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RESEARCH NOTES

A Study in Estimation of Linkages for Crop-Cattle Production Activities in Haryana

The positive shifts in agricultural production over time could be attributed to several institutional, economic and technological factors. Nevertheless, changes in agricultural sector have a great bearing on the changes in the livestock sector due to the complementary relationships between these two. Several farm surveys carried out in different parts of the country over the years show that about 20 to 30 per cent of the total working time of farm workers is spent on maintenance of livestock and related activities (Mishra and Sharma, 1990). Livestock is a renewable, natural resource, while petroleum based energy is non-renewable and exhaustible.

Dependence of crop production on animal draught power and manure and of milk production on green fodder and crop by-products are endowed with technical complexities which preclude any strategy development of one of the sectors in isolation (Mishra, 1978). Actually lack of such mutual exclusiveness gives rise to the fact that the regions which are endowed with developed crop husbandry are also rich in livestock production. Haryana is one such state in India where fast agricultural growth has improved feed and fodder availability specially of the concentrates and dry fodder as crop by-products (Arya, 1987). It thus created conditions for improvement in the productivity of livestock and reduction in their numbers (Arya and Rawat, 1989, 1990).

Many studies covering the Punjab-Haryana region have also reported important linkages between crop-cattle enterprises at farm level which, in effect, provide non-cash cost sharing and use of resources whose opportunity cost is zero or negligible (Dhawan and Johl, 1967; Kahlon and Aggarwal, 1967; Katiyar and Ranjan, 1972; Kahlon *et al.*, 1975; Saini, 1975; Patel, 1981).

The impressive temporal growth rates in agricultural and livestock sectors are, however, composed of several uneven growth rates in different districts, owing to inter-district variations in resource endowments in Haryana (Gupta, 1985; Bhalla and Tyagi, 1989). The present study is thus an attempt to examine the extent to which the pace and pattern of agricultural growth has succeeded in altering linkages between crop and livestock sectors at district level for one of the high growth states in the country.

METHODS AND MATERIAL

The Data

The study is based on published and unpublished secondary data for a period of 15 years (1966-67 to 1980-81).

The following estimations were used in generating the district level data, not readily available, for measuring linkages.

Cultivated green fodder: Production figures of various green fodder crops for the period from 1966-67 to 1980-81 were not readily available. In order to arrive at the production figures, the average yields of various fodder crops were obtained from the Haryana Agricultural University and from the offices of "Intensive Cattle Development Project" in various districts. These figures forming the average yields of different fodder crops were used to

estimate the temporal availability of cultivated fodder for all districts and the state.

Crop residues: The dry fodder availability over time was similarly estimated on the basis of the assumption of a fixed technical ratio between the output of straw or crop residues with that of the grains. These technical ratios vary from crop to crop and also for different varieties of the same crop. This necessitated separate working out of the ratios for local and high-yielding varieties (HYVs) of wheat, paddy, bajra, jowar and maize. The same was attempted, following Nirman *et al.* (1982). For the rest of the crops, ratios given in ICAR *Handbook of Agriculture* were taken as the basis for estimations.

Concentrates: Estimations of temporal availability of concentrates from different feeds were based on the coefficients generated in the *Report of the National Commission on Agriculture 1976* (Government of India, 1976).

Energy conversions: In order to estimate the total energy available from all sources of feeds and fodders, the available quantities were converted into total digestible nutrients (TDN) on dry matter basis. These were then converted into digestible energy (DE/Mcal/kg). These mega calorie (Mcal) figures of digestible energy were finally converted into mega jouls (MJ), following McDonald *et al.* (1973).

Bullock power: Information on bullocks was available only for the census years 1966, 1972 and 1982. Figures for other years were interpolated at the given growth rates between two quinquennial livestock census periods. For estimating energy value of bullock power, per pair of bullock was stipulated to create energy equivalent of 2,144 mega jouls per year of 100 working days, following Pathak (1982).

Manure: For estimation of manures, on an average, an yield of 8 kg wet dung per animal (cattle and buffaloes) per day for all age groups was assumed. About 70 per cent of it was assumed to be used as manure and 16 per cent of it was assumed to have dry matter content. It was converted into energy value on the basis of 0.3 mega jouls per kg of dry matter content of manure, following Pathak (1982).

Milk: Milk productivity data from organised farms, research institutes and University farms formed the basis for estimation of districtwise milk production over time. Besides, the annual data on average milk yield by cattle and buffaloes were also obtained from the office of Animal Husbandry Department of Haryana State. Finally, to fill the missing data gaps, interpolation was carried out (Arya and Rawat, 1990) on the secondary data from the organised sector farm data.

Methodology

To examine the degree of interdependence between crop and cattle sector, forward and backward linkages were studied, following Hirschman (1965).

The estimation of forward and backward linkages between crop and cattle production activities was preceded by generation of zero-order correlation matrix between all the variables considered in the present study for estimation of linkages. These included production of green fodder (X_1), dry fodder (X_2), concentrates (X_3), bullock power (X_4), manure produced by bovines (X_5), milk production (X_6) and production of principal crops (X_7). The zero-order correlation matrices were generated for all districts as well as for the state to identify the degrees of association between crop and cattle production activities. In determining the relative strength of the production linkage between crop and cattle production

activities, the methods suggested by Namboodiri (1979) were used.

Backward linkages from crops or cattle's forward linkages with crops were defined as total utilisation of resources provided by the livestock sector to the crop sector as a percentage of total output of the livestock sector. Similarly, crops' forward linkage or backward linkage in cattle production was defined as the total intermediates of crop sector to the livestock sector as a percentage of total crop output.

Thus backward linkage in sector j (livestock sector)

$$= \frac{\text{Total intermediate input of sector j}}{\text{Total output of sector j}}$$

$$= \frac{\text{Bullock power + manure of dairy sector}}{\text{Total livestock output (milk)}}$$

Similarly, the forward linkage in sector i (crop sector)

$$= \frac{\text{Total intermediate demand for the output of sector j}}{\text{Total demand for sector i}}$$

$$= \frac{\text{Green fodder + dry fodder + concentrates}}{\text{Total crop output}}$$

RESULTS AND DISCUSSION

In order to estimate the backward and forward linkages between livestock and crop production activities, the zero-order correlation matrix was run between the elements of crop production which can link themselves with livestock activity. A perusal of Table I would reveal that the crop sector elements (X_1, X_2, X_3, X_7) and the livestock sector elements (X_4, X_5, X_6) displayed a stronger degree of association uniformly for the district of Jind. There were inter-district variations in such associations for individual variates. For instance, green fodder (X_1) was strongly related to all livestock variates (X_4, X_5, X_6) for Jind and Rohtak districts, moderately for Gurgaon, Ambala and Hisar districts and weakly related with Karnal and Mahendragarh districts. The degree of association of availability of concentrates (X_3) with livestock variables was more strongly related in all districts except Mahendragarh and Gurgaon districts. In the case of bullock power (X_4) as well, there is a strong degree of association with all crop activities (X_1, X_2, X_3, X_7) in the districts of Hisar, Rohtak and Jind. Further, the degree of association of manure (X_5) with crop (X_1, X_2, X_3, X_7) is the strongest in all districts except Gurgaon and Rohtak. Similar tendencies were discernible for production of milk (X_6). As a result, the aggregate degrees of association in crop (X_1, X_2, X_3, X_7) and livestock (X_4, X_5, X_6) have emerged with consistent strength in all districts of the state. A minor exception to this is absence of relationship of green fodder with milk production which leads to the conclusion that milk production, by and large, is

TABLE I. SIGNIFICANT* DISTRICTWISE DEGREES OF ATTRIBUTES BETWEEN ASSOCIATION RELATED TO CROP AND LIVESTOCK ACTIVITIES IN HARYANA (1967-81)

District (1)	$X_{1,4,5,6}$** (2)	$X_{2,4,5,6}$ (3)	$X_{3,4,5,6}$ (4)	$X_{4,1,2,3,7}$ (5)	$X_{5,1,2,3,7}$ (6)	$X_{6,1,2,3,7}$ (7)	$X_{7,4,5,6}$ (8)
Hisar	4,5	4,5,6	4,5,6	1,2,3,7	1,2,3,7	2,3,7	4,5,6
Rohtak	4,5,6	4,6	4,5,6	1,2,3	1,3	1,2,3	-
Gurgaon	4,5	6	(-)4,6	1,(-)3	1	2,3	-
Karnal	5	5,6	(-)4,5,6	(-)2,(-)3,(-)7	1,2,3,7	2,3,7	(-)4,5,6
Ambala	5,6	(-)4,5,6	(-)4,5,6	(-)3	1,2,3	1,2,3	-
Jind	4,5,6	4,5,6	4,5,6	1,2,3,7	1,2,3,7	1,2,3,7	4,5,6
Mahendragarh	rh(-)5	5,6	5,6	-	(-)2,3,7	2,3,7	4,5,6
Haryana	4,5	4,5,6	4,5,6	1,2,3,7	1,2,3,7	2,3,7	4,5,6

* Significance at 5 per cent level.

** The variables expressed in mega joules energy units include X_1 = green fodder production, X_2 = dry fodder production, X_3 = concentrates and feeds, X_4 = bullock power, X_5 = manures, X_6 = milk production and X_7 = production of principal crops.

TABLE II. DISTRICTWISE ESTIMATION OF FORWARD AND BACKWARD LINKAGES BETWEEN CROP AND LIVESTOCK PRODUCTION IN HARYANA (1967-81)

	Years															
District (1)	1967 (2)	1968 (3)	1969 (4)	1970 (5)	1971 (6)	1972 (7)	1973 (8)	1974 (9)	1975 (10)	1976 (11)	1977 (12)	1978 (13)	1979 (14)	1980 (15)	1981 (16)	Range (17)
Ambala																
AG.FL	12.08	14.90	13.80	17.32	15.54	16.51	12.02	14.97	20.91	17.81	17.44	16.08	16.01	12.83	15.32	12.02-20.91
AG.BL	0.02	0.04	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.02	0.02	0.03	0.02	0.02- 0.04
Gurgaon																
AG.FL	11.60	12.75	29.79	11.91	12.56	10.80	9.56	10.93	9.49	10.93	8.45	11.74	12.10	10.94	12.74	8.45-29.79
AG.BL	0.04	0.03	0.04	0.02	0.03	0.03	0.04	0.05	0.04	0.03	0.03	0.03	0.06	0.02	0.02	0.02- 0.06
Hisar																
AG.FL	13.18	14.14	10.29	16.05	17.37	14.80	14.97	18.51	13.17	17.96	16.06	18.25	14.95	19.45	9.79	9.79-19.45
AG.BL	0.03	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.02	0.01- 0.03
Karnal																
AG.FL	17.25	18.23	16.09	21.76	25.64	27.06	21.03	26.30	23.55	25.30	22.61	24.26	25.98	20.79	19.65	16.09-27.06
AG.BL	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01- 0.03
Jind																
AG.FL	7.34	4.76	13.89	19.52	19.73	19.41	27.55	23.39	17.81	19.88	17.43	15.21	16.52	11.93	12.10	4.76-27.55
AG.BL	0.03	0.02	0.03	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.03	0.02	0.02- 0.03
Mahendragarh																
AG.FL	7.63	6.67	5.53	6.02	8.87	8.29	6.05	9.72	4.18	9.07	10.14	9.78	9.95	8.55	11.68	4.18-11.68
AG.BL	0.03	0.02	0.03	0.01	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01- 0.03
Rohtak																
AG.FL	11.87	12.53	11.03	14.99	15.72	13.58	12.16	12.64	11.34	12.54	12.39	11.14	11.10	10.29	12.20	10.79-15.72
AG.BL	0.03	0.02	0.03	0.02	0.01	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01- 0.03
Haryana																
AG.FL	12.38	15.06	11.75	15.99	20.89	16.44	14.54	16.76	14.99	17.09	14.02	15.30	15.97	13.70	14.27	11.15-20.89
AG.BL	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02- 0.03

1. AG.FL = Agricultural forward linkage.
2. AG.BL = Agricultural backward linkage.

still obtained in this milk-surplus state with the help of crop residues and dry fodder in proportionately much larger areas than in irrigated areas allocated to green fodder crops.

In order to analyse the magnitudes in detail, the estimation of linkages was worked out (Table II). The results revealed that, on an average, while the contribution of crops to cattle ranged between 11 and 20 per cent of the total output, the contribution of cattle to crops ranged only between 0.02 and 0.03 per cent of the total value of cattle output. The inter-district variations in forward linkages revealed high year to year variability in the district of Jind (4 to 27 per cent) and Gurgaon (8 to 29 per cent). Depending upon the frequency of

occurrence of high forward linkage values, Karnal, Jind and Gurgaon can be considered as districts endowed with high crop to cattle linkages. Medium linkages were registered for Ambala (12 to 20 per cent) and Hisar (9 to 19 per cent). Other districts including Mahendragarh and Rohtak were endowed with weaker crop-cattle linkages. In terms of backward linkages, Ambala and Gurgaon registered a high degree of cattle-crop linkages (0.02 to 0.04 and 0.02 to 0.06 per cent respectively). All other districts showed linkages ranging from 0.01 to 0.03 per cent. Over time for the state also it can be seen that while the crop to cattle (forward linkage) contribution registered an ascending tendency, the cattle to crop contributions registered a downward trend. The results reveal distinctly that the contributions of cattle to crop production process (backward linkages) were initially of lower magnitude, which over time further declined giving rise to increasing gap and resultant incongruence in the two main production activities in the farm sector of Haryana State.

In terms of proportions, almost similar tendencies (Table III) of increasing forward (crop-cattle) and shrinking backward (cattle-crop) linkages were discernible for all the districts of the state. Over time, however, the districts showing more or less ascending distribution of degree of forward linkage included Gurgaon, Hisar, Mahendragarh and Rohtak. Similarly, the districts endowed with ascending backward linkages included only Hisar.

TABLE III. RELATIVE CONTRIBUTION OF CROP TO CATTLE AND CATTLE TO CROP PRODUCTION ACTIVITIES IN HARYANA (1967-81)

(per cent)

	Years															
District	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Range
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Ambala																
1.C-D	33.25	62.84	39.36	61.22	61.69	58.40	59.32	63.47	70.14	61.55	65.09	63.53	63.21	66.10	64.95	33.25-70.14
2. D-C	29.76	27.96	26.30	26.08	25.86	23.97	22.21	24.68	23.40	22.30	21.20	19.14	18.57	17.15	17.11	17.11-29.76
Gurgaon																
C-D	57.16	52.41	55.74	52.01	55.80	56.45	59.65	63.05	56.40	56.40	56.68	56.94	57.35	58.03	60.12	52.01-63.05
D-C	24.06	22.71	21.75	21.54	21.53	20.09	18.28	21.24	17.14	20.45	20.45	18.94	17.60	15.96	14.96	14.96-24.06
Hisar																
C-D	59.48	52.74	55.80	47.19	49.89	53.80	57.04	59.70	59.65	55.65	53.01	49.06	48.15	51.11	45.82	45.82-59.70
D-C	19.76	18.74	18.20	18.66	19.14	18.28	17.59	19.20	18.96	18.70	17.38	15.63	15.39	14.79	14.56	14.56-19.76
Jind																
C-D	45.64	56.06	47.04	54.50	61.87	58.45	57.40	61.92	63.11	56.56	44.34	44.18	47.75	50.79	47.14	44.18-63.11
D-C	20.45	24.40	23.76	23.48	23.69	22.31	21.60	24.03	24.01	23.18	22.29	20.49	19.26	17.58	16.66	16.66-24.40
Karnal																
C-D	64.75	62.40	61.26	42.00	49.69	52.69	65.87	73.45	64.97	65.34	58.74	62.31	62.73	62.00	64.06	42.00-73.45
D-C	26.12	24.79	23.61	23.76	23.89	22.46	20.95	23.44	22.30	21.30	20.35	18.50	17.94	16.80	16.47	16.47-26.12
Mahendragarh																
C-D	48.96	38.79	47.01	32.64	41.56	44.64	42.49	42.98	32.25	42.12	41.96	42.76	42.80	42.08	54.76	32.25-54.76
D-C	15.21	14.03	13.04	12.84	12.67	11.55	10.35	12.64	12.86	13.12	13.48	13.01	13.22	13.03	13.35	10.35-15.21
Rohtak																
C-D	53.94	50.57	53.21	51.85	48.37	54.58	53.95	59.44	54.78	54.98	55.19	55.29	48.54	55.92	56.29	48.37-59.44
D-C	23.00	21.80	20.76	20.92	21.04	19.76	18.44	21.19	20.60	20.03	19.60	18.08	17.55	16.65	16.44	16.44-23.00
Haryana																
C-D	49.69	55.15	53.10	52.10	55.53	55.84	59.51	61.68	60.16	58.96	50.74	56.06	56.50	57.00	56.96	49.69-61.68
D-C	23.43	22.23	21.19	21.32	21.46	20.14	18.74	21.47	20.69	20.02	19.35	17.70	17.11	16.11	15.75	15.75-23.43

1. C-D = Relative contribution of crops' total output in cattle production.
2. D-C = Relative contribution of cattle's total output in crop production.

The results revealed that the districts of Karnal, Ambala and Gurgaon were endowed with higher relative contribution of crop to cattle productivity. Similarly, although on a temporal decline, Ambala, Rohtak, Karnal and Jind were endowed with higher cattle-crop contributions than other districts of the state. The results reveal that cattle production process registered diminishing tendencies during the 15-year period beginning 1966. For, their linkages were generated mainly from manure and bullock power. It seems certain that while bullock power is constantly being substituted by tractor,[1] manures have been substituted increasingly by fertilisers[2] giving rise to weak livestock-crop linkages.

CONCLUSION AND POLICY IMPLICATION

The results presented in the present study inescapably point out that over time, the already weaker cattle to crop linkages have been further weakened by massive external substitutions of two main elements, *viz.*, manures and bullock by fertilisers and tractors respectively. The traditional strength in terms of using the farm produced resource with zero or near zero opportunity cost for high value production of crop-livestock linkages which provided resilience to both activities has given way to specialised livestock production activities with milk production as a predominant objective. Any physical and financial failure or even removal of subsidisation for these activities would result in total break down of production system in the absence of diversification of yore.

In order that livestock provides strength in linkages to crop production activities commensurate with the same by crops, a joint strategy of enhancing the value addition process by manures using biogas technology and bullocks in the rural transport sector, coupled with efficient marketing for bullocks, would go a long way in mitigating such imbalance.

Limitations

The results of this study have some inherent limitations. The interpretational value of the results have consequently been limited narrowly to crop-cattle relationships. Especially, lower magnitudes of backward linkages of cattle to crops have not taken into account the contribution of the same toward transport and energy sector. Similarly, poultry, goats and sheep are kept out of the scope of this study.

Further, some of the estimates are based on assumptions which have sufficient scope for modification when more of such data and coefficients are made available.

Swarn Lata Arya and Jagdeesh C. Kalla*

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* Scientist (Economics), Central Soil and Water Conservation Research and Training Institute, Research Centre, Chandigarh and Director, National Academy of Agricultural Research Management, Rajendranagar, Hyderabad (A.P.), respectively.

NOTES

1. The quinquennial livestock census data suggest that while for the state, the number of bullocks almost stagnated at 9.5 lakh heads in 1981 from 9.2 lakhs in 1966, the number of tractors increased from 4,803 in 1966 to 52,689 in 1981 (*Statistical Abstracts of Haryana State*, published by Economic and Statistical Organisation, Government of Haryana).

2. The resultant lack of availability of manure coupled with economic consideration has increasingly resulted in massive substitution of manures. Fertiliser statistics in this regard reveal a 16-fold increase in total (N,P,K) fertiliser use on farms from 13,347 tonnes in 1966 to 2.3 lakh tonnes in 1981. This has essentially been done to cope with increased cropping intensity of the state from 134 per cent in 1966 to 181 per cent in 1981 (*Statistical Abstracts of Haryana State*, published by Economic and Statistical Organisation, Government of Haryana).

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