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# STRUCTURE AND PRODUCTIVITY OF CAPITAL IN THE AGRICULTURE OF TAIWAN AND THEIR POLICY IMPLICATIONS TO AGRICULTURAL FINANCE

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AGRICULTURAL FINANCE CENTER

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## FOREWORD

The Agricultural Finance Center of the Ohio State University, through a contract with the United States Agency for International Development is conducting a world-wide research project on "An Analysis of Programs for the Development and Improvement of Agricultural Credit Institutions and Services." This project is designed to develop principles and guidelines useful to AID and developing countries in the establishment and operation of permanent and effective institutions and systems for providing agricultural credit in developing countries.

To function as an effective tool of economic development, an agricultural credit system must allocate its funds to productive uses. Specifically, it must finance capital inputs which generate sufficient additional returns to retire the loan and increase the borrower's net income. This report looks to the identification of those productive inputs in Taiwan and to estimation of the levels of their productivity. More fundamentally, perhaps, it suggests a practical methodology whereby comparatively limited data may be employed in the production of such estimates.

For additional detail the reader is referred to Dr. Chen's Ph.D. dissertation by the same title, (The Ohio State University, 1967), from which the materials herein were abstracted. Other descriptive and background materials are included in AFC Research Publication 109, "Agricultural Credit in Taiwan," the Agricultural Finance Center, The Ohio State University, August, 1966.

Upon completion of his graduate work in 1967, Dr. Chen returned to his position as Senior Specialist with the Joint Commission on Rural Reconstruction in Taipei, Taiwan. His research was done as research assistant on the Agricultural Finance Center research project staff. Dr. Bailey served as his faculty advisor and project director. While they drew heavily upon others for counsel--and notably upon Dr. Francis E. Walker on methodology--they are solely responsible for the content and accuracy of the report.

# INTRODUCTION

## The Problems

The per capita national income of Taiwan in 1963 was NT $5,358[1/] or about US $135 if converted at the official exchange rate of NT $40= US $1. Of the net domestic national product, 29 per cent was contributed by agriculture, forestry and fisheries, which together provided livelihood for about 47 per cent of the total population.

Since the turn of this century, Taiwan's economy has made steady progress. The economic progress has been especially significant during the post World War II years. During the decade 1951 to 1960, the economy grew at an average annual rate of 3.7 per cent, in terms of real per capita gross national product. Taking 1953 as the base, the index number of real per capita gross national product reached 125 in 1960.

To facilitate the economic development of Taiwan, the government has carried out four consecutive Four-Year Economic Development Plans with the fourth one currently in progress. Planning has emphasized development of agricultural products to meet the increasing demands of domestic consumption, of the export market as well as of industrial processing. Each plan called for substantial capital investment in order to achieve the established goals. Undoubtedly, government planning facilitated the rapid economic growth experienced during the aforementioned period.

Many factors are identified as the crucial ingredients of economic development and growth. The list of variables includes land, capital, labor, technology and entrepreneurship, government planning and other socio-cultural environments. While the list may be longer or shorter, all economic theories of growth and development to date have used capital, either in terms of the existing capital stock of the economy at a point in time, or in terms of the addition to the existing capital stock over a period of time; i.e., the rate of investment as one of the basic determinants. Capital is the sole independent variable of the neo-classical growth model which investigates whether, or under what conditions, a modern economy might generate sufficient aggregate demand to warrant continued growth. These models are concerned with the role of capital accumulation as a possible factor which inhibits economic growth.

It is often suggested that in developing countries capital is limited in the sense that increases in the supply of capital would significantly improve production organizations, increase agricultural output, promote agriculture's contribution to gross national product, and increase return imputed to the human agent in agriculture.

Agriculture is the oldest or traditional means of livelihood of the people, providing nearly 50 per cent of employment opportunities and generating approximately 30 per cent of the gross national product in Taiwan; it commands a high share of the total capital resources of the economy, in spite of the fact that the capital employed per farm worker is very low. Agriculture's roles in the growth and development of the total economy include the provision of food, labor, and markets for the newly emerging non-agricultural sector. Provision of capital may be added as another role. This does not refer to existing capital squeezed out of agriculture, but to capital accumulated through the production of surpluses at the farm level. This poses a question whether capital used in agriculture is productive and whether capital in certain uses is more productive than in others.

Static economic theory suggests that factor productivity tends to equilibrate through processes of automatic adjustment. In the actual dynamic world, however, disequilibrating movement is at work simultaneously. Because of the continuous relative changes in both endogenous and exogenous factors, capital productivity may deviate substantially among different uses amidst equilibrating adjustments. Disequilibrium may also be caused by the failure of effective adjustments on the part of the farmers. To attain higher efficiency of capital use in different farm investments by different types of farms under different sets of conditions, it is necessary to study the structure and productivity of capital at the farm level.

Positive marginal revenue productivity of capital is a theoretical prerequisite for more capital investment in agriculture. Without this prerequisite more investment cannot be justified. Moreover, merely to study the economic merits of more capital investment is not sufficient to improve capital allocation either at the aggregate or at the farm level. Besides justification or disapproval of more capital investment in general terms, it is preferable if something can be said about what kind of capital in more specific terms, based on empirical evidence. Here lies the major problem to which this study is addressed.

## The Objectives

Based on the problem identifications outlined above, the objectives of this study are as follows:

1. To estimate the functional relationship between capital investment and farm output at the farm level;

2. To estimate the marginal revenue productivity of different capital input items; and

3. assess the agricultural credit and finance policy implications of the findings at the aggregate, institutional and farm levels.

## The Hypotheses

The hypotheses to be tested in this study are as follows:

a. Farm output is a function of capital investment and the marginal productivity of capital is positive. This implies that capital investment is a factor which determines the output level of the individual farm and that more capital investment will bring forth greater gross farm revenue and larger net farm income.

b. The marginal revenue productivities of different physical imput items; that is, land, labor, and capital (excluding land value) are not equal.

c. The marginal revenue productivities of investment per dollar in different farm assets are not equal. If this is true adjustment in capital allocation within the farm so as to equalize marginal revenue product is a way to maximize profit for the farm in question.

d. The marginal productivities of investment per dollar in different farm operating expenses are not equal. Since profit maximization requires realization of equal marginal revenue product per monetary unit of operating expenses, this indicates that opportunities for profit maximization in terms of farm operating expense investments are not fully exploited.

## The Procedures

The hypotheses to be tested relate primarily to the problem of productive resource use and allocation. This suggests that the farm production function is the keystone of the structure. The general approach to this problem is to estimate a production function from which to measure the elasticity coefficients of production and the marginal productivity of the input factors.

The coefficients of the production function are estimated from a cross section sample containing 277 farms, using least squares regression techniques applied to the logarithms of the variables. The gross farm output is used as the dependent variable which is then regressed on the various input factors, or the independent variables.

In farm production, capital investment has two different dimensions. The first is related to the stock concept of capital which is the asset value of the farm as appears in the asset side of the balance sheet of the particular farm. The second is related to the flow concept of investment which is the operating expenses made during the production period. The former is a static figure at a point in time and the latter is a cumulative figure covering a certain period

of time. Since it is conceptually difficult to add together these two types of capital investment as the independent variables.*

Many algebraic forms can be used to fit the production function. The Cobb-Douglas form; that is, an equation linear in the logarithms of the variables, is chosen mainly because of its goodness of fit to the data,** but also because of the ease of interpretation of the obtained regression coefficients.

The production function thus estimated enables one to infer what would be the optimum resource combination in order to maximize net profit. Conclusions can be drawn from the marginal revenue productivities of the different items of resource input under consideration. The marginal revenue productivities of different resource inputs can be calculated from the elasticity coefficients by fixing the relevant variables at the geometric mean level.

The two capital input variables are then disaggregated into their constituent elements and elasticity coefficients and marginal revenue productivities of the component factors are estimated from the disaggregated models.

## The Variables

As an efficiency criterion, either gross farm recepits per unit of factor input or net farm income defined as gross farm receipts minus farm operating expenses may be used. Since net income is a function of both gross receipts and operating expenses it is affected by the differences in the ownership of farm assets. For this reason, the gross farm receipts is used as the single dependent variable.

Land is an independent variable of the model. Two kinds of measurement may be used to represent land as a factor of production. One is land value based on market price and the other is the physical quantity of land. In this study, physical quantity in terms of crop area is used as the measurement of land as one of the independent variables.

The measurement of labor input is a difficult problem in subsistence agriculture. In an economy where substantial disquised unemployment exists in agriculture, farm labor does not have any opportunity cost. If labor input is measured by wage expenses,

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* One way to combine these two types of capital is to convert the asset into flow figures by using depreciation and interest expenses or rental value.

** Equations linear in natural numbers of variables show somewhat lower $R^2$ values.

valuing family labor at wage rates on hired labor, the problem lies in the zero opportunity cost of farm family labor. In this study, labor input is measured by days actually worked on the farm. By doing so, valuation problems can be partly avoided. There seems little problem in measuring hired labor by work days, since the farms never hire labor unless the work is absolutely necessary. This is not true in the case of family labor, especially during slack seasons when there are few off-farm employment opportunities. However, it seems that there is no better alternative available for treating the existing data.

Capital is the most important element on which this study is conducted. In this study, capital is classified into two categories based upon stock and flow concepts of capital. Capital is, in fact, a collection of physical items different from each other in many respects, and should be viewed as a vector of multi-components instead of a single value. Treating capital as a multi-component vector facilitates the disaggregation of capital into various component items.

The most thorny problem encountered here is how to distinguish between productive and non-productive capital. Theoretically speaking, only productive capital, or operating assets, which contribute directly to production should be included, and assets not directly related to farming should be excluded. The problems arise when one recognized the fact that farm production and family living are not mutually exclusive nor separable from each other. The farm house, for instance, is both a means of farm production and family living. Some farmers may have much better housing than others, but housing is something more than a shelter in human life. To the extent that comfortable living cultivates the energy and incentive to work harder and produce more, there exists no legitimate borderline between necessary and superfluous capital investment. In this study, therefore, no attempt is made to distinguish between productive and non-productive capital, and all farm assets are treated as productive capital.

Since capital is a multi-component vector, aggregation from the raw data becomes a necessary step. A statistical model which includes a large number of variables tends to be limited by the lack of statistical significance of the estimated elasticity coefficients, while one which includes too few variables, is handicapped by the biased estimate of the elasticity coefficients.[4/] On the other hand if capital is aggregated into too large a group, then little can be deduced for practical policy recommendations. Aggregation is made according to the degree of correlation between items. It is theoretically preferable if one can aggregate all items highly correlated to each other, into one single category, and those not significantly correlated with the previous into another group. Thus, within a category all items are highly correlated to each other but between categories no items are significantly correlated. However, this is not possible when the data are of non-experimental origin. In addition to correlations, *a priori* knowledge of the nature of capital inputs is employed to supplement the judgement.

## The Data

The data used in this study are taken from the report of a farm record-keeping program in Taiwan. In 1963, 277 farmers completed the program, and the final report provides the basic data used in this study.

Due to the selective nature of the program, the whole sample tends to represent a little higher than average farm. For instance, the sample average farm size is 1.4 hectares whereas the all-farm average farm size is 1.05 hectares. The sample average family size is 8.84 persons but the all-farm average family size is 6.80. The farmers can be regarded as relatively commercially-minded and better capitalized also. The final report of the program covers the following information for every farm included in the sample.41/

a. General economic conditions: farm area, crop area, cropping index, rice yield per unit of farm area, family size, man-equivalent per family and major crops;

b. Balance sheet: current assets, fixed assets, breakdown of asset items, current liabilities, fixed liabilities, and net worth;

c. Farming expenses: seed and seedlings, fertilizers, wages to hired labor, materials for farming equipment, insecticides and pesticides and disease control, rent, miscellaneous farm expenses, depreciation and repair of buildings and equipment, farm tools, irrigation charges, interests, taxes and fees, livestock and poultry, and feeds;

d. Farm receipts: crop and crop products, livestock and poultry, farm-products processing, forestry receipts, fishery receipts, and other farming receipts;

e. Non-farm receipts: property, off-farm labor, sideline business, and others;

f. Monthly labor inputs: human labor, animal labor, and machinery time.

## CAPITAL STRUCTURE

### Farm Capital

In everyday use, capital has many different meanings. It may refer to a capital good; it may refer to financial assets such as bond, stock, security or deed, or any document that represents a claim to an income-producing capital good. Often in common parlance it is thought of as a sum of money. In economic theory, however, capital refers to physical capital goods defined to include all previously produced goods used by the enterprises in the course of further production, whether such goods are long-lived equipment like machines, or simply stocks of raw materials or semi-processed components.1/ Spitze further specifies that "Capital is produced goods and services saved from consumption and used by, or as part of, the human agent in further production."40/ According to this definition, capital must meet three requirements: It is used in production; it resulted from past production; and, it is saved from consumption.

For the purpose of this study, capital may be defined simply as anything that yields a flow of productive services over a period of time. This is a definition of capital in a financial sense rather than an economic sense; because in the financial context, income-yielding claims such as bonds and stocks are capital. In the economic sense only the tangible capital goods represented by these claims are considered capital. However, to study capital at the micro-level, the financial concept of capital may serve the purpose better than the economic concept of capital. According to the concept accepted above, the whole asset side of the balance sheet of the individual farm is regarded as farm capital. Since the farm assets also include any claims to assets, capital used in this study includes both tangible and intangible assets. It may or may not meet the three requirements mentioned in the preceding paragraph.

Defined this way, farm capital includes farm land, because farm land is not only an item of farm assets but also usually is by far the most important source of farm income. It is incompatible with the tripartite traditional classification of factors of production in which land, labor and capital are placed on the same level. In modern agricultural industry, farm land is no longer merely a physical measure in the Ricardian sense which defines land as the original and indestructible powers of the soil. Farm land is really a produced good, produced by the endless human toil of discovery, clearing, preparation, improvement, maintenance and cultivation of fertility, human combat against hostile elements, and many other types of continuous and painstaking efforts. Thus the term land has been expanded by economists to include the permanent sources of utilities added by human investment, either of labor or of capital or of both. Land thus becomes an integral part of capital, subject to the same economic principle of acquisition and use as other capital goods.27/

What distinguishes land from capital in the classical tradition is that the former is physically indestructible; and therefore, land is not depreciated. As far as economic value is concerned, however, farm land may become useless as a factor of farm production if soil fertility is not adequately maintained. In the process of farm production, organic and other matters must be constantly added to the soil. Part of the fertilizer and tilling expenses are closely parallel to depreciation charges on machinery. The capital component of farm land bears higher and higher weights. At best, one can only consider farm land as a somewhat special kind of capital, but it can still be included in farm capital in a broader sense as defined previously.

In the literature of business finance, total capitalization or invested capital is often defined as the sum total of long-term debt including mortgage and other long-term loans, all outstanding debenture issues, outstanding preferred and common stock, and retained earnings. If this definition is employed, capital structure will mean the composition of long-term debt or funded debt and equity capital, or the composition of the credit side of the balance sheet minus current liabilities. In this case, current liabilities or current debt is excluded from the total capitalization, because current debt such as accounts and notes payable and tax liabilities are, to a large extent, not deliberately planned capitalization although they do constitute part of the source of funds of the firm. Closely related to this is the term financial strucutre which refers to the entire right-hand side of the balance sheet, i.e., the financing of the resources acquired by the firm. While capital structure refers to the permanent financing of the firm, financial structure represents the total financing, long-term as well as short-term of the firm. The left-hand side of the balance sheet, representing the firm's resources which must be financed, is called asset structure.

In this study, the term capital structure is defined more widely to include the composition of both sides of the balance sheet. It is considered as a term which means in general the asset structure, the financial structure and the permanent financial structure (or the capital structure in the narrower sense) of the individual farm. By capital structure, therefore, the whole make-up of the balance sheet is to be studied.

## The Asset Structure

The average farm assets of the 277 sample farms are listed in Table 1. Here the average sample farm is shown to be equipped with NT $224,855 (US $5,621) worth of assets per farm, or NT $158,349 (US $3,957) per hectare of farm land. Of the farm assets, 86 per cent are fixed and only the remaining 14 per cent are current assets. This points out the fact that the majority of the farm investment is in assets lacking liquidity.

TABLE 1. -- Average Asset Values of the 277 Record-keeping Farmers in Taiwan (December 31, 1963)

| | Item | Ave. Asset Value (NT $)[1] Per Farm | Per Hectare of Farm Land[2] | Per Cent of Total |
|---|---|---|---|---|
| I. | Current Assets | 30,742 | 21,650 | 13.67 |
| | Cash | 2,170 | 1,528 | 0.96 |
| | Deposits, receivables, prepaid, securities, etc. | 4,253 | 2,995 | 1.89 |
| | Farm products in storage | 8,819 | 6,211 | 3.92 |
| | Growing crops | 5,891 | 4,149 | 2.62 |
| | Livestock and poultry | 7,277 | 5,125 | 3.24 |
| | By-products and processing products | 732 | 515 | 0.33 |
| | Farming materials and equipment | 1,600 | 1,127 | 0.71 |
| II. | Fixed Assets | 194,113 | 136,699 | 86.33 |
| | Land | 154,627 | 108,892 | 68.76 |
| | Buildings | 26,199 | 18,450 | 11.65 |
| | Fixtures, furniture and household equipment | 5,657 | 3,984 | 2.52 |
| | Orchards and trees | 2,240 | 1,577 | 1.00 |
| | Farm machinery | 5,390 | 3,796 | 2.40 |
| | Total (I + II) | 224,855 | 158,349 | 100.00 |

1. NT $40 = US $1

2. Per farm figure divided by average farm size of 1.42 hectares.

Source: Report of Farm Record-Keeping Families in Taiwan, 1963. Department of Agriculture and Forestry, Taiwan Provincial Government (October, 1964), pp. 80-83.

By far the most important single item of farm asset is land, which accounts for about 29 per cent of total farm assets. The second most important farm investment in assets is buildings, including living quarters, animal and poultry sheds. Buildings account for about 12 per cent of total assets. [illegible] important asset item is farm production in storage, which [illegible] already harvested but not yet marketed. This item [illegible] about 4 per cent of total farm assets.

The item of fourth [illegible] is livestock and poultry, amounting to a little more than 3 [illegible] the total assets. The majority of the farmers keep at least one [illegible] animal, either yellow cattle or buffalo, which is the major [illegible] power for cultivation and short-range transportation. Besides draft animals, the farmers usually raise a few hogs as a source of cash income. All other asset items make up less that 3 per cent of the total.

Capital can be related to gross output directly. Dividing capital by gross output, the resultant quotient is called the capital-output ratio, or capital coefficient of production, a measurement which shows how many dollars of capital are needed to produce one dollar's worth of output.* The capital-output ratio of the sample farms is calculated in the following:

(1) Average investment in farm assets: NT $224,855
(2) Average gross farm output (receipts): NT $ 62,290
(3) Capital-output ratio: (1) / (2): 3.61

The resultant capital-output ratio of 3.61 implies that, on the average, the sample farms invest 3.61 dollars in farm assets in order to bring forth, within a one-year period, one dollar's worth of farm output. The capital-output ratio is often used to measure capital intensity of production.

In the above calculations, land is included in the farm assets. In measuring capital coefficient of production, land value is sometimes excluded from the total capital. If land is excluded from the calculation, then the capital-output ratio may be calculated in the following way:

(1) Average investment in farm assets excluding land: NT $70,228
(2) Average gross farm output (receipts): NT $62,290
(3) Capital-output ratio: (1) / (2): 1.13

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*Capital, as defined in this study, is a stock variable while output is a flow variable. Being a flow variable, output is related to time period involved. The longer the time period under consideration, the larger the gross output. Since farm production usually has a one year cycle, output is measured on a [illegible] basis in this study.

The result of the calculation implies that 1.13 dollars capital investment in farm assets, excluding land, brings forth, on the average, a one dollar increase in gross farm output in one year. The functional relationship between these two variables is almost one to one.

For measuring the efficiency of the use of capital invested in farm assets, the total asset turnover ratio may be calculated. This ratio shows how many times, within a given period, the invested capital is turned over into the gross farm output. This ratio is used as an overall efficiency measure of the use of total assets employed by the farm.

(1) Average gross farm output (receipts): NT $62,290
(2) Average investment in farm assets: NT $224,855
(3) Total asset turnover, (1) / (2): 0.28

The resultant total assets turnover figure implies that the total asset investments are turned over into gross farm products only 0.28 times a year. On the average, it takes about 3.57 years to recover, in gross farm receipts, the total capital invested in farm assets.

Capital-output ratio and total asset turnover are in fact reciprocals of each other. Therefore, a high capital-output ratio is associated with low assets turnover, and vice versa. The two measurements deal with the same problem from opposite points of view.

To measure the liquidity position of the farm, the current ratio, calculated by dividing current liabilities into current assets, is computed. This ratio shows the margin of safety of the farm with regard to meeting current obligations as they come due, from the current assets.

(1) Average current assets: NT $30,742
(2) Average current liabilities: NT $10,269
(3) Current ratio, (1) / (2): 3.00

The computed current ratio of 3 to 1 may be considered quite high, although there is no absolute reference norm to decide whether it is high enough or too low. Usually the industry's average figure is employed to serve as the frame of reference. The relatively high current ratio of the average sample farm is the result of very low current liabilities in the financial structure, although current assets are also considered quite low.

The working capital position is usually expressed by computing the amount of net working capital, or the portion of current assets in excess of current liabilities. The net working capital per farm in the sample is NT $20,472 (U.S. $512) . If the current assets

can be disposed of at their book values, a farm will have, on the average, funds of about UR $512 after meeting all current obligations.

## The Financial Structure

Table 2 shows the credit side of the balance sheet of the 277 sample farms expressed in per farm and per land unit terms. As shown in this table, the total liabilities per farm are NT $10,401 (US $260) and total net worth per farm is NT $214,454 (US $5,381). Consequently, of the total financing 95 per cent comes from internal sources and only the remaining 5 per cent from external sources. The ratio of internal to external financing is 19 to 1. The equity ratio, i.e., the internal financing in relation to total financing (95 per cent) is very high indeed.

Of the current liabilities, short-term borrowings make up the largest component. These are from both institutional and non-institutional sources and constitute only 3.3 per cent of the total financing. The balance of current liabilities, or 1.3 per cent of total financing, is accounts payable and pre-received proceeds, which are incidental to farm business operations. Payables and pre-receipts are more or less passive in nature, i.e., the amount in this category is not purposefully adjusted to the farm business volume by the farm operators. For this reason, the real debt of the farmers may be only the sum of short-term borrowing and fixed liabilities which add up to only 3.33 per cent of the total financing. The high ratio of internal financing to total financing indicates the fact that for the group of farmers included in the sample, external sources provide only a negligible portion of the total financing.

Of the total net worth of NT $214,454; NT $204,781 is invested capital; that is, the original capital which existed at the beginning of the year. The original capital includes that acquired from inheritance and from accumulated net profit. Original capital is by far the most important item of internal financing. Surplus, which is the net profit of the current year, is about NT $10,000 or 4.3 per cent of total assets.

In order to study the relationship between debt financing and equity financing and the effect of debt financing on returns, the concept of leverage is usually employed in financial management. Leverage can be defined in many ways. It may be defined at the ratio of debt charges to net operating income.37/ For the present study, leverage is defined as the ratio of total liability to total net worth or the ratio of total debt to residual ownership claims. Defined this way, the leverage is recognized as the best single measure of good risk. The leverage calculation follows:

(1) Total liabilities per farm: NT $10,401
(2) Total net worth per farm: NT $214,454
(3) Leverage, (1) / (2) : 4.85%

TABLE 2. -- Average Liability and Net Worth of the 277 Record-keeping Farmers in Taiwan (December 31, 1963)

| Item | NT $[1] Per Farm | NT $[1] Per Hectare of Farm Land[2] | Per Cent |
|---|---|---|---|
| I. Current Liabilities | 10,269 | 7,232 | 4.57 |
| Short-term borrowing | 7,345 | 5,173 | 3.27 |
| Accounts payable and pre-received | 2,924 | 2,059 | 1.30 |
| II. Fixed Liabilities | 132 | 93 | 0.06 |
| Total Liabilities, (I + II) | 10,401 | 7,325 | 4.63 |
| III. Net Worth | 214,454 | 151,024 | 95.37 |
| Surplus | 9,673 | 6,812 | 4.30 |
| Capital | 204,781 | 144,212 | 91.07 |
| Total (I + II + III) | 224,855 | 158,349 | 100.00 |

1. NT $40 = U.S. $ 1.00

2. Per farm figure divided by average farm size 1.74

Source: Report of Farm Record-keeping Families in Taiwan, 1963 Department of Agriculture and Forestry. Taiwan Provincial Government (October, 1963) pp. 86-)

## Leverage and Returns

Leverage is often employed to increase returns on equity capital. If the business operation is successful, and the return on total investment is higher than the cost of borrowed capital, leverage will

work to magnify net return on equity capital, because the borrowed funds earn more than they cost and the excess of earnings over costs will contribute to increase residual profits to be shared by the owners of equity capital. On the other hand, if the business operation is unsuccessful in the sense that the borrowed funds do not earn enough to cover their cost, return to equity capital will be smaller than otherwise. Leverage thus may work toward either direction, to increase or decrease returns on equity capital.

On the average, the sample farms have a leverage of less than 5 per cent. There exists on the average no significant leverage, although two of the sample farms are totally debt financed and 8 of them have leverages of more than 50 per cent. The low leverage financing may become an element of security when the farming business is plagued by adverse conditions, but it retards rapid accumulation of capital and expansion of business in prosperous periods because opportunities for gain provided by borrowed capital are missed.

Due to the low leverage in financing employed by these farmers, there is little difference between the gross output to net worth and the gross output to total investment in assets. The gross output to net worth is computed as follows:

(1) Gross farm output (receipts) per farm: NT $62,290
(2) Net worth per farm: NT $214,454
(3) Gross output to net worth, (1) / (2): 29.05%

The difference between gross output to net worth (29 per cent) and gross output to total investment (28 per cent) is only about 1 percentage point. This indicates that net profit, if any, is practically all earned by the equity capital invested by the farmers themselves and that borrowed money does not contribute much to returns. If equity capital is exhausted and if marginal return to additional investment is higher than the cost of external funds, more use of leverage will increase net returns to the equity capital invested by the farmer. However, the average leverage indicates that this opportunity is not likely to be fully exploited.

When a firm is financed with equity capital only, all profits are earned and shared by equity capital and all losses incurred are absorbed by equity capital. When debt financing is initially introduced, the cost of capital becomes lower and the value of the firm becomes higher, mainly due to the leverage effect. As debt financing increases and leverage becomes higher, risk elements loom larger and the cost of capital starts rising. The capital cost curve thus shows a U-shaped movement. If this point of view is valid, then there exists an optimum financial structure or leverage defined as the mix of debt and equity

capital which will maximize market value of a firm; i.e., the aggregate value of the claims and ownership interests represented on the credit side of its balance sheet.

The advantage of having an optimal financial structure, if such an optimum does exist, is two-fold. On the one hand, it maximizes the market value of the firm and hence the wealth of its owners; on the other, it minimizes the firm's cost of capital, which in turn increases its ability to find new wealth-creating investment opportunities.37/ The classical point of view maintains that there exists such an optimum point or range of financial structure for given market and price conditions.

Opposed to this classical point of view is the now well-known Modigliani-Miller hypothesis that says the total market value of all the securities in the capitalization of a firm will not change despite the changes in the debt-equity mix. Their argument is that the advantage in improved earnings on the common stock derived by using higher proportions of lower cost debt financing is exactly offset by the deterioration in the price-earning ratio due to the increased risk which the equity capital is to bear. Accordingly, they conclude that the financial structure of a firm has no effect on its valuation or cost of capital.28/

The relationship between cost of capital and financial structure is still an unsettled problem. The recent literature in economics and finance abounds in both theoretical and empirical studies supporting or rejecting either one of the two hypotheses. In fact, empirical studies show that in some cases empirical data are consistent with the classical hypothesis and in other cases consistent with Modigliani-Miller thesis. The basic difficulty may be that among other things these two models specify leverage as the single variable which affects cost of capital and valuation of a firm. Indeed, leverage may be an important element, but conceivably it is not the only important variable.

In agriculture, leverage does not pose such an important problem, mainly because of the family operation found in farming. In family farms, capitalization is relatively simple. Internal financing comes only from owner's investment in the form of either accumulated surplus or original investment. External financing comes from long-term or short-term borrowings, but not from a security issue of any form. The cost of funds is not complicated structurally. However, the correlation between return on assets and leverage can be examined in Table 3. Return on assets is defined here as farm income net of operating expenses divided by total assets. The distribution of the sample farmers according to leverage and return on total assets does not suggest any significant correlation between these two variables.

The correlation coefficient between rate of return on total assets and leverage ratio is only 18.72 per cent which means the correlation

TABLE 3.--Effect of Leverage on Return to Total Assets Investments (Number of Farms)

| Return to Assets (Per Cent)[2] | Leverage (Per Cent)[1] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 to 0.9 | 1.0 to 2.9 | 3.0 to 5.9 | 6.0 to 9.9 | 10.0 to 19.9 | 20.0 to 29.9 | 30.0 to 49.9 | 50.0 or more | Total |
| 0- 4.9 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 4 |
| 5.0- 9.9 | 12 | 5 | 5 | 3 | 5 | 1 | 0 | 3 | 34 |
| 10.0-14.9 | 34 | 18 | 13 | 9 | 5 | 1 | 2 | 0 | 82 |
| 15.0-19.9 | 20 | 7 | 8 | 11 | 8 | 1 | 1 | 1 | 57 |
| 20.0-29.9 | 23 | 12 | 7 | 7 | 9 | 2 | 3 | 0 | 63 |
| 30.0-39.9 | 5 | 3 | 6 | 5 | 1 | 1 | 0 | 2 | 23 |
| 40.0-49.9 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 5 |
| 50.0- | 1 | 2 | 0 | 3 | 0 | 1 | 0 | 2 | 9 |
| Total | 98 | 48 | 41 | 40 | 29 | 7 | 6 | 8 | 277 |

1. Leverage is defined as: Total liabilities / Total net worth.

2. Return on assets is computed as (Gross farm receipts - Farm Operating Expenses) / Total Assets.

between these two variables is not significant. Based on a priori knowledge, there is little ground to hypothesize that they are very meaningfully correlated. If the leverage is high, the reason may be that unsuccessful business operation in the past resulted in large debt, but the reason may also be that successful performance in the past convinced the lender to provide considerable funds despite low-equity capitalization. If return on assets is high, the farm may have accumulated sufficient surpluses from the net profit in the past to result in a low leverage ratio. On the other hand, high rate of return may also encourage and enable the operator to borrow and invest more funds made available by external sources, resulting in a high leverage ratio. There are therefore good reasons to believe that rate of return on total assets is not closely correlated to leverage ratio or financial structure of the group of farms included in the sample.

## Interim Conclusions

First, the investments made by the sample farms covered in this study are predominantly in the category of fixed farm assets. On the average, this group of farms commits 86 per cent of its total investments to fixed farm assets consisting of farm land and buildings as the major component. The liquid farm assets, on the other hand, share only a minor importance in the asset structure; they constitute only 4 per cent of the total investment.

Second, the farm investment is predominantly financed from internal sources. This fact is revealed in the very high equity ratio, the ratio of equity capital or net worth to total financing. This ratio is 95 per cent, indicating that the sample farms as a whole and on the average, financed 95 per cent of their farm investment from internal sources and only 5 per cent from external sources. The extremely high equity ratio may be the result of either financial affluence on the part of the farmers, making borrowing unnecessary, or of internal and/or external capital rationing imposed upon the farmers.

Third, the turnover of farm-assets investment is very low, or conversely, the capital-output ratio is very high. The average capital-output ratio of the sample farms is 3.6, implying that every 3.6 dollars of capital investment produced one dollar output during a period of one year. Conversely, the total asset turnover ratio is 28 per cent meaning that the total investment in farm assets is turned over into gross output 0.28 times during a period of one year. It can be concluded that the efficiency of capital use in terms of generating gross farm output is very low.

Finally, the total investment per farm is NT $224,855 (equals US $5,621). Total investment per hectare of farm land is NT $148,349 (equals US $3,959). On a per-farm basis, capital invested is very limited, and it is on this basis that people say agriculture in underdeveloped countries is "capital hungry." On a per-farm land unit

basis, however, capital investment is very large. The investment of the equivalent of US $4,000 per hectare is impressive when compared, for example, to an average investment of less than one-tenth that amount in the United States. It may be concluded, therefore, that capital shortage exists on a per-farm basis but neither on a per-hectare basis nor on the basis of aggregative agriculture.

## CAPITAL PRODUCTIVITY

### Farm Production Function

The Cobb-Douglas type production function fitted to the logarithms of the data generated by the 277 sample farms is estimated as follows:

$$\log Y = 1.471 + 0.230 \log X_1 + 0.065 \log X_2 + 0.158 \log X_3 + 0.513 \log X_4$$

where Y = gross farm receipts in local currency units (called New Taiwan Dollars. NT \$40 = US \$1.00)

$X_1$ = crop area in hectares,
$X_2$ = farm labor in work days,
$X_3$ = total farm asset investment in NT \$, and
$X_4$ = total farm operating expenses in NT \$.

In order to facilitate comparison, the elasticity coefficients, the marginal revenue productivity and squares of partial correlation coefficients of the independent variables are tabulated in Table 4.

The estimated elasticity coefficients, $b_i$, show the output response associated with a small change in factor inputs. For instance, a 1 per cent increase in crop area is associated with a 0.23 per cent increase in gross farm output; a 1 per cent increase in farm labor is associated by a 0.065 per cent increase in gross farm output; a 1 per cent increase in farm asset investment is accompanied by a 0.158 per cent increase in gross farm output and the same percentage increase in farm operating expenses is accompanied by a 0.513 per cent increase in gross farm output. The sum total of the elasticity coefficients of production is 0.966, implying slightly decreasing returns to scale, because when all factor inputs are increased by 1 per cent simultaneously the gross farm output increases only by 0.966 per cent.

The standard deviations of the elasticity coefficients are quite small, resulting in a large value of T-statistics for testing H: $b_i = 0$. The results of the T-test performed on the elasticity coefficients show that all coefficients are significant at a level of 0.001, except the coefficient of labor input which is only statistically significant at the 0.1 level (in fact, it is significant at a level of only slightly below 0.05).

The multiple correlation coefficient is 0.938, implying that the correlation between the dependent variable and the combined independent variables is quite high. The coefficient of multiple determination is 0.88 which means that the four explanatory variables specified in the

Table 4.--Elasticity coefficients, marginal revenue productivity, partial correlation coefficients of land, labor, farm assets and operating expenses investments.

| Variable | Elasticity coefficient of production, $b_i$ | Marginal revenue productivity (NT$ per input unit) | Partial correlation coefficients (squared) |
|---|---|---|---|
| Constant terms | 1.471 | ----- | ----- |
| Crop area, hectare $X_1$ | 0.230 | 4,554 | 13.81% |
| Farm labor, work days $X_2$ | 0.065* | 6.738 | 1.35 |
| Farm assets investment, NT$ $X_3$ | 0.158 | 0.1439 | 14.91 |
| Farm operating expenses, NT$ $X_4$ | 0.513 | 1.2419 | 48.08 |

Sum of elasticity coefficients, 0.966
Multiple correlation coefficient, R = 0.938
Coefficient of multiple determination, $R^2$ = 0.880
Sample size - 277

*The elasticity coefficient is significant at the 0.1 level. All other coefficients are significant at the 0.001 level.

model taken together explain 88 per cent of the variations in the gross farm output of the sample farms.

The simple correlation coefficients between each pair of variables are listed in Appendix Table 1. These correlation coefficients suggest that gross farm output is more closely correlated to farm operating expenses and crop area than to labor input and farm asset investment. Between independent variables of crop area and farm operating expenses, crop area and farm labor input are more closely correlated to each other than are other pairs of the independent variables. In order to enable comparison of the absolute output response per unit of factor inputs, it is necessary to compute the marginal revenue productivity of each factor input, holding all independent variables at the geometric mean levels. The computed marginal revenue productivities of the land, labor, farm assets and farm operating expenses are also listed in Table 4.

The marginal revenue productivity of farm land is NT $4,554 per crop area, implying that an increase of one hectare in crop area will be accompanied by an increase of NT $4,554 in gross farm receipts, holding other input items constant at their respective geometric mean levels. Since most land economically accessible to the farmers at the present level of technology is already under cultivation, increase of crop area by expanding the extensive margin of cultivation does not seem likely to occur. However, increase of crop area by expanding the intensive margin of cultivation, or more specifically, by growing more crops per year from the farm land presently under cultivation, can be expected as an effective way of increasing gross farm receipts while holding all other resource inputs at the geometric mean level.

Farm labor has a marginal revenue productivity of NT $6.74 per work day, indicating that a change of one day in farm work will be associated with a NT $6.74 change in the same direction in gross farm receipts. Farm labor is measured by work days of both hired and family labor. Wages paid to the hired labor varies substantially according to the nature of farm work. On the average, however, the sample farms paid NT $34.43 per day wages during the year under observation. The marginal revenue productivity of labor is only about 20 per cent of the farm wage rate. Here is evidence of over-intensive application of labor in agriculture.

The low marginal revenue productivity of farm labor in relation to wage rates on hired labor does not necessarily lead to the conclusion that a reduction in the farm work days will bring forth increases in net farm income. The reasons are twofold. Outside labor is only hired during peak-load seasons to break the bottleneck of labor shortage during those seasons. It may seem rather paradoxical to say that labor shortages exist in the agriculture in which under-employment of farm labor prevails. But it should be noted that under-employment of farm labor exists only during slack seasons, and when labor demand is at a seasonal peak, labor supply by the family is insufficient. Thus, the hired labor is in all cases absolutely necessary and cannot be reduced without lowering net output.

During slack seasons, farm labor usually does not have outside employment opportunities. Hence it has no opportunity cost. This is the reason why farm labor is usually considered as family income rather than a farming cost. Any additional income the family labor may earn contributes to the farmer's net income because it has no opportunity cost to be deducted; hence the only price a farmer has to pay is to give up some leisure time. Under this situation, reduction in work days of farm labor cannot be suggested as a measure to increase net farm income although the marginal revenue productivity of farm labor is much lower than the wage rate on hired labor. The solution to this problem may lie in technological development which will enable the farmers to level off the seasonal peaks and troughs of the farm labor demand pattern, and in the development of rural industry which will more fully utilize farm labor during slack seasons.

The marginal revenue productivity of farm assets is NT $0.1439 per NT dollar investment in farm assets. Since the marginal revenue productivity is measured on the basis of gross output, it includes expenses necessary to maintain the investment values. Comparable period bank interest rates on secured loans are quoted at 14.4 per cent per annum.* Thus, the marginal product obtainable from investment in farm assets is barely enough to cover the cost of money.

In addition to interest cost, depreciation should be charged on some types of farm assets. The depreciable assets account for about 22 per cent of the total assets, which if depreciated on a ten-year straight line schedule should be charged at 2.2 per cent of the total asset value. The marginal product then is short of rental value or investment costs, including interest expenses and depreciation charges, by about 2.2 per cent. In the same year, the wholesale price index rose about 4.6 per cent. On the assumption that farm assets appreciate in value in proportion to the movement of the wholesale price index, the net marginal revenue product of farm asset investment becomes roughly NT $0.024 per NT dollar, or only about 2.4 per cent of the investment made in farm assets.

The extremely low marginal revenue productivity of investment made in farm assets may stem from many factors. First of all, investment in farm land may be excessive. This does not imply over-investment in improvements in farm land but rather the price of farm land is high in relation to its revenue productivity when used for farming purposes.

The low marginal revenue productivity of farm assets may also be explained partly by the productivity-inelastic investment in farm buildings. Very often farm buildings are found to be far from proportional to their operational scale. As in the case of farm land, there is some social motivation or non-economic incentive involved in farmers' decision-making about investment in farm buildings. Buildings are often considered necessary to keep the farmers in a particular social class and little consideration is given to economic returns. In fact, it may be true that larger investment in farm building is enabled by higher profitability realized in the past, but it is not necessarily true that larger investment in farm building will generate proportionally higher gross returns. The same statement may also be made as regards

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*The borrowing rate may not be relevant to the farmers because their surplus funds are not likely to earn this much. In this sense, farmers' lending rate may be a more appropriate measurement. However, the purpose here is to compare the marginal product of farm asset investment with operating expenses investment and the borrowing rate is used in both cases. In fact, it is extremely difficult to determine the appropriate lending rate of farmers. Since most farmers rely, to varying degrees, on external financing to supplement equity capital the borrowing rate rather than the lending rate is employed here.

some other farm assets. These factors help explain the low marginal revenue productivity of farm asset investments.

The marginal revenue productivity of investment in farm operating expenses is NT $1.24 per NT dollar. Since one dollar of the marginal product is the recovery of the original investment, because the marginal productivity is computed in gross terms, the net marginal product is NT $0.24 per NT dollar investment, or 24 per cent of the original investment.

The farm operating expenses investment is a flow variable representing the accumulated amount of investment made throughout the year. If the investment is turned over twice or three times a year, the accumulated amount of operating expense investment will be two or three times the amount of funds needed to finance this investment. This means that in order to finance one dollar of accumulated investment in farm operating expenses, the required stock of funds is only about one-half or one-third of one dollar. This is true if more than one crop is grown from the same piece of farm land, in which case sales proceeds of the first crop becomes a source of funds to finance investment needs of the second, or if more than one litter of hogs is raised during one year and marketing proceeds of the first shipment become a source of funds to finance investment needs of the following period. The reinvestment of the recovered capital makes the cumulative figure larger than the existing stock of funds.

In the case of rice growing, the major crop which alone contributes about 50 per cent of the gross national product of the agricultural sector, it takes about four months to grow a crop. Farm operating expenses do not represent a once-for-all investment to be made at the beginning of the production process. Rather, the investment is made continuously throughout the whole production process. If a constant flow of investment throughout the whole production period is assumed, the average investment is exactly half of the accumulated total. However, in view of the fact that surplus funds are only available for a very short period, the funds earmarked for farm operating expenses are not suitable for even temporary investment outside of the farm. It may be reasonable to consider that the accumulated investment in one production cycle represents the total financing tied up in the production process.

The sample farms, on the average, utilized their farm land 2.24 times during the year. Hence, it may be considered that their investment in operating expenses turned over 2.24 times that year, resulting in an average production period of 4.9 months. On the assumption that the interest rate on unsecured farm loans, 1.38 per cent per month, is applicable to the operating expense investment, the interest charge on this investment is about 6.8 per cent. After deducting this 6.8 per cent interest cost from the 24 per cent net income before interest, the balance is 17.2 per cent per production period. This net return

on operating expenses investments is equivalent to 38 per cent per annum, compared with 2.4 per cent per annum on farm assets investments.

The very high marginal revenue product generated by investment in farm operating expenses implies that there is substantial under-investment in operating expenses. It further implies that if funds can be borrowed at an interest rate considerably lower than 24 per cent per production period or 53 per cent per annum, such debt invested in operating expenses will result in higher net revenue, even after allowance is made for increasing risk and possible decrease in marginal revenue product. The marginal revenue product of 53 per cent per year before interest suggests that farmers can economically justify payment of an interest rate approaching 53 per cent per annum on capital for investment in operating expenses. Prevailing non-institutional interest rates range between 20 and 30 per cent per annum. Even if the farmers have to pay usurious interest rates for external financing, it is highly profitable for them to borrow and invest more in farm operating expenses.

The coefficient of multiple determination, usually expressed by the symbol $R^2$, measures the portion of the variations in the dependent variable associated with or explained by all the independent variables. Hence it measures the importance of all of the independent variables specified in the model. For instance, the $R^2$ value of the production function estimated in this section, which is 88 per cent, indicates that the four combined explanatory variables, crop area, work days, farm assets, and operating expenses explain 88 per cent of the variation in the gross farm output.

In addition to this overall measure (the coefficient of multiple determination) it is also desirable to measure the importance of each of the individual variables taken separately, while simultaneously allowing for the variation associated with the remaining independent variables. There are two different types of such measures, namely, the "coefficients of partial correlation" and the "beta coefficients." In this study, only one, the partial correlation coefficient, is calculated.*

Coefficients of partial correlation measure the correlation between the dependent variable and each of the several independent variables, while eliminating any linear tendency of the remaining independent variables to obscure the correlation. Thus in the problem where gross farm receipts are correlated with crop acreage, farm labor in work days, farm assets investment in dollars and farm operating expense investment, the partial correlation of farm receipts with crop area--while holding constant farm labor, farm assets and operating expenses--indicates what the correlation would

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*Ezekial Mordecai and Karl Fox present in detail the computation of these two coefficients.10/

be between crop area and farm receipts of the sample farms. The squares of coefficients of partial correlation are presented in the last column of Table 4.

The squares of partial correlation coefficients (which may be termed as coefficient of partial determination) show that investment in farm operating expenses is by far the most important variable explaining about 50 per cent of the variations observed in the gross farm receipts of the sample farms. The proportion of the variations of farm output accounted for by other variables are: investment in farm assets, 15 per cent; crop area, 14 per cent; and farm labor, 1 per cent.

## Productivity of Farm Assets

Since farm asset investment is a vector of a multi-component variable, far from homogeneous in nature, the findings of the previous section are not very useful as a direct guide for practical decision making. A production function must, therefore, be fitted to the disaggregated component elements of farm asset investment to yield somewhat more specific conclusions. In this section, the farm assets variable is disaggregated into its component factors.

The first step is to disaggregate farm assets into fixed and liquid assets. The estimated regression coefficients, marginal revenue productivity, and the partial correlation coefficients, of this model are presented in Table 5. The estimated elasticity coefficients of production indicate that the percentage increases in gross farm receipts associated with a one per cent increase in factor inputs are: crop area 0.165, farm labor 0.083, farm operating expenses 0.452, liquid farm assets 0.226 and fixed farm assets 0.042.

The disaggregated model shows a better statistical goodness of fit, with the $R^2$ value increased from the original 88 per cent to 90 per cent. The sum of the coefficients of all independent variables is 0.968, implying slightly diminishing returns to scale. The very high T-value for testing H: $b_i = 0$ indicates that $b_2$ and $b_6$ are statistically significant at the level of 0.01 and all other $b_i$'s are significant at a level of 0.0001.

The marginal revenue productivities of the input factors, as calculated at the geometric mean level of all variables, are listed in Table 5. The estimated marginal revenue productivity of liquid farm assets is NT \$0.4886 while that of fixed farm assets is only NT \$0.0150, per NT dollar of investment. The former is about 30 times the latter. The NT \$0.4886 marginal revenue productivity indicates that investment in liquid farm assets is not only much more productive than the investment in fixed farm assets but also is even higher than the marginal productivity of investment in farm operating expenses.

Table 5.--Elasticity Coefficients, Marginal Revenue Productivity and Partial Correlation Coefficients of the Estimated Farm Production Function with Disaggregated Farm Assets Investments.

| Variable | Elasticity Coefficient of Production, $b_i$ | Marginal Revenue Productivity (NT $ per unit) | Squares of Partial Correlation Coefficients (%) |
|---|---|---|---|
| Constant term | 1.260 | ----- | ----- |
| Crop area, hectares, $X_1$ | 0.165 | 3 295 | 8.51 |
| Farm labor, work days, $X_2$ | 0.083* | 8.6543 | 2.60 |
| Farm operating expenses, NT$, $X_4$ | 0.452 | 1.1010 | 45.10 |
| Liquid farm assets, NT$, $X_5$ | 0.226 | 0.4886 | 26.67 |
| Fixed farm assets, NT$, $X_6$ | 0.042* | 0.0150 | 2.44 |

Sum of elasticity coefficients = 0.968
Multiple correlation coefficient, R = 0.9498
Coefficient of multiple determination, $R^2$ = 0.9021
Sample size - 277

* The elasticity coefficients are significant at the 0.01 level. All other coefficients are significant at 0.001 or higher levels.

Assume an interest rate of 15 per cent per annum and five-year straight-line depreciation, with a depreciation charge of 20 per cent per annum, are applicable to the liquid farm assets. The net return (marginal) to investment in liquid farm assets is about 14 per cent, (49 - 15 - 20 = 14), disregarding the possibility of value appreciation due to price level change. The misallocation of capital between liquid and fixed farm assets as revealed in the difference of the respective marginal revenue productivities is very significant. More investment in liquid farm assets relative to investment in fixed farm assets will

bring forth much higher gross returns to the sample farms. The coefficients of partial correlation (squared) are also presented in Table 5. In the model with farm assets disaggregated into liquid and fixed assets, the farm operating expenses still represent the most important variable; one which alone explains 45 per cent of the variations in gross farm receipts. The liquid farm assets investment is second in importance and explains 27 per cent of the variation in the dependent variable. The third variable in importance is land, followed by farm labor and fixed farm assets investment.

Both liquid farm assets and fixed farm assets are multi-component vectors composed of large numbers of heterogeneous items. Being related to a collective variable, conclusions about either vector have little practical application since they do not necessarily apply to each of the individual components. Under this situation, more specific implications may be drawn by further disaggregating the two asset categories into their constituent elements. The further disaggregated model yields elasticity coefficients, marginal revenue productivities and partial correlation coefficients of the input factors presented in Table 6.

Compared to the farm production function with farm assets disaggregated into two categories of liquid and fixed farm assets, the elasticity coefficients of production estimated from the model with liquid and fixed farm assets disaggregated into their constituent factors are somewhat different. Two coefficients, crop area and farm operating expenses, are higher in the latter than in the former model. The coefficient of labor, however, is smaller in the latter model, although the difference is very small.

Of the component factors of farm assets, farm products in storage and growing crops has the highest elasticity coefficient of 0.066, followed by 0.0297 of cash and cash equivalent, 0.0284 of by-product, processing product and working equipment, and 0.0212 of buildings and fixtures. The negative elasticity coefficient of farm machinery is a surprising result. The negative value is not economically reasonable and, in fact, the T-test performed for testing H: $b_{13} = 0$ does not reject the null hypothesis, meaning that the elasticity coefficient of farm machinery is not significantly different from zero. An increase in the investment in farm machinery on the average, will contribute nothing to gross farm output since the elasticity coefficient is not significantly different from zero.

The T-test performed on the regression coefficients indicates that the coefficient of farm machinery is not significantly different from zero; those of poultry and livestock; buildings; and fixtures, are significant only at the 20 per cent level, that of farm labor input is significant at the 10 per cent level and all other coeffi-

cients are statistically significant at 1 per cent or even higher levels. Except farm machinery, therefore, the estimated elasticity coefficients are in general statistically meaningful.

The computed marginal revenue productivities of the input factors in the disaggregated liquid and fixed farm assets model presented in Table 6 show that when liquid and fixed farm assets are disaggregated into their constituent elements, the marginal revenue productivity of land and farm operating expenses becomes higher and that of labor becomes lower than the marginal revenue productivities estimated from the model in which liquid and fixed farm assets are included as totals. These marginal revenue productivities of the disaggregated farm assets, arranged in descending order of absolute value are: orchard and trees, NT $2.8210; by-product, processing products, and working equipment, NT $1.2003; cash and cash equivalent, NT $0.7969; farm products in storage, NT $0.3276; livestock and poultry, NT $0.1935; buildings and fixtures, NT $0.0478; and farm machinery,-NT $0.0583, per NT $ investment respectively. The estimated marginal revenue productivity suggests that except for buildings and fixtures and farm machinery, all input factors are very productive in the sense that potential returns are higher than the cost of capital. The marginal revenue productivity is especially high in the case of orchard and trees, by-product, processing product and working equipment, and financial assets such as cash and cash equivalent. The extremely high marginal revenue productivity of investment made in orchard and trees reflects the growing profit opportunities in fruit farming.

All constituent items in the liquid farm asset category have marginal revenue productivities higher than the cost of money. Some of these liquid items are highly productive. The by-product, processing product, and working equipment items, for example, have a marginal revenue productivity of NT $1.20 per NT $ investment. Other liquid constituents are less productive: livestock and poultry have a marginal revenue productivity of NT $0.19 per NT $ investment which is only slightly higher than the prevailing institutional interest rate on unsecured loans.

Another interesting finding is that the marginal revenue productivity of farm machinery is not significantly different from zero. Contrary to the generally accepted hypothesis that investment in farm machinery is highly productive in the United States, the estimated farm production function derived from farm records of Taiwan does not support this hypothesis. The major reason may be two fold. In the first place, machinery is a labor -saving device. But if the farm labor replaced by machinery has insufficient or no alternative employment opportunities, the introduction of machinery cannot be expected to increase the gross farm output. In the second place, the tiny scale of operation (on the average, 1.42 hectares in land area or 3.17 hectares in crop area for

Table 6.--Elasticity Coefficients, Marginal Revenue Productivity and Partial Correlation Coefficients of the Estimated Farm Production Function with Disaggregated Liquid and Fixed Farm Assets Investments

| Variable | Elasticity Coefficient of Production, $b_i$ | Marginal Revenue Productivity (NT$ per input unit) | Partial Correlation Coefficient (Squared) (%) |
|---|---|---|---|
| Constant term | 1.6101 | ------ | ----- |
| Crop area, hectares, $X_1$ | 0.1733 | 3,453 | 7.79 |
| Farm labor, work days, $X_2$ | 0.0613*** | 6.4018 | 1.26 |
| Farm Operating Expenses, NT$, $X_4$ | 0.5194 | 1.2655 | 49.40 |
| Cash and cash equivalent, NT$, $X_7$ | 0.0297 | 0.7969 | 6.91 |
| Farm products in storage and growing crops, NT$, $X_8$ | 0.0660 | 0.3276 | 7.12 |
| Livestock and poultry, NT$, $X_9$ | 0.0186** | 0.1935 | 0.90 |
| By-product, processing product & working equipment NT$, $X_{10}$ | 0.0284 | 1.2003 | 2.98 |
| Buildings & fixtures, NT$, $X_{11}$ | 0.0212* | 0.0478 | 0.68 |
| Orchard & trees, NT$, $X_{12}$ | 0.0084 | 2.8210 | 2.40 |
| Farm machinery, NT$, $X_{13}$ | -0.0027* | -0.0583 | 0.02 |

Sum of elasticity coefficients = 0.9236
Multiple correlation coefficient, R = 0.9432
Coefficient of Multiple determination, $R^2$ = 0.8896
Sample size - 277

*The regression coefficient is not significantly different from zero.
**The regression coefficient is significant at the 0.2 level.
***The regression coefficient is significant at the 0.1 level. All other coefficients are significant at the 0.01 level or higher.

the sample farms) as presently practiced in Taiwan may not warrant economic use of farm machinery. As a matter of fact, the same farm records show that as an average, the sample farms employed only 9.81 days of machinery work during the year under observation. One farm used 363 days (conceivably mostly in off-farm work) and three others used a little over 100 days, but the majority used less than 30 days of machinery work. With machinery employment during the year at this low level, there is no reason to suppose that it should be productive relative to the high investment needed.

However, farm use is not the only employment opportunity for farm machinery. More often than not, small power tillers ranging from 5 to 10 horse power are used for short-range transportation of farm products and farming materials. Farm machinery is custom-hired to work on neighboring farms also. In many cases, off-farm work is even more important than work on the owner's farm. If off-farm employment is sufficiently remunerative, investment in farm machinery may still have economic merit.

Again, farm machinery is a collective or multi-component variable, in which power tillers, irrigation pumps, motors, powered threshers, and many other items are included. The finding that farm machinery as a whole has a low marginal revenue productivity does not necessarily mean that all types of farm machinery are equally unproductive. Some items of machinery within the highly heterogeneous farm machinery variable might indeed be highly productive. However, the present farm record data do not supply the information needed for further analysis. A specialized survey on this problem might prove fruitful in obtaining more specific answers.

The partial correlation coefficients (squared) of the variables included in the model in which liquid and fixed farm assets are disaggregated into their constitutent elements are presented in the last column of Table 6. The computed coefficients of partial correlation (squared) indicate the portion of the variations in the farm receipts explained by the independent variable under consideration.

## Productivity of Farm Operating Expenses

The next step is to study the productivity of investment made in farm operating expenses. For this purpose, the disaggregated farm operating expenses, together with the aggregated farm assets investment, are specified as the independent variables of the model. The elasticity coefficients, marginal revenue productivities, and the partial correlation coefficients estimated from this model are presented in Table 7.

Table 7.--Elasticity Coefficients, Marginal Revenue Productivities and Partial Correlation Coefficients of the Estimated Farm Production Function with Disaggregated Farm Operating Expenses Investments.

| Variable | Elasticity Coefficient Of Production, $b_i$ | Marginal Revenue Productivity (NT $ per input unit) | Partial Correlation Coefficients (Squared) (%) |
|---|---|---|---|
| Constant term | 1.9024 | ----- | ----- |
| Crop area, hectares, $X_1$ | 0.2559 | 5,098 | 1.32 |
| Farm labor, work days, $X_2$ | 0.1021 | 10.66 | 0.26 |
| Farm assets, NT$, $X_3$ | 0.2117 | 0.1940 | 2.23 |
| Fertilizer expenses, NT$, X14 | 0.1636 | 1.4719 | 9.56 |
| Wages paid on hired labor, NT$, X15 | 0.0247 | 1.0185 | 4.29 |
| Material expenses, NT$, $X_{16}$ | 0.0429 | 1.2746 | 2.04 |
| Livestock, poultry & feed expenses, NT$, $X_{17}$ | 0.1496 | 1.4650 | 26.81 |
| Irrigation charges, NT$, $X_{18}$ | 0.0139 | 1.4705 | 1.54 |

Sum of elasticity coefficients = 0.9641
Multiple correlation coefficient, R = 0.9299
Coefficient of Multiple determination, $R^2$ = 0.8647
Sample size - 277

All regression coefficients are significantly different from zero at 0.05 or higher levels.

The estimated elasticity coefficients of production shown in Table 7 indicate that the percentage increases in gross farm output associated with a one per cent increase in the factor inputs are: crop area, 0.26; farm assets, 0.21; fertilizer expenses, 0.16; livestock, poultry and feed expenses, 0.15; farm labor (in work days), 0.10; materials expenses including seeds, seedlings, insecticides and pesticides, 0.04; wages paid on hired labor, 0.03; and irrigation charges, 0.01. The sum total of the elasticity coefficients is 0.96, implying a slight diminishing returns to scale. The multiple correlation coefficient is 93 per cent and the coefficient of multiple determination is 86 per cent.

Owing to the low standard deviation of the estimated elasticity coefficients, the computed T-statistics for testing H: $b_i = 0$ are quite high. The coefficient for irrigation charges is significantly different from zero at the 0.05 level, that of material expenses at the 0.02 level while the coefficients for other input factors are statistically significant at a level of 0.01 or higher.

The marginal revenue productivities of the various components of farm operating expenses investment, estimated by holding all specified variables at their respective geometric mean levels, as presented in Table 7, are: NT $5,098 for one hectare of crop area; NT $10.66 per work day of farm labor; and NT $0.19 per dollar of farm asset investments. The marginal revenue productivity thus estimated is a little higher than the estimates obtained from the model in which both farm assets and farm operating expenses are specified as aggregated variables.

Among the five categories of farm operating expenses, fertilizer expenses and irrigation charges return the highest marginal revenue productivity equal to NT $1.47 per NT $ investment. This means that every dollar of investment made in these expense categories generates, on the average, NT $1.47 gross return. Since the productivity is measured in gross terms, one dollar of the gross return is the recovery of the original investment. Thus the net return is NT $0.47 per dollar investment. The average production period is 4.9 months, giving an annual net return of 115 per cent. The second highest marginal revenue productivity of NT $1.465 is observed for livestock, poultry and feeds expenses, followed by investments in materials and wages paid on hired labor. Some considerations relevant to the interpretation of the marginal revenue productivities of these farm operating expenses items are provided below.

It is a well-recognized fact that agricultural production in Taiwan depends heavily on chemical fertilizers. It is a fertilizer-consuming industry. As a matter of fact, when the farm land is continuously tilled for growing crops through the entire year, practically without any fallow period, the soil is not capable of generating sufficient nutrients through decomposition processes and crop production has to

rely heavily on fertilization. The degree of dependence of Taiwan's agricultural production on the chemical fertilizer input can be observed from the data in Table 8, in which consumption of commercial fertilizer nutrients by the agricultural sector of some developing countries, together with that of the United States, is compared. According to this table, fertilizer nutrients consumption per hectare of arable land in Taiwan is 190 Kg, which is only lower than the Netherlands and Japan which consume 519 Kg and 270 Kg respectively, but much higher than all other developing countries included in the USDA study. Although fertilization is heavy, the marginal revenue productivity of fertilizer expenses investment is still very high. In fact, it yields an annual net return of 115 per cent before interest. More investment in fertilizer expenses will increase both gross and net farm receipts.

Table 8.--Consumption of Commercial Fertilizer Nutrients per Hectare of Arable Land, Kg, 1962-1963

| Country or Area | Fertilizer Nutrient Consumed Per Hectare of Arable Land, Kg. |
|---|---|
| Taiwan | 190.0 |
| Netherlands | 518.5 |
| Japan | 270.1 |
| United Arab Republic | 109.8 |
| Costa Rica | 86.2 |
| Israel | 85.2 |
| Greece | 80.3 |
| Poland | 55.5 |
| Yugoslavia | 38.9 |
| United States | 37.6 |
| Spain | 36.3 |
| Chile | 17.3 |
| Brazil | 11.4 |
| Colombia | 11.3 |
| Mexico | 10.1 |
| Pakistan | 5.7 |
| India | 3.4 |

Source: Changes in Agriculture in 26 Developing Nations, 1948 to 1963, U.S. Department of Agriculture, Foreign Agricultural Economic Report, No. 27 (November, 1965), p. 47.

Irrigation charges yield gross returns as high as those from investment in fertilizer expenses. With a marginal revenue productivity of NT $1.47 per NT dollar, investment in irrigation expenses also yields an annual net return of about 115 per cent before interest. Irrigation fees are collected twice a year shortly after harvest of the two paddy crops. Since the payment is made after harvest, investment in the irrigation fees does not require any additional interest charges. Interest is in fact already charged and included in the fees assessed.

Despite the high marginal revenue productivity of irrigation charges it cannot be recommended that the farmers should individually invest more in irrigation expenses. The amount of assessment is determined independent of the decision-making of the individual farmers. The fees are determined on the construction and maintenance costs of the irrigation facilities and on the administrative expenditures of the irrigation association. The total cost is equally divided on the basis of land area, irrespective of how much the irrigation water contributes to the marginal yield of that particular piece of land. In other words, the irrigation charges are a fixed cost on a given area of land: the farmers cannot increase irrigation fees investment by consuming a little more water, or reduce it by consuming a little less irrigation water, under given irrigation arrangements. Under these situations, the relevant decision is between water and no water, but not between a little more or a little less water.9/

The marginal revenue productivity of the investment in livestock, poultry and feeds expenses is NT $1.465 per NT dollar investment, almost as high as the marginal revenue productivity of the fertilizer expenditures and irrigation charges. The NT $1.465 marginal revenue productivity represents a net annual return of NT $0.465 before interest. In the case of livestock, the average production period is longer than for poultry. Some farmers keep hogs for as long as 10 months or longer before marketing, and most farmers spend 8 to 10 months to raise hogs to a slaughter-weight of about 90 Kg. each. In the case of poultry farming, the production period is much shorter. On the average, therefore, it is estimated that the average investment period is about 6 months. Since the invested principal can be turned over twice a year, the net return becomes NT $0.93 per year before interest or NT $0.78 after interest of 15 per cent per annum is charged.

When the livestock and poultry investment is measured as a stock variable in farm assets it yields an annual return of only 19 per cent before interest, which is just sufficient to cover interest costs. But when investment in livestock, poultry and feeds is measured as a flow variable, appearing in the profit and loss statement, it is highly productive, yielding an annual net return of about 93 per cent. The results suggest that in order to maximize profits, more investment in

slower-turnover capital expenditures should be the direction of intrafarm adjustment. The low marginal productivity of livestock as a farm asset may be in part due to the inefficient use of the animal, which is in turn due to small scale operation, and in part due to the farmer's practice of keeping hogs for too long a period. Shortening the raising period and expediting the marketing of livestock and poultry when ready, or in other words, increasing the turnover velocity, would result in considerably increased returns to the farmers.

The category of next importance is investment in farming materials, such as seeds, seedlings, insecticides and pesticides, but excluding fertilizers. The marginal revenue productivity of farm operating expenses in this category is NT $1.27 in gross terms, or NT $0.27 in net terms. Since the average investment period is less than half a year, the effective net annual return before interest amounts to about 55 per cent. Applying the 15 per cent per annum interest rate to this investment, the net return after interest is as high as 40 per cent per year. This also suggests that investment in farming materials is far from reaching the saturation point where marginal cost equals marginal revenue. Since the prospective revenue product is much higher than the prevailing interest rate, more investment for this purpose would increase returns to the farmers.

Among farm operating expenses, wages paid on hired labor generate the lowest marginal revenue product of NT $1.0185 per NT dollar. In net terms, it yields only 1.85 per cent. On the assumption that the wage payment is turned over 2.5 times a year, the effective net annual rate of return before interest is 4.7 per cent which is far from sufficient to meet interest costs. However, since the net return before interest cost is positive, the farmer's loss is only foregone rather than actual returns, for the gain or loss is measured on the basis of borrowing rate. If the foregone alternative, or the potential earning open to farm capital is the criterion, 4.7 per cent per year may be about enough to break even. It is interesting to note that in this model, the marginal revenue productivity of the total labor input in physical terms is only NT $10.66 per work day, which is about 30 per cent of the market wage rate, while the marginal revenue productivity of wages paid on hired labor is NT $1.0185 per NT dollar. This fact implies that farmers are recovering enough to cover the cost of hired labor from gross farm output although family labor is only renumerated at a return of about 30 per cent of the wage rate on hired labor.

The partial correlation coefficients of the independent variables specified in this model are listed in descending order of importance in Table 7. Table 7 shows that as far as disaggregated farm operating expenses are concerned, livestock, poultry and feed expenses as a group explains 27 per cent of the variation in the dependent variable, followed by fertilizer which accounts for about 10 per cent of the

variation in gross farm receipts. The other three variables account for 4.29 per cent, 2.04 per cent and 1.54 per cent respectively, adding up to only about 8 per cent.

In addition to the model of the previous sections, the collective farm asset investment may be disaggregated into liquid and fixed farm assets in the disaggregated farm operating expenses model. The elasticity coefficients, the marginal revenue productivities and partial correlation coefficients estimated from this model are presented in Table 9. Compared to the previous model in which farm assets investment is specified as an aggregative variable, the present model has a slightly higher goodness of fit, with the value of the coefficient of multiple determination increased by about 2 percentage points.

While the elasticity coefficients of the present model are somewhat different from those of Table 7, they are quite close to each other. As a matter of fact, their relative orders are the same in both models. The shapes of the production functions are thus very similar to each other. The only difference is that two variables of the present model generate elasticity coefficients of lower statistical significance than in the previous model. Since the statistics presented in Table 9 are self-explanatory, no further elaborations are attempted here.

## Interim Conclusions

According to the aggregated farm assets and operating expenses model--investment in farm operating expenses is highly productive but investment in farm assets is not productive enough to cover interest costs. According to the disaggregated farm assets and aggregated farm operating expenses model, liquid assets are highly productive but fixed assets are not. If the farm assets factor is further disaggregated, the productive farm assets items in descending order of productivity are: orchard and trees; by-products, processing product and working equipment; cash and cash equivalent; farm products in storage and growing crops; livestock and poultry. The unproductive farm assets are buildings and fixtures, and farm machinery. According to the aggregated farm assets and disaggregated farm operating expenses model, all farm operating expenses items except wages paid on hired labor are highly productive. When liquid farm assets, fixed farm assets and disaggregated farm operating expenses are specified in the same model, liquid farm assets, fertilizer expenses, livestock, poultry and feed expenses, and materials expenses are productive but none of the other farm expenses are productive. These findings suggested some capital items are already over-invested while others are under-invested.

Table 9.--The Elasticity Coefficient, Marginal Revenue Productivity and Partial Correlation Coefficients of Crop Area, Farm Labor, Liquid Farm Assets, Fixed Farm Assets and Disaggregated Farm Operating Expenses

| Variable | Elasticity Coefficients | Marginal Revenue Productivity (NT $ per input unit) | Partial Correlation Coefficient (Squared) (%) |
|---|---|---|---|
| Constant term | 1.6899 | ----- | ----- |
| Crop area, hectares, $X_1$ | 0.1900 | 3,792 | 8.26 |
| Farm labor, work days, $X_2$ | 0.1184 | 12.3860 | 3.94 |
| Liquid farm assets, NT$, $X_5$ | 0.2611 | 0.5647 | 29.14 |
| Fixed farm assets, NT$, $X_6$ | 0.0474 | 0.0170 | 2.59 |
| Fertilizer expenses, NT$, $X_{14}$ | 0.1551 | 1.3980 | 10.00 |
| Wages paid on hired labor NT$, $X_{15}$ | 0.0234 | 0.9667 | 4.46 |
| Materials expenses, NT$, $X_{16}$ | 0.0353** | 1.0507 | 1.60 |
| Livestock, poultry and feed expenses, NT$, $X_{17}$ | 0.1195 | 1.1724 | 20.27 |
| Irrigation charges, NT$, $X_{18}$ | 0.0091* | 0.9645 | 0.78 |

Sum of elasticity coefficients = 0.9593
Multiple correlation coefficient, R = 0.9404
Coefficient of multiple determination, $R^2$ = 0.8843
Sample size - 277

Estimates based on the model: $\log Y = a + \sum b_i \log X_i + U$.

*The elasticity coefficient is significant at the 20 per cent level.

** The elasticity coefficient is significant at the 5 per cent level.

All other elasticity coefficients are significant at the 1 per cent or higher levels.

Marginal revenue productivity is estimated at the geometric mean level of all variables.

## COMPARISON OF CAPITAL PRODUCTIVITIES

### Productivity of Farm Assets and Operating Expenses Investment

In the preceding chapter the productivities of farm assets and of farm operating expenses investments were measured independently, holding operating expenses or farm assets as a single aggregated variable in the model. Since some degree of correlation may exist between any pair of the constituent elements of these two investment categories, combination of both disaggregated farm asset items and farm operating expense items in one model may serve as a useful basis for the comparison of the productivity of the investment made in farm assets and farm operating expenses. The elasticity coefficients, marginal revenue productivities and partial correlation coefficients estimated from this model are presented in Table 10.

As the elasticity coefficients suggest, the percentage change in gross farm output in response to a 1 per cent change in factor inputs are in descending order: crop area, 0.246; fertilizer expenses, 0.172; livestock, poultry and feeds expenses (appearing as the operating expenses of the income statement), 0.154; farm labor, 0.101; farm products in storage, and growing crops, 0.052; buildings and fixtures, 0.050; and all other items are less than 0.05. The elasticity coefficient for farm machinery is -0.004, indicating that more investment in farm machinery will be associated with a smaller gross farm output. However, the negative value of the elasticity coefficient is statistically not significantly different from zero. The sum of the elasticity coefficients is 0.9236, implying a slight tendency of diminishing returns to scale. All independent variables taken together show a 93 per cent correlation with the dependent variable, and as the coefficient of multiple determination suggests, the explanatory variables specified in the model together account for 87 per cent of the variations in the dependent variable.

The marginal revenue productivities of the factor inputs of this model, estimated by holding all variables at their respective geometric means are also presented in Table 10. Since the marginal revenue productivity is estimated in gross terms, 1.0000 should be subtracted from the marginal revenue productivity of operating expenses, that is, $X_{14}$ through $X_{18}$; and appropriate depreciation charges from the marginal revenue productivity of farm assets where applicable. On the assumption that farm operating expenses can be turned over at least twice a year, the net marginal revenue productivity of farm operating expenses must be doubled. After these manipulations, the marginal revenue productivities of the disaggregated farm assets and farm operating expenses are listed below in descending order of magnitude. The marginal revenue productivity is expressed in terms of NT $ per unit (also in NT $) per year.

Table 10.--The Elasticity Coefficients and Related Statistics of the Estimated Farm Production Function with Disaggregated Farm Assets and Operating Expenses Investments.

| Variable | Elasticity Coefficient $b_i$ | Marginal Revenue Productivity (NT $ per input unit) | Partial Correlation Coefficient (Squared) (%) |
|---|---|---|---|
| Constant term | 2.2255 | ------ | ------ |
| Crop area, hectares, $X_1$ | 2.2455 | 4,893 | 11.00 |
| Farm labor, work days, $X_2$ | 0.1010 | 10.5464 | 2.55 |
| Cash and cash equivalent, NT $, $X_7$ | 0.0434 | 1.6425 | 11.49 |
| Farm products in storage and growing crops, NT $, $X_8$ | 0.0418 | 0.2571 | 3.59 |
| Livestock and poultry, NT $, $X_9$ | 0.0047* | 0.0489 | 0.04 |
| By-product, processing product and working equipment NT $, $X_{10}$ | 0.0307 | 1.2974 | 2.73 |
| Buildings and fixtures, NT $, $X_{11}$ | 0.0501 | 0.1129 | 3.09 |
| Orchard and trees, NT $, $X_{12}$ | 0.0048 | 1.6127 | 0.66 |
| Farm machinery, NT $, $X_{13}$ | -0.0040* | -0.0864 | 0.04 |
| Fertilizer expenses, NT $, $X_{14}$ | 0.1724 | 1.5510 | 10.08 |
| Wages paid on hired labor, NT $, $X_{15}$ | 0.0272 | 1.1216 | 5.05 |
| Materials expenses, including seeds, seedlings, insecticides and pesticides, NT $, $X_{16}$ | 0.0337 | 1.0013 | 1.20 |
| Livestock, poultry and feed expenses, NT $, $X_{17}$ | 0.1541 | 1.5091 | 23.09 |
| Irrigation charges, NT $, $X_{18}$ | 0.0082** | 0.8675 | 0.52 |
| Sum of elasticity coefficients | | = 0.9236 | |
| Multiple correlation coefficient, R | | = 0.9309 | |
| Coefficient of multiple determination, $R^2$ | | = 0.8666 | |

Farm production function estimate based on: $\log Y = a + \sum b_i \log X_i + U$. $(i=1,2,7,\ldots\ldots\ldots 18)$

*The elasticity coefficient is statistically not significantly different from zero.

**The elasticity coefficient is significant at the 0.3 level. All other coefficients are significant at the 0.1 or higher levels.

| | | |
|---|---|---|
| 1. | Cash and cash equivalent (no depreciation) | 1.64 |
| 2. | Orchard and trees (no depreciation) | 1.61 |
| 3. | By-product, processing product and working equipment (10% depreciation) | 1.20 |
| 4. | Fertilizer expenses (0.55 x 2) | 1.10 |
| 5. | Livestock, poultry and feed expenses (0.51 x 2) | 1.02 |
| 6. | Farm products in storage and growing crops (no depreciation) | 0.26 |
| 7. | Wages on hired labor (0.12 x 2) | 0.24 |

All other items are not productive since their potential net return is not sufficient to cover an annual interest rate of 15 per cent. Investment in farm machinery and irrigation charges have negative marginal revenue productivities, but their respective elasticity coefficients are not significantly different from zero. However, it may be noted that some asset items are more productive than farm operating expenses, although if they are measured in aggregate terms, farm operating expenses are much more productive than farm assets.

Capital Productivity of Geographical Sub-Groups

Differences in the type of farming associated with different geographical areas give rise to the differences in the intensity of factor utilization or factor proportion in agricultural production. This fact may be observed in the different output response to the same factor input in different farm regions. For this reason, it will be informative to estimate production functions from the data generated by sample farms of different geographical regions.

Generally speaking, northern Taiwan is more densely populated and the farmers have better access to consumption markets for farm produce. In this region, vegetable and fruit growing is very common. But in many parts of the region the soil is poor and the farm land is not intensively cultivated. The central region is considered the best farming area. Very fertile soil, sufficient irrigation water, and long growing period enable intensive cultivation of farm land. It is the granary of Taiwan and produces rice of high quality and yield. In addition to grain, this region produces important quantities of vegetables, especially as an intercropping harvest between crops of rice. The southern region, on the other hand, has relatively poor soils and dry weather. Mainly limited by the insufficient water supply for irrigation, farming in this area is rather extensive. This is an important producing area of sugarcane and other unirrigated upland crops, although banana and citrus fruits have gained popularity in recent years.

The elasticity coefficients of the estimated production function of the Cobb-Douglas type, together with marginal revenue productivity of crop area, farm labor, farm assets, and farm operating expenses

investments, are presented in Table 11. In general, the shape of the production functions for the three regions are similar, although they do deviate from one another in certain respects. The general tendency is that operating expenses have the highest elasticity coefficients in all regions, followed by farm assets in the north and central regions and land in the southern region. The regression coefficients of labor are in all cases very low.

The marginal revenue productivity of operating expenses is without exception very high in all regions. However, among the three, the northern region has the lowest marginal revenue productivity of operating expenses and the highest marginal revenue productivity of farm assets. This fact may suggest that in the northern part of the island, where truck farming is important, more investment is made in the form of operating expenses than farm assets. The marginal revenue productivity of farm land is highest in the most extensively cultivated southern region and lowest in the most intensively cultivated central region of Taiwan. However, no apparent explanation can be given for the fact that the lowest marginal revenue productivity of labor is found in the northern area where there are more off-farm employment opportunities, although the prevalence of truck-farming which requires more manual labor may partly account for this finding.

A farm production function may be fitted to each of the geographical sub-sets of the sample, with disaggregated farm assets investments. From the elasticity ceofficients estimated from the Cobb-Douglas type production function, marginal revenue productivities of the input factors may be computed. They are presented in Table 12.

Some factor inputs of the different regions have approximately the same marginal revenue productivities. Land and farm operating expenses are in this category. Others, however, show substantially different marginal revenue productivities from region to region. For instance, orchard and trees has a marginal revenue productivity of NT $4.16 in the north; NT $1.39 in the central; but only NT $0.32 in the southern region. The marginal revenue productivities of by-product, processing product and working equipment are NT $2.52, NT $1.53 and NT $0.69 for the north, central and south areas respectively. On the other hand, labor is not productive at all in the north, but moderately productive in both central and south areas. The deviation of the marginal revenue productivities from region to region indicates the misallocation of productive resources of agriculture among different geographic regions.

When disaggregated farm operating expenses are specified side by side with aggregated farm assets in the same model, the marginal revenue productivities of the input factors of the three geographical regions, estimated from the Cobb-Douglas type production function, are as presented in Table 13.

The marginal revenue productivity estimated at the geometric mean level of all input factors differs from area to area. The materials

Table 11.--Elasticity Coefficients and Marginal Revenue Productivities of Crop Area, Farm Labor, Farm Assets and Operating Expenses Investments of Different Geographical Regions

| | Aggregate | North | Central | South |
|---|---|---|---|---|
| Sample Size | 277 | 86 | 96 | 95 |
| Elasticity Coefficient | | | | |
| 1. Constant term | 1.4707 | 1.7108 | 1.3380 | 1.4516 |
| 2. Crop area, $b_1$ | 0.2296 | 0.2393 | 0.1902 | 0.2430 |
| 3. Farm labor, work days, $b_2$ | 0.0653** | 0.0232* | 0.1076** | 0.0947** |
| 4. Farm assets Investment, $b_3$ | 0.1581 | 0.2197 | 0.1208 | 0.0763** |
| 5. Farm operating expenses, $b_4$ | 0.5134 | 0.4163 | 0.5619 | 0.5859 |
| 6. Sum of $b_1$--$b_4$ | 0.9664 | 0.8985 | 0.9805 | 0.9999 |
| Multiple Correlation Coefficient, R | 0.9379 | 0.8556 | 0.9614 | 0.9583 |
| Coefficient of Multiple Determination, $R^2$ | 0.8797 | 0.7321 | 0.9241 | 0.9183 |
| Marginal Revenue Productivity (NT $) | | | | |
| 1. Crop area, $X_1$ | 4,554 | 4,593 | 3,859 | 4,919 |
| 2. Farm labor, work days, $X_2$ | 6.74 | 2.41 | 10.81 | 10.33 |
| 3. Farm assets investment $X_3$ | 0.1439 | 0.1862 | 0.1247 | 0.0666 |
| 4. Farm operating expenses, $X_4$ | 1.2419 | 1.0965 | 1.3284 | 1.3716 |

*The coefficient is not significantly different from zero.

**Coefficients are statistically significant at a level of 10 per cent. All other regression coefficients are significant at a level of 1 per cent or higher.

Table 12.--Marginal Revenue Productivities of Input Factors for North, Central, and South Regions, Estimated for Disaggregated Liquid and Fixed Farm Assets (NT$ Per Input Unit)

| Variable | | North | Central | South |
|---|---|---|---|---|
| Crop area, hectares | $X_1$ | 2,877 | 2,602 | 3,168 |
| Farm labor, work days | $X_2$ | -1.6320 | 12.1703 | 11.2345 |
| Farm operating expenses, NT $ | $X_4$ | 1.2098 | 1.3729 | 1.3121 |
| Cash and cash equivalent, NT $ | $X_7$ | 2.0373 | 0.4765 | 0.5084 |
| Farm products in storage and growing crops, NT $ | $X_8$ | 0.5427 | 0.1815 | 0.3789 |
| Livestock and poultry, NT $ | $X_9$ | -0.2654 | 0.2991 | 0.0010 |
| By-product, processing product and working equipment, NT $ | $X_{10}$ | 2.5176 | 1.5349 | 0.6855 |
| Buildings and fixtures, NT $ | $X_{11}$ | -0.0094 | 0.0154 | 0.1232 |
| Orchard and trees, NT $ | $X_{12}$ | 4.1634 | 1.3946 | 0.3224 |
| Farm machinery, NT $ | $X_{13}$ | -0.2891 | -0.0359 | -0.2147 |

All negative values of the estimated marginal revenue productivity are statistically not significantly different from zero.

The marginal revenue productivity is estimated at the geometric mean level of all variables.

Table 13.--Marginal Revenue Productivity of Input Factors for North, Central and South Regions Estimated with Disaggregated Farm Operating Expenses Investment

| Variable | | North | Central | South |
|---|---|---|---|---|
| Crop area hectares, | $X_1$ | 5,261 | 4,353 | 6,139 |
| Farm labor, work days, | $X_2$ | 0.2287 | 12.3110 | 21.6845 |
| Farm assets, NT $ | $X_3$ | 0.2124 | 0.1756 | 0.1618 |
| Fertilizer expenses, NT $ | $X_{14}$ | 2.2478 | 1.0643 | 1.1525 |
| Wages paid on hired labor, NT $, | $X_{15}$ | 0.0744 | 0.8866 | 1.6997 |
| Materials expenses, including seeds, seedlings, insecticides, pesticides, NT $, | $X_{16}$ | 2.3180 | 2.2978 | -0.4491 |
| Livestock, poultry and feeds expenses, NT $ | $X_{17}$ | 1.2295 | 1.7105 | 1.4546 |
| Irrigation charges, NT $, | $X_{18}$ | -0.5412 | 1.7558 | 1.7733 |

All marginal revenue productivities of negative value are statistically not different from zero.

Marginal revenue productivity is estimated by holding all variables constant at their respective geometric mean level.

expenses investment has the highest marginal revenue productivity in the northern and central region: NT $2.32 and NT $2.30 per NT dollar respectively. But in the south region, the marginal revenue productivity of this input item becomes - NT $0.45, although the T-test of the elasticity coefficient shows that this negative value is in fact not significantly different from zero. Irrigation charges have a very high marginal revenue productivity in both central and south regions, NT $1.76 and NT $1.77 respectively. The coefficient is -NT $0.54 for the north region, but this value is not significantly different from zero. The fertilizer expenses investment generates the highest marginal revenue productivity in the northern region and the lowest in the central, while the investment in livestock, poultry and feeds expenses is almost equally productive throughout all regions. Wages paid on hired labor do not return enough to cover even the original investment in either the north or central region, but they are highly productive in the south. While in both north and central regions a diminishing returns to scale is observed, the south shows increasing returns to scale. The aforementioned deviations in the marginal revenue productivity generated by different farm operating expenses investment in different farming areas indicate that the degree of maladjustment or misallocation of productive resources is different both in terms of different investment items in the same area and in terms of the same investment item over the different areas.

The marginal revenue productivities of the farm assets and operating expenses investment, both disaggregated, for the three regions, estimated at the respective geometric mean level of the input factors, are compared in Table 14. Some input factors are without exception highly productive in all three regions. This is true of financial assets, by-product, processing product and working equipment, fertilizer expenses, livestock, poultry and feeds expenses, although they are more productive in some regions than in others. However, for some other input factors the differences in marginal revenue productivity are quite phenomenal. Orchards and trees, for example, are highly productive in the north and central regions, but their marginal revenue productivity is not significantly different from zero in the south. Farm products in storage and growing crops are equally productive in the north and south but not at all in the central region. Wages paid on hired labor, are highly productive in the south, only potentially so in the central, but not at all in the north. Materials expenses are highly productive in the central region, while its marginal revenue productivity is not significantly different from zero in the north and south regions.

## Capital Productivity of Commercialized and Non-Commercialized Farms

The sample farms may be classified into sub-categories based on certain attributes which represent sub-sets of population more homogeneous with respect to the purpose of this study. This sub-classification should produce better production function estimates,

Table 14.--Marginal Revenue Productivities of Input Factors for North, Central and South Regions Estimated with Disaggregated Farm Assets and Operating Expenses Investments (NT $ Per Input Unit)

| Variable | | North | Central | South |
|---|---|---|---|---|
| Crop area, hectares, | $X_1$ | 5,378 | 3,878 | 4,055 |
| Farm labor, work days, | $X_2$ | -0.3430* | 11.2915 | 20.5948 |
| Cash and cash equivalent, NT $, | $X_7$ | 2.1767 | 0.7102 | 0.9836 |
| Farm products in storage and growing crops, NT $, | $X_8$ | 0.4401 | 0.0601* | 0.4576 |
| Livestock and poultry, NT $, | $X_9$ | -0.5593 | 0.2638 | -0.4377 |
| By-product, processing product and working equipment, NT $, | $X_{10}$ | 2.1880 | 1.8194 | 1.4770 |
| Buildings and fixtures, NT $, | $X_{11}$ | 0.0609* | 0.0648 | 0.1819 |
| Orchard and trees, NT $, | $X_{12}$ | 2.2911 | 1.2459 | -4.0301* |
| Farm machinery, NT $, | $X_{13}$ | -0.4154* | 0.0821* | -0.0223* |
| Fertilizer expenses, NT $, | $X_{14}$ | 2.1722 | 1.3277 | 1.7115 |
| Wages paid on hired labor, NT $ | $X_{15}$ | 0.1662* | 0.9771 | 1.8775 |
| Materials expenses, including seeds, seedlings, insecticides and pesticides, NT $, | $X_{16}$ | 1.1725* | 2.7971 | 1.1104* |
| Livestock, poultry and feed expenses, NT $, | $X_{17}$ | 1.4138 | 1.7093 | 1.6208 |
| Irrigation charges, NT $, | $X_{18}$ | -1.0823* | 0.4194* | 1.3278 |

Estimated at the geometric mean level of all variables.

*The elasticity coefficient is not significantly different from zero.

since the output response to changes in factor inputs may be parallel to each other if the sample farms have more common attributes. The commonly used basis of classification is type of farming.

In Taiwan, practically all farms are general-type crop farms, with varying degrees of diversification in the kinds of crops raised and with varying degrees of poultry and livestock as supplementary sideline enterprises. There are some large-scale chicken farms as well as dairy cattle farms, but in general these are not commonly considered farms. Of the 277 sample farms, only 4 have gross farm receipts generated by poultry and livestock exceeding receipts generated by crops. Some farms emphasize fruits, vegetables, or grain crops, but the difference is in degree rather than in kind. The majority of the farms are general-type rice or sugarcane farms but they also grow several other kinds of crops, supplemented by chicken and hog raising. Under these conditions, it is obviously not possible to sub-classify them into mutually exclusive rice farms, vegetable farms, chicken farms and hog farms. For practical purposes, most farms engage in all these enterprises.

One important sub-classification, however, can be established to compare the production function estimates for each sub-group. That is classification of the sample farms into commercialized and non-commercialized farms. It is a common practice of the farmers to grow grain and other crops primarily to meet home consumption demand and then market any surplus off-farm. This means that there is practically no completely commercialized farming in which all products are marketed off-farm The only difference again is in the degree of commercialization.

Some farmers use most of the produce for family consumption while some sell most of the produce for cash revenue, depending on the kind of crops grown, acreage of land cultivated, size of family, and other factors. In this study, therefore, the commericalized farm is defined as one on which more produce is marketed off-farm than consumed on-farm, or one which generates more cash income than non-cash income. Conversely, if more of its produce is consumed on-farm than is marketed off-farm, or if non-cash income exceeds cash income, the farm is classified as non-commercialized. The elasticity coefficients estimated from the Cobb-Douglas type production function for the commericalized and non-commercialized farms are compared in Table 15.

Statistics presented in Table 15 suggest that data generated by the farms in commercialized group have better goodness of fit to the Cobb-Douglas production function model in that they are associated with higher values of multiple correlation coefficient (R) and coefficient of multiple determination ($R^2$) compared to those generated by the non-commercialized group of farms. However, the difference in their statistical goodness of fit is not very significant. Both groups of farms show a slight tendency to diminishing returns to scale, since the sums of the elasticity coefficients are a little smaller than unity.

Table 15.--Production Functions for Commercialized and Non-Commercialized Farms, with Aggregate Farm Assets and Operating Expenses Investments

| Variables | Commercialized Farms | Non-commercialized Farms |
|---|---|---|
| Sample size | 144 | 133 |
| Elasticity coefficients, $b_i$ | | |
| Constant term | 1.1999 | 1.8919 |
| Crop area, hectares, $X_1$ | 0.1638 | 0.3147 |
| Farm labor work days, $X_2$ | 0.0756* | 0.0633* |
| Farm assets investments, NT \$, $X_3$ | 0.2337 | 0.0884 |
| Farm operating expenses, NT \$, $X_4$ | 0.4960 | 0.4833 |
| Sum of elasticity coefficients | 0.9691 | 0.9502 |
| Multiple correlative coefficients, R | 0.9440 | 0.9370 |
| Coefficients of multiple determination, $R^2$ | 0.8911 | 0.8779 |

Estimate based on the model: $\log Y = a + \sum b_i \log X_i + U$ (i - 1, 2, 3, 4).

*The regression coefficients is significantly different from zero at the 0.10 level.

All other coefficients are significantly different from zero at the 0.01 level or higher.

The elasticity coefficients of production of these two groups of farms show substantial deviations from one another. In the case of crop area, the non-commercialized farm group has a much higher elasticity coefficient, about twice as high than that of the commercialized group. For other input factors, on the other hand, the commercialized group has much higher elasticity coefficients. This is especially true in the case of investment in farm assets. In the case of farm labor and investment in farm operating expenses, the elasticity coefficients for both groups are almost equal, although in both cases, the commercialized group has a little higher elasticities.

The marginal revenue productivities of the input factors of the commercialized and non-commercialized groups are compared in Table 16. The marginal revenue productivity of the commercialized and non-commercialized farms reveal very distinct differences between these two groups of farms.

Table 16.--Marginal Revenue Productivity of Input Factors for Commercialized and Non-commercialized Farms, with Aggregated Farm Assets and Operating Expenses Investments (NT $ Per Input Unit)

| Variable | Commercialized Farms | Non-commercialized Farms |
|---|---|---|
| Crop area, hectares, $X_1$ | 3,143 | 6,493 |
| Farm labor, work days, $X_2$ | 7.7097 | 6.8094 |
| Farm assets investment, NT $, $X_3$ | 0.1889 | 0.0910 |
| Farm operating expenses investment, NT $, $X_4$ | 1.2237 | 1.1640 |

Estimated at the geometric mean level of all variables.

First of all, the marginal revenue productivity per hectare of crop area is NT $3,143 in the commercialized farm group and NT $6,493 in the non-commercialized farm group. The latter is twice as high as that of the former. It is known that non-commercialized farms have a higher degree of part-time farming; and consequently, rely more on non-farm income. More often than not, these farmers cultivate their land with spare time in non-farm or off-farm occupations. The commercialized farms, on the other hand, are necessarily operating on a more nearly full-time basis, to generate more farm surplus to be marketed off-farm. The land utilization is therefore most intensive on commercialized than on non-commercialized farms. The lower marginal revenue productivity of crop area in the commercialized farm group reflects the higher intensity of farm land use compared to the non-commercialized farm group. Increase in the crop area of the non-commercialized farm group will be associated with almost twice as high marginal revenue product as will increase in the crop area of the commercialized farm group.

The marginal revenue productivity of farm labor shows an opposite tendency. It is a little higher in the commercialized than in the non-commercialized farm group. It suggests that compared to the commercialized farm group, the non-commercialized farm group has a higher degree of over-application of farm labor. It is understandable that the part-time farmers are apt to inject whatever amount of labor is available in their farming operations, and their labor input may be inferior quality-wise with respect to farming. The full-time farmers have to supplement seasonal labor shortage with hired labor. Their labor use is conceivably more profit - or return - oriented and thus their labor use efficiency is higher. However, the difference in their marginal revenue productivity is not very large.

Both investments in farm assets and investments in operating expenses generate higher marginal revenue productivity on commercialized than on non-commercialized farms. This is especially true for investments in farm assets which produce a marginal revenue of NT $0.1889 per NT $ investment for the commercialized farm group but only NT $0.0910, for the non-commercialized farms, or only half that of the commercialized group. Due to the smaller scale operations, the non-commercialized farm group tends to over-invest available funds in farm assets, at least in relation to the degree of utilization of farm assets that this group of farms can make. The investment in farm assets of the commercialized farm group generates barely enough marginal revenue product to cover depreciation and interest costs. The investment in the farm assets of the non-commercialized farm group, on the contrary, is not productive at all. The investment in farm operating expenses is productive for both groups of farms, although the marginal revenue productivity is higher in the commercialized farm group than the non-commercialized farm group.

The investments in farm assets and farm operating expenses can be disaggregated into their consitutent elements to study the output response to the change in the disaggregated input factors when they are specified in the same model.

When both disaggregated farm assets and farm operating expenses investments are specified in the model, the marginal revenue productivity of the input factors, estimated by holding all variables constant at their respective geometric mean levels, are as presented in Table 17. The general trend is that while the non-commercialized farm group is characterized by a higher marginal revenue productivity of crop area compared to the commercialized group, the latter enjoys a much higher marginal revenue productivity of farm labor compared to the former.

Except for a few items, the marginal revenue productivity of investments in farm assets and farm operating expenses of the two groups of farms tend to deviate considerably from each other. The only items which have nearly equal marginal revenue productivity

17.--Marginal Revenue Productivity of Input Factors for Commercialized and Non-commercialized Farm Groups, with Disaggregated Farm Assets and Operating Expenses Investment (NT $ Per Input Unit)

| Variable | Commercialized Farms | Non-commercialized Farms |
|---|---|---|
| Crop area, hectares, $X_1$ | 4,339 | 5,197 |
| Farm labor, work days, $X_2$ | 15.1440 | 3.8851 |
| Cash and cash equivalent, NT $, $X_7$ | 1.0724 | 0.1536 |
| Farm Products in storage and growing crops, NT $, $X_8$ | 0.2213 | 0.6358 |
| Livestock and poultry, NT $, $X_9$ | 0.0786 | 0.2180 |
| By-product, processing product and working equipment, NT $, $X_{10}$ | 1.4359 | 0.9102 |
| Buildings and fixtures, NT $, $X_{11}$ | 0.1583 | 0.1224 |
| Orchard and trees, NT $, $X_{12}$ | 1.1841 | 2.1680 |
| Farm machinery, NT $, $X_{13}$ | -0.2440 | 0.2956 |
| Fertilizer expenses, NT $, $X_{14}$ | 1.5409 | 1.4213 |
| Wages on hired labor, NT $ $X_{15}$ | 0.9384 | 1.1206 |
| Materials expenses, including seeds, seedlings, insecticides and pesticides, NT $, $X_{16}$ | -0.3494 | 3.0477 |
| Livestock, poultry and feeds expenses, NT $, $X_{17}$ | 1.4587 | 1.0791 |
| Irrigation charges, NT $, $X_{18}$ | -0.1106 | 1.6776 |

Estimated from the model: $\log Y = a + \sum b_i \log X_i \; U$ ($i = 1,2,7 \ldots \ldots 18$).

Estimated by holding all variables at their respective geometric mean levels.

The negative marginal revenue productivity is statistically not significantly different from zero.

are fertilizer expenses which generates NT $1.54 per dollar for the commercialized group and NT $1.42 per dollar for the non-commercialized group; and buildings and fixtures, which generates NT $0.16 per dollar for commercialized and 0.12 for non-commercialized group. Farm machinery investment generates a negative marginal revenue productivity for the commercialized group of the farms but a positive productivity for the non-commercialized group. But neither of them is significantly different from zero.

Investments in orchard and trees are highly productive, yielding a marginal revenue productivity of NT $1.18 and NT $2.17 per dollar respectively for commercialized and non-commercialized farms. However, it is almost twice as productive for non-commercialized as for commercialized farms. Investment in fertilizer expenses yields approximately equal marginal revenue productivity of NT $1.54 and NT $1.42 per dollar in gross terms. Investment in livestock, poultry and feed expenses is highly productive for the commercialized group of farms, but it is only about enough to cover interest costs for the non-commercialized group. Farm products in storage and growing crops are productive for both groups, although more so for the non-commercialized than for the commercialized group. The reason may be that the non-commercialized group of farms is in fact hardly able to produce a surplus for storage. Investment in buildings and fixtures returns barely enough for the commercialized group to cover interest charges, while it clearly does not yield enough for the non-commercialized group to meet interest costs. If a depreciation charge is taken into consideration, investment in this category does not seem to be profitable for either group of farms.

Wages on hired labor yield only NT $0.94 per dollar for the commercialized group of farms, while it yields NT $1.12 for the non-commercialized farms. The difference may be made by the fact that the latter group of farms depends more on family labor than on hired labor. This explanation is consistent with the finding that when the labor input is specified in terms of work days, its marginal revenue productivity is much lower for the non-commercialized group and much higher for the commercialized group. It should be noted that investments in materials expenses and irrigation charges are highly productive for the non-commercialized group but they are not at all productive for the commercialized group. The explanation may be that the commercialized group has already made enough investment in these input items.

## Interim Conclusions

In the model in which both farm assets and operating expenses are disaggregated, production function estimates for the overall sample (277 farms) show that the productive items are, in descending order: cash and cash equivalent; orchard and trees; by-product, processing product, and working equipment; fertilizer expenses; livestock, poultry and feed expenses; farm products in storage and growing crops. All other items are not productive.

For geographical sub-groups--from productivity estimates based on the model in which both farm assets and operating expenses are specified as disaggregated variables--the following conclusions are obtained. The input factors which are productive in three regions without exception are: cash and cash equivalent; by-product, processing product and working equipment; fertilizer expenses; livestock, poultry and feeds expenses. The one input factor which is unproductive throughout all regions is farm machinery. None of the other variables show a uniform tendency throughout the three geographical sub-groups.

For commercialized and non-commercialized sub-groups, productivity estimates based on the disaggregated farm assets and operating expenses model indicate that cash and cash equivalent, farm products in storage and growing crops, by-product, processing product and working equipment, orchard and trees, fertilizer expenses, and livestock, poultry and feed expenses are either highly or potentially productive for both groups of farms. All other items are productive for one group, either commercialized or non-commercialized, but not the other.

Remembering that farm assets investment is a flow variable, it is clear that the marginal revenue productivities of the capital inputs in gross terms are not directly comparable for formulating policy recommendations. The following adjustments are needed to place on a comparable basis the marginal revenue productivities of capital inputs estimated from disaggregated farm assets and operating expenses investments:

a. Depreciation on farm assets--7 per cent per annum on buildings and fixtures on the assumption of a 15 year economic life; and 10 per cent per annum on farm machinery on the assumption of a 10 year economic life. No depreciation is charged on other asset items.

b. Turnover of operating expenses--twice a year, assuming an average investment period of six months. The value is deducted from the computed gross marginal revenue productivity and then the balance is multiplied by 2 to obtain the net marginal revenue productivity on a per annum basis.

The final conclusions, after making the adjustments described above, are summarized in Table 18. This table shows that two capital input items, by-product, processing product and working equipment ($X_{10}$) and fertilizer expenses ($X_{14}$) are always productive without exception; three items, financial assets ($X_7$) farm products in storage and growing crops ($X_8$) and livestock, poultry and feeds expenses ($X_{17}$) are productive either absolutely or potentially; two items, buildings and fixtures ($X_{11}$) and farm machinery ($X_{13}$) are more likely to be unproductive then productive. General conclusions cannot be drawn about the other variables which are productive in some cases but not in others.

Table 18.--Net Marginal Revenue Productivity of Input Factors Estimated From Disaggregated Farm Assets and Operating Expenses Model, on Per Annum Basis

| Variable | Overall | Region | | | Type | |
|---|---|---|---|---|---|---|
| | | North | Central | South | Commercial | Non-Commercial |
| I. Farm Assets | | | | | | |
| Cash and cash equivalent, $X_7$ | + | + | + | + | + | 0 |
| Farm products in storage and growing crops, $X_8$ | + | + | 0 | + | + | + |
| Livestock and poultry, $X_9$ | - | - | + | - | - | + |
| By-product, processing product, and working equipment, $X_{10}$ | + | + | + | + | + | + |
| Buildings and fixtures, $X_{11}$ | - | - | - | 0 | - | - |
| Orchard and Trees, $X_{12}$ | + | + | + | - | + | + |
| Farm machinery, $X_{13}$ | - | - | - | - | - | 0 |
| II. Farm operating expenses | | | | | | |
| Fertilizer, $X_{14}$ | + | + | + | + | + | + |
| Wages on hired labor, $X_{15}$ | + | - | - | + | - | + |
| Materials expenses, $X_{16}$ | - | + | + | + | - | + |
| Livestock, poultry feeds, $X_{17}$ | + | + | + | + | + | 0 |
| Irrigation Charges, $X_{18}$ | - | - | - | + | - | + |

"+" denotes productive, representing net marginal revenue productivity larger than 0.2.

"0" denotes potentially productive, representing net marginal revenue productivity of less than 0 2 but larger than 0.1 which is approximately enough to cover interest costs.

"-" denotes not productive, representing net marginal revenue productivity of less than 0.1.

## CREDIT AND FINANCE POLICY IMPLICATIONS

The findings of this study have certain farm credit and finance policy implications. These are discussed at the farm level, institutional (farm credit institutions) level and aggregate or national level in the following.

### At the Farm Level

The low asset turnover velocity indicates that the efficiency of capital use by the average sample farm is low. This may be a result of excess investment in capital items which are not directly productive or not fully utilized for income-generating purposes. Examples are buildings and fixtures, draft animals and farm machinery. While it may not be practicable to suggest liquidation of the existing capital stock, their fuller utilization for income-generating purposes should be encouraged. Adjustments in the farm asset structure by way of channeling more investment to capital items of higher productivity; collective or cooperative ownership of capital items infrequently used and yet requiring large initial investments; and use of custom-hire services in so far as they are available, are additional ways to improve efficiency of capital use.

It was found that investments in liquid farm assets generated much higher marginal revenue productivity than investments in fixed farm assets. If no further information is available to facilitate decision-making, liquidity should be a criterion for considering investment alternatives. However, liquidity is not an absolute criterion because some fixed farm asset items show higher marginal revenue productivity than some liquid farm asset items. What is true in general and overall terms is not necessarily true of disaggregated component factors.

It was also made clear that investments in farm operating expenses in general tended to generate higher marginal revenue productivity than did investments in farm assets. This suggests the existence of excess investment in farm assets relative to farm operating expenses; hence, more investment in farm operating expenses is a way to reduce misallocation of capital resources between these two categories and thus increase gross return to the farmers. However, this generalization must also be qualified in that certain operating expense items are relatively less productive than some asset items. Certain operating expense items, in fact, are absolutely unproductive and more unproductive than some farm asset items.

Table 18 presents specific conclusions on the productivity analysis. There are two investment items that are absolutely productive without exception in all situations: investment in by-product, processing product and working equipment, and investment

in fertilizers. There are three investment items which are absolutely productive in five of the six sub-classifications and potentially productive in the sixth. These three items are: financial assets; farm products in storage and growing crops; and livestock, poultry and feeds expenses. More investment in these five categories of investment items can be expected to yield larger marginal revenue products than other farm assets or operating expense items.

On the other hand, investments in buildings and fixtures, and investments in farm machinery are not productive for farms in any sub-set of the sample. Investments in other categories are productive for farms in some regions, or for either the commercialized or non-commercialized group, but not in other sub-sets of the sample. In this case, implications for decision-making can only be derived in the light of specific information about the individual farm.

Last, but not least, since some capital investments--either farm assets or operating expenses--yield high returns, and since the equity ratio is very high, increased capital investment by means of external financing is profitable on the sample farms. The high equity ratio suggests that the farmers are in a position to borrow, and the high marginal revenue productivity in certain capital categories suggests that the farmers have opportunities to profit from more investment. After borrowing, the financial position as expressed by the debt-to-equity ratio will of course deteriorate. However, so long as the additional investment financed by borrowed funds is productive, the increased income will strengthen the financial position of the borrowing farm via leverage effects. In fact borrowing is an effective means to increase returns on ownership capital as long as the returns from the additional investment financed by the borrowing exceed the cost of money. If at present the available equity capital limits farmers' investment, more borrowing from outside sources will help to fully exploit profit opportunities.

## At the Institutional Level

The very high equity ratio, with equity capital representing 95 per cent of the total financing, implies that the sample farms as a whole have enough backing to support additional borrowing from external sources. Since the degree of indebtedness of the sample farms is very low, it is more likely that the principal and interest will be recovered through disposal of security in case of default by the borrower. From the point of view of their security position the sample farmers are good prospective borrowers, although this is only one of several criteria by which to evaluate credit worthiness.

Many capital uses by the sample farms generate impressively high marginal revenue productivities; much higher than the prevailing market rate of interest. This means that capital investment in certain uses is far below the optimum level, since the prospective marginal revenue

is higher than the marginal cost. While a portion of this under-investment may be due to internal (self-imposed by the borrower) capital rationing, some part is almost certainly the result of external (lender-imposed) rationing of credit.

It is recognized that credit rationing by institutions may be involuntary and justified by risk considerations or by restricted loanable funds. To the extent that institutional rationing is voluntary in the sense that available funds are withheld from farmer applicants whose low risk and high net marginal productivity positions demonstrate their capacity to productively utilize credit, such voluntary institutional rationing does not appear to be justified. Such voluntary rationing in fact, is contrary to the stated objectives of some institutions and should be eliminated.

Apart from the technical point of complicance with the policy objectives stated for their institutions, there appear to be compelling reasons for increased agricultural lending by credit institutions. These center on the farmers' relatively high security position, as evidenced by their average equity ratio of 95 per cent, and on the high capacity to utilize and repay loans evidenced by the high productivity of additional investments in various uses.

Lenders must, of course, be selective in increasing their agricultural portfolios. Not all uses of capital are productive; neither are all farmers' security positions sufficient to insure collectibility. The materials contained in this paper, however, provide a basis for the exercise of the necessary selectivity on these points by lending institutions. With this selectivity, coupled by effective lender consideration of relevant risk and individual lender characteristics, lending institutions can justifiably allocate more loanable funds to agriculture.

Traditionally, farm credit institutions have preferred to make farm loans to finance investment in fixed farm assets over those for liquid assets or operating expenses. The major reason for this practice is the tangibility and durability of the fixed farm assets as mortgagable security. Fixed farm assets are easily controlled by the lender. However, it should be noted that investments in fixed farm assets are by and large not sufficiently productive to yield enough return to cover interest costs. Compared to investments in liquid farm assets and farm operating expenses, investment in most fixed farm assets will not produce sufficient net income for loan repayments. If the security has to be liquidated after default of the loan, it is doubtful that the whole cost involved can be recovered from the sale of the security. Thus, the security-oriented loan screening practice may be self-defeating in the end.

In view of the above facts it is suggested that credit institutions will find it advantageous to shift their lending emphasis from the financing of fixed farm assets to the financing of liquid assets and farm

operating expenses. It is further suggested that attention be given to devising means whereby high productivity and its resultant repayment capacity can be substituted for tangible collateral as acceptable assurance of loan collectibility.

The results of analysis of geographical and commercialized/non-commercialized sub-sets of the sample data form the basis for a final policy recommendation for credit institutions. It will be recalled that investments in some capital items were found to be productive, without exception, in all sub-sets (Table 18). The profitability of other items was not uniformly productive throughout all sub-sets.

Here the implied policy recommendation is mainly negative. In the case of prospective loans for those capital investment items which are not listed (Table 18) as productive for all sub-sets, the institution cannot automatically assume that the investment will be productive. Careful individual investigation of such proposed loans is required to determine its productivity. This suggests that in order to be operationally efficient, loan policies should be differentiated according to the use of the loan, the locality in which the farm is located, and the degree of commercialization of the particular farm.

At the National Level

It was revealed that the average total investment made by the sample farms in 1963 was NT $224,855 (US $[illegible],621) per farm or NT $158,349 (US $3,959) per hectare of farm land. While the per farm investment figure is small, the per land unit figure is very high. Accordingly, the total capital which agriculture as a whole commands is a very large amount.

At the farm level, some capital items are highly productive while others are not productive at all. Since the total investment at the macro-level is already high, this suggests two policy guidelines: one is selective investment in capital items which have higher marginal revenue productivities, and the other is capital adjustments within the farm. To be effective, government policies should incorporate these two components.

Low marginal revenue productivities may stem from the under-utilization or excess capacity of the capital items. In the future, cooperative or collective ownership, establishment of service stations of some kind to provide the needed service, or encouragement of custom-hire arrangements are suggested as partial solutions to the problem of under-employment of invested capital. For the last two or three decades, farmers'associations have been successful in developing cooperative ownership of rice warehousing and processing facilities. While economic return is not the sole motive for the farmers to secure ownership of certain capital items, the extension of cooperative investment should be encouraged and assisted by policy means. Substitution

of social overhead for private capital in some items also merits consideration.

The high ratio of fixed to total assets is mainly due to high land prices. The average land price of the sample farms is about NT $107,380 (US $2,685) per hectare or about US $1,080 per acre. Undoubtedly, such high land prices have exhausted most of the capital at the disposal of the farmers. The government policy, then, should aim at the lowering of farm land prices, or at least the prevention of further and rapid increases. This can be done in part by prohibiting speculation in farm land. Of course, stabilization of farm land prices will not improve the financial situations of the already established farms; but it will help those who are going to start farming, those who are going to expand farm size and those who are inheriting farms but have to make compensation to other heirs for their shares.

The marginal revenue productivity of machinery is surprisingly low. There are, therefore, difficulties in replacing low cost labor with high cost machinery. Because of the small scale of operation, power tillers are under-employed and the replaced labor has insufficient alternative employment opportunities. In attempting to mechanize farming, government policy should aim at increasing the marginal revenue productivity of farm machinery, both by increasing off-farm employment opportunities for labor released from farm work and by fuller use of the power tiller, including off-farm use such as rural transportation.

One of the very important findings is the high productivity of chemical fertilizers. Although fertilizer use is already at a high level, increasing the supply of fertilizers through import and domestic production will still considerably increase farm output. Since the chemical fertilizer supply is controlled at the source by government agencies, macro-policy should emphasize increase in the supply of fertilizer.

Technical innovation may be classified as capital-using or capital-saving according to their impact on capital use and capital requirements. According to Hicksian concepts, at a given capital-labor ratio, capital-using technical innovations raise the marginal productivity of capital more than that of labor, and by so doing induce more use of capital. Capital-saving technical innovations raise the marginal productivity of labor by more than that of capital and thus discourage use of capital. Government-sponsored research work should emphasize development of capital-using technological innovations with regard to those capital items characterized by low marginal revenue productivities. This might result in a more nearly equal marginal revenue productivity of all capital inputs.

Research and educational programs on optimum capital allocation and efficient capital use may also contribute to the solution of the capital problems in the context of this study. To date, little comprehensive

research has been done on capital and investment problems, and farm education programs do not cover farm financial management. In this unexplored area, related research and educational activities would prove remunerative even in the short-run.

## APPENDIX 1

### Methodology

1. Estimation of Elasticity Coefficients

The single equation model of the production function employed in this study is specified as:

(1) $Y = f(N, L, K)$
where $Y$ = gross farm output (receipts),
$N$ = Land (crop area),
$L$ = Labor (work day), and
$K$ = Capital investment.

Since K represents capital investments of two different dimensions, the model can be revised to include $K_1$, a stock variable, and $K_2$, a flow variable. The model then becomes:

(2) $Y = f(N, L, K_1, K_2)$
where $K_1$ = farm assets, and
$K_2$ = farm operating expenses.

Expressed in the logarithmic form of the Cobb-Douglas type function, equation (2) can be expressed as:

(3) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + U$
where $Y$ = Gross farm output in NT \$ (NT \$40 = US \$1)
$X_1$ = Crop area in hectares,
$X_2$ = Farm labor in work days,
$X_3$ = Farm assets investment in NT \$,
$X_4$ = Farm operating expenses in NT \$,
$a, - b_1 \ldots b_4$ = constants, and
$U$ = Residuals.

When the farm assets investment is disaggregated into its constituent components, leaving farm operating expenses as an aggregative variable, the model takes the form of:

(4) $Y = f(N, L, K_{1i}, K_2)$
or in the logarithmic form of the Cobb-Douglas production function,

(5) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + U,$

and

(6) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_4 \log X_4 + b_7 \log X_7 + b_8 \log X_8 + b_9 \log X_9 + b_{10} \log X_{10} + b_{11} \log X_{11} + b_{12} \log X_{12} + b_{13} \log X_{13} + U$

where $X_5$ = liquid farm assets, NT $,
$X_6$ = fixed farm assets, NT $,
$X_7$ = cash and cash equivalent, NT $,
$X_8$ = farm products in storage and growing crops, NT $,
$X_9$ = livestock and poultry, NT $,
$X_{10}$ = by-product, processing product and working equipment, NT $,
$X_{11}$ = buildings and fixtures, NT $,
$X_{12}$ = orchard and trees, NT $,
$X_{13}$ = farm machinery, NT $,
$X_1$, $X_2$, $X_4$ = same as specified under equation (3),
a, $b_1$, $b_2$, $b_4$.....$b_{13}$ = constants, and
U = residuals.

When the farm operating expenses investment is disaggregated into its component factors, leaving farm asset investment as an aggregative variable, the model follows:

(7) $Y = f\ (N, L, K_1, K_{2i})$

or, in the logarithmic form of the Cobb-Douglas type production function,

(8) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_{14} \log X_{14} + b_{15} \log X_{15} + b_{16} \log X_{16} + b_{17} \log X_{17} + b_{18} \log X_{18} + U$

where $X_{14}$ = fertilizer expenses, NT $,
$X_{15}$ = wages paid on hired labor, NT $,
$X_{16}$ = materials expenses (seeds, seedlings, insecticides, pesticides, etc.), NT $,
$X_{17}$ = livestock, poultry and feeds expenses, NT $,
$X_{18}$ = irrigation charges, NT $,
$X_1$, $X_2$, $X_3$ = as specified under equation (3),
a, $b_1$..$b_3$.....$b_{14}$...$b_{18}$ = constants, and
U = residuals.

When both farm assets and farm operating expenses are disaggregated into their constituent elements, the model becomes:

(9) $Y = f\ (N, L, K_{1i}, K_{2i})$

or in the logarithmic form of the Cobb-Douglas production function,

(10) $\log Y = a + \sum b_i \log X_i + U\ (i = 1, 2, 7.....18)$

All variables and parameters are as specified before.

Applying least squares technique to fit the aforementioned models to the observed data, the estimated parameters, $b_i$'s, represent the elasticity coefficients of production.

## APPENDIX II

### Correlation Coefficients Between Variables

| | $X_{18}$ | $X_{17}$ | $X_{16}$ | $X_{15}$ | $X_{14}$ | $X_{13}$ | $X_{12}$ | $X_{11}$ | $X_{10}$ | $X_9$ | $X_8$ | $X_7$ | $X_6$ | $X_5$ | $X_4$ | $X_3$ | $X_2$ | $X_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | .460 | .604 | .620 | .373 | .743 | .492 | .201 | .440 | .531 | .521 | .580 | .376 | .450 | .809 | .901 | .694 | .697 | .825 |
| $X_1$ | .474 | .402 | .549 | .298 | .750 | .463 | .198 | .379 | .498 | .466 | .579 | .235 | .489 | .669 | .764 | .576 | .724 | |
| $X_2$ | .317 | .342 | .595 | .186 | .650 | .425 | .173 | .293 | .424 | .342 | .392 | .226 | .299 | .523 | .666 | .458 | | |
| $X_3$ | .210 | .381 | .395 | .260 | .434 | .507 | .212 | .824 | .353 | .450 | .431 | .494 | .604 | .756 | .603 | | | |
| $X_4$ | .466 | .702 | .658 | .437 | .767 | .475 | .120 | .395 | .447 | .496 | .468 | .323 | .466 | .694 | | | | |
| $X_5$ | .317 | .499 | .460 | .290 | .527 | .408 | .140 | .407 | .458 | .605 | .613 | .556 | .486 | | | | | |
| $X_6$ | .321 | .317 | .355 | .160 | .372 | .350 | .166 | .494 | .258 | .260 | .339 | .290 | | | | | | |
| $X_7$ | .039 | .173 | .264 | .187 | .148 | .293 | .091 | .242 | .065 | .181 | .113 | | | | | | | |
| $X_8$ | .395 | .360 | .315 | .170 | .401 | .297 | .006 | .280 | .471 | .350 | | | | | | | | |
| $X_9$ | .225 | .566 | .243 | .068 | .376 | .305 | .146 | .283 | .300 | | | | | | | | | |
| $X_{10}$ | .360 | .239 | .378 | .097 | .486 | .302 | .166 | .262 | | | | | | | | | | |
| $X_{11}$ | .107 | .218 | .240 | .163 | .274 | .371 | .151 | | | | | | | | | | | |
| $X_{12}$ | .006 | .111 | .171 | -.005 | .121 | .179 | | | | | | | | | | | | |
| $X_{13}$ | .217 | .362 | .423 | .131 | .353 | | | | | | | | | | | | | |
| $X_{14}$ | .450 | .317 | .589 | .291 | | | | | | | | | | | | | | |
| $X_{15}$ | .102 | .166 | .277 | | | | | | | | | | | | | | | |
| $X_{16}$ | .388 | .325 | | | | | | | | | | | | | | | | |
| $X_{17}$ | .274 | | | | | | | | | | | | | | | | | |

2. Estimation of Marginal Revenue Productivities Let the Production Function be:

(1) $\log Y = a + b_1 \log X_1 + b_2 \log X_2 + \ldots\ldots\ldots + b_n \log X_n$

Set $X_1, X_2 \ldots X_n$ at their respective geometric means levels, then

(2) $\log Y = a + b_1 \log \bar{X}_1 + b_2 \log \bar{X}_2 + \ldots\ldots + b_n \log \bar{X}_n$

The marginal productivity of $X_1$, holding all variables at their respective geometric mean levels, is estimated with:

(3) $\log \bar{Y} = a^* + b_1 \log \bar{X}_1$
where $a^* = a + b_2 \log \bar{X}_2 + \ldots\ldots\ldots + b_n \log \bar{X}_n$

(4) $\bar{Y} = (\text{antilog } a^*) . \bar{X}_1^{b_1}$

(5) $$\frac{dY}{d\bar{X}_1} = \frac{d\ (\text{antilog } a^*) . \bar{X}_1^{b_1}}{d\bar{X}}$$

$$= b_1\ (\text{antilog } a^*)\ \bar{X}_1^{b_1 - 1}$$

$$= \frac{b_1\ (\text{antilog } a^*)\ \bar{X}_1^{b_1}}{\bar{X}_1}$$

$$= \frac{b_1 . \bar{Y}}{\bar{X}_1}$$

(6) $$\frac{dY}{d\bar{X}_i} = b_i \frac{\bar{Y}}{\bar{X}_i}$$

where $\frac{dY}{d\bar{X}_i}$ = marginal productivity of the i-th input factor, $X_i$, holding all variables at their respective geometric mean levels,

$b_i$ = elasticity coefficient of $\log X_i$

$\bar{Y}$ = geometric mean of the dependent variable, Y, and

$\bar{X}_i$ = geometric mean of the i-th independent variable, $X_i$.

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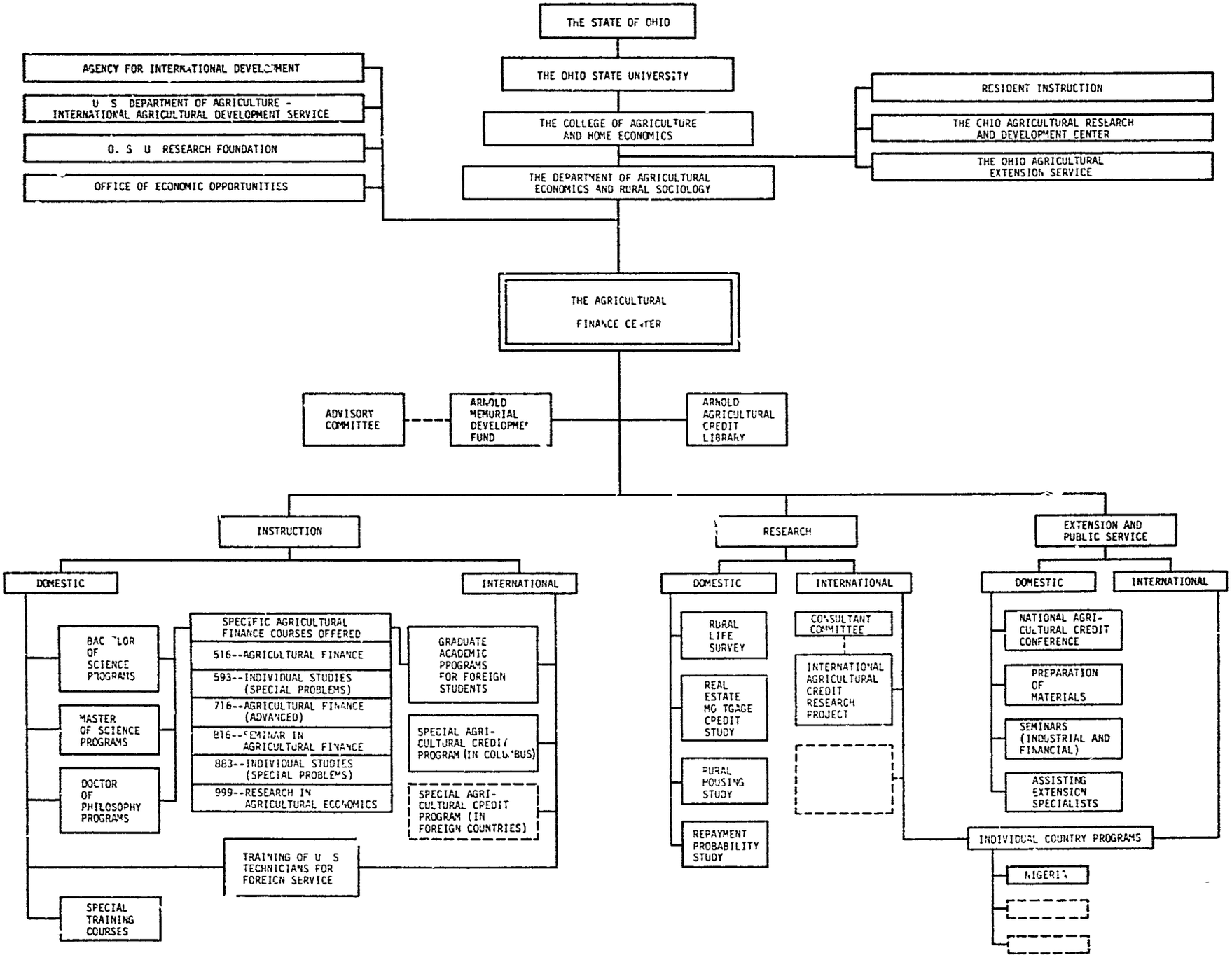
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