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CONSTRUCTION OF INDEX OF ADOPTION RATE OF IMPROVED AGRICULTURAL TECHNOLOGY

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SUMMARY

One approach for determining the impact of various components of new agricultural technology is to develop some suitable index which would reflect the aggregate of adoption rates of different components of improved agricultural technology. In this paper different procedures for developing such indices have been investigated. The procedures have also been illustrated empirically.

Keywords : Simple index; Weighted indices; Adoption rate; Correlations; Coefficient of determination; Goodness of fit.

Introduction

The new agricultural strategy involves the adoption of the various recommended improved practices for optimising the yield level. However, as is well known, the adoption rates of different components of new agricultural technology vary widely from one farmer to the other even in the same village. Thus, while one farmer may apply substantial doses of fertilisers, adopt improved management practice like timely sowing, seed treatment, weeding etc. and take all other measures necessary for achieving high yield level, another farmer might not go beyond use of HYV seeds and application of low doses of fertilisers. Obviously, the adoption rates of different components taken individually would not be much meaningful or even valid since they are not independent of each other (fertiliser rates depend upon the availability of irrigation, etc.) and their separate contribution to the overall yield is also not known. In other words, only the total impact of all the components of the new agricultural technology taken together would be reflected in the level of yield obtained.

One approach for determining the impact of various components of new technology is to develop some suitable index which would reflect the aggregate of adoption rates of different components of improved agricultural technology. The reliability of such an index would be indicated by the extent of its correlation with the yield obtained. It was in this context that a study for developing suitable indices of adoption rate of new agricultural technology was undertaken. Different procedures for developing a suitable index have been investigated and are discussed in this paper.

2. Construction of Index of Adoption Rate

Three procedures for developing suitable indices of adoption rate of new technology have been developed and are presented in the following paragraphs.

Let p_{ij} denote the proportion representing the contribution of *i*th improved practice like irrigation, fertilisers, plant protection measures, use of improved implements, etc. for the *j*th cultivator in the overall impact. In case the practice is of a kind that no quantitative measure is available, except it is adopted or not adopted, p_{ij} $(= a_{ij}/A_j)$ will be obtained as the proportion of area (a_{ij}) in which this practice is adopted by the *j*th cultivator out of the total area (A_j). For such of the practices which can be quantitatively measured like use of chemical fertilisers for which actual and recommended levels of application are known, obviously these would also have to be taken into account for determining the adoption rate. For a component like chemical fertilisers, the product of the proportion of area receiving chemical fertilisers and the ratio of actual doses applied in relation to the recommended levels is worked out for getting the corresponding value of p_{ij} i.e.

$$p_{ij} = \frac{a_{ij}}{A_j}\frac{r_{ij}}{R_i} \tag{2.1}$$

where r_{ij} is the actual level/dose of the *i*th improved practice adopted by the *j*th cultivator and R_i is the recommended level/dose for the *i*th improved practice. These proportions are then aggregated for different improved practices adopted by the *j*th cultivator and average index I_j is obtained as follows

$$I_j = \sum_{i=1}^{k} w_{ij}p_{ij} \Big/ \sum_{i=1}^{k} w_{ij} \tag{2.2}$$

where w_{ij} is the weighing factor for p_{ij} to be determined suitably and k denotes the number of components of improved agricultural technology considered.

2.1 *Simple Index*

If the various components of improved agricultural technology are considered equally important, we may assign them equal weights. This situation may arise when a package of practices for a newly developed crop variety is recommended in which each component of the package has to be adopted at the recommended level and is, therefore, as important as any other component. Another situation may be when we consider only a few important components as, for example, with availability of irrigation water in a rainfed area, the major components of improved technology would be crop variety, irrigation, fertiliser application and use of plant protection chemicals and all of these may be considered equally important. In such a case, with w_{ij}'s equal, a Simple Index of adoption of modern technology for the jth cultivator may be obtained as

$$I_{1j} = \sum_{i=1}^{k} \frac{p_{ij}}{k} \qquad (2.1.1)$$

2.2 *Weighted Index*

In case some components are considered more important, Simple Index based on the average of the individual adoption rates would not be appropriate. Suitable weights may, therefore, be assigned to each of the components in working out the index of adoption. For this purpose, one approach would be to use the cost per hectare incurred on the different components as weights for the corresponding adoption rate. Alternatively, the average area receiving the different components may be used as weights for the respective adoption rates. Yet another approach would be to use the crop responses to the components as weights. However, in survey approach where the responses could vary for a given type and level of a component on account of other factors and further since the responses to different components are not directly comparable, this approach may not prove to be very effective or useful. This approach may perhaps be tried in case the data on comparable responses of different components of new technology (as in case of field experiments) are available. Under each of the first two schemes, four different types of weighted indices are suggested as follows :

2.2.1 INDEX BASED ON COST OF COMPONENTS

Under this scheme, the general form of the index will be

$$I_j = \sum_{i=1}^{k} c_{ij}\, p_{ij} \Big/ \sum_{i=1}^{k} c_{ij} \qquad (2.2.1.1)$$

where c_{ij} denotes the cost incurred per hectare on the ith component by the jth cultivator in the sample/village.

Although it will be more appropriate to take cost of a component separately for each of the randomly selected cultivators, these costs may be highly variable and therefore not much reliance can be placed on cultivator and figures of cost. The average cost on the ith component $c_i \left(= \sum_{j}^{n} c_{ij}/n\right)$ based on all the sampled (n) cultivators would be more stable and appropriate. Using this approach the weighted indices of modern technology are as follows :

(i) The first weighted index under this approach will be

$$I_{2j} = \sum_{i=1}^{k} c_i \, p_{ij} \Big/ \sum_{i=1}^{k} c_i \tag{2.2.1.2}$$

where c_i and p_{ij} are as defined earlier.

(ii) The second weighted index will be

$$I_{3j} = \sum_{i=1}^{k'} c_i \, p_{ij} \Big/ \sum_{i=1}^{k'} c_i \tag{2.2.1.3}$$

where k' refers to the number of components of new technology actually adopted by the jth cultivator out of k components under consideration.

(iii) The third weighted index under this approach is defined as

$$I_{4j} = \sum_{i=1}^{k} c_i' \, p_{ij} \Big/ \sum_{i=1}^{k} c_i' \tag{2.2.1.4}$$

where $c_i' \left(= \sum_{j}^{n_i} c_{ij}/n_i'\right)$ denotes the average cost per hectare incurred on the ith component, based only on those (n_i') cultivators who actually adopted the ith component out of 'n' cultivators in the sample.

(iv) The fourth weighted index under this approach is defined as

$$I_{5j} = \sum_{i=1}^{k'} c_i' \, p_{ij} \Big/ \sum_{i=1}^{k'} c_i' \tag{2.2.1.5}$$

where c_i', p_{ij} and k' are as defined earlier.

2.2.2 INDICES BASED ON AREA UNDER THE CROP RECEIVING DIFFERENT COMPONENTS

Under this approach, the general form of the index will be as follows :

$$I_j = \sum_{i=1}^{k} A_i \, p_{ij} \Big/ \sum_{i=1}^{k} A_i \tag{2.2.2.1}$$

where A_i denotes the average area under the crop receiving the *i*th component in the district/region.

Since A_i's are not known, these are estimated from the sample of cultivators. Using this approach, the weighted indices of adoption of modern technology are as follows :

(i) The first weighted index under this approach will be

$$I_{6j} = \sum_{i=1}^{k} a_i\, p_{ij} \Big/ \sum_{i=1}^{k} a_i' \qquad (2.2.2.2)$$

where p_{ij} and k are as defined earlier and $a_i \left(= \frac{1}{n} \sum_{j}^{n} a_{ij} \right)$ is the estimate of A_i from the sample of cultivators.

(ii) The second weighted index will be

$$I_{7j} = \sum_{i=1}^{k'} a_i\, p_{ij} \Big/ \sum_{i=1}^{k'} a_i \qquad (2.2.2.3)$$

where k' is as defined earlier in (2.2.1.3).

(iii) The third weighted index under this approach is defined as

$$I_{8j} = \sum_{i=1}^{k} a_i'\, p_{ij} \Big/ \sum_{i=1}^{k} a_i' \qquad (2.2.2.4)$$

where $a_i' = \sum_{j}^{n_i'} a_{ij}/n_i'$ denotes the average area under the crop receiving the *i*th component based only on n_i' cultivators adopting the *i*th component and not on all the cultivators.

(iv) The fourth weighted index under this approach is defined as

$$I_{9j} = \sum_{i=1}^{k'} a_i'\, p_{ij} \Big/ \sum_{i=1}^{k'} a_i' \qquad (2.2.2.5)$$

where a_i', p_{ij} and k' are as defined earlier.

In what follows, the above nine indices respectively would be referred to as $I_{1j}, I_{2j}, \ldots, I_{9j}$ or as type 1, type 2, . . . , type 9.

3. Empirical Illustration

For an empirical illustration of the methodology developed for building up indices of adoption rate of new technology, data collected during the rabi season under the project 'Pilot sample survey to study the impact of new technology on crop production; itsdis posal and employment in agriculture in Delhi state' for the period 1976-77 to 1978-79 have been utilised. The following components of new technology, the data on which were available under the project have been considered for the purpose :

(i) Irrigation
(ii) Bulky manure
(iii) Nitrogenous fertilisers
(iv) Phosphatic fertilisers
(v) Potassic fertilisers
(vi) Plant protection measures
(vii) Seed treatment
(viii) Use of improved implements
(ix) Weed control measures and other intercultural operations
(x) Rat control measures

Data for rabi season for the 3 years of 1976-77 to 1978-79 were available for 209, 207 and 232 cultivators respectively.

To investigate the degree of association between different types of indices with the yield level achieved, simple correlations were worked out between the adoption index and yield of cultivator. The coefficients of correlation so obtained are presented in Table-1 for the simple index and different types of weighted indices.

It may be seen from the Table that the coefficient of correlation between the yield level of a cultivator and corresponding index of adoption under different procedures described above were generally low, sometimes even less than 0.1. However, the simple index showed a relatively higher value of correlation coefficient in all the three years. Of the weighted indices, the coefficient of correlation for the indices corresponding to type 2, 4, 6 and 8 were significant and always higher than those of the other four indices which were not significant. Among these four indices also, the coefficients of correlation for type 2 under the price weight scheme and type 6 under the area weight scheme were somewhat higher than the other corresponding indices. It may, therefore, be sufficient to study the three indices corresponding to type 1 (a simple index), type 2 (weighted index with prices of inputs as weights) and type 6 (weighted index with average area under the crop receiving different inputs as weights).

One reason for the low value of coefficient of correlation between the index of adoption and yield of a cultivator is the inter-cultivator variability on account of a host of factors like soil type, soil fertility, rainfall, etc. which vary from field to field. Thus, for a given level of adoption of modern technology the yield level might vary substantially from one cultivator to the next and, therefore, the correlation coefficient is likely to be low. Since, the cultivators consitute a random sample, the problem of variable effect of these uncontrollable factors may be overcome by suitably grouping the cultivators into different classes on the basis of the value of the adoption index (after arranging the cultivators in ascending order) such that in each class there is a substantial number of observations. This will serve the dual purpose of averaging out the effect of uncontrollable factors by assuming that the cultivators in a class are a random set from the overall sample and further the variability of the adoption index in a class would also be small giving a homogeneous set of cultivators in so far as the adoption of improved practices is concerned. In the present study three group sizes were studied namely 10, 20 and 30 cultivators in a class.

Having seen that there is a high degree of association between the adoption index and the yield of a group of farmers for which the adoption index is of the same order (as evident from the high value of coefficient of correlation discussed above), it would be of interest to investigate the type and degree of relationship between the two variables. In other words we may like to quantify the effect of adoption index on the yield level achieved and the extent to which the yield is affected by a change in the value of adoption index. This was done by fitting a linear regression of yield upon adoption index for all the three types of indices and three types of grouping of cultivators. The results are presented in Table-3. It may be seen from the results that the coefficient of linear regression was highly significant in all the three years in the case of 'no grouping' i.e. when individual cultivators were considered. When grouping of cultivators was done, the coefficient of linear regression was significant for the first and sixth types of indices of adoption in all the 3 years while for the second type it was significant only in the first year. In the group size with 20 cultivators, the coefficient of linear regression was significant for the first and sixth types of indices of adoption in the first and third year. However, when the group size was increased to 30, the coefficient of linear regression was not significant for any index in any year. This is obviously on account of the reduction in the number of observations on account of increase in group size which affects the significance of the regression coefficients. On the other hand, the coefficient of determination increased very substantially from the case of 'no grouping' to grouping with 10 cultivators and also when the group size was increased to 20. Increase in the group size to 30 did not show much increase in the coefficient of determination except for one or two cases.

4. Conclusions

Of the nine indices discussed above, the simple index and the two weighted indices corresponding to type 2 and type 6 appear to be appropriate in view of the higher and significant value of coefficient of correlation between the yield level of a cultivator and corresponding index of adoption under these three indices consistently in all the years, compared to the other six indices. The group size of 10 or at most 20 would be adequate for averaging out the random effects of uncontrollable factors between the cultivators, there being no improvement in the goodness of fit beyond the group size of 20. On the other hand the coefficient of linear regression was not significant with group size of 30.

Apparently, therefore, the group size of 10 to 20 seems to be appropriate for the study of the effect of the index of adoption on the yield rate achieved, the coefficient of determination being of the order of 0.75 or more and the coefficient of linear regression being also significant in most of the cases. It may be observed that with a larger body of data other schemes of grouping of the cultivators could also be investigated.

TABLE 1—AVERAGE INDEX VALUE AND COEFFICIENT OF CORRELATION BETWEEN YIELD AND ADOPTION INDEX UNDER DIFFERENT TYPES OF INDICES

Type of index	*1976-77*		*1977-78*		*1978-79*	
	Av. index	*Coefficient of correlation*	*Av. index*	*Coefficient of correlation*	*Av. index*	*Coefficient of correlation*
I_1	35.14	0.3345*	31.90	0.2454*	35.77	0.2584*
I_2	70.16	0.3260*	69.90	0.1963*	74.04	0.1344*
I_3	93.24	0.1165*	91.56	0.0490	91.96	0.0049
I_4	55.56	0.2596*	53.45	0.2005*	55.34	0.1173
I_5	94.19	0.0957	91.74	−0.0195	91.33	−0.0608
I_6	59.79	0.4044*	59.08	0.2540*	64.65	0.2406*
I_7	88.33	0.1340	85.66	0.0584	86.84	0.0208
I_8	31.61	0.3840*	29.46	0.2437*	34.26	0.2624*
I_9	91.01	0.0912	87.17	0.0529	86.08	−0.0478
Yield (in Kg.)	2243		2332		2318	
No. of observations	209		207		232	

TABLE 2—COEFFICIENT OF CORRELATION UNDER DIFFERENT GROUPING SCHEMES FOR INDICES I_1, I_2 AND I_6 DURING 1976-77 TO 1978-79

Type of index	*Grouping scheme (No. of cultivators per class)*	*Coefficient of correlation*		
		1976-77	*1977-78*	*1978-79*
I_1	No grouping	0.3345*	0.2454*	0.2584*
	10	0.7428**	0.5379*	0.7097**
	20	0.8586**	0.7061*	0.8661**
	30	0.8014*	0.8908**	0.9379**
I_2	No grouping	0.3260*	0.1963*	0.1344*
	10	0.6774**	0.4657*	0.3728
	20	0.8012**	0.5834	0.5285
	30	0.8155*	0.5036	0.5808
I_6	No grouping	0.4044*	0.2540*	0.2406*
	10	0.8373**	0.5970**	0.6819**
	20	0.8887**	0.7747**	0.9084**
	30	0.9589**	0.8024*	0.8902**

*Significant at 5% level of significance
**Significant at 1% level of significance

TABLE 3—COEFFICIENT OF DETERMINATION (r^2), INTERCEPT (a) AND REGRESSION COEFFICIENT (b) UNDER THE LINEAR MODEL $y = a + bx$ FOR THE THREE INDICES

Type of index	*Grouping scheme (No. of cultivators per class)*	*1976-77*			*1977-78*			*1978-79*		
		r^2	a	b	r^2	a	b	r^2	a	b
	No grouping	0.1119	1613	17.92**	0.0602	1801	16.62**	0 0668	1749	15.92**
I_1	10	0.5518	1543	19.91**	0.2893	1817	16.01*	0.5037	1625	20.08**
	20	0.7372	1684	19.50*	0.4986	1886	13.68	0.7501	1620	20.36*
	30	0.6422	1532	20.20	0.7935	1804	16.40	0.8797	1672	18.67
	No grouping	0.1063	1316	13.21**	0.0385	1657	9.64**	0.0181	1828	6.61*
	10	0.4589	1187	15.08**	0.2169	1628	10.15	0.1390	1780	7.24
I_2	20	0.6419	1162	15.55*	0.3404	1572	11.17	0.2793	1730	7.94
	30	0.6650	1189	15.08	0.2536	1725	8.77	0.3373	1736	7.91
	No grouping	0.1635	1322	15.39**	0.0645	1984	12.09**	0.0579	1625	10.72**
	10	0 7011	1196	17.49**	0.3564	1623	11.98*	0.4650	1482	13.31**
I_6	20	0.7898	1264	16.24**	0.6002	1686	10.92*	0.8252	1418	14.44*
	30	0.9165	1156	18.12	0.6438	1675	11.11	0.7925	1545	12.34

*Significant at 5% level of significance

**Significant at 1% level of significance