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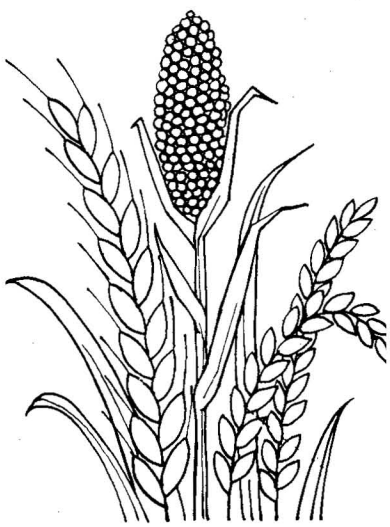

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SOME FACTORS INFLUENCING THE ECONOMY OF MILK PRODUCTION

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Introduction

Milk production in India is in the hands of millions of small producers scattered all over the country and to a large proportion of whom it is a secondary item incidental to maintenance of cattle for agricultural purposes. Most of the producers are illiterate and are not in a position to maintain any detailed or systematic account. The milk producers are not only ignorant of the quantitative aspect of the enterprise but even unmindful of the production capabilities of their animals. It is only in big cities, that too on a limited scale, that producers take up milk trade on commercial line but the proportion of animals maintained in the urban areas is very low as compared to a vast majority maintained in the rural areas. The knowledge of the economics of milk production in the rural areas would be of immense help for planning for improvement of dairy animals and in formulating animal husbandry plans on sound lines. Although there are as many as 25 distinct breeds of cattle and 8 breeds of buffaloes in the country, very little information is available about the productivity of each of these breeds and their economics. It is only in some farms which maintain a few animals of distinct breeds of cows and buffaloes, studies have been undertaken to work out the economics of these milch animals. But the results obtained for animals maintained in farm conditions may not be similar to those in village management conditions. Hardly any extensive work has been carried out to study the economics of milch stock maintained under village conditions excepting the studies carried out by the Institute of Agricultural Research Statistics (I.C.A.R.) which conducted large scale sample surveys in some urban and typical rural areas in order to evolve a suitable sampling technique for objective estimation of the cost of production of milk. Studies have also been made on a very limited scale on the economics of milk production by the Anand Agricultural Institute (1951), Jamia Institute of Agricultural Economics and Rural Sociology (1952-53) and the Punjab Board of Economic Enquiry (1953-54). In the present paper, an attempt has been made to study the effect of some factors like dry period, lactation length, components of maintenance cost, etc., which influence milk production and its economy in the case of Hariana cows maintained under village conditions.

Nature and Extent of Data

The material utilized for the study was taken from the large scale sample survey conducted by the Institute of Agricultural Research Statistics to estimate the cost of raising young stock and of maintaining adult cattle and buffaloes in the Hissar district of Haryana State during 1963-67 with a view to evolving a suitable sampling technique for the purpose. A random sample of 408 stalls containing cattle and buffaloes was selected from 103 villages for recording detailed

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data relating to the maintenance of bovines. The approach adopted for the enquiry was one of cost accounting, each selected stall being visited both morning and evening once in a fortnight by a trained investigator stationed in the villages. Data on milk yield of individual animals and feeds given were recorded by actual weighment and other information by direct observation and careful enquiry. The selected stalls were kept under observation continuously for a period of three years.

Data for 106 Hariana cows about which complete information on lactation length, dry period, milk yield, feeds fed, etc., were available have been utilized for the present study. Out of these 106 cows, 12 were in the first order of lactation, 23 each in the second and third order, 20 in the fourth order, 10 in the fifth order and the remaining cows in the sixth to ninth order of lactations.

Average Lactation Yield

As mentioned earlier, the milk yield of individual cows was recorded by actual weighment at a regular interval of a fortnight. The lactation yield of each cow was worked out following the usual procedure explained by Amble, *et al.*[1] The average yield per lactation taking all the 106 cows into consideration was 733 kg. in a lactation period of 262 days. The average calving interval was 453 days.

Effect of Preceding Dry Period and Lactation Length on Lactation Yield

It is an established fact that dry period is essential for giving rest to reproductive organs and for recoupment of the exhausted lacteal tissues of milking animals. Successive lactation yield is greatly influenced by the length of dry period preceding it. If the dry period is longer, the milk producer is economically hit as he gets less returns in the form of milk in exchange of feeds fed, labour utilized and money invested. Research workers, particularly in more advanced countries, have indicated that an optimum dry period is essential to attain higher milk yield and longer period has adverse effect on the lactation yield.

Arnold and Becker[2] reported 31 days to 60 days as an optimum dry period preceding any lactation for the Jersey cows maintained at Florida Station. A dry period longer than 91 days was likely to result in lower milk production than a shorter one. A dry period less than 30 days appeared to cause an early decline in milk yield in the next lactation. On the basis of a study on Finnish Ayrshire cows at the Agricultural Experimental Station, Tikkwila, Finland, Lonka[3] observed that the effect of dry period on subsequent lactation yield was not significant. Berdnick[4] reported positive correlation between dry period and

1. V. N. Amble, M. Rajagopalan and B. S. Gill, "Sampling of Daily Milk Records for Estimating Lactation Yield of Cows," *Indian Journal of Veterinary Science*, Vol. 29, No. 4, 1959, pp. 13-25.
2. P. T. Arnold and R. B. Becker, "Influence of Preceding Dry Period of Mineral Supplement of Lactation," *Journal of Dairy Science*, Vol. 19, 1936, pp. 257-260.
3. T. Lonka, "Dry Period and Milk Yield," *Dairy Science Abstracts*, Vol. IX, 1946, p. 160.
4. P. P. Berdnick, "Effect of the Length of Dry Period on the Productivity of Cows in the Subsequent Lactation," *Dairy Science Abstracts*, Vol. XIV, No. 4, 1951, p. 252.

subsequent lactation yield of Russian cows with a suggestion of 45 to 60 days as essential dry period for high milk-yielders. Clark[5] noted 4 to 9 weeks as optimum dry period for Queensland cows in order to get higher milk yield with higher butter fat content. In order to know the effect of the length of dry period on milk yield and the percentage of butter fat content in milk of Latavian Red cows, Petraitis[6] carried out two series of studies. In the first series, he observed that milk yield and total butter fat were not affected significantly by dry periods ranging from 0 to 60 days but declined markedly as the period increased from 60 to 100 days. In the second series, there was a clear peak performance when the dry period remained between 40 to 60 days but declined both when the dry period was less than 40 days and more than 60 days.

A very few studies of similar nature have been carried out for some breeds of Indian cows. Jha and Biswas[7] obtained a negative correlation between preceding dry period and lactation yield in Tharparkar cows maintained at Government Livestock Farm, Patna. Singh and Mallick[8] observed non-significant correlation and regression between preceding dry period and lactation yield in Sahiwal cows at Government Livestock Farm, Hissar; but significant correlation and regression between preceding dry period and lactation length. All the studies mentioned so far confined to farm animals. An attempt has been made in this paper to make similar study for Hariana cows maintained under village conditions in the breeding tract of Hissar district.

The linear, quadratic and the Cobb-Douglas functions have been fitted to work out the relationship of preceding dry period (x_1) and lactation length (x_2) with lactation yield (y). Least square method was employed for fitting the curve of each type. The functions fitted are given in Table I along with the amount of variation explained due to each curve. This study has been made for cows in each of the second, third, fourth and fifth order of lactation and also for all the animals ignoring the order of lactations. Functions are not fitted separately for cows in each of the higher order lactations due to inadequate number of observations in each order. However, functions have been fitted for all the cows ignoring the order of lactation similar to the studies carried out by other workers as it would be useful in those cases where the order of lactation of individual animals cannot be ascertained.

It is observed that Cobb-Douglas function explained the maximum variation in all the cases excepting for the animals in the fifth order of lactation when quadratic explained about 10 per cent additional variation over Cobb-Douglas. But the quadratic function has not been considered as best fit in each case because none of the regression coefficients was found to be significant and only a few degrees of freedom were left after allowing for the constants fitted. As such the Cobb-Douglas type was considered as the appropriate fit in each case. In this function,

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5. C. H. Clark, "Evidence Favours 4-9 Weeks Dry Period for Dairy Cows," *Animal Breed Abst.*, Vol. 28, 1959, p. 38.
6. I. Petraitis, "Effect of the Length of Dry Period on Performance and Reproduction of Cows," *Dairy Science Abstracts*, Vol. XXII, 1959, p. 169.
7. B. N. Jha and S. C. Biswas, "Effect of the Length of Dry Period on the Successive Lactation Yield in Tharparkar Cows," *Indian Veterinary Journal*, Vol. 41, No. 6, 1964, pp. 404-409.
8. M. Singh and D. D. Mallick, "Effect of and Relationship of Dry Period with Economic Milk Traits of Sahiwal Cows," *Indian Journal of Dairy Science*, Vol. 20, No. 4, 1967, pp. 161-164.

TABLE I—RELATIONSHIP OF PRECEDING DRY PERIOD AND LACTATION LENGTH WITH LACTATION YIELD

Order of lactation	Nature of curve	Fitted curve	$R^2 \times 100$ (percentage of variation explained)
Second (23)	Linear	$Y = -5.3758 - 0.5677x_1 + 4.0163^{**} x_2$	58.6
	Quadratic	$Y = -1420.3083 + 5.1806x_1 + 12.6560x_2 - 0.0084x_1^2 - 0.0149x_2^2 - 0.0114x_1x_2$	61.3
	Cobb-Douglas	$Y = 1.7000\ x_1^{-0.1660}\ x_2^{1.2820**}$	71.9
Third (23)	Linear	$Y = 91.5705 - 0.4172x_1 + 3.3088x_2^{**}$	75.8
	Quadratic	$Y = -258.5166 - 1.0633x_1 + 7.3350x_2 + 0.0059x_1^2 - 0.0070x_2^2 - 0.0065x_1x_2$	78.6
	Cobb-Douglas	$Y = 1.8480\ x_1^{-0.0564}\ x_2^{1.1559**}$	88.3
Fourth (20)	Linear	$Y = -223.3865 - 0.1145x_1 + 4.3094x_2^{**}$	81.2
	Quadratic	$Y = 2830.6753 - 10.3896x_1 - 10.7089x_2 + 0.0080x_1^2 + 0.0174x_2^2 + 0.0251x_1x_2$	83.9
	Cobb-Douglas	$Y = 0.0116x_1^{-0.0300}\ x_2^{2.0346**}$	86.0
Fifth (10)	Linear	$Y = 59.1542 - 1.1293x_1 + 3.4139x_2^{*}$	82.2
	Quadratic	$Y = 482.2852 - 17.5458x_1 + 7.4350x_2 + 0.0097x_1^2 - 0.0329x_2^2 + 0.0819x_1x_2$	93.4
	Cobb-Douglas	$Y = 3.8820\ x_1^{-0.5997}\ x_2^{1.4863*}$	83.3
Second to fifth (76)	Linear	$Y = 11.2025 - 0.4319x_1 + 3.6401^{**}x_2$	72.1
	Quadratic	$Y = -131.1477 + 0.2185x_1 + 4.4045x_2 - 0.0011x_1^2 - 0.0014x_2^2 - 0.0004x_1x_2$	72.3
	Cobb-Douglas	$Y = 1.8961\ x_1^{-0.1651}\ x_2^{1.2480**}$	80.4
Second to ninth (overall) (94)	Linear	$Y = 35.1425 - 0.4142x_1 + 3.4029^{**}x_2$	55.1
	Quadratic	$Y = 120.9686 - 1.5011x_1 + 3.7447x_2 + 0.0020x_1^2 - 0.0012x_2^2 + 0.0005x_1x_2$	55.5
	Cobb-Douglas	$Y = 3.2100\ x_1^{-0.1879}\ x_2^{1.1604**}$	63.2

N. B.: Figures in brackets in the first column indicate the number of cows.
* Significant at 5 per cent level.
** Significant at 1 per cent level.

if C_1 and C_2 are the coefficients of elasticity then one per cent increase in x_1 would result in C_1 per cent increase (if C_1 is positive) or decrease (if C_1 is negative) in Y for fixed x_2. Similarly, one per cent increase in x_2 would result in C_2 per cent increase (when C_2 is positive) or decrease (when C_2 is negative) in Y for fixed x_1. Examining the fitted functions it is observed that C_1, though not significant, is in all the cases negative indicating thereby decrease in lactation yield for any increase in the preceding dry period. The coefficient C_2 is positive and highly significant showing that there would be an increase in lactation yield for an increase in the lactation length. As an example, consider the Cobb-Douglas function fitted for cows ignoring the order of lactation. In this case, Cobb-Douglas curve explained about 63 per cent of variation as compared to 55 per cent by each of linear and quadratic functions. The elasticity coefficient of Y with respect to x_2 is 1.16 which is highly significant and shows that one per cent increase in lactation length would increase 1.16 per cent in lactation yield without any change in the preceding dry period. The elasticity coefficient of Y with respect to x_1 is —0.19 which is not significant. Consider a specific case where the preceding dry period of a cow was 200 days, lactation period 250 days and lactation yield 719 kg. From the fitted curve, it is worked out that one per cent increase (*i.e.*, 2 days) in the preceding dry period would result in a decrease of 1.35 kg. in lactation yield. Similarly, one per cent increase in lactation length would increase 8.34 kg. in lactation yield.

The function fitted would provide proportional increase in yield due to reduction in dry period and increase in lactation length. It is of considerable importance to know whether the additional yield obtained during a lactation due to change in lactation length and dry period would be beneficial to the producer, because prolonging lactation length would mean incurring additional expenditure for production ration over and above the maintenance ration. It is not desirable to increase the lactation length keeping dry period constant as it would mean prolonging the calving interval. The appropriate consideration would be to increase lactation length and simultaneously decrease dry period so as to keep the calving interval constant. In order to examine the economic implications under these circumstances a specific example is worked out considering the curve (Table I) :

$$Y = 3.2100\ x_1^{-0.1879}\ x_2^{-1.1604}$$

which was fitted taking into account all the animals ignoring the order of lactation. Assuming average calving interval of a cow to be 450 days, the estimated milk yields for different combinations of lactation length and dry period are as follows :

Lactation length (days)	250	253	255
Dry period (days)	200	197	195
Lactation yield (kg.)	719	731	739.1

When the lactation length would be enhanced by 3 days and dry period reduced by the same number of days keeping calving interval constant, *i.e.*, 450 days, the lactation yield would be increased by 12 kg. as estimated from the fitted function. Additional maintenance cost required for a cow for milk production as given in the report prepared by the Institute of Agricultural Research Statistics was 69

paise per day in the Hissar district during the period of enquiry. As the prevailing market rate of cow milk was 70 paise per kg. in the area, the additional gross return during the lactation was worked out to be Rs. 8.40, of which Rs. 2.07 would be spent for production ration. The producer would get a net return of Rs. 6.33 on account of additional milk production by prolonging the lactation period by 3 days and simultaneously reducing the dry period to the same extent.

Relationship of Feed Cost with Other Factors

The Institute of Agricultural Research Statistics worked out the estimates of cost of production of milk in the rural areas of Hissar utilizing the data considered in the present study. The overall cost of production was Re. 1 per kg. of cow milk when family labour was included and 80 paise when it was excluded. These estimates were obtained on the basis of the procedure explained by Panse, *et al.*[9] The estimates of cost of production of milk for Hariana cows in Delhi City and its surrounding villages as well as in Calcutta were worked out by Raut and Amble.[10] Similar studies have also been made by Puri and Singh[11] for Tharparkar, Sahiwal and Red Sindhi cows maintained at the National Dairy Research Institute. In all these studies, it was observed that feed cost accounted for 60 to 70 per cent of the gross cost. As feed cost is the most important component of cost, it is of interest to study its relationship with other factors like lactation yield, number of days in milk and dry period. Linear and Cobb-Douglas type functions have been fitted to obtain a suitable relationship between feed cost per kg. of milk (Y), total lactation yield (x_1), lactation length (x_2) and dry period (x_3) and the results are presented in Table II. In the present study, the relationship has been worked out for cows in individual order of lactations from first to fourth as well as for all the cows ignoring the order of lactations.

It is observed that in all the cases Cobb-Douglas type was the appropriate fit as it explained higher percentage of variation. The elasticity coefficient of Y with respect to x_1 was negative and highly significant whereas elasticity of Y with respect to x_2 and x_3 were positive and significant. The Cobb-Douglas function fitted for all the cows irrespective of their order of lactation explained about 82 per cent of variation as compared to only 50 per cent of variation explained by linear fit and all the three elasticity coefficients were highly significant. The elasticity of Y with respect to x_1 is —0.93 which indicates that one per cent increase in lactation yield would result in 0.93 per cent decrease in feed cost per kg. of milk keeping x_2 and x_3 constant. The elasticity coefficients of Y with respect to x_2 and x_3 are positive and highly significant indicating that a decrease (or an increase) in lactation length and dry period would result in a decrease (or an increase) in feed cost per kg. of milk.

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9. V. G. Panse, V. N. Amble and T. R. Puri : Cost of Milk Production (Delhi State), I.C.A.R. Report Series No. 6, New Delhi, 1961; V. G. Panse, V. N. Amble and K. C. Raut : Cost of Milk Production in Madras, I.C.A.R. Report Series No. 10, 1963, "Cost of Production and Price of Milk," *Gosamvardhana*, Vol. XII, June, 1964, pp. 1-20, and Cost of Milk Production in West Bengal, I.C.A.R. Report Series No. 28, 1967.

10. K. C. Raut and V. N. Amble, "Breed Variation in Cost of Milk Production," *Agricultural Situation in India*, Vol. XXIII, No. 11, February, 1969, pp. 1131-1136.

11. T. R. Puri, "Economics of Cost of Production of Milk," *Indian Journal of Agricultural Economics*, Vol. XVIII, No. 2, April-June, 1963, pp. 42-45; T. R. Puri and B. Singh, "Statistical Studies on the Economics of Milk Production," *Indian Journal of Dairy Science*, Vol. 17, 1964, pp. 29-35.

TABLE II—RELATIONSHIP OF LACTATION YIELD, LACTATION LENGTH AND DRY PERIOD WITH FEED COST PER KG. OF MILK

Order of lactation	Nature of curve	Fitted curve	$R^2 \times 100$ (percentage of variation explained)
First (12)	Linear	$Y=63.7766-0.0908^{**} x_1 + 0.2224^{*}x_2 + 0.1002x_3$	70.0
	Cobb-Douglas	$Y=128.0000\ x_1^{-0.8449^{**}}\ x_2^{0.7283^{**}}\ x_3^{0.1700}$	78.7
Second (23)	Linear	$Y=130.6389-0.1620^{**} x_1 + 0.1642x_2 + 0.2734x_3$	52.2
	Cobb-Douglas	$Y=754.0000\ x_1^{-1.0382^{**}}\ x_2^{0.5424^{**}}\ x_3^{0.2888}$	89.6
Third (23)	Linear	$Y=134.0777-0.0850^{*} x_1 + 0.8240\ x_2 + 0.2314\ x_3$	74.1
	Cobb-Douglas	$Y=2150.0000\ x_1^{-0.9197^{**}}\ x_2^{0.2816}\ x_3^{0.2185^{*}}$	94.3
Fourth (20)	Linear	$Y=73.6867-01167^{**} x_1 + 0.2716^{*}x2 + 0.0940x_3$	79.3
	Cobb-Douglas	$Y=69.7000\ x_1^{-0.7964^{**}}\ x_2^{0.6398^{*}}\ x_3^{0.3222^{**}}$	88.0
First to fourth (78)	Linear	$Y=105.9700-0.1283^{**}x_1 + 0.1607^{*}x_2 + 0.1888^{*}x_3$	52.6
	Cobb-Douglas	$Y=505.0000\ x_1^{-0.9500^{**}}\ x_2^{0.5233^{**}}\ x_3^{0.2680^{**}}$	85.6
First to ninth (overall) (106)	Linear	$Y=92.6742-0.1152^{**}x_1 + 0.1638^{**}x_2 + 0.1842^{**}x_3$	50.3
	Cobb-Douglas	$Y=797.2700x_1^{-0.9300^{**}}\ x_2^{0.5654^{**}}\ x_3^{0.2242^{**}}$	81.5

N. B.: Figures in brackets in the first column indicate the number of cows.
* Significant at 5 per cent level.
** Significant at 1 per cent level.

The relationship between the cost on feed to produce one kg. of milk (Y) and other factors like the total lactation yield (x_1), number of days in milk (x_2) and number of dry days (x_3) can also be obtained by working out the correlation coefficients between feed cost per kg. of milk and other factors. The partial and multiple correlation coefficients between these factors have been worked out and are given in Table III.

TABLE III—CORRELATION COEFFICIENTS BETWEEN DIFFERENT FACTORS

Correlation coefficients	Order of lactation				
	First	Second	Third	Fourth	Overall
$r_{y1.23}$	—0.885**	—0.952**	—0.811**	—0.927**	—0.923**
$r_{y2.31}$	0.849**	0.734**	0.555**	0.624**	0.663**
$r_{y3.12}$	0.550**	0.646**	0.728**	0.718**	0.665**
R_y (1, 2, 3) ..	0.885**	0.942**	0.972**	0.940**	0.940**

** Significant at 1 per cent level.

It is seen that the cost per kg. of milk is related with the total lactation yield, number of days in milk and number of dry days, the correlation coefficients being highly significant in all the cases. It is clear from the table that the cost of production is less for high producing animals as well as for those which have lesser days in milk or dry days, the yield being kept constant. The multiple correlation coefficient which is 0.94 and highly significant indicates that the knowledge of lactation yield, lactation length and dry period provides sufficient information to work out the cost on feed per kg. of milk.

Marginal Feed Cost

It is established as could be seen from the previous section that the feed cost per kg. of milk is highly correlated with the factors like lactation yield, lactation length and dry period. It is also observed that Cobb-Douglas type of curve is the most appropriate fit to explain the relationship between the feed cost per kg. of milk and other factors. The marginal increase in feed cost has been worked out utilizing the curve (Table II) :

$$Y = 797.2700 \; x_1^{-0.9300} \; x_2^{0.5654} \; x_3^{0.2242}$$

which was fitted for all the cows ignoring the order of lactation. These derived expressions are as follows :

$$\frac{dy}{dx_1} = 741.4611 \; x_1^{-1.9300} \; x_2^{0.5654} \; x_3^{0.2242} \quad \ldots\ldots\text{(i)}$$

$$\frac{dy}{dx_2} = 450.7764 \; x_1^{-0.9300} \; x_2^{-0.4346} \; x_3^{0.2242} \quad \ldots\ldots\text{(ii)}$$

$$\frac{dy}{dx_3} = 178.7479 \; x_1^{-0.9300} \; x_2^{0.5654} \; x_3^{-0.7758} \quad \ldots\ldots\text{(iii)}$$

The first expression indicates that for higher lactation yield there is scope for reduction in feed cost without any change in the lactation length and dry period. The second expression indicates that any further increase in lactation length would result in an increase in feed cost per kg. of milk at a decreasing rate keeping lactation yield and dry period fixed. Similarly, the third expression indicates that any increase in dry period would result in an increase in feed cost at a decreasing rate for fixed lactation yield and the number of days in milk.

A producer would like to know that if he is interested in reducing the feed cost by one paisa per kg. of milk, how much milk yield in a lactation should be increased without prolonging the lactation length and dry period. A reduction in feed cost can also be attained by reducing the lactation length as well as dry period without affecting the lactation yield. It is worked out that the cost on feed could be reduced by one paisa per kg. of milk if the milk yield per lactation would be increased by about 8.5 kg. without affecting the inter-calving period. A reduction of one paisa per kg. of milk can be attained by decreasing the lactation length by 6 days without affecting lactation yield and dry period. A decrease in dry period by 7 days would also decrease the feed cost by one paisa per kg. of milk without affecting lactation yield and lactation length. Similar studies carried out by Puri and Singh on Tharparkar, Sahiwal and Red Sindhi cows maintained at the National Dairy Research Institute showed that the cost on feed would be reduced by one paisa per kg. of milk if the milk yield per lactation would be increased by 81, 70 and 64 kg. for the three breeds respectively without affecting the inter-calving period. A reduction of one paisa per kg. can also be attained by decreasing the lactation period by 15, 14 and 13 days or decreasing the number of dry days by 24, 23 and 22 days for the three breeds respectively without affecting lactation yield.