COMPARATIVE ANALYSIS OF SELECTED MICHIGAN DAIRY FARM INTENSITIES IN 1968 AND 1974: PRODUCTION FUNCTION APPROACH

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I. INTRODUCTION

As far as farming strategy is concerned, two alternatives are possible, either:

a) Improve and increase the means of production aiming for a larger size of production without expanding land, or;

b) Expand production by acquisition of new land.

The option for either of the two alternatives depends on the farmer's own management and expectation.

The first alternative would increase the farmer's net wealth through increasing operating profit (shorter term than for the second alternative), whereas the second option would be based on the farmer's expectation of increasing his net worth through inflationary capital gains as well as return to current resource use.

The dairy farmers, like any other farmers, face the same alternatives:

a) Dairy farmers can expand production by new land acquisition which would allow larger herds, or

b) Alternatively, they can intensify the production by operating a larger herd and purchasing externally.

Problem Setting: Hypotheses

Assuming that farmers are seeking profit maximization, the question is: Which investment strategy is better?

In other words, is it better to expand production by (a) increasing herd sizes providing external feed purchases or (b) increasing land holdings?

Our interest is to empirically analyze the soundness of these managerial strategies; that is, look into the real world and appraise the performance of each strategy. Therefore, analyzing the relationship between farmers gross income and the density of cows per tillable acre will allow for a verification of the above mentioned hypotheses.

Background and References

The return on fixed and variable inputs is a function of the relative output and input prices. As far as the feed prices of the dairy farmers are concerned,[1] there are two levels for every single feed component, namely:

-the so-called "barn door" or field price for the feed sold off the farm; and,

-the "laid down at the farm" price for feed purchases.

Moreover, the authors of 'Farm Management Analysis' pointed out that ". . . for the general farmer the margin of profit (net revenue) received for converting the feed crops into livestock products is very narrow." To obtain some profits from the transformation of feed into livestock products, the authors suggested the following "rules of thumb."

(1) The feed, especially roughages, must be fed on the farms where produced.

(2) The purchased feed must be largely limited to those

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[1] Farm Management Analysis by L.A. Bradford and G.L. Johnson, 207-219.

needed to supplement the feed produced (factory products, by-products of high protein content, grains to supplement forage production).

(3) The larger the size of production, the better technology and management are. Size of the livestock enterprise has a significant bearing on cost.

They also advocate that for family farmers "the size of those livestock enterprises adapted to the feed and market situation should be pushed well toward full use of the limiting resources." Moreover, the larger the size of herd, the larger must be the investment in machinery and improvement.

As to the capital gains by the farms' assest, Melichar and Sayre have shown "indirect financial savings."(2) In fact, the authors of this unpublished paper studied at a national level the capital gains in the U.S. farming sector from 1940-1974. The results of this paper can be summarized as follows. The real capital gains (adjusted for inflation) represented:

(a) 1961-1967: 1/3 to 2/3 of the net farm income

(b) 1968-1970: only 2% of the net farm income

(c) 1971-1973: 92% of the net farm income

(d) 1974 (capital loss): -50% of the net farm income

The Approach

In view of the above "rules of thumb" suggested by Bradford and Johnson and the findings of Melichar and Sayre, it is important to empirically determine (1) how farmers did react and, (2) which investment strategy was most productive. More specifically, my interest is to determine whether or not running an intensive dairy farm is economically more efficient than operating an extensive dairy farm. In other words: does it pay to expand the herd size at the expense with the purchase of feed? However, "laid down at the farm" price of feed is usually larger than the so-called "barn door" price. This would call for a comparison of different marginal value products (MVP's) of some selected inputs given a certain level of output prices. These MVP's are being peculiar to the specific dairy farm type of intensity of production. This intensity of production will be measured by the ratio cows/tillable acre.

Historical data from MSU Telfarm will be analyzed in two selected years: 1968 and 1974. The option to use these two selected years is based on the observation that in 1968 real capital gains in the U.S. farming sector were almost "zero" (2% of the net farm income) while they were negative (minus 50% of the net farm income) in 1974.

To sum up, the approach will be based on the establishment of an empirical production function for different categories of dairy farms, i.e., extensive dairy production versus intensive dairy production farms.

II. CONCEPTUAL FRAMEWORK AND METHODOLOGY

In order to appraise the effectiveness of the management options, i.e., extensive dairy production versus intensive dairy operation, we will compare the MVP's of some selected inputs as generated by production functions. The method will consist of the following steps:

(1) Draw the data from actual dairy farms' records. These records have been provided by MSU Telfarm Project and cover the area of southwest Michigan. The selection of the farms has been based on the following criteria:

- must be a "specialized southern dairy farm." All the "mixed," "unspecified" and "cattle fed" types of farms have been rejected.
- reliable data information: all "specialized southern dairy farms" with suspicious information have been dropped out.

For 1968, 272 farms were selected out of 310 specialized southern dairy farms. For 1974, the study concerns 271 farms out of 302 specialized southern dairy farms.

(2) Select two years of concern to apply a cross-section analysis. In this case, the two years will be 1968 and 1974. These selected years had different output-input price relationships for the dairy farming sector. In fact, in a dairy farm case study,[2] the author presents in Graph 4 the following output-input price relationships measured

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[2] M.S. Plan B Paper: El-Hamrouni A. "Inflation and Taxation Effects on the Debt Carrying Capacity," 1976.

as 1967=100:[3]

-dairy farm inputs weighted price: 1968=99 and 1974=201

-milk price: 1968=105 and 1974=162

i.e., inflation has differently affected input prices (grains) and output (mainly milk). Notice that input prices and output prices have a direct effect on the MVP's, i.e., the results in 1968 and 1974 are expected to be quite different. That is to say, it might be more efficient to run an intensive dairy farm in 1968 and less efficient in 1974 or vice-versa.

(3) For each of the two selected years:

(a) Classify the whole dairy farm population according to their cows/tillable acre ratio distribution.

(b) Determine 3 classes of farms related to the ratio of cows/tillable acre:

-Class A: farms with a low ratio: less than .250 cows/tillable acre

-Class B: farms with average ratio: from .250 to .350 cows/tillable acre

-Class C: farms with high ratio: more than .350 cows/tillable acre.

(c) Establish the production function for each class and for each year in order to determine the MVP's of some selected inputs which will be presented in a later section.

(4) In order to appraise the efficiency of the management options, the following method and related steps will be used for both years 1968 and 1974:

(a) Determine the level of economies of scale of each class according to the sum of the elasticities of the output with respect to each input. Then, compare between the classes their respective MVP's of each input.

(b) Rule for the appraisal: for a given input, the higher the MVP relative to MFC (marginal factor cost), the more of that input that should be used.

Variables of the Model

A. Dependent Variable of the Model

The gross income as defined and computed by MSU Telfarm is used as the dependent variable. The gross income will be expressed in terms of dollars and it includes all the receipts (dairy and non-dairy revenues). It also includes the changes in crop inventories as well as livestock inventory changes.

However, it does not include improvements (dairy facilities and real estate improvement), machinery depreciation or land appreciation.

B. Independent Variables of the Model

(1) Cows

This variable is expressed in terms of cow units as determined by MSU Telfarm. Since the size of herd is of importance in both sides, i.e., cost per cow and revenue per cow, the cow variable is of major importance as a predominant input factor. The estimated coefficient will express the net earning power of one unit: it will determine the amount of the gross income earned due to adding one cow unit holding other inputs constant.

(2) Tillable Land

This variable will be expressed in acres. It is assumed that dairy production efficiency is closely related to the size of the farm land. This variable also serves the purpose of this study in the sense that land is an input of major concern as far as dairy production intensity is concerned.

Tillable land includes owned and rented land since this land has been used to support a given size of herd and generate the respective gross income. The MVP of land will be the $ return per acre of tillable land.

(3) Improvement Investment

This variable includes dairy facilities, real estate improvement, dwellings and will be expressed in terms of dollars. Since gross income was not adjusted for depreciation and/or appreciation of assets, the improvement variable will not be adjusted for depreciation. This variable is defined as: Beginning value + new purchases (if any). This would mean that improvement investment should cover any interest change plus depreciation cost. The return on the improvement capital invested is determined through the estimated coefficient of this variable. Thus, the MVP of this input will be expressed as the $ return on a $ invested in improvement.

(4) Machinery Investment

This variable will be expressed in terms of dollars.

The inclusion of this variable recognizes the capital machinery requirement for a dairy operation. The higher the intensity of the dairy operation, the higher the expected machinery investment.

Similarly to the improvement investment, the machinery investment will not be adjusted for depreciation and will be: Beginning value + purchases - sales (if any). The return on machinery should normally provide at least enough for depreciation compensation as well as interest. The MVP's, determined through the estimated coefficient will be expressed as the $ return from machinery to every $ invested in machinery.

(5) Operator and Family Labor

This variable will express the total hours per year of operator and family labor. The MVP of the operator and family labor will be expressed in dollars per hour of labor per year.

(6) Hired Labor

This variable is expressed in terms of total hours/year of hired labor. The MVP of this variable would be measured in $ return per hour of hired labor.

(7) Forage Produced and Fed on the Farm

The dollar amount of this input category is based on "barn door" prices. The level of use of this input will have an impact on the overall gross income since "barn door" prices are lower than market prices. Practically, this input will be computed as follows: $ forage produced on the farm + \$ beginning value of inventory - \$ ending value. The MVP of this variable will be expressed as \$ gross return on each \$ of forage.

(8) Feed Grains Produced and Fed on the Farm

This variable is expressed in terms of dollars. The rationale behind the use of this variable is the fact that the margin of profits derived from the conversion of the grains fed into marketable food is higher than the margin of profits associated with the forage. Therefore, the gross income is expected to be sensitive to the proportion of grown grains in the feed crop acreages. The MVP of this input will express the \$ return on each \$ grain feed.

(9) Feed Purchases

The input is expressed in terms of dollars. This variable is a separate input in order to assess the complimentarity of feed purchases as a consequence of the management option to operate an intensive dairy farm.

The MVP of the feed purchases associated with the production function is to be used to appraise the value of purchased feed. The MVP will be expressed in terms of \$ return on each \$ of purchased feed.

(10) Operating Costs

The \$ invested in the operating expenses has a direct effect on the size of the gross income. The figures related to this variable cover all the common variable costs. The operating costs do not include labor costs, depreciation, interest (cash and non-cash), land rental expenses, real estate taxes and capital investment such as machinery, improvement and livestock purchases.

However, they include machinery operating expenses, improvement maintenance, livestock operating costs, crop expenses and utilities expenses. The appraisal of the effectiveness of the operating costs will be made through the analysis of the MVP of this variable for each class. These MVP's will be expressed as the $ return on each $ used as operating costs.

The Model

The model used to empirically derive the production functions for each of the classes to be studied has been suggested from "Farm Management Analysis," Bradford and Johnson, pp. 145-148. The relationship between gross income (dependent variable denoted y) and the factors of production on inputs X_i used during period t (independent variables will be expressed in a Cobb-Douglas production function. The generalized form will be:

$$Y_t = \beta_0 \; X_{1t}^{\beta_1} \; X_{2t}^{\beta_2} \; X_{3t}^{\beta_3} \; . \; . \; . \; X_{it}^{\beta_i} \; e^{ut} \qquad (1)$$

Knowing the values of the β's in this relationship will allow us to see how output varies with differing quantities of the various inputs, assuming that the disturbance term does not change when inputs are changed.

An interesting property of the Cobb-Douglas production function is that the cases of increasing, constant or decreasing returns to scale can be found simply by taking the sum $\sum_{1}^{i} \beta_i$.

$\sum_{1}^{i} \beta_i > 1$: increasing returns to scale

$\sum_{1}^{i} \beta_i = 1$: constant returns to scale

$\sum_{1}^{i} \beta_i < 1$: decreasing returns to scale

Another property of the Cobb-Douglas production function is that each β_i may be interpreted as the elasticity of output with respect to input i: if x_i is increased by 1%, and all other inputs are held constant, the output Y will increase by β_i percent.

In order to estimate the value of the β's, we will use the logarithmic transformation and equation (1) will become:

$$\text{Log } Y_t = \log \beta_o + \beta_1 \log X_{1t} + \beta_2 \log X_{2t} + \beta_3 \log X_{3t} + \ldots + U_t \qquad (2)$$

Let define $\text{Log } Y_t = Y_t'$ $\qquad$ $\text{Log } X_{it} = X_{it}'$

$\text{Log } \beta_o = \alpha$

Substituting into equation (2) we will have:

$$Y_t' = \alpha + \sum_{1}^{i} \beta_i X_{it}' + U_t \qquad (3)$$

where U_t meets the usual assumptions of the Ordinary Least Square Method (OLS).(1) Using the OLS technique on the variables defined in equation (3), the estimators

$\hat{\alpha}$, $\hat{\beta}_1 \ldots \hat{\beta}_i$ of the parameters are best linear and unbiased (BLUE).[2]

The marginal value product of any input X_i can be measured as:

$$MVP_{x_i} = \frac{\beta_i \hat{Y}_t}{X_{it}}$$ where $\hat{Y}_t$ is the estimated gross income.

Major Assumptions of the Model

The model used in the cross-section analysis as defined earlier is underlined by some assumptions peculiar to the stratification. These assumptions are the following:

(1) Input and output prices are assumed to be the same for all farms in a given year.

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[1] Assumptions that are necessary in order for OLS estimators to be BLUE--

$E\ (U_t) = o$

$E\ (U_t^2) = \sigma_u^2$ finite, constant variance

$E\ (U_t\ U_s) = o$ for $t \neq s$

$E\ (X_t,\ U_t) = o$

[2] Even though $\hat{\alpha}$ is an unbiased estimator of α, i.e., $E(\hat{\alpha}) = \alpha$, $\hat{\beta}_o$ is not an unbiased estimator of β_o since $\alpha = \log\ \beta_o$ and the estimator of β_o would be $\hat{\beta}_o = e^{\hat{\alpha}}$ and $E\ (\beta_o) \neq e^{E(\hat{\alpha})} = e^{\alpha} = \beta_o$. Thus, $\hat{\beta}_o$ is a biased but consistent estimator of β_o.

(2) For a given class in a given year, it is assumed that:

a) All the dairy cows are of equal worth. In fact, the independent variable 'number of cows' is expressed in physical measurement. Thus, the return per cow is not due to the 'cow effect' but rather to other managerial factors.

b) The tillable land has the same value per unit for all the concerned farms. The MVP of land varies not because of the quality of land but because of other managerial factors.

c) The wage and quality of one hour operator and family labor is the same for all the concerned farms. This is also true for the 'hired labor' hour wage. The MVP's of both types of labor vary from one class to another not because of the labor quality but because of other managerial factors.

Limits and Shortcomings

In order to prevent any fallacy in the final interpretation some shortcomings should be recognized:

(1) The Physical Inputs' Error

Age of cows, fertility of land and labor wage are not likely to be the same for all the observed farms. Therefore, the approximation made in the above assumptions would affect the final outcome. However, this study has minimized this effect by undertaking analysis on:

a) a homogeneous group of dairy farms assumed to operate potentially equal cows and

b) a homogeneous geographical area (southwest Michigan) which would minimize land productivity differences and labor wage disparity.

(2) Data Error

Another shortcoming might be related to the reliability of the data used in this study. In fact, the validity of the findings, if any, relies on the accuracy of the reported information. While every effort has been made to obtain accurate data, including elimination of 38 and 31 farms with suspicious data respectively in 1968 and 1974, errors may still occur.

III. RESULTS, ANALYSIS AND INTERPRETATION

In order to determine the most relevant inputs, that is, the independent variables which have a significant impact on the dependent variable, the stepwise regression method will be used to find a "best" set of independent variables. Essentially this method computes a sequence of regression equations, at each step adding or deleting an independent variable. Since the independent variable "cows" is a meaningful variable because the observed cases are dairy farms, the stepwise regression technique will be used with the variable "cows" as never deleted. The retained independent variables will only be those inputs having a degree of significance less or equal to .250. Therefore, this method will select the most significant inputs.

1968 Results and Analysis

The total number of farms, 272, has been classified into three classes according to the ratio of cows/tillable acre.

3.1 Observed Farms and Their Classification--Year 1968

	Cows/Till. Acre	# of Farms	% of Farms
Class A	less than .250	193	71.0%
Class B	from .250 to .350	62	22.8%
Class C	more than .350	17	6.2%
Total		272	100.0%

(1) 1968 Class A

The production function for Class A farms is:

$$\log(\text{gross farm income}) = \underset{(.1577)}{1.6745} + \underset{(.0529)}{.3888}\log(\text{cows}) + \underset{(.0450)}{.1682}\log(\text{till. acres}) + \underset{(.0118)}{.0394}\log(\text{improvement}) + \underset{(.0358)}{.0699}\log(\text{machinery}) + \underset{(.0529)}{.3758}\log(\text{operating costs})$$

or:

$$\text{gross farm income} = 10^{1.6745} * (\text{cows})^{.3888} * (\text{till. acres})^{.1682} * (\text{improvement})^{.0394} * (\text{machinery})^{.0699} * (\text{operating costs})^{.3758}$$

Related Statistical Results:

F for the overall regression = 224.7883

Level of significance for the overall regression:

$\alpha = .0005$

Multiple regression coefficient: $R^2 = .8574$ and

$\bar{R}^2 = .8535$

Economic Analysis--The production function for Class A in 1968 exhibits an increasing return to scale since $\sum_{1}^{i} \beta_i = 1.0421$.

Since MVP_{xi} is in general equal to $\frac{\beta_i \hat{Y}}{X_i}$ where β_i equals the X_i coefficient, $\hat{Y}$ is the estimated gross income and X_i is the level of input used, the estimates of the marginal value products earned will be derived from the above production function using the class average use of resources (Table 3.2). The net earning power (the marginal value products) of the different inputs were computed for a "specific" farm having as endowments the class average amounts of resources used.

3.2 1968 Class A: MVP's of the Retained Inputs

	Gross Farm Income	Constant	X_1 Cows	X_2 Land	X_3 Improv.	X_4 Machinery	X_{10} Oper.Cost	$\Sigma \beta i$
Regression Coef.	----	1.6745	.3888	.1682	.0394	.0699	.3758	1.0421
Level of use of inputs for specific farm	$64,590	----	49.76	316.4	$23,867	$24,022	$15,612	----
MVP of inputs ($)	----	----	506.77	34.33	.11	.19	1.55	----

The marginal value products earned by the different input categories explain that:

- an additional cow unit will contribute $506.77 to gross income
- one more acre of tillable land would produce $34.33 gross farm income
- a return of $.11 is obtained from an additional dollar spent on improvement investment
- a return of $.19 is earned from an additional dollar invested in machinery
- a return to the operating costs at a rate of $1.55 is earned for ad additional dollar spent.

From an analytical standpoint, at the margin, the land is earning an estimated $34.33 per tillable acre, the

Related Statistical Results:

F for the overall regression = 112.69

Level of significance of the overall regression:

α = .0005

Multiple regression coefficient: R^2 = .9096 and

$\bar{R}^2$ = .9015

Economic Analysis--The sum of the regression coefficients associated with the retained independent variables (elasticities of gross farm income to the concerned inputs) is equal to .9843. Thus, 1968 Class B production function exhibits a decreasing return to scale. As mentioned earlier, the marginal value products are estimated from the above production function using the class average use of resources (Table 3.3).

3.3 1968 Class B: MVP's of the Retained Inputs

	Gross Farm Income	Constant	X_1 Cows	X_3 Improv.	X_6 Hired Labor	X_7 For. Pro. fed.	X_{10} Oper.Cost	Σ βi
Regression Coef.	----	1.7089	.4763	.0709	.0309	.0708	.3349	.9843
Level of use of inputs for specific farm	$52270	----	69.12	30117	2661	11707	17520	----
MVP of inputs ($)	----	----	360.16	.12	.607	.32	.99	----

The marginal value products earned by the different input categories (in the amounts used on the average farm) are:

- cows $360.16 per cow unit
- improvement $ .12 per dollar invested

- hired labor $ .61 per hour
- forage produce fed $ .32 per dollar invested
- operating costs $ .99 per dollar spent

The above rates of return are net to the last unit of each input, that is, one additional cow unit would contribute $360.16 to the gross farm income; the last $100 invested in improvement will return 12 cents on the dollar invested; the last hour of hired labor provides only 61 cents. This would suggest that farmers should cut down on hired labor since the wage rate per hour is higher than sixty-one cents. The last $100 value of forage will return $32; the operating costs are paying only 99 cents on the dollar spent.

More operator and family's labor could be used jointly with a contraction in hired labor in order to increase annually the expenditures. At the margin, improvement investment returns are adequate with a rate of return of 12 percent.

(3) 1968 Class C Farms

This class includes all the farms operating intensive dairy production, that is, using less than 3 acres of tillable land for every cow unit. These farms account for about 6 percent of the total observed cases in 1968. The production function obtained for 1968 Class C is:

$$\log(\text{gross farm income}) = \underset{(.366)}{2.3998} + \underset{(.1743)}{.5399}\log(\text{cows})$$

$$+ \underset{(.093)}{.0868}\log(\text{improvement})$$

$$+ .2242 \log (\text{forage prod. fed}) \quad (.061)$$

or:

$$\text{gross farm income} = 10^{2.3998} * (\text{cows})^{.5399} * (\text{improvement})^{.0868} * (\text{forage prod. fed})^{.2242}$$

Related Statistical Results:

F for the overall regression = 17.0262

Level of significance of the overall regression:

α = .0005

Multiple correlation coefficient: $R^2 = .7971$ and $\bar{R}^2 = .7503$

Economic Analysis--The production function of this class exhibits a decreasing return to scale since the sum of the elasticities of the gross income with respect to the input categories is less than unity ($\sum_1^i \beta_i = .8512$). The most relevant inputs affecting the gross income of these farms are: the dairy cattle size, the level of the forage produced and fed on the farm and the level of improvement investments (excluding maintenance and/or depreciation).

The net earning power of the different inputs is computed with the same procedure as seen in earlier sections (Table 3.4).

3.4 1968 Class C: MVP's of the Retained Inputs

	Gross Farm Income	Constant	X_1 cows	X_3 Improv.	X_7 For Pro. fed	$\sum_1^i \beta i$
Regression Coef.	----	2.3998	.5399	.0868	.2242	.8512
Level of use of inputs by specific farms	$49,660	----	74.38	$23,302	$11,[illegible]	----
MVP of inputs ($)	----	----	360.53	.18	1.01	----

marginal value product of the retained inputs in their respective production functions will help to determine the relative efficiency of each class.

(1) The retained independent variables or relevant inputs: From Table 3.5 it appears that the gross farm income is dependent on five input categories in the case of extensive farms (Class A) and semi-intensive farms (Class B) and three input categories in the case of intensive dairy operation (Class C). The "cow" variable has never been subject to deletion as stated earlier and the variable "improvement investment" has been retained in all three production functions related to Classes A, B and C.

However, the variables "operator labor" and "grains produced and fed on the farm" have been constantly dropped out for non-significant effect on the gross farm income. The variables "land" and "machinery" are relevant only for Class A; also the variable "hired labor" for Class B.

"Forage produced and fed on the farm" variable has been retained in Class B and C, whereas the "operating cost" variable is significant for Class A and C.

Similarities and differences between intensive and extensive dairy farms:

(a) Similarities--The herd size and the investment in dairy facilities, real estate improvement and dwellings are highly correlated to the gross farm income for both types of dairy operations.

(b) Differences--The level of forage produced is influent

3.5 1968: Retained Inputs and Their Respective MVP's (Summary)

Class		Estimated Gross farm Income	Constant	X_1 cows unit	X_2 Land (acres)	X_3 Improv. ($)	X_4 Machinery ($)	X_6 Hired Labor (hours)	X_7 for Pro. fed ($)	X_{10} Oper. Costs ($)	Σ bi
CLASS A	Regression Coefficients of Retained Inputs	----	1.6745	.3888	.1662	.0394	.0699	----	----	.3758	1.0421
	Level of use of Inputs by specific farms	$64,590	----	49.76	316.4	23,867	24,022	----	----	15,612	----
	MVP of Inputs ($)	----	----	504.77	34.33	.11	.19	----	----	1.55	----
CLASS B	Regression Coefficients of Retained Inputs	----	1.7089	.4763	----	.0709	----	.0309	.0708	.3349	.9843
	Level of use of Inputs by specific farms	$52,270	----	69.12	----	30,117	----	2,661	11,707	17,520	----
	MVP of Inputs ($)	----	----	360.16	----	.12	----	.61	.32	.99	----
CLASS C	Regression Coefficients of Retained Inputs	----	2.3998	.5399	----	.0868	----	----	.2242	----	.3512
	Level of use of Inputs by specific farms	$49,660	----	74.38	----	23,302	----	----	11,033	----	----
	MVP of Inputs ($)	----	----	360.53	----	.18	----	----	1.01	----	----

on farm income for intensive dairy farms, whereas the machinery investment, the land and operating cost input categories have a significant impact only in the case of extensive dairy farming.

(2) Comparative analysis of some retained input MVP's:

(a) Cows: according to Table 3.5, the MVP of the cow unit is higher in extensive rather than intensive dairy operation: the return per cow unit, $504.77, in Class A versus about $360 in Class B and C indicating need for a larger herd.

(b) Improvement: the return to each dollar invested in facility and land improvement is significantly higher for intensive than extensive dairy farms. Since this input would display an economy of scale, i.e., the dollar invested in improvement is smaller for a larger herd, there is a more significant impact on the gross farm income for intensive dairy farms which seems to be more efficient with respect to this input.

(c) Forage produced and fed on the farm: this category of input is non-significant for the most extensive types of farms. However, for a marginal cost of one dollar, the larger the relative size of the dairy herd with respect to the potential tillable acres (Class C) the more return is obtained; in intensive dairy farming, one dollar invested in forage would return $1.01, whereas only thirty-two cents are returned per dollar invested in forage for the extensive farms. Even though the margin of profit is very narrow (1 cent per dollar invested) the intensive farms have an important need for producing forage on the farm.

(d) Operating costs: these current expenditures are paying a high return (1.55) on the dollar spent for the extensive farms. The high return of this input in Class A implies that extensive farms could increase their efficiency by a larger investment in livestock and forage since these farms have a tillable land that could support a larger dairy herd. As another alternative, this excess of land could be used for cash crops or any other commercial farm product. For extensive dairy farms, the gross receipts depend on inputs other than land.

1974 Results and Analysis

The 1974 study concerns 271 farms located in southwestern Michigan (a list of the counties and related number of farms is provided in the appendix). According to the ratio of cows per tillable acre, these farms have been classified into three classes.

(1) 1974 Class A

Using the same procedure as for 1968, i.e., the stepwise regression method, the production function for Class A is:

3.6 Observed Farms and Their Classification--Year 1974

	Cows/Till. Acre	# of Farms	% of Farms
Class A	less than .250	185	68.3%
Class B	from .250 to .350	64	23.6%
Class C	more than .350	22	8.1%
Total		271	100.0%

$$
\begin{aligned}
\log(\text{gross farm income}) = {} & \underset{(.1680)}{1.2308} + \underset{(.0467)}{.1500} \log(\text{cows}) \\
& + \underset{(.0731)}{.1085} \log(\text{till. acres}) \\
& + \underset{(.0182)}{.0367} \log(\text{improvement}) \\
& + \underset{(.0466)}{.1129} \log(\text{machinery}) \\
& + \underset{(.0088)}{.0134} \log(\text{hired labor}) \\
& + \underset{(.0681)}{.5403} \log(\text{operating costs})
\end{aligned}
$$

or:

$$
\begin{aligned}
\text{gross farm income} = {} & 10^{1.2308} * (\text{cows})^{.1500} * (\text{till. acres})^{.1085} \\
& * (\text{improvement})^{.0367} * (\text{machinery})^{.1129} \\
& * (\text{hired labor})^{.0134} \\
& * (\text{operating costs}^{.5403}
\end{aligned}
$$

Related Statistical Results:

F for the overall regression = 153.6210

Level of significance for the overall regression:

α = .0005

Multiple regression coefficient: R^2 = .8381 and

$\overline{R}^2$ = .8327

Economic Analysis--The sum of the elasticities of gross farm income to the relevant inputs (sum of the regression coefficients associated with the retained independent variables) is equal to .8618. Thus, a decreasing return to scale prevails. Using the method outlined in the previous section, the marginal value products derived from the above production function are:

3.7 1974 Class A: MVP's of the Retained Inputs

	Gross Income	Constant	X_1 Cows	X_2 Land (acres)	X_3 Improv. ($)	X_4 Machinery ($)	X_6 Hired Labor (Hour)	X_{10} Oper. Costs ($)	$\Sigma\ \beta i$
Regression Coef.	--	1.2308	.1500	.1085	.0367	.1129	.0134	.5403	.9618
Level of use of inputs	$946.50	--	66.62	389.3	42453	45825	2178	34157	--
MVP of inputs ($)	--	--	213.12	26.39	.08	.23	.58	1.50	--

The above estimates indicate that the following marginal values were being earned: cows--$213.12 per cow unit; land--$26.39 per tillable acre; improvement--8% on the investment; machinery--23% on the investment; hired labor--58 cents per hour and forage produced and fed on the farm--$1.50 on the dollar invested in forage.

The land, earning $26.39 per tillable acre, could support a larger dairy herd, whereas $100 spent on operating costs returns $150 annually. The rate of return on machinery (23 percent) is high if we consider an appropriate return between 10 and 20 percent. This indicates efficient machinery use. The return on improvement is found somewhat low (only 8 percent). The last hour of hired labor provides only 58 cents which is low with respect to the hourly wage rate paid. An expansion in forage investment, since the tillable land is available, could be done jointly with a larger investment in livestock for a more efficient use of improvement investment and a contraction in hired labor.

(2) 1974 Class B

The generated production function for Class B is:

$$\log(\text{gross farm income}) = \underset{(.4357)}{2.1562} + \underset{(.1933)}{.6096}\log(\text{cows}) + \underset{(.0343)}{.0708}\log(\text{hired labor}) + \underset{(.1556)}{.2984}\log(\text{forage prod. fed})$$

or:

$$\text{gross farm income} = 10^{2.1562} *(\text{cows})^{.6096} *(\text{hired labor})^{.0708} *(\text{forage prod. fed})^{.2984}$$

Related Statistical Results:

F for the overall regression = 59.2405

Level of significance of the overall regression:

$\alpha = .0005$

Multiple regression coefficient: $R^2 = .7476$ and

$\bar{R}^2 = .7350$

Economic Analysis--For 1974 Class B, a decreasing return to scale prevails since an increase in all inputs by 1.0 percent would increase output by less than 1.0 percent ($\sum_{1}^{i} \beta_i = .9788$). The estimated marginal value products derived from the above production function are in Table 3.8.

3.8 1974 Class B: MVP's of the Retained Inputs

	Gross Farm Income	Constant	X_1 Cows	X_6 Hired Labor (Hours)	X_7 For Pro. Fed. ($)	$\Sigma\ \beta i$
Regression Coef.	--	2.1562	.6096	.0708	.2984	.9788
Level of use of inputs by avg. farm	$93538	--	93.50	3570	36634	--
MVP of inputs ($)	--	--	309.86	1.85	.76	--

Cows are earning $309.86 per cow unit; the hired labor is estimated at $1.85 per hour at the margin and the forage produced and fed on the farm only $.76 on the dollar value. In this case the return on hired labor is substantially higher ($1.85 vs $.58) than in Class A farms but still lower than the market price.

(3) 1974 Class C

In this class the farms are operating at most 2.8 acres per cow unit. The production function generated for this intensive type of farm is:

$$\log(\text{gross farm income}) = \underset{(.8950)}{.1917} + \underset{(.3233)}{.1098} \log(\text{cows})$$

$$+ \underset{(.1730)}{.4498} \log(\text{improvement})$$

$$+ .6247 \log (\text{operating costs}) \quad (.2601)$$

or:

$$\text{gross farm income} = 10^{.1917} * (\text{cows})^{.1098} * (\text{improvement})^{.4498} * (\text{operating costs})^{.6247}$$

Related Statistical Results:

F for the overall regression = 14.1932

Level of significance of overall regression: $\alpha = .0005$

Multiple correlation coefficient: $R^2 = .7029$ and $\bar{R}^2 = .6533$

Economic Analysis--The size of the dairy herd, the level of improvement investment and the operating costs are the most relevant inputs in this class category. With respect to the sum of the elasticities of the gross income to the outlined inputs, the production function exhibits an increasing return to scale with $\sum_{1}^{i} \beta_i = 1.184$.

The marginal value products earned are:

3.9 1974 Class C: MVP's of the Retained Inputs

	Gross Farm Income	Constant	X_1 Cows	X_3 Impr. ($)	X_{10} Oper. Costs ($)	$\Sigma\ \beta i$
Regression Coef.	--	.1917	.1098	.4498	.6247	1.184
Level of use of inputs for avg.farm	$103286	--	111.83	50965	38828	--
MVP of inputs ($)	--	--	101.40	.91	1.68	--

The above rates of return show that one additional cow unit would provide $101.40 to the gross farm income; $91 is returned on $100 invested in improvement and the operating costs are paying $1.65 on the dollar spent annually.

1974--Comparative Analysis of the Three Classes

The production functions associated with Classes A, B and C show significant differences in the following points:

- number and type of input categories retained
- differences in terms of MVP for a given input
- the level of return to scale

Assuming that input and output prices do not change among all observed farms for the year 1974, a comparison of the earning power of the relevant inputs between extensive and intensive types of dairy farms will reflect an empirical judgment on their relative efficiency.

(1) The retained independent variables or relevant inputs: According to the previous sections related to 1974, the results indicate that the gross farm income is significantly related to 6 input categories in Class A and 3 input categories in the case of semi-intensive (Class B) and intensive farms (Class C).

The "cow" variable has never been subject to deletion since considered as a meaningful input in the case of dairy farms. The variable "tillable land" and "machinery" are relevant only for Class A and also the input category "forage produced" with respect to Class B. The variables "improvement investment" and "operating expenses" have been retained in extensive and intensive dairy farms, whereas "hired labor" input has been relevant for extensive and semi-intensive (Class A and B, respectively) types of farms. However, the "operator labor" and "grain produced on the farm" input categories have been dropped out for their non-significant relevance to the gross farm income.

(2) Comparative analysis of some retained input MVP's:

(a) Cows: The highest return per cow unit has been earned in the case of semi-intensive dairy farms: about $310 in Class B versus $213 in Class A and only $101 in the intensive farms as also shown by the elasticity figures of this resource: .60 for Class B, .15 and .11 for Class A and C, respectively.

(b) Improvement: For the last $100 invested, dairy facilities, real estate improvement and dwellings, return an appropriate rate of about 8 percent, whereas the rate of return is significantly higher (91 percent) for the intensive dairy farms. Since the variables "land, forage produced and fed on the farm, and machinery" have not been retained in the production function associated with Class C, this figure would be the combined MVP of the above input categories and the improvement input.

(c) Operating costs: For the extensive dairy farms, the operating expenses are paying $1.50 on the last dollar spent. As said earlier for Class A 1968, this high return would suggest a larger investment in livestock and forage or cash crops in order to increase their efficiency with the availability of tillable land returning about $26 per acre. For the intensive farms, the return on the dollar spent is very narrow, about 8 cents. That is, the current expenditures become less important as the production means are expanded.

(d) Forage produced and fed on the farm: The relevance of this input category concerns only the semi-intensive farms--the last dollar invested in forage would return 76 cents. In Class A and B this input would not have a significant impact on the gross farm income and its earning power would eventually be combined with the MVP figures of land for extensive farming and improvement for the intensive group of farms.

Comparison Between 1968 and 1974--All Classes

Following the analysis, in the previous sections, of the generated production functions inherent to the different classes of farms, a comparison of the resulting outcomes will determine the relative efficiency of each class. In the matter of farm efficiency comparisons, as mentioned by Heady in "Economics of Agricultural Economics and Resource Use": "economists found that net farm income was unsatisfactory as an index of resource or production efficiency." Thus, two measures of profit, management return and labor income were substituted for net income as an index of efficiency of resource combination. But, a gross income figure would be more appropriate where appraising resource efficiency on groups of farms and using

Selected indexes, their sources and absolute values of some selected farm factors are annexed in Table 5. The comparative analysis of the MVP and AMFC of the outlined inputs, cows and land, are indicated in Table 3.10.

3.10 Class A and Class C Comparative Analysis of Adjusted MVP and AMFC: 1968 versus 1974--(1967=100)

	Class A		Class C	
	1968	1974	1968	1974
Cows (1) (ad) MVP (1967=100)	$480.73	$131.55	$343.36	$62.59
(2) (ad) AMFC(1967=100)	60.52	64.33	60.52	64.33
(3) (1) - (2)	+420.21	+67.22	+282.84	-1.74
Land (1) (ad) MVP (1967=100)	32.08	15.17	--	--
(2) (ad) AMFC(1967=100)	34.36	36.13	--	--
(3) (1) - (2)	-2.28	-20.96	--	--

Note: The above figures are detailed in Annex 6.

This comparative analysis will focus mainly on extensive types of farms (Class A) versus intensive farms (Class C).

(3) Comments

(a) The cow variable

Recall that all adjusted MVP's are at the class mean level of resource use. According to the results summarized in Table 3.10, the 1974 Class C farms are almost at the optimum point of use of the "cow" each retained input which is a function of the estimated gross farm income $\hat{Y}$, the regression coefficient β_i (or elasticity of the gross income with respect to the concerned input i) and the level of use of the input i, has been estimated for a "specific" (or average) farm having as endowments the class average amounts of resource used.

(1) Summary of the findings

As outlined in the previous part dealing with the generated production functions and their related analysis, some findings associated particularly with the comparative analysis of extensive and intensive types of dairy farms in 1968 and 1974 can be summarized as follows:

1968 Class A: This extensive type of farm could increase the level of use of the "cow" resource and should maintain the same level of use of land. In other words, 1968 Class A would tend toward an intensification of the dairy operation.

1968 Class C: Since the residual (MVP - AMFC) of cow is about $282, and in order to reach the optimum where the marginal value product equates the "average" marginal factor cost, this type of farm would have to increase its herd size.

1974 Class A: In this case, it would not pay to have additional tillable acres because MVP (land) is less than AMFC (land), but more cow units would be profitable for the dairy operation since MVP (cow) is greater than AMFC (cow) with a residual of about $67.

1974 Class C: With respect to the "cow" resource, this class would be at a quasi-optimum since the residual ($ - 1.74) is close to zero, i.e., MVP (cow) - AMFC (cow) $\doteq$ 0.

The above empirical findings are subject to limitations and shortcomings.

(2) Limitations

Even though the observed dairy farms are from the same geographical area, namely, southwest Michigan, the nature of the land and its related productivity differs from farm to farm within the same class, and its effect is more relevant between groups of farms. Poor, medium and rich quality land would explain the type of appropriate farming: extensive dairy farms (with a low ratio cows/ till. acre) would take place on poor quality land; a land of medium quality would be generally used for semi-intensive to intensive dairy farms, whereas cash crops would be more profitable on rich quality land. The proposed study was assuming the same land productivity for all observed farms, but the findings show a substantial bias due to this factor: in 1968 and 1974 Class A, the variable "tillable acres" has been retained as having a significant impact on the gross farm income, whereas this factor was dropped from Classes B and C in both years. It can be suggested that Class A land is more productive than that of the other groups of farms. According to the earning power of this input (which will be further discussed later)--about $34 and $26 in 1968 and 1974, respectively--more substantial profit could be earned with cash crops or a larger investment in livestock and forage from the resulting excess of land.

Another limitation out of control would be the weather which might generate a bias in the estimates, and therefore a larger error when comparing 1968 and 1974 results.

As mentioned in Part II, the data were provided by MSU Telfarm Project, and some information drawn from the observed farms' records might be inaccurate resulting in less reliable estimates.

(3) Shortcomings

The major shortcomings resulting from the outlined model and its variables concern essentially the marginal value products of the retained variables or most relevant inputs. Even though those figures are unbiased because of the range of the classification, they are less reliable in the sense that they would not indicate the exact (or real) earning power of the associated input because of the phenomena of complementarity and substitutability of some inputs.

(a) Complementarity effect

In 1968 and 1974 Class A (refer to Tables 3.5 and 3.7) the variable "land" has been retained with an

MVP of about \$34 and \$26 for 1968 and 1974, respectively, and the input "forage produced and fed on the farm" has been dropped out, whereas in Class B for both years and Class C for 1974 the situation was reversed. In the extensive group of farms, the MVP of land would represent the combined earning power of land and forage produced and fed on the farm since these two inputs are somewhat complementary. For 1968 and 1974 Class B and 1968 Class C, the figures in Tables 3.5 and 3.8 would refer to the combined MVP of the two mentioned inputs.

As to 1974 Class C, the variables "forage produced" and "land" have been dropped in the generated production function, but the high rate of return on investment (91 percent) would suggest that this figure indicates the combined rates of return on the above outlined inputs and eventually on machinery.

(b) Substitutability effect

From the analysis of the previous results, the input category "operator and family labor" has been constantly dropped out from the model, whereas the "hired labor" variable has been only relevant for the extensive farms in 1974 and for the semi-intensive group in both years. The earning power of this input would be, in this case, the combined MVP of operator and hired labor since these two inputs are substitutes.

(c) Other shortcomings

With regard to the classification of the observed farms into three catagories with respect to the ratio of cows per tillable acre, one might question the decision about the distribution of these farms: Are the number of classes and their arbitrary limits appropriate? The multiplication of strata or classes might be profitable in the sense that the variability of the estimated gross farm income might be reduced. Thus, in the statistical standpoint the creation of only three classes might have an effect on the precision essentially on the MVP's which have been computed with respect to the average class.

Another shortcoming more related to the provided data would be the accuracy in the inventory prices concerning especially the inputs forage produced and fed on the farm and the operating expenses. Depending on the prices associated with the beginning and ending inventories, the values of these inputs would change accordingly (i.e., whether or not the price change at the end of one year from the beginning of the same year has been taken into account).

In short, the study conducted as reported herein did show substantial differences between the dairy intensities' management options. Moreover, the stepwise regression method helped determine the most relevant inputs in different dairy intensities' management. A follow-up to this paper might extend this study by testing an OLS method against the current stepwise technique. The OLS method would have as independent variables those retained inputs selected by the method used in this paper. Since most of the returns to scale displayed by the generated classes' production functions are close to the "constant returns" ($\Sigma\beta_i \doteq 1.000$), it would be of interest in considering linear production function types. These suggested methods would enable more systematic analysis of MVP_i and MFC_i for all classes' production functions would have the same inputs. These analyses are of major interest in the appraisal of the dairy farmers' decision making with respect to changing domestic economics.

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Annex 1

Geographical Distribution and Number of Observed Farms

County NO.	County Name	Number of observed Farms in 1968	Number of observed farms in 1974
03	Allegan	28	31
08	Barry	18	25
09	Bay	1	1
11	Berrien	1	1
12	Branch	7	6
13	Calhoun	13	14
14	Cass	2	3
19	Clinton	26	22
23	Eaton	7	6
25	Genessee	10	5
29	Gratiot	4	4
30	Hillsdale	22	29
32	Huron	5	11
33	Ingham	28	21
34	Ionia	26	19
37	Isabella	23	23
38	Jackson	18	12
39	Kalamazoo	9	13
41	Kent	24	25
TOTAL	19	272	271

Annex 2 1968 All Classes: Retained Variables and Related Statistical Information

INDEPENDENT VARIABLES	REGRESSION COEFFICIENTS			STD. ERRORS OF COEFFICIENTS			LEVEL OF SIGNIFICANCE			SINGLE CORRELATION OF X_1 WITH OTHER VARIABLES		
	A	B	C	A	B	C	A	B	C	A	B	C
CONSTANT	1.6745	1.7089	2.3998	.1577	.2833	.3667	.0005	.0005	.0005	-		
X_1 = Cows	.3888	.4763	.5399	.0529	.1125	.1743	.0005	.0005	.0005	1.0000	1.0000	1.0000
X_2 = Tillable Acres	.1682	-	-	.0450	-	-	.0005	(.348)	(.804)	.7005	.9818	.6731
X_3 = Improvement	.0394	.0709	.0868	.0118	.0405	.092	.0005	.0005	.0005	.3360	.5992	.5643
X_4 = Machinery	.0699	-	-	.0358	-	-	.0005	(.507)	(.530)	.6347	.7267	.3034
X_6 = Hired Labor	-	.0309	-	-	.0120	-	(.300)	.0005	(.682)	.3428	.6041	.0633
X_7 = Forage Produced Fed	-	.0708	.2242	-	.0594	.061	(.300)	.0005	.0005	.7998	.7949	.4642
X_{10} = Operating Costs	.3758	.3349	-	.0529	.1066	-	.0005	.0005	(.551)	.8046	.9074	.8176
Dependent var: gross income										.8584	.9264	.8325
Overall regression	ΣBc = 1.0421	.9843	.8512				.0005	.0005	.0005	R^2 = .8574	.9096	.7971
										$\bar{R}^2$ = .8535	.9015	.7503

Note: ( ) indicates the significance of the variable if it were added in the final regression.

Annex 3 1974 All Classes: Retained Variables and Related Statistical Information

INDEPENDENT VARIABLES	REGRESSION COEFFICIENTS			STD. ERRORS OF COEFFICIENTS			LEVEL OF SIGNIFICANCE			SINGLE CORRELATION OF X_1 WITH OTHER VARIABLES		
	A	B	C	A	B	C	A	B	C	A	B	C
CONSTANT	1.2308	2.1562	.1417	.1680	.4357	.8949	.0005	.0005	.0005	-	-	-
X_1 = Cows	.1500	.6096	.1098	.0467	.1933	.3233	.0005	.0005	.0005	1.0000	1.0000	1.0000
X_2 = Tillable Acres	.1085	-	-	.0732	-	-	.0005	(.327)	(.441)	.7196	.7223	.8774
X_3 = Improvement	.0367	-	.4498	.0182	-	.1730	.0005	(.942)	.0005	.4786	.7198	.6090
X_4 = Machinery	.1129	-	-	.0466	-	-	.0005	(.396)	(.849)	.6639	.7994	.7109
X_6 = Hired Labor	.0134	.0708	-	.0088	.0343	-	.0005	.0005	(.855)	.5037	.7276	.3276
X_7 = Forage Produced Fed	-	.2984	-	-	.1554	-	(.508)	.0005	(.850)	.7114	.8816	.7639
X_{10} = Operating Costs	.5403	-	.6247	.0681	-	.2601	.0005	(.562)	.0005	.7470	.9473	.7336
Dependent var: gross income										.7700	.8419	.6692
Overall regression							.0005	.0005	.0005	R^2 =	.7476	.7029
										.8381	.7350	.6539
										$\bar{R}^2$ =		
										.8327		

Note: ( ) indicates the significance of the variable if it were added in the final regression.

Annex 4 1968 and 1974 All Classes: ANOVA Tables

	CLASS A			CLASS B			CLASS C		
	SUM OF SQUARE	DEGREE OF FREEDOM	MEAN SQUARE	SUM OF SQUARE	DEGREE OF FREEDOM	MEAN SQUARE	SUM OF SQUARE	DEGREE OF FREEDOM	MEAN SQUARE
1968									
Regression	6.33714214	5	1.26742843	2.70752866	5	.54150573	.24096484	3	.08032161
Error	1.05436582	187	.00563832	.26910046	56	.00480537	.06132777	13	.00471752
Total	7.39150796	192	--	2.97662912	61	--	.30229261	16	--
1974									
Regression	9.48986523	6	1.581644421	4.50095682	3	1.50031894	.92665568	3	.30888523
Error	1.83264478	178	.01029576	1.51955524	60	.02532592	.39173307	18	.02176295
Total	11.32251002	184	--	6.02051206	63	--	1.31838876	21	--

Annex 5 Selected Farm Factor Prices and Related Indexes

	1967		1968		1974	
	INDEX	ABSOLUTE VALUE	INDEX	ABSOLUTE VALUE	INDEX	ABSOLUTE VALUE
	1	2	3	4	5	6
Land prices[1]	100	$275	107	$294	174	$503
Average real estate tax rate[2]	-	-	-	.035	-	.025
Interest rate[2]	-	-	-	.09	-	.10
Dairy cow prices[3]	100	$301	99	$274	166	$500
Price of 100 lbs. of beef[2]	-	-	-	$ 17	-	36.20
Dairy product prices[2]	100	-	105		162	-

Sources: (1) Farm Real Estate Market Developments, USDA July 1972 and July 1974

(2) Agricultural Prices, Annual summary 1968 and 1974

(3) Agricultural statistics, 1969 and 1975.

Annex 6 Text Table 3.10 Related Figures Computations

Row (1)

Column (1) $\frac{504.77 * 100}{105} = 480.73$

Column (2) $\frac{213.12 * 100}{162} = 131.55$

Column (3) $\frac{360.53 * 100}{105} = 343.36$

Column (4) $\frac{101.40 * 100}{162} = 62.59$

Row (2)

Column (1) $60.52 = \frac{100}{99} [((274 - (600* .17) * \frac{1}{4}] + \{[\frac{274+(600*.17)}{2}]*.09]$

Column (2) $64.33 = \frac{100}{[illegible]} [((500-(600 * .36)] * \frac{1}{4}] + [(\frac{500+(600x.36)}{2}]*.10]$

Row (4)

Column (1) $\frac{34.33 * 100}{107} = 32.08$

Column (2) $\frac{26.39 * 100}{174} = 15.17$

Row (5)

Column (1) $\frac{100}{107} [294 * (.035 + .09)] = 34.36$

Column (2) $\frac{100}{174} [503 * (.025 + .10)] = 36.13$