, pp. 79-87.

12. Dayanatha Jha, "Acreage Response of Sugarcane in Factory Areas of North Bihar," *Indian Journal of Agricultural Economics*, Vol. XXV, No. 1, January-March, 1970, pp. 79-91.

13. Michael Lipton, "The Theory of the Optimising Peasant," *Journal of Development Studies*, Vol. IV, No. 3, April, 1968.

14. S. C. Gupta and A. Majid: Producers' Response to Changes in Prices and Marketing Policies, Agricultural Economics Research Centre, University of Delhi, 1965, Chapter IV and p. 51.

factory concentration, the price of gate-cane was affected by the fixation of minimum prices. These floor prices, being linked to the price of white sugar, and announced in advance of the season, created the semblance of a 'perfect' market for cane in these areas. In normal times, growers located nearby preferred to sell cane to the factories,[15] partly for convenience, and partly because minimum prices were pegged at relatively attractive levels.[16] Consequently, cultivators would appear to have responded more to the level of gate prices than to their movements. In effect, their response was to factory *demand* for cane (given the price). Dharm Narain has given this demand, on a qualitative plane, the status of a "leading impulse."[17] Thus, though the proportion of cane used for sale to factories averaged less than 20 per cent of the total during the period, its influence, he argues, may have been somewhat stronger.

Price support measures often tend to stabilise agricultural crop cycles,[18] but in the U.P. the problem was that when over-production occurred, these prices could not be held. Surplus could not be purchased and stored, and storage facilities for sugar were very limited. Factory demand for cane was not infinitely elastic, since consumer demand for sugar was itself price-inelastic, and since India was not allowed to export sugar.[19] Therefore, when sugar prices fell, factories could (as in 1936-37 and 1939-40) force down the floor price of cane by refusing to crush cane in mid-season.

In the model (below), deflated *gur* prices will be used to represent the price variable. Firstly, it is difficult to introduce demand as an explicit variable. Secondly, there was an inter-relation between factory demand and *gur* prices. The mechanism of the post-Independence crop cycle[20] appears to have some relevance to the 1930s. In the upswing of the cycle, factory demand for cane was high, gate prices were attractive, and *gur* prices remunerative, so that more land was brought under cultivation of cane. Ultimately, sugar output exceeded its demand, factory demand for cane fell off, and cane was diverted into *gur* production. *Gur* demand also being price-inelastic, *gur* prices declined, inducing a downswing in the cycle, with a contraction in area under cultivation. Ultimately, there would be a shortage of sugar and demand for *gur* (a one-way substitute) would rise. *Gur* prices would rise, factories would also bid for scarce cane supplies, and the upswing in acreage would begin again.

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15. See Dharm Narain: *op. cit.*, pp. 102-104.
16. See the evidence of the ISMA, which claimed that in its experience factory-gate prices of over 5 annas a maund for cane led to "too much enthusiasm amongst the agriculturalists to grow sugarcane." Indian Tariff Board, 1938, Oral Evidence, Vol. IV, p. 59.
    Gate prices were just over 5 annas during much of the 1930s.
17. Dharm Narain: *op. cit.*, p. 105.
18. See F. V. Waugh, "Cobweb Models," in Karl A. Fox and D. Gale Johnson (Eds.): Readings in the Economics of Agriculture," American Economic Association, Richard D. Irwin, Inc., Homewood, Illinois, U.S.A., 1970, especially pp. 98-100.
19. Under international agreement.
20. See P. C. Joshi, *op. cit.*

The inter-relation between price and acreage, with a one-year gestation lag, portrays, according to Dharm Narain, "in essentials the working of the cobweb theorem."[21] The periodicity of his cycle (3-5 years) is not consistent with the length of the gestation period. However, it is consistent with the above hypothesis. Thus, cultivators do not *immediately* react to movements in *gur* prices—either up or down. Firstly, though *gur* prices might decline relative to other crops, cane could yet remain a profitable crop, and acreage continues to rise until prices fall to definitely unprofitable levels. The resultant collapse would then be more spectacular; farmers would have difficulty in disposing of their produce, and crops might end up being left standing in the fields or even burnt.[22] Consequenly, a greater pessimism would follow, and the farmers' initial reaction to a revival in prices would be tentative. Secondly, there would, in any case, be constraints on adjustment to price movements, since acreage expansion would involve decisions regarding the allocation of scarce inputs such as fertilizers and irrigation water between cane and alternative crops; and such decisions—once taken—would not be instantaneously reversible.

The Model

The hypothesis suggests the use of a distributed lag model. We intend to examine acreage response to price in the inter-war period, using a basic Nerlovian "adjustment" model.[23] The period will then be sub-divided into two—1921-22 to 1930-31 (Period 1: prior to protection), and 1931-32 to 1940-41 (period 2: post-protection)—for purposes of comparison.

Though distributed lags may be the result not only of adjustment constraints but also of expectational factors, it is extremely difficult to specify separate lag coefficients for adjustment and expectational variables.[24] Therefore, a choice must be made at the outset. Both approaches yield the same reduced form,[25] but problems of serial correlation are simplified in the use of the adjustment model. For convenience, we therefore assume the 'adjustment' approach.

The basic functional form is :

$$(1) \quad Y^*_t = a + bP_{t-1} + cZ_{t-1} + dR_t + eS_{t-1} + u_t$$

where, Y^*_t = acreage under cane that farmers would plant in time 't', if there were no difficulties in adjustment (thousand acres),

21. Dharm Narain: *op. cit.*, p. 101.
22. This actually occurred in parts of the U.P.
23. Marc Nerlove: The Dynamics of Supply: Estimation of Farmers' Response to Price, Johns Hopkins University Press, Baltimore, 1958, and Distributed Lags and Demand Analysis for Agricultural and Other Commodities, United States Department of Agriculture, Washington, D.C., 1958.
24. See Raj Krishna, *op. cit.*, p. 480, and Marc Nerlove: The Dynamics of Supply, *op. cit.*, pp. 236-240, for a discussion of the difficulties involved.
25. See Carl F. Christ: Econometric Models and Methods, John Wiley & Sons, Inc., New York, 1966, pp. 204-208.

P_{t-1} = price of *gur* deflated by the Index of Agricultural Prices; time 't—1' (Rs. per maund),

Z_{t-1} = yield of sugarcane; time 't—1' (lbs. per acre),

R_t = rainfall in February-March (inches),

S_{t-1} = sugar production by vacuum pan factories in India (thousand tons); time 't—1',

u = error term.

$$(2)\ Y_t - Y_{t-1} = \beta\ (Y_t^* - Y_{t-1}) \quad \ldots \quad \ldots \quad \ldots \quad 0 < \beta < 1$$

where Y_t = acreage *actually* planted under cane; time 't',

β = the coefficient of 'adjustment,'

i.e., farmers are able to increase their acreage under cane in any year only by (a fraction) β of the difference between the acreage they would like to plant and the acreage actually planted in the preceding year.

(1) and (2) yield the reduced form:

$$(3)\quad Y_t = a_0 + a_1 P_{t-1} + a_2 Z_{t-1} + a_3 R_t + a_4 S_{t-1} + a_5 Y_{t-1} + v_t$$

where, $a_0 = a\beta$, $a_1 = b\beta$, $a_2 = c\beta$, $a_3 = d\beta$, $a_4 = e\beta$, $a_5 = 1 - \beta$, and $v_t = \beta u_t$.

The advantage of the adjustment model over the expectational model is that if v_t is found to be serially uncorrelated, then since $v_t = \beta u_t$, u_t is also serially uncorrelated.[26]

The inclusion of Z, R and S is to test the influence of non-price variables, and to see if, as Raj Krishna suggests, the inclusion of appropiate non-price variables improves the specification of the model.[27] The inclusion of Z is because cane yields increased greatly during the period, and because fluctuations in yields reflected the presence of such factors as crop pests and disease, climate and irrigation facilities. R is explicitly included however because it has not been lagged. It represents rainfall during the months of heaviest sowings in the U.P. S has been included to see whether growers were influenced by va-

26. The expectational model would start with :

$$P_t^* - P_{t-1}^* = \beta\ (P_{t-1} - P_{t-1}^*),\ 0 < \beta \leq 1$$

yielding virtually the same reduced form as equation (3). But the error term $w_t = u_t - (1 - \beta)\ u_{t-1}$; so that if u_t is assumed to be serially uncorrelated then w_t is automatically serially correlated.

27. Raj Krishna, *op. cit.*, p. 486.

riations in factory output. Due to data difficulties, all-India figures have been used, and too much significance should not be attached to its behaviour. See the Appendix for details of data.

Estimates

Multiple regression coefficients of equation (3), with combinations of variables are presented in Table I. Problems of multicollinearity prevent the presentation of all variables together in a single equation.

The equations must be tested for serial correlation in the disturbance term. As Griliches has shown[28] the Durbin-Watson statistic cannot be used in a distributed lag model, for it is seriously biased towards the null hypothesis. However, Durbin's 'm' statistic has been shown to be reliable and possessing virtually no small sample biases.[29] We have accordingly tested for serial correlation using the 'm' test.

The initial set of regressions have been run for the period 1921-22 to 1940-41, with a Dummy[30] included to differentiate between pre-and post-tariff decades. The two decades (1921-22 to 1930-31, and 1931-32 to 1940-41) have then been run as separate sets of regressions.

Table II gives estimates of short-run and long-run price elasticities of supply, together with the adjustment coefficients, β.

The initial set of regressions (Period 1 + 2) brings out the significance of the price variable. All equations here exhibit a good fit, and the Dummy in equations (3) and (6) suggests a significant difference between Periods 1 and 2, worth investigating further. The two periods are then examined separately. All regressions in Period 1 are poorly determined; all, in Period 2, are well determined. It is interesting that the price variable is insignificant in the pre-tariff period, but highly significant *after* protection. Also that the size of its coefficient increases between comparable equations [say (*i*) and (*a*)], and hence an increase in elasticities of response.

28. Zvi Griliches, "Distributed Lags: A Survey, " *Econometrica*, Vol. 35, No. 1, January, 1967, pp. 16-49, especially p. 36.

29. The procedure for the Durbin 'm' test is to regress the calculated OLS residual Z_t on the lagged residual and the set of pre-determined variables.

If $y_t = a_0 + a_1 x_t + a_2 y_{t-1} + u_t$ .. .. (*i*)

then $z_t = b_0 + b_1 x_t + b_2 y_{t-1} + b_3 z_{t-1} + v_t$ .. .. (*ii*)

If b_3 is not significantly different from zero, the hypothesis of no serial correlation in (*i*) is accepted. Byron G. Spencer has shown through simulated experiments that the 'm' statistic is reliable and preferable to the alternative Durbin-'h' statistic, which possesses small sample biases, and cannot be calculated if sampling fluctuations cause the denominator of

$$h = 1 - \frac{1}{2} d \sqrt{\frac{N}{1 - N\hat{V}(a_2)}}$$ to go negative.

See B. G. Spencer, "The Small Sample Bias of Durbin's Tests for Serial Correlation," *Journal of Econometrics*, Vol. 3, 1975, pp. 249-254.

30. Adopting the values 0,0,0,......, 0 for the pre-tariff period and values of 1,1,1,...., 1, for the post-tariff period, with an appropriate intercept.

TABLE I—ESTIMATED ACREAGE RESPONSE FUNCTIONS FOR SUGARCANE

Period	Equation	Constant	Deflated *gur* prices P_{t-1}	Yield Z_{t-1}	Rainfall R_t	Sugar production S_{t-1}	Dummy D	Lagged acreage Y_{t-1}	R^2	Serial correlation Durbin-'m' test
Period	(1)	—952.3	193.6	0.15				0.82	0.76	No S.C.
(1 + 2)		(—2.34)	(3.75)	(1.11)				(3.61)		
1921-22	†(2)	302.7	117.1	0.23		0.60		0.02	0.83	No S.C.
to		(0.46)	(2.05)	(1.84)		(2.25)		(0.06)		
1940-41	(3)	—446.5	177.2	0.02			280.3	0.68	0.81	No S.C.
		(—1.00)	(3.71)	(0.11)			(2.05)	(3.12)		
	(4)	202.1	131.4	0.13		0.41	158.6	0·19	0.83	No S.C.
		(0.30)	(2.22)	(0.79)		(1.26)	(0.96)	(0.43)		
	*(5)	—543.9	134.6	0.21	16.8			0.63	0.72	No S.C.
		(—1.07)	(1.98)	(1.43)	(0.30)			(2.24)		
	*(6)	—199.6	140.5	0.08	43.2		275.5	0.50	0.78	No S.C.
		(—0.39)	(2.23)	(0.52)	(0.80)		(1.85)	(1.87)		
Period 1	(*i*)	505.1	57.3					0.45	0.16	No S.C.
(Pre-tariff)		(0.63)	(0.87)					(1.09)		
	(*ii*)	560·0	19.5	0.3				0.08	0.23	No S.C.
		(0.68)	(0.24)	(0.79)				(0.13)		
	(*iii*)	375.2	82.2			2.6		0.36	0.28	No S.C.
		(0.46)	[(1.18)			(1.02)		(0.86)		
	(*iv*)	434.2	50.5	0.22		2.28		0.10	0.32	No S.C.
		(0.50)	(0.54)	(0.55)		(0.80)		(0.15)		
	(*v*)	947·0	—(45.3)		51.6			0.13	0.25	No S.C.
		(0.98)	(0.66)		(0.87)			(0.23)		
Period 2	(*a*)	—547.9	253.8					0.72	0.78	No S.C.
(Post-tariff)		(—1.06)	(4.27)					(3.65)		
	(*b*)	—841.6	273.8	0.13				0.63	0.80	No S.C.
		(—1.3)	(4.15)	(0.8)				(2.68)		
	(*c*)	—443.1	245.7			0.04		0.67	0.78	No S.C.
		(—0.44)	(2.71)			(0.13)		(1.44)		
	(*d*)	—332.9	232.8	0.21		0.31		0.22	0.82	No S.C.
		(—0.33)	(2.55)	(1.02)		(0.69)		(0.35)		
	**(*e*)	—848.5	313·0		52.7			0.71	0.72	S.C. detected
Adjusted		(—1.02)	(2.61)		(0.42)			(2.61)		
	‡(*e'*)	—150·0	315.7		143.9			0.32	0.66	
		(—0.27)	(4.59)		(2.35)			(1.56)		

Note:— Figures in brackets are t-ratios.
* Period is 1921-22 to 1939-40.
**Period is 1931-32 to 1939-40.
† Computer indicates presence of multicollinearity.
‡ Equation (*e*) recomputed by Cochrane-Orcutt method, adjusting for serial correlation.

TABLE II—ESTIMATED COEFFICIENTS OF ADJUSTMENT (β) AND PRICE ELASTICITIES OF ACREAGE

Period	Equation No.	Adjustment coefficient (β)	Elasticity	
			Short-run	Long-run
Period (1+2)	(1)	0.28	0.55	1.96
	(2)	0.98	0.33	0.34
	(3)	0.32	0.50	1.57
	(4)	0.81	0.37	0.46
	(5)	0.37	0.38	1.03
	(6)	0.50	0.40	0.80
Period 1	(*i*)	0.55	0.20	0.37
	(*ii*)	0.92	0.07	0.07
	(*iii*)	0.64	0.29	0.45
	(*iv*)	0.90	0.18	0.20
	(*v*)	0.87	0.16	0.19
Period 2	(*a*)	0.28	0.60	2.13
	(*b*)	0.37	0.64	1.74
	(*c*)	0.33	0.58	1.75
	(*d*)	0.78	0.55	0.62
	(*e*)	0.29	0.71	2.46
	(*e'*)	0.68	0.72	1.06

The size of the adjustment coefficient (Table II) declines after protection, with the lagged acreage variable becoming statistically significant in some equations (Table I). Firstly, an inter-relation between acreage and price is suggested. After protection, price determines acreage and price is determined by acreage. Secondly, after protection, cultivators appear to respond more to the level of prices than to actual movements in prices.[31] Non-price varibles appear to play no significant role in any equation save (*e*), which when adjusted for serial correlation produces a significant rainfall variable. It is difficult to determine how much credence should be given to this result, since rainfall is an insignificant variable in equations (5) and (6). If it is accepted at face value, and given that rainfall appears insignificant in Period 1, a plausible argument is that as farmers became increasingly price sensitive they started taking advantage of favourable weather conditions.[32]

The results are consistent with the earlier hypothesis. Prior to protection, prices of wheat and rice, which competed for acreage were relatively attractive. After 1931, with yields improving, demand for cane increasing, and prices of alternative crops affected by the depression, sugarcane became a relatively more attractive crop to cultivate.

31. This interpretation is derived from Koyck's pioneering work on distributed lags. See L. M. Koyck: Distributed Lags and Investment Analysis, Amsterdam, 1954, especially p. 109.

If $Y_t = a + bP + cY_{t-1}$ (Y=acreage, P=price), then, as c tends to unity, the equation can be re-expressed as :

$Y_t - Y_{t-1} = a + bP$, suggesting that acreage responds to the level of price. As c tends to zero the converse would be true.

32. Dayanatha Jha uses such an argument in explaining his model for North Bihar, *op. cit.*

Low adjustment coefficients reflect constraints on the cultivators' response to price. However, expectational lags may also have been working, probably resulting from the inter-relation with the organized sugar market. As Dharm Narain suggests, "Delayed reactions on the part of the farmer, the fact that he clings a year longer to the optimism generated by a high price and extends the sown area even when a reversal in the price situation sets in, lengthen the duration of the cycle."[33] Distributed lags therefore provide a plausible explanation of the periodicity of the cycle, which—after all—was longer than the gestation period of the crop.

The Durbin 'm' test suggests the absence of serial correlation in all regressions but (*e*), which has been recomputed by the Cochrane-Orcutt method (adjusting for serial correlation). As a further check, all the other regressions were similarly recomputed, and the results were found to be consistent with those in Table I.

Possibly, our choice of the deflator of *gur* prices (Index of Agricultural Prices) is not entirely appropriate, as it includes non-competing crops. All the equations were re-run using a new price variable, in which *gur* prices were deflated by wheat prices alone (wheat being a major competing crop in the U.P.). It was found that the results were entirely consistent with the estimates in Table I.

Conclusion

The results are consistent with the hypothesis that a causal relationship existed between protection and acreage instability, operating through the price variable. In essence, therefore, the scheme of substantive tariff protection to the white sugar industry generated instability in sugarcane acreage through the operation of factors inherent in its logic and objectives. The Indian Tariff Board, which was responsible for the scheme, was clearly concerned about this instability and considered it undesirable in the context of their dual objective—to assist the cultivator, and to promote the development of the manufacturing industry. To this extent the scheme of protection proved self-defeating.

DILEEP M. WAGLE*

APPENDIX

Data for the statistical analysis were mainly derived from: (1) Dharm Narain: The Impact of Price Movements on Areas under Selected Crops in India, 1900-1939, *op. cit.* and (2) George Blyn: Agricultural Trends in India, 1891-1947: Output, Availability and Productivity, University of Pennsylvania Press, Philadelphia, U.S.A., 1966.

More specifically, sugarcane acreage figures for the U.P. (Y_t and Y_{t-1}) from (1), Statistical Appendix, Table 24, p. 196 (generally consistent with figures in (2), Appendix, Table 3A, pp. 283-284).

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33. Dharm Narain: *op. cit.*, p. 102.

* Senior Economist, Tata Economic Consultancy Services, Bombay.

Deflated *gur* prices (P) from (1), Appendix, Table 27, p. 201. They refer to prices at Cawnpore and the deflator is the Index of Agricultural Prices for the corresponding period. Yield of sugarcane per acre (Z) from (1), Appendix, Table 28, p. 202 (consistent with (2), Appendix, Table 3A). Rainfall (R) from (1), Table 29, p. 203. Sugar production (S) from the Report on the Marketing of Sugar, Delhi, 1943, Appendix XXI, p. 300. The Dummy variable was incorporated as explained in a footnote to the text.

The entire regression analysis was conducted by computer. The Cambridge University's IBM 370 was used in conjunction with two programmes of the Department of Applied Economics: (*i*) REX, and (*ii*) M. H. Pesaran's 'Programmes for Small Sample Estimation of Dynamic Economic Models' (incorporating the Cochrane-Orcutt technique).

It was possible to use the REX programme to conduct the Durbin 'm' test. Residual variables were automatically generated in the different OLS estimates, and a simple procedure transforms them into lagged residuals.

RESOURCE PRODUCTIVITY IN RELATION TO FARM MECHANIZATION*

The evolution of high-yielding variety strains of foodgrains coupled with increased use of growth promoting inputs such as fertilizer and irrigation has brought an upward shift in the production function in Indian agriculture. The effectiveness of this new technology is dependent very much on timely, adequate and proper accomplishment of farm operations, where the traditional sources of power, that is, human and bullock, exclusively may prove to be a handicap. It is in this context that the mechanical source of power assumes paramount importance as an essential ingredient of the new high-yielding farm technology and the tractor, pumpsets, threshers, etc., are introduced on the farms to meet the increased energy requirement. The studies conducted so far have mainly been concerned with the impact of farm mechanization on labour employment with relatively low emphasis on examining the impact of farm mechanization on cropping pattern, crop yields, and resource productivity. In the present study an attempt is made to examine these aspects on sample farms operating at different levels of farm mechanization in Meerut district of Western Uttar Pradesh.

SAMPLE AND DATA

The input-output data pertaining to the agricultural year 1971-72 used in the present study are taken from a project "Impact of Farm Mechanization on Human and Bullock Labour Use in Two Regions of Uttar Pradesh" conducted by the Department of Agricultural Economics, G. B. Pant University of Agriculture and Technology, Pantnagar. In the project two districts, *viz.*, Meerut from Western region and Jaunpur from the Eastern region were selected as they had overall highest ranking performance with respect

* This paper is based on the thesis of the senior author, Jagdish Lal submitted under the guidance of Dr. L. R. Singh.