ON ESTIMATION OF PRICE SPREAD

By

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1. Introduction

The amelioration of the economic conditions of our farmer depends to a great extent on the improvement of our marketing organisation. The main aim of the efficient agricultural marketing is to ensure fair returns to the farmers and all other persons involved in carrying agricultural produce to the consumer. Price spread is the share of different agencies operating in the market to the consumer's rupee spent. The study of price spread involves not only the ascertainment of actual prices at various stages of marketing channel, but also the cost incurred in the process of movement of the produce from the farm to the consumer and the margin of various intermediaries. The study of price spread helps in identifying the short-comings of the marketing system. This study is also important for formation and implementation of an appropriate price policy, improving efficiency of various factors in marketing system for reducing cost and in planning for development etc.

Nath (1963) studied the estimation of price spread of vegetables in Delhi. In the report of marketing of fruits and vegetables published by the directorate of Marketing and Inspection (1966), and in the report of Sub-group Committee on Granding of Marketing (1975), the estimates of price spread are provided for rice, wheat and vegetables. In the above review the results are reported without the standard error of the estimates. Zurmati (1977) studied for the first time the estimation of price spread alongwith the associated standard error. He considered four sampling schemes. However, the estimators considered by him were all biased. In the present paper almost unbiased estimators of price spread have been considered for four different sampling schemes. These sampling

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schemes have been compared for their efficiency. The usefulness of the sampling schemes has been illustrated with the help of data collected for four vegetables for the periods January, February and March, 1977.

2. Statement of the Problem

Consider a marketing channel involving 'k' stages of marking for a commodity and a period (month, week, etc.) of 'N' days for which estimators of price spread are required. Let the average prices for the 'k' stage of marketing be $\bar{Y}_1, \bar{Y}_2, \ldots, \bar{Y}_k$. The price spread P is a vector of shares of different agencies functioning in the marketing which is given by

$$P=(P_1, P_2, \ldots, P_k)$$

where $$P_1=\frac{\bar{Y}_1}{\bar{Y}_k}$$

and $$P_i=\frac{\bar{Y}_i-\bar{Y}_{i-1}}{\bar{Y}_k},$$

$$i=2, \ldots, k$$

so that $$\sum_{i=1}^{k} P_i=1$$

The problem under investigation is to estimate this P vector. The estimate of P based on a sample is given by

$$\hat{P}=(\hat{P}_1, \hat{P}_2, \ldots, \hat{P}_k)$$

Here P_i is estimated by $\hat{P}_i$. Let V_i be the sampling error associated with estimator $\hat{P}_i$ given by

$$V_i=E(\hat{P}_i-P_i)^2,$$

$$i=1, 2, \ldots, k.$$

For obtaining a measure of error of $\hat{P}=(\hat{P}_1, \hat{P}_2, \ldots, \hat{P}_k)$ we consider the following :

(i) $$F_1=\sum_{i=1}^{k} V_i$$

(ii) $$F_2=\sum_{i=1}^{k} \frac{V_i}{P_i} \qquad \ldots(1)$$

It may be mentioned here that these measures are similar to those proposed by Murthy (1977) for estimation of frequency distribution.

3. Sampling Schemes

We consider the following sampling schemes for estimation of price spread.

Sampling-Scheme—1. In this sampling scheme, a sample of 'n' days out of the period (population) of 'N' days is selected by SRSWOR. These days are kept common for collecting the information on prices at all stages of marketing.

Let y_{ij} be the average price of a commodity for j-th day at i-th stage of marketing ($i=1, 2, \ldots, k$; $j=1, 2, \ldots, n$) and $\bar{y}_i$ be the mean price at i-th stage of marketing based on the sample given by

$$\bar{y}_i = \frac{1}{n} \sum_{j=1}^{n} y_{ij}$$

The simple estimator of price spread is given by

$$\hat{P} = (\hat{P}_1, \ldots, \hat{P}_k),$$

where

$$\hat{P}_1 = \frac{\bar{y}_1}{\bar{y}_k},$$

$$\hat{P}_i = \frac{\bar{y}_i - \bar{y}_{i-1}}{\bar{y}_k},$$

$$i = 2, \ldots, k.$$

The expression for the bias of the estimators of different components of price spread for this sampling scheme are as follows :

$$B(\hat{P}_1) = \left(\frac{1}{n} - \frac{1}{N}\right) \frac{1}{\bar{Y}_k^2} (S_k^2 R_{1k} - S_{1k}),$$

where

$$R_{ij} = \frac{\bar{Y}_i}{\bar{Y}_j},$$

$$S_i^2 = \frac{1}{N-1} \sum_{t=1}^{N} (Y_{it} - \bar{Y}_i)^2,$$

$$i = 1, 2, \ldots k$$

and $$S_{ij}=\frac{1}{N-1}\sum_{t=1}^{N}(Y_{it}-\bar{Y}_i)(Y_{jt}-\bar{Y}_j),$$

$i\neq j=1, 2,\ldots\ldots, k.$

$$B(\hat{P}_i)=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}\left[S_k^2\,(R_{ik}-R_{i-1k})-S_{ik}+S_{i-1k}\right]$$

$i=2,\ldots\ldots, k.$

The simple estimators of different components of price spread considered above are biased. The almost unbiased estimators of different components of price spread can be obtained by using Quenouille's (1956) technique. For this the sample of 'n' days is split randomly into r subsamples of 'm' days each such that $r\,m=n$. The almost unbiased estimators of different components of price spread are given by

$$\hat{P}_{iu}=-\frac{1}{r(r-1)}\sum_{b=1}^{r}\hat{P}_{ib}+\frac{r}{r-1}\hat{P}_i,\ r\neq 1$$

and $i=1, 2,\ldots, k$

where $$\hat{P}_{1b}=\frac{\bar{y}_{1b}}{\bar{y}_{kb}},$$

$$\hat{P}_{ib}=\frac{\bar{y}_{ib}-\bar{y}_{i-1b}}{\bar{y}_{kb}},$$

$i=2,\ldots, k$

and $\bar{y}_{ib}$ is the mean for b-th subsample of 'm' days at i-th stage of marketing.

The expressions for the variances of the estimators of different components of price spread for this sampling scheme are as follows:

$$V(\hat{P}_{1u})=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}\left[S_1^2+S_{1k}^2R_{1k}^2-2\,S_{1k}R_{1k}\right]$$

$$V(\hat{P}_{iu})=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$[S_{i-1}^2+S_i^2+S_k^2\,(R_{i-1k}-R_{ik})^2-2\,S_{i-1\,i}-2\,(S_{i-1\,k}-S_{ik})(R_{i-1\,k}-R_{ik})],$$

$$i=2,\ldots,k.$$

The efficiency of the biased estimator $\hat{P}_i$ and almost unbiased estimator $\hat{P}_{iu}$ is same upto first order of approximation.

The two measurements of errors defined in (1) after simplification take the form :

$$F_1=\sum_{i=1}^{k} V_i=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{2}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-1} S_i^2+S_k^2\left(\sum_{i=1}^{k-1} R_{ik}^2-\sum_{i=1}^{k-2} R_{ik}\,R_{i+1k}\right)\right.$$

$$-\sum_{i=1}^{k-2} S_{i\,i+1}-S_{k-1\,k}\,R_{k-1\,k}-\sum_{i=1}^{k-1}(S_{i-1\,k}-S_{ik})$$

$$\left.(R_{i-1\,k}-R_{ik})\right]$$

$$F_2=\sum_{i=1}^{k}\frac{V_i}{P_i}=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-1}\frac{(R_{i+1\,k}-R_{i-1\,k})\,S_i^2}{(R_{i+1\,k}-R_{ik})(R_{ik}-R_{i-1\,k})}+\frac{S_k^2\,R_{k-1\,k}}{1-R_{k-1\,k}}\right.$$

$$\left.-2\,\frac{S_{k-1\,k}}{1-R_{k-1\,k}}-2\sum_{i=1}^{k-2}\frac{S_{ii+1}}{(R_{i+1\,k}-R_{ik})}\right]$$

Sampling Scheme—2. In this sampling scheme, the required sample of 'n' days out of a population of 'N' days is selected by SRSWOR independently at all stages of marketing. The values of F_1 and F_2 under this sampling scheme reduce to :

$$F_1=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{2}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-1} S_i^2+S_k^2\left(\sum_{i=1}^{k-1} R_{ik}^2-\sum_{i=1}^{k-2} R_{ik}\, R_{i+1\,k}\right)\right]$$

$$F_2=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-1}\frac{(R_{i+1\,k}-R_{i-1\,k})\,S_i^2}{(R_{i+1\,k}-R_{ik})\,(R_{ik}-R_{i-1\,k})}+\frac{S_k^2\,R_{k-1\,k}}{1-R_{k-1k}}\right]$$

Sampling Scheme—3. In this sampling scheme, a sample of 'n' days out of a population of 'N' days is selected by SRSWOR for 1st stage of marketing. From these 'n' days, a sample of 'q' days is kept common for all stages of marketing and supplemented by a sample of '$n—q$' days selected randomly at each stage of marketing from the remaining days of the period. The values of F_1 and F_2 for this sampling scheme are given by :

$$F_1=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{2}{\bar{Y}_k^2}\left[\sum_{i-1}^{k-1} S_i^2+S_k^2\left(\sum_{i=1}^{k-1} R_{ik}^2\right.\right.$$

$$\left.\left.-\sum_{i=1}^{k-2} R_{ik}\, R_{i+1k}\right)\right]-\frac{2q^2}{n^2}\left(\frac{1}{q}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-2} S_{i\;i+1}+S_{k-1\;k}\,R_{k-1\;k}+S_{1k}\,R_{1k}\right.$$

$$\left.+\sum_{i=1}^{k-2}\left(S_{ik}-S_{i+1k}\right)\left(R_{ik}-R_{i+1k}\right)\right]$$

$$F_2=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{2}{\bar{Y}_k^2}\left[\sum_{i=1}^{k-1}\frac{(R_{i+1k}-R_{i-1k})\,S_i^2}{(R_{i+1k}-R_{ik})\,(R_{ik}-R_{i-1k}}\right.$$

$$\left.+\frac{S_k^2\;R_{k-1k}}{1-R_{k-1k}}\right]-\frac{q^2}{n^2}\left(\frac{1}{q}-\frac{1}{N}\right)$$

$$\frac{2}{\bar{Y}_k^2}\left[\frac{S_{k-1k}}{1-R_{k-1k}}+\sum_{i=1}^{k-2}\frac{S_{i\;i+1}}{(R_{i+1k}-R_{ik})}\right]$$

Sampling Scheme—4. Under this sampling scheme, a sample of 'n' days of 'N' days is selected by SRSWOR at 1st sage of marketing. From this sample of 'n' days, a sample of 'q' days is kept common for 2nd stage of marketing and supplemented by a sample of '$n-q$' days selected randomly out of '$N-n$' days for 2nd stage of marketing. Further, from the sample of 'n' days at 2nd stage of marketing, a subsample of 'q' days is kept common for 3rd stage of marketing and supplemented by a sample of '$n-q$' days selected afresh out of '$N-n$' days for 3rd stage of marketing and so on. The values of F_1 and F_2 under this sampling scheme are as follows :

$$F_1=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{2}{\bar{Y}_k^2}\left[\sum_{i=1}^{k-1}S_i^2+S_k^2\right.$$

$$\left.\left(\sum_{i=1}^{k-1}R_{ik}^2-\sum_{i=1}^{k-2}R_{ik}\,R_{i+1k}\right)\right]$$

$$-\frac{2q^2}{n^2}\left(\frac{1}{q}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-2}S_{i\;i+1}+S_{k-1\;k}\,R_{k-1\;k}\right]$$

$$F_2=\left(\frac{1}{n}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}\left[\sum_{i=1}^{k-1}\frac{(R_{i+1k}-R_{i-1k})\,S_i^2}{(R_{i+1k}-R_{ik})(R_{ik}-R_{i-1k})}\right.$$

$$+\frac{S_k^2 \; R_{k-1k}}{1-R_{k-1k}}\Big]-\frac{2q^2}{n^2}\left(\frac{1}{q}-\frac{1}{N}\right)\frac{1}{\bar{Y}_k^2}$$

$$\left[\sum_{i=1}^{k-2}\frac{S_{i\;i+1}}{(R_{i+1k}-R_{ik}}+\frac{S_{k-1k}\;R_{k-1k}}{1-R_{k-1k}}\right]$$

It may be mentioned that for sampling schemes 2, 3 and 4, the simple estimators of price spread and almost unbiased estimators of different components of price spread are the same as in sampling scheme—1.

4. Comparison of Different Sampling Schemes

We now compare the different sampling schemes by using the differences of F_1 and F_2 values of different sampling schemes. For simplicity, let us make the following assmptiones :

$$\left.\begin{array}{lll} (i) & S_{ij} \geqslant 0 \text{ For} & i, \neq j = 1,2,\ldots, k \\ (ii) & S_{ik} \leqslant S_{i+1,k}, & i = 1,2,\ldots, k-1 \end{array}\right\} \quad \ldots(2)$$

It is worthwhile to mention here that these assumptions are not at all unreasonable because the variables under study are the prices at different stages of marketing. The first assumption implies that the prices have a positive correlation among themselves which generally holds true. Further, the second assumption implies that as we approach the last stage of marketing the correlation of that stage with the last stage also increases which is very realistic to expect in practice.

Denoting by $(F_1)_h$ for $h=1, 2, 3, 4$, the values of F_1 for the h-th sampling scheme, it can be easily verified that under the above assumptions (2), $(F_1)_h-(F_1)_k$ are positive for the (h, k) pairs given by (2, 1), (3, 1), (4, 1), (2, 3), (2, 4) and (4, 3).

Thus leading to the ordering :

$$(F_1)_1 \leqslant (F_1)_3 \leqslant (F_1)_4 \leqslant (F_1)_2 \quad \ldots(3)$$

Similarly working out the differences for the values of F_2 under different sampling schemes, it is found that

$$(F_2)_1 \leqslant (F_2)_3 \leqslant (F_2)_4 \leqslant (F_2)_2 \quad \ldots(4)$$

for the same assumptions given in (2).

From (3) and (4), we can therefore conclude that sampling scheme-1 is the best, followed by schemes-3, 4 and 2 in that order.

5. *Numerical Illustration.* The usefulness of the different sampling schemes considered for estimation of price spread have been illustrated with the help of data collected for January, February and March (1977) on four vegetables namely Tomato, Brinjal, Peas and Cauliflower by the Indian Agricultural Statistics Research Institute under the project 'A pilot sample survey to evolve a suitable sampling methodology for the estimation of price spread and losses in transit at different stages of marketing of vegetables in Delhi'.

In Delhi, there is generally a three stage/channel marketing system for vegetables. The growers themselves bring their produce to the wholesalers in the Azadpur Mandi for sale. The produce of the grower is generally purchased by the mashakhors (semi-wholesalers) in the Azadpur Mandi in open auction of the entire lot. The retailers purchase vegetables mostly from the mashakhors in units of 5 kgs. or its multiples. Consumers purchace the vegetables from retailers. For the collection of data from growers and mashakhors, four clusters of two wholesalers each and four clusters of two mashakhors each were selected randomly. Four enumerators were posted for the collection of data on various aspects of marketing. Each enumerator was assigned one cluster of two wholesalers and one cluster of two mashakhors. The time of the enquiry was from 6.00 A.M. to 12.00 noon on all the working days in the following phased manner for each enumerator :

Wholesalers	*Mashakhors*
6.00 A.M.— 7.00 A.M.	6.30 A.M.— 7.30 A.M.
8.00 A.M.— 9.00 A.M.	8.30 A.M.— 9.30 A.M.
10.00 A.M.—11.00 A.M.	10.30 A.M.—11.30 A.M.

For the collection of information from retailers regarding the price, the entire Delhi region was divided into four zones namely, East, West, South and North. From each zone, two clusters of three locality/colonies each were selected randomly. From each selected locality, two retailers were further selected randomly for the collection of data. One enumerator was assigned the work of data collection from one cluster of three colonies and thus eight enumerators were posted for this work.

The estimates of average prices per day at three stages of marketing in accordance with sampling design used in the survey for the four vegetables namely, Tomato, Brinjal, Peas and Cauli-flower are given in Table-1. The estimates of price spread from the average prices per day have been worked out and are given in Table 2.

TABLE 1

Average prices (Rs. per kg.) at different stages of marketing for different months

VEGETABLES

	Tomato			*Brinjal*			*C. Flower*			*Peas*		
	Agencies											
Month	*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*
January	.76	1.46	2.10	.47	.66	1.27	.37	.59	.90	1.27	1.62	2.21
February	.88	1.52	2.28	.63	.75	1.33	.55	.66	1.01	1.06	1.15	1.63
March	.96	1.79	2.66	.79	1.03	1.48	.73	.98	1.52	.81	1.45	1.93
Average	.87	1.59	2.35	.63	.81	1.36	.55	.74	1.14	1.05	1.41	1.92

G indicates Grower

M indicates Mashakhor (Semi Whole saler)

R indicates Retailer

TABLE 2

Components of price spread at different stages of marketing for different months

VEGETABLES

	Tomato			*Brinjal*			*C. Flower*			*Peas*		
	Agencies											
Month	*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*
January	.36	.33	.31	.38	.15	.47	.41	.24	.35	.57	.15	.28
February	.38	.28	.34	.47	.09	.44	.54	.10	.36	.64	.06	.30
March	.37	.30	.33	.53	.16	.31	.48	.16	.36	.42	.33	.25
Average	.37	.30	.33	.46	.15	.41	.48	.16	.36	.54	.18	.28

Note : G indicates Grower's share, which also include 4% commission charges.
M indicates Mashakhor (semi wholesaler).
R indicates Retailer.

TABLE 3

Variance and covariance components for different vegetables and for different months.

Vegetables		*Tomato*			*Brinjal*			*C. Flowers*			*Peas*		
							Agencies						
Months		*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*	*G*	*M*	*R*
	G	.013	.015	.013	.013	.002	.009	.008	,007	.007	.138	—.001	.115
January	M		.095	.073		.009	.005		.034	.006		.221	.046
	R			.098			.046			.010			.152
	G	.007	—.002	.002	.015	.011	.006	.004	.005	—.001	.061	.051	.044
February	M		.034	.008		.013	.004		.011	.001		.046	.045
	R			.051			.012			.001			.055
	G	.023	.010	.018	.031	.020	.007		.007	—.001	.033	.022	.046
March	M		.048	.018		.051	.033	.023	.016	—.002		.128	.152
	R			.116			.042			,036			.313

Note : G indicates Grower
M indicates Mashakhor
R indicates Retailer

TABLE 4

Values of F_1 and F_2 for different sampling schemes and % efficiency compared to sampling scheme-2 (in brackets).

Months	*Vegetables Error measures*	*Tomato Sampling scheme*				*Brinjal Sampling Scheme*			
		1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
January	F_1	.001607 (269.30)	.004324 (100.00)	.002626 (164.66)	.003089 (139.99)	.002053 (130.08)	.002670 (100.00)	.002284 (116.89)	.002430 (109.89)
	F_2	.004930 (272.33)	.013423 (100.00)	.008115 (165.42)	.009494 (141.38)	.008430 (123.50)	.010412 (100.00)	.009173 (113.50)	.009432 (110.38)
February	F_1	.001346 (110.15)	.001482 (100.00)	.001397 (106.10)	.001430 (103.68)	.001159 (203.29)	.002356 (100.00)	.001608 (146.54)	.001732 (136.01)
	F_2	.004246 (109.90)	.004666 (100.00)	.004403 (105.96)	.004532 (102.96)	.004719 (309.69)	.014617 (100.00)	.008431 (173.37)	.008619 (169.57)
March	F_1	.001583 (131.19)	.002077 (100.00)	.001786 (117.45)	.001817 (114.29)	.002909 (205.97)	.005992 (100.00)	.004065 (147.38)	.004365 (137.28)
	F_2	.004749 (134.86)	.006405 (100.00)	.005370 (119.27)	.005582 (114.74)	.011142 (226.44)	.025231 (100.00)	.016425 (153.60)	.017681 (142.69)

TABLE 4

Values of F_1 and F_2 for different sampling schemes and % efficiency as compared to sampling scheme-2 (in brackets),

Months	*Vegetables Errors measures*	*C. Flower Sampling Scheme*				*Peas Sampling scheme*			
		1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
January	F_1	.005220 (142.67)	.007447 (100.00)	.006055 (122.98)	.006226 (117.73)	.009213 (125.88)	.011597 (100.00)	.010107 (114.74)	.011049 (104.96)
	F_2	.017910 (142.57)	.025535 (100.00)	.020769 (122.94)	.021386 (109.38)	.047079 (109.00)	.052082 (100.00)	.049392 (105.44)	.050177 (103.79)
February	F_1	.001314 (152.71)	.002007 (100.00)	.001546 (129.80)	.001675 (127.50)	.001011 (654.87)	.006615 (100.00)	.003113 (212.53)	.004050 (163,34)
	F_2	.005502 (225.54)	.012400 (100.00)	.008089 (153.30)	.008170 (151.76)	.004190 (1293.66)	.054206 (100.00)	.022946 (236.24)	.024326 (222.81)
March	F_1	.001664 (147.38)	.002453 (100.00)	.001870 (131.13)	.001951 (125.71)	.003701 (284.09)	.010512 (100.00)	.006255 (168.06)	.007470 (140.72)
	F_2	.005398 (176·27)	.009516 (100.00)	.006686 (142.32)	.006974 (136.44)	.011958 (301.98)	.036107 (100.00)	.021014 (171.82)	.024414 (147.88)

The estimates of different components of variances and covariances appearing in the expressions of variances of price spread are given in Table-3. It can be seen from Table-3 that most of covariance components are positive. However, some of these have been noted to be negative also. The positive correlations were found to be significant generally whereas the negative ones were not found to be so. The assumption (*ii*) of (2) regarding the correlation between any stage of marketing and the last stage is also seen to be satisfied in most of the cases. The error measures F_1 and F_2 of the four samgling schemes have been worked out for $n=10$ and $q=5$ by substituting the values of various terms from Table-3, and the values are given in Table-4. The figures in the brackets are the percentage efficiencies over sampling scheme-2 which confirm the theoretical results (3) and (4). The gain in efficiency of sampling scheme-1 over sampling scheme-2 is also considerable. Thus for estimation of price spread, sampling scheme-1 can be used successfully.

SUMMARY

The study of price spread helps in ascertaining from time to time the share of the producer and the margins of various intermedaries involved in the sale and purchase of commodity at various stages of marketing in the consumer's rupee. In this paper, four sampling schemes have been considered for the estimation of price spread. Almost unbiased estimators (*i e.* estimators whose bias is zero upto first order of approximation) of different camponents of theprice spread have been suggested alongwith the combined measure of the error associated with these estimators. The relative effleiencies of different sampling schemes have been considered both theoretically and empirically.

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