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APPENDIX 2

SIMPLE CORRELATION MATRICES WITH ADJUSTED DATA FOR FARM BUSINESS (CROP HUSBANDRY ONLY) ON THE FARMS IN SAHARANPUR AND MEERUT DISTRICTS OF WESTERN UTTAR PRADESH (1965-66)

	Real estate (Rs.)	Productive livestock (Rs.)	Operating capital (Rs.)	Machinery and implements (Rs.)	Family labour (days)	Hired labour (Rs.)	Returns (Rs.)
	X_1	X_2	X_3	X_4	X_5	X_6	Y
A. Paddy farms							
X_1	1.0000	—0.0092	0.5446	0.2853	—0.1702	0.4101	0.5172
X_2		1.0000	0.2753	0.0475	0.7071	—0.5010	0.4421
X_3			1.0000	0.4202	0.3107	0.0804	0.8844
X_4				1.0000	0.0547	0.1478	0.4443
X_5					1.0000	—0.8770	0.4751
X_6						1.0000	—0.0592
B. Sugarcane farms							
X_1	1.0000	0.6213	0.4552	0.4405	0.1921	0.4027	0.8202
X_2		1.0000	0.3454	0.7683	0.2678	0.2461	0.5745
X_3			1.0000	—0.1572	0.4615	0.1733	0.4773
X_4				1.0000	—0.0191	0.3070	0.6113
X_5					1.0000	—0.5694	0.0362
X_6						1.0000	0.5193
C. Wheat farms							
X_1	1.0000	—0.0512	0.5873	0.0871	0.3984	0.1085	0.7352
X_2		1.0000	0.0983	0.5084	—0.2355	0.2942	0.2153
X_3			1.0000	0.1663	0.2712	0.0948	0.7980
X_4				1.0000	—0.1201	0.2334	0.3078
X_5					1.0000	—0.2463	0.4855
X_6						1.0000	0.0853

ECONOMICS OF TRACTOR UTILIZATION*

Introduction

In spite of an increase in the number and rise in demand for tractors in agriculture in India during the last two to three decades, the need for large scale use of tractors on farms has remained a highly controversial issue. The present paper does not intend to resolve this issue, but seeks to shed some light on the economic efficiency of farm tractorisation in the context of the multiple cropping and high-yielding varieties (HYV) programme adopted by the State.

The principal objectives of the study are (*i*) to analyse the effects of tractorisation on cropping intensity, crop yields and adoption of high-yielding

*This paper presents some of the doctoral dissertation of the author, which was accepted by the Indian Agricultural Research Institute, New Delhi. The author is highly indebted to Dr. R. K. Patel, Head, Division of Dairy Economics & Statistics, National Dairy Research Institute, Karnal for his valuable guidance for this project.

Grateful thanks are also due to Dr. M. G. Pavaskar of Tata Economic Consultancy Services, and to the referees of the Editorial Board of this Journal for going through the script and making useful suggestions.

varieties; (*ii*) to analyse the effect of tractorisation on human labour employment; (*iii*) to determine the utilization and per unit cost of tractor power according to the farm size; and (*iv*) to compare the different costs and profits for bullock and tractor operated farms according to the farm size.

Sample and Data

The Union Territory of Delhi has the highest number of tractors per thousand hectares of cropped area among the Indian States and Union Territories.[1] Of the five community development blocks of the Union Territory of Delhi, Alipur block had the highest number of tractors. Hence, Alipur block was selected for this study.

Four villages, namely, Alipur, Badli, Holambikalan and Holambi Khurd, which had the largest number of tractors operating in Alipur block formed the sample villages. For the selection of cultivators from these villages, multi-stage stratified random sampling was done from three farm size-groups, namely, small, medium and large.* Twenty tractor farms were selected from each size-group. Thus, in all 60 tractor holdings were selected for the study. The tractors used in the sample holdings were not of the same size. However, as the object of the study was mainly to analyse the effects of tractorisation, the lack of homogeneity with respect to the size of tractors used would not vitiate the results of the study. To provide a basis for comparison, an equal number of bullock operated holdings in the same villages and in the same size-groups was randomly selected. The total sample holdings selected for the study thus numbered 120. The data were obtained for the sample holdings for the agricultural year 1968-69.

The total cultivated area, irrigated area as per cent of total cultivated area for both the bullock and tractor operated farms are presented in Table I.

TABLE I—DISTRIBUTION OF IRRIGATED AREA

Size-group (hectares)	Type of farm	Total cultivated area (hectares)	Total irrigated area (hectares)	Irrigated area as per cent of cultivated area
Upto 6 ..	B	414.88	352.73	85.00
	T	555.97	432.42	77.70
6—10	B	816.66	680.76	80.30
	T	914.27	766.01	83.70
10 and above ..	B	1,312.10	988.40	75.30
	T	1,907.61	1,508.54	79.00
All farms	B	2,543.64	2,021.89	79.48
	T	3,377.85	2,706.97	80.10

B refers to bullock operated farms.
T refers to tractor operated farms.

1. See Indian Agriculture in Brief, Tenth Edition, Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India, 1970, pp. 30 and 41.

* Farms below 6 hectares—small, 6-10 hectares—medium and 10 hectares and above—large.

It can be observed from the table that on an average, the percentage area irrigated was nearly the same (80 per cent) on both the bullock and tractor operated farms. The differences in the proportions of irrigated area on the bullock and tractor farms of various size-groups were also not significant.

Findings

A. *Cropping Intensity*

The total cultivated area, cropped area and intensity of cropping for both the tractor and bullock operated farms in the sample are shown in Table II.

TABLE II—INTENSITY OF CROPPING ON BULLOCK AND TRACTOR FARMS IN THE SAMPLE FARMS OF ALIPUR BLOCK: 1968-69

(*hectares*)

Size-group (hectares)	Bullock farms			Tractor farms		
	Cultivated area per farm	Cropped area per farm	Intensity of cropping (per cent)	Cultivated area per farm	Cropped area per farm	Intensity of cropping (per cent)
Upto 6	3.39	5.64	166.05	4.55	8.51	187.00
6—10	6.68	11.03	164.90	7.49	12.56	167.84
10 and above	10.74	17.10	159.13	15.62	25.13	162.01
All farms	6.94	11.25	162.11	9.22	15.46	167.70

The intensity of cropping for the tractor owners was found to be 167.70 per cent whereas it was 162.11 per cent for the bullock farms. Analysis of variance technique revealed no significant difference in crop intensity between the tractor and non-tractor farms in the medium and large size-groups and also for all farms overall intensity. However, the cropping intensity was found to be significantly higher (at 5 per cent level of significance) for the tractor farms in comparison to those operated by bullocks for the small size-group of farms.

The intensity of cropping had an inverse relationship with farm size for both the tractor and bullock farms. For farms operated with bullocks, the correlation coefficient worked out to be —0.2682 which is significantly less than zero at 5 per cent level of significance. For the tractor farms the correlation coefficient was found to be —0.2735 which is significantly less than zero at 5 per cent level of significance. This shows that there was an inverse relationship between the farm size and intensity of cropping and it was found significant for the tractor farms as well as the bullock operated farms.

B. *Yield Rate of Important Crops*

The average yields per hectare of important crops on the tractor and bullock operated holdings according to the farm size are presented in Table III. The overall average crop yields per hectare were found to be higher on the tractor farms as compared to that on the bullock operated farms.

TABLE III—PER HECTARE YIELD OF IMPORTANT CROPS IN THE SAMPLE FARMS OF ALIPUR BLOCK

(*quintals*)

Size-group (hectares)	Bajra (L)		Bajra (H)		Maize (L)		Maize (H)		Wheat (L)		Wheat (H)		Sugarcane (*gur*)	
	B	T	B	T	B	T	B	T	B	T	B	T	B	T
Upto 6 ..	16.37	17.94†	28.13	27.74	17.52	17.82†	30.98	33.45†	22.29	25.50***	37.03	41.69***	12.08	11.66
6—10	14.91	14.85†	24.39	29.63***	18.54	18.68†	34.46	35.51†	24.35	25.91	36.19	39.90***	10.62	13.75†
10 and above	17.06	18.22†	24.91	29.22**	18.44	19.14†	34.58	35.92†	23.51	27.81**	36.43	43.58***	10.41	14.53†
All farms ..	15.93	17.23†	25.34	28.81***	18.17	18.59†	33.60	34.54	23.33	26.10	36.11	41.84***	10.92	14.16*

* Significant at 10 per cent level.
** Significant at 5 per cent level.
*** Significant at 1 per cent level.
† Test of significance could not be done due to less number of observations.
B = Bullock operated farms.
T = Tractor operated farms.
L = Local.
H = Hybrid/high-yielding.

't' test was applied to test the difference between yield per hectare for the tractor and bullock operated farms in different size-groups. It was found that the yields on the tractor farms were higher than the bullock operated farms at one per cent level for high-yielding wheat (all size-groups and all farms), hybrid bajra (medium farms and all farms only) and local wheat (small farms only). The yields of hybrid bajra and local wheat on the large tractor farms were found to be significantly higher at 5 per cent level. The yield of sugarcane (all farms) was superior on the tractor farms at 10 per cent level. The yields of local bajra, local and hybrid maize and sugarcane (medium and large farms) were not significantly different in two categories of farms. In the remaining cases the yield comparisons could not be tested statistically for want of requisite number of observations.

Higher yields on the tractor farms may be attributed to adequate tillage operations, timely sowing, precision in depth of planting and plant population control which are made possible due to the use of tractors.

C. *Adoption of High-Yielding Varieties*

The allocation of area to high-yielding varieties for two major crops of the region on the tractor and bullock farms is shown in Table IV.

TABLE IV—ALLOCATION OF AREA TO HIGH-YIELDING VARIETIES OF CROPS

(hectares)

Size-group (hectares)	Type of farm	Wheat		Bajra	
		Total area	Area under high-yielding varieties	Total area	Area under high-yielding varieties
Upto 6	B	61.07	26.66 (42.02)	17.20	10.52 (61.16)
	T	86.20	76.08 (88.26)	35.33	29.26 (82.82)
6—10	B	133.35	93.48 (70.02)	37.64	33.18 (88.15)
	T	132.94	113.11 (85.08)	41.68	41.68 (100.00)
10 and above	B	197.09	142.05 (72.07)	46.94	38.45 (81.91)
	T	262.85	261.23 (99.38)	75.48	71.83 (95.16)
All farms	B	391.51	261.19 (66.71)	101.78	82.15 (80.71)
	T	481.99	450.42** (93.45)	152.49	142.77* (93.62)

Note : Figures in parentheses indicate the percentage area under HYV to local area under the crop in the respective size-groups.
B refers to bullock operated farms.
T refers to tractor operated farms.
* Significant at 10 per cent level of probability.
** Significant at 5 per cent level of probability.

About 67 per cent of the total wheat area sown was allocated for the high-yielding wheat varieties on the bullock operated farms whereas 93 per cent of wheat area was accounted for by the high-yielding varieties on the tractor farms. Thus, on the tractor farms the high-yielding varieties of wheat accounted for a greater share in the wheat area. In the case of bullock operated farms a clear trend was observed, in the sense that the percentage share allocated to the high-yielding wheat increased with the size of farm. However, on the tractor farms the high-yielding varieties of wheat accounted for a greater share in the total wheat area on the large farms, followed by the small farms, while the medium farms accounted for the lowest percentage among the three size-groups.

Statistical analysis indicated that the tractor farms had higher acreage under the high-yielding varieties of wheat as compared to the bullock operated farms and the difference was significant at 5 per cent level of probability.

The proportion of area devoted to hybrid bajra on the bullock and tractor farms was found to be 80.71 per cent and 93.62 per cent respectively. The area under hybrid bajra did not show any clear trend with the farm size. It was highest on the medium farms and lowest on the small farms in the case of both bullock and tractor operated farms.

Statistical analysis indicated that the tractor farms had higher acreage under the high-yielding varieties of bajra and the difference was significant at 10 per cent level of probability.

D. *Human Labour Employment*

The utilization of human labour for farm business as a whole per hectare of gross cropped area according to different size-groups is given in Table V.

TABLE V—HUMAN LABOUR UTILIZATION IN SAMPLE FARMS OF ALIPUR BLOCK

(hours/hectare)

Size-group (hectares)	Bullock operated farms			Tractor operated farms		
	Family labour	Hired labour	Human labour	Family labour	Hired labour	Human labour
Upto 6	375.67	318.74	694.41	323.19 (13.97)	111.70 (64.95)	434.89 (37.37)
6—10	357.81	332.60	690.41	327.41 (8.50)	136.11 (59.08)	463.52 (32.86)
10 and above	349.81	459.20	809.01	226.46 (35.26)	361.89 (21.19)	588.35 (27.27)
All farms	355.35	364.79	720.14	287.68 (19.04)	203.24 (44.28)	490.92 (31.83)

Note : Figures in parentheses indicate the percentage decrease in labour utilization in relation to the bullock operated farms.

On an average, the bullock and tractor operated farms utilized 720.14 and 490.92 hours of human labour per hectare respectively. Hired labour

employment per hectare showed a positive trend with increase in the farm size for both the tractor and bullock operated farms. Family labour tended to decrease with increase in the farm size for the bullock operated farms. No such relation was, however, observed for the tractor farms even though the use of family labour per hectare was much lower on the large farms as compared to the small farms.

There has been a fall of total human labour employment to the extent of about 32 per cent on the tractor farms as compared to the bullock farms. The displacement effect of tractorisation on human labour was more in the case of hired labour except for the large farms where it was more for family labour. Thus, it is clear that tractorisation decreased human labour employment on the sample farms.

Tractorisation may lead to a higher demand for labour only with the introduction of multiple cropping in the nature of three or four crops per year. In Alipur block, however, there was little difference in the intensity of cropping between the bullock and tractor operated sample farms. Therefore, tractorisation resulted in displacement of labour. Unless the farmers in the region could grow three or more short duration crops per year per unit area, the scope to utilize human labour may not be vastly different between the tractor and bullock operated farms.

E. *Employment Pattern and Unit Cost of Tractor Power according to Size of Farm*

Tractor power costs can be divided into two categories, fixed and variable. Fixed costs which are independent of use, include depreciation, interest on investment, insurance, taxes and housing. Variable costs include fuel, lubrication, repair and operator costs.

For farm implements powered from the tractor, the tractor's fixed cost must be assigned to the operation of the implements. There is no agreed way for doing this, but the commonly adopted method is to charge by the hour of tractor time. Such a method apportions the fixed costs of the tractor among the implements according to the amount of use the implement has for the tractor. The operating costs of the tractor fuel, oil and labour, can also be assigned directly to the operation on an hourly basis.

The unit cost of tractor power and employment pattern of tractors according to farm size are presented in Table VI.

TABLE VI—PER UNIT COST OF TRACTOR POWER ACCORDING TO SIZE OF FARM

Size-group (hectares)	Average working hours per year	Average hours hired out per year	Fixed cost per hour (Rs.)	Variable cost per hour (Rs.)	Power cost per hour (Rs.)
Upto 6	374.79	34.18	6.3060	10.5840	16.89
6—10	671.79	35.44	3.8707	10.2495	14.12
10 and above	1243.46	9.25	2.3562	10.8069	13.16
All farms	763.34	26.29	4.1775	10.5425	14.72

The utilization of tractors taking all farms together was found to be about 763 hours a year as against the recommended norm of 1,000 hours a year by the tractor manufacturers. The variation, however, was very wide, the range being 375 to 1,243 hours. Tractor use per year increased with the farm size. The average working hours per year being only 375 for the lowest size-groups of farmers, correspondingly the fixed costs are also the highest for this size-class. The variable costs per hour varied within a narrow range from Rs. 10.25 to Rs. 10.80 for different size-classes. The fixity of a large part of maintenance cost of tractors resulted in a heavy burden of cost on the small sized farms. With respect to custom work the small farms and medium farms hired out tractors for 34 to 35 hours respectively, as against only nine hours for the large farms. There is considerable scope for more tractor custom work by the small and medium farms.

F. *Costs and Returns*

The economic efficiency of tractor use depends on the comparative analysis of costs and returns for the tractor operated farms vis-a-vis those for the bullock operated farms. The concept of costs and incomes adopted for this analysis were as follows :

Costs

(*i*) *Cost* A_1 includes value of hired human labour, value of hired and owned bullock/tractor labour, value of seed, value of manures and fertilizers, value of pesticides, irrigation charges, land revenue, depreciation, interest on working capital.

(*ii*) *Cost* A_2 includes Cost A_1 plus rent paid for leased-in land.

(*iii*) *Cost B* is Cost A_2 plus rental value of own land plus interest on owned fixed capital (excluding land).

(*iv*) *Cost C* is Cost B plus imputed value of family labour.

Income

(*i*) *Farm business income* = Gross value of farm output—Cost A_1 (Cost A_2 in the case of tenant operated land).

(*ii*) *Family labour income* = Gross value of farm output—Cost B.

(*iii*) *Net income* = Gross value of farm output—Cost C.

The net incomes, family labour incomes and farm business incomes for the sample bullock and tractor operated farms of three selected sizes are presented in Table VII.

TABLE VII—MEASURES OF FARM PROFIT FOR BULLOCK AND TRACTOR OPERATED FARMS OF THE SAMPLE VILLAGES IN ALIPUR BLOCK

Size-group (hectares)	Income (Rs.)					
	Net		Family labour		Farm business	
	B	T	B	T	B	T
Upto 6	36.07	44.87 (24.40)	272.74	248.48 (—8.90)	762.92	985.07 (29.11)
6—10	449.14	603.65 (34.40)	674.56	809.92 (20.05)	1,107.47	1,422.84 (28.48)
10 and above	271.62	579.18 (113.34)	491.86	721.85 (46.75)	937.86	1,255.42 (33.86)
All farms	259.62	412.25 (58.78)	483.49	593.49 (22.75)	939.23	1,221.18 (29.93)

B = Bullock operated farms.
T = Tractor operated farms.
Note: Figures in parentheses indicate per cent increase over bullock farms.

The table reveals that all the measures of farm returns were higher for the tractor farms of all size-groups. The only exception was the family labour income for the small farms. The difference in net income between the tractor and bullock operated farms was the highest for farms in the large size-groups. Though such difference was smaller for the medium size farms, the net income on the tractor operated medium size farms was, in fact, even higher than that of the large size farms. It, therefore, appears that the tractor operated farms were economically more efficient than the bullock operated farms especially in the case of farms of medium and large sizes.

Summary and Conclusion

To sum up, the main findings of the study are:

(1) The cropping intensity is significantly high for the small size tractor farms in comparison to those operated by bullocks.

(2) The average crop yields per hectare are higher on the tractor farms than those on the bullock operated farms.

(3) The tractor farms devote a large share of the area to the high-yielding varieties as compared to the bullock operated farms.

(4) There is some displacement of human labour following tractorisation if there is no change in the cropping intensity.

(5) The total power cost on account of tractor use is higher for the small farms than for the large ones.

(6) The net farm returns are higher for the tractor farms than for the bullock operated farms.

The evidence presented in this paper clearly establishes the economic efficiency of tractor use on farms. However, to ensure that tractorisation does not lead to displacement of labour, it is necessary to increase the cropping intensity through rapid extension of multiple cropping programme. The use of tractors indisputably raises both the farm production levels and returns to farmers. With the envisaged legislation on ceiling of agricultural land, it may also be desirable to undertake more empirical studies on the subject with a view to suggesting a suitable size of tractor which will be more economical to the Indian farmer.

G. MOTILAL*

PRICING EFFICIENCY OF THE INDIAN APPLE MARKET†

Fruits, vegetables and agricultural processing industries have not got sufficient attention in marketing research programmes in India. Fruit and vegetable production is of vital importance as it provides three to four times more calories of energy and cash incomes than cereals per hectare of land. Thus fruit and vegetable crops hold a great promise for fostering economic growth particularly in the backward hilly areas of the country and improving the diet of the people. The fruit and vegetable industry can be immensely expanded provided the producers are assured of better marketing facilities and reasonable prices for their produce.

Interest in apple production has rapidly increased during recent years in India. Apple has a great commercial value. A gross income of more than Rs. 30,000 per hectare is no longer a surprise from a well maintained apple orchard.[1] However, in the absence of regulated markets for apple and insufficient knowledge of the private market system for this commodity, producers face a number of difficulties in the marketing of this fruit. It is observed that in spite of very close interdependence of inter-market price movements, there exist wide inter-and intra-market price spreads net of transport and other marketing cost in the channels of trade. Along with increased production and marketed supply, the consumers' price of apple has also increased whereas farm prices received by the producers over the years have remained almost static for commercial varieties and have fallen for inferior varieties of apple.[2]

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† This Research Note is based on the author's Ph.D. thesis, "Economic and Operational Efficiency in Marketing of Apples in India," Indian Agricultural Research Institute (IARI), New Delhi, 1971. The author gratefully acknowledges the financial support given by the Indian Council of Agricultural Research, New Delhi and guidance given by Dr. D. Jha, Economist, IARI, throughout the course of the study. Thanks are due to Miss Lakshmi Menon, Institute of Co-operative Management, Ahmedabad, for secretarial assistance during the preparation of the manuscript.

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