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THE EFFECTS OF THE RENT REDUCTION IN TAIWAN: A GENERAL EQUILIBRIUM ANALYSIS

By

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ABSTRACT

THE EFFECTS OF THE RENT REDUCTION IN TAIWAN
A GENERAL EQUILIBRIUM ANALYSIS

By

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Applying two general equilibrium models formalized for an economy of four industries (non-agricultural, non-rice agricultural, rice produced from tenant-cultivated paddy fields, and rice produced from self-cultivated paddyfields) and five factors of production (labor, capital, dry land, tenant-cultivated paddyfield, and self-cultivated paddyfield), this study examines the economic effects of the rent reduction instituted in Taiwan for regulating land rental received from most of the paddyfields.

In model I, we derive an equilibrium tenant rental-acreage trade-off relationship based on the assumption that market demand forces play a dominant role in the determination of the land area used for tenancy. This relationship provides information to trace the excess demand for tenant land induced by the rent reduction.

In model II, we examine the relationships between land acreage used for tenancy and the variables such as input or output prices, industry outputs, and the real income levels obtainable by various consumer groups, based on the assumption that market supply forces play a dominant role in the determination of the land area used for tenancy. The model provides more information in the evaluation of the effects of

the rent reduction.

A numerical analysis is conducted in this study based on the Taiwanese data. Our findings indicate that, in an economy initially starting from a competitive equilibrium state, the introduction of land rent reduction would result in a non-negligible decrease in the national product and a real income distribution favoring capitalists and dry land owners while hurting wage workers and the owners of both types of paddy fields. We also find that rent reduction policy able to alleviate the tenant market distortions would promote productive efficiency.

A sensitivity test is conducted to the numerical analysis by changing the magnitude of the cross-elasticities of substitution in production. The findings assure that rent reduction does not always lead to a more equalized income distribution.

To My Mother and My Late Father

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CHAPTER I

INTRODUCTION

Rent reduction was introduced as a measure of land reform in Taiwan in 1949. It regulates rental ceiling on farm land at 37.5 percent of the main crop yield in 1948 record. It was designed to reduce land rent to a reasonable level, to raise tenant farmers' share of income from cultivation, to provide tillers with incentives to improve productivity, and to promote agricultural development.

Immediately after the implementation of the rent reduction, some visible changes, such as lower tenant land rent, depreciated land price, and income distribution between landlords and tenant farmers, occurred. We believe that, following these primary effects, substitution in production and consumption would generate a long-term impact on input prices, output prices, national income and income distribution among landlords, tenant farmers, and other groups of consumers.

This study aims at tracing the secondary economic effects of the rent reduction. It is conducted through a competitive general equilibrium framework of two sectors (agricultural and non-agricultural), three commodities (rice, non-rice agricultural goods, and non-agricultural goods), four industries (non-agricultural, non-rice agricultural, rice produced from tenant-cultivated paddyfields, and rice produced from self-cultivated paddyfields), five factors of production (labor, capital, dry land, paddyfield used for self cultivation, and paddyfield used for tenant cultivation), and five classes of consumers (laborers, capitalists, dry land owner-cultivators, paddyfield landlords, and paddyfield owner-cultivators).

At least two approaches can be used to analyze the effects of the rent reduction: a partial equilibrium approach and a general equilibrium approach. The partial equilibrium approach is valid to examine the effects of rent reduction if the land reform measure involves changes in the factor income which is small relative to national income (Diewert, 1974b: 477). Because tenant land rental bill is large relative to national income, its change affects the demand functions (and possibly also the supply functions) that the agricultural and nonagricultural sectors face. To examine the effects of rent reduction on multiple sectors of an economy, a general equilibrium approach is more desirable (Harberger, 1962; Jones, 1971a, 1971b; Diewert, 1974a, 1974b; Koo, 1982).

The application of the general equilibrium approach to determine the effects of the rent reduction was initiated by Koo (1977, 1982), who formed a model of two industries (rice and potatoes) and three factors of production (labor, tenant land, and self-cultivated land) to represent the agrarian economy of Taiwan, where owners of tenant paddyfields are assumed to receive a higher monopoly rent than owners of self-cultivated land. Koo (1982:66) also assumed that land and labor are two homogeneous factors of production, fully employed and fixed in total amount; and that redistribution of income among consumers do not change the pattern of demand. Allowing for a complete general equilibrium in the two output markets, on the labor market, on the owner-cultivated land market, assuming a fixed factor intensity and the same elasticities of substitution between land and labor in the two productions, Koo (1982:86) concluded that "the impact of rent reduction goes further than distribution of gains and losses between monopoly landlords and tenants, ... When the secondary effects are accounted for, a part of the gains goes to the non-monopoly landlords."

Prior to Koo's study of the effects of the rent reduction, the general equilibrium approach was used by Johnson and Mieszkowski (1970), Jones (1971a), Magee (1971), Batra and Pattanaik (1971), Bhagwati and Srinivasan (1971), and Diewert (1974a, 1974b) to analyze the effects of various factor price distortions. The underlying model of these studies is due to Harberger. Harberger (1962) examined the incidence of the corporate income tax through a model of two industries (corporate and non-corporate) and two factors of production (labor and capital). In the model, income tax is levied merely on the earnings of capital in the corporate industry. Harberger (1962:215-216, 224) assumed that: "both industries are competitive, with production in each governed by a production function which is homogeneous of the first degree"; "the available quantities of labor and capital will be fully employed" but "are not affected by the existence of the tax"; and "redistribution of income among consumers do not change the pattern of demand." According to Harberger (1962: 227), the solution of the tax incidence is varied, depending upon the values of initial distributive shares, the price elasticity of demand for the taxed commodity, the relative factor intensities of the two productions, and the elasticity of substitution in the two productions.

This study attempts to extend Koo's analysis by adding a non-agricultural sector to the analytical framework based on the belief that rent reduction affects agricultural as well as nonagricultural sectors. There are three additional major differences between Koo's and this study.

First, instead of using three factors of production, this study employs five: labor, capital, dry land, tenant-cultivated paddyfield, and self-cultivated paddyfield. Labor and capital are two important elements needed for all productions. Paddyfields are used by owners and tenants for rice production. Dry lands are used by owners for non-rice agricultural production. The rent reduction regulations initially affects merely the rental income received from the tenant-cultivated paddyfields.

Secondly, this study assumes that market for tenant paddyfields is initially perfectly competitive. Although this assumption significantly differs from Koo's monopolistic assumption, it does not affect the validity of our impact analysis.

Thirdly, this study uses duality theory (Shephard, 1953;

Diewert, 1973) and Shephard's Lemma (1953:11) to derive aggregate demands for factors and commodities. The duality theory has been used by, among others, Diewert (1971a, 1974a and 1974b), Epstein (1974), and Woodland (1973). Diewert (1974b:478) detailed the advantages in the use of the theory in a general equilibrium system:

> The practical advantage of duality theory ... is that it enables us to derive reduced form consumer and producer supply and demand functions simply by differentiating the appropriate dual function. Thus, the economy's system of supply-equals-demand equations ... is easy to derive using duality theory, and moreover, when we attempt to do the comparative statics of a general equilibrium system, ..., the use of duality theory involves inverting matrices which are much smaller than those which would be obtained if we used traditional 'primal' methods.

Typical duality theorems between the cost and the production functions state that:

> (1) a concave production function yields a cost function homogeneous of degree one in price, given specified regularity conditions, (2) a cost function homogeneous of degree one in input price yields a concave production function, given specified regularity conditions, and (3) the cost function derived from a particular production function will in turn yield that production function. (Henderson and Quandt, 1982:118)

A similar duality also exists between the expenditure and the utility functions (Henderson and Quandt, 1982:44-45).

According to Shephard's Lemma, the partial derivative of a cost function dual with respect to an input price is the cost-minimizing input value needed by a producer for producing a unit of output, and the partial derivative of an expenditure function dual with respect to an output price is equal to the expenditure-minimizing output value needed by a consumer for attaining a unit of utility. Applying Shephard's Lemma respectively to the assumed cost and the assumed expenditure function duals in this study, we derive aggregate demands for the inputs and the commodities.

Setting the derived aggregate demand equal to market supply, we formalize the demand-equal-to-supply equilibrium conditions for the input and output markets.

Our two theoretical models are constructed based on eleven assumptions (see section 4.2.1 of chapter 4 for details).

In model I, seventeen equations are formalized to represent the general equilibrium conditions of the economy. They are: three demand-equal-to-supply equations in the commodity markets; five demand-equal-to-supply equations on the factor markets; four zero-profit relationships; and five consumer budget constraints. The seventeen equations are expressed in the seventeen endogenous variables: three commodity prices; five factor prices; four industry outputs; and five utility levels. The dominant feature of market demand forces is emphasized in the determination of the market equilibrium conditions. The zero-profit relationships indicate that selling price equals unit producing cost in each industry. The consumer budget constraints state that consumer's utility level is determined by the input/output prices and the consumer's income and preferences.

Rent reduction induces increase in the quantity of land needed by tenant farmers who cultivate rice. The increase in demand is assumed to be realized through the conversion of paddyfield usage from self cultivation to tenancy.

To trace the effects of the rent reduction, a comparative static analysis is conducted to the system of the seventeen equations in model I, based on a hypothetical one percent increase (from the initial equilibrium level) in the land area used for tenancy. The analysis generates an impact vector containing valid information (on the equilibrium tenant rental-acreage trade-off relationship) to evaluate the increased demand for tenant land induced by the rent reduction.

Model II is also composed of seventeen equations. Except the tenant market equilibrium condition, all the equations appeared in model I are retained as the equilibrium conditions. An equilibrium tenant land supply function is introduced here as the tenant market equilibrium condition to capture the practically dominant feature of the tenant market supply forces in the determination of land area used for tenancy. The seventeen equations are expressed in the same seventeen endogenous variables as those of model I.

In model II, an impact vector is derived from a comparative static analysis based on a one percent decrease (from the initial equilibrium level) in the land area supplied for tenancy. All farm lands withdrawn from tenancy are assumed to be used in self cultivation after the implementation of the rent reduction. The impact vector contains valid information to evaluate the effects of the rent reduction on the endogenous variables.

The numerical values of the above two impact vectors are determined based on the Taiwanese data. The numerical results from model I indicate that the excess demand for tenant land would approximately be one thousand twenty seven times the original area of land used in tenancy after the land rent is lowered by the government-set target rate. The numerical results from model II are generally consistent with the competitive market model. It is confirmed that the secondary effects of the rent reduction would go far beyond redistribution of income between landlords and tenant farmers. The effects include a decrease in the gross national output and in the real incomes for laborers, paddyfield landlords, and paddyfield owner-cultivators. The rate of decrease in real income is the same for paddyfield landlords and paddyfield owner-cultivators and about twice the size as that for laborers. On the other hand, a slight increase occurs on the real incomes for capitalists and dry land owners.

A sensitivity test is conducted to the impact analysis based on various assumptions about the magnitude of the cross-elasticities of substitution in production. The results of the sensitivity test indicate that signs of the rate of changes in most endogenous variables are not sensitive to the magnitude of the elasticity of substitution when values of these elasticity terms vary within the range of positive numbers. However, sizes of the rate of changes in the endogenous variables are varied, depending upon the magnitude of these elasticity terms.

This study is composed of six chapters. Chapter one states the research problem, the objectives, and the procedures in conducting the study. Chapter two presents a historical retrospective on the land reform in Taiwan. Chapter three presents a review of the literature relevant to land market and land tenure reform. Chapter four presents two theoretical models to determine the effects of the rent reduction. Chapter five describes the data used for the impact analysis and interpretes the results of the numerical and the sensitivity analysis. Chapter six is a summary and conclusion.

Three appendixes are attached to this study. Appendix 1 presents seventeen tables to describe the sources of data for this study. In appendix 2, elements of the impact vectors (generated from the comparative static analysis) are expressed in the partial derivative forms and as functions of the various distributive shares and the elasticities of substitution in production and consumption. Appendix 3 presents the computer program used in this study for calculating the solutions of the impact analysis.

CHAPTER II

LAND REFORM IN TAIWAN

This chapter presents a historical retrospect on the land reform in Taiwan in the following sequences: the prereform land market conditions; the objectives and justifications of the reform; the process of the reform; the contributory factors to the success of the reform; and the postreform progress and development.

2.1 Prereform Land Market Conditions

In 1948, one year before the land reform was implemented, total cultivated land area was 863,157 hectares, which is approximately one fourth of the total 3,600,000 hectares of the geographical area of Taiwan. Table 2.1 indicates that, out of the total cultivated land area, paddyfields and dry lands were respectively 526,385 and 336,772 hectares; public and private lands were respectively 176,031 and 687,126 hectares. Of the public lands, 71,967 hectares were paddy-fields and 104,064 hectares were dry lands. Of the private lands, 454,418 hectares were paddyfields and 232,708 hectares were dry lands (Shong, 1951:139).

The prereform land market conditions are elaborated in terms of the distribution of private land ownership, the composition of farmers (who leased lands and who owned lands), and the prices and rental rates prevalent in the land market.

Table 2.1

Area of Cultivated Land
by Type of Land and Ownership, 1948

	Area (Hectare)	Percentage
Total Cultivated Land	863,157	100.00
Public Land	176,031	20.39
Paddyfield	71,967	8.34
Dry Land	104,064	12.06
Private Land	687,126	79.61
Paddyfield	454,418	52.65
Dry Land	232,708	26.96

Source: T.S. Shong, "Land Distribution in Taiwan." In T.T. Bao (ed.), The Cabinet Rent Reduction Report. Chinese Research Institute of Land Economics, Taipei, 1951, p. 139.

Data on the characteristics of private landownership are not available for the years 1939-1951 (Lee, 1972). This, nevertheless, does not impede our understanding of the prereform land market conditions, because private land ownerships of 1952 are generally believed acceptable to carry the same characteristics of that of 1948. Table 2.2 indicates that a large portion of land was held by a small number of big landowners, and the majority of landowners held small pieces of land. Average size of landholding was 0.2336 hectares for owners who held less than 0.5 hectares of land; 0.7190 hectares for owners who held land between 0.5 and 1.0 hectares; 1.6492 hectares for owners who held land between 1 and 3 hectares; 4.8160 hectares for owners who held land between 3 to 10 hectares; and 21.40 hectares for owners who held land more than 10 hectares. It seems correct to conclude that the landownership tends to be concentrated in the hands of a small number of big land owners.

Based on the data of column (1), the distribution of agricultural population, Table 2.3, we learn that the concentration of land ownership was a serious problem in 1948. Due to the heavy dependence on the agrarian sector at that time, tenants stood as the majority of land tillers. The total population of Taiwan was 6,807,611 persons in 1948 (Shong, 1951:149). The agricultural population (4,045,188 persons) was 59.4 percent of the total population. The group of tenants plus hired laborers (1,722,416 persons in total) who owned no land was 42.58 percent of the agricultural

Table 2.2
Characteristics of Private Land Ownership, 1952

Size of Holding (Hectare)	Number of Landowners Household	Number of Landowners Percentage	Total Area Hectare	Total Area Percentage
Below 0.5	288,955	47%	67,511	10%
0.5 - 1.0	142,659	23%	102,577	15%
1.0 - 3.0	138,178	23%	227,890	33%
3.0 - 10.0	36,350	6%	175,064	26%
Over 10.0	5,051	1%	108,108	16%
Total	611,193	100%	681,150	100%

Source: Y.K. Mao, "Land Reform and Agricultural Development in Taiwan", in C.M. Ho and T.S. Yu (eds.), Agricultural Development in China, Japan and Korea. Academia Sinica, Taipei, 1980, pp. 862-863.

population. Adding the group of partial owners, farmers who relied on tenant land (994,791 persons) were 67.17 percent of the agricultural population.

The problem of landownership concentration is also displayed in column (2), the distribution of agricultural households, Table 2.3. The group of agricultural households who relied on tenant land for living (the 429,205 households of partial owners, tenants, and hired laborers) was 66.54 percent of the total 645,941 agricultural households.

Based on the data of column (3), the distribution of cultivated land area, in Table 2.3, we learn that, of the total 863,157 hectares of cultivated land, 58.18 percent was used for owner cultivation and 41.82 percent for tenancy.

The average cultivated land area per agricultural household was 1.3363 hectares (obtained by dividing the 863,157 hectares of cultivated land by the 645,941 agricultural households). Assuming that partial owners owned 50 percent and leased another 50 percent of the cultivated lands, the area of average cultivated land would have been 1.708 hectares for owner-cultivator households, 1.239 hectares for partial owner-cultivator households, and 1.170 hectares for tenant households.

Because of the heavy concentration of landownership and a high demand for cultivated land, serious pressures were placed on the rental rates. Economists, among others, Tang (1954), Chen (1961), Koo (1968:31), Lee (1972:44), and Mao (1980:857), all pointed out that the average rental on farm land, prior to

Table 2.3
Agricultural Population, Farm Households, and
Area of Cultivated Land by Type of Tiller, 1948

	(1) Agricultural Population (Person)	(2) Farm Households (Household)	(3) Area of Cultivated Land (Hectare)
Owner-Cultivators	1,327,981 (32.83%)	216,736 (33.55%)	502,153 (58.18%)
Partial Owners	994,791 (24.59%)	154,460 (23.91%)	
Tenants	1,489,959 (36.83%)	231,224 (35.80%)	361,004 (41.82%)
Hired Laborers	232,457 (5.75%)	43,521 (6.74%)	
Total	4,045,188 (100.00%)	645,941 (100.00%)	863,157 (100.00%)

Sources: Columns (1) and (2) are cited from Taiwan Agricultural Yearbook (1949). PDAF, Taiwan, 1951.

Column (3) is cited from T.S. Shong, "Land Distribution in Taiwan," in T.T. Bao (ed.) The Cabinet Rent Reduction Report. Chinese Research Institute of Land Economics, Taipei, 1951, p. 149.

the reform, was approximately 50 percent of the total annual main crop yield. Higher grade of land engendered a higher rental rate. The highest rental charge, of more than 70 percent of the annual crop yield, was imposed on fertile land in densely populated area; rental rate of less than 50 percent was imposed on less fertile land. A large portion of rental was arranged in the form of "ironclad", which requires a fixed amount of rental payment regardless of weather or harvest condition (Koo, 1968:31). Rental arrangements were often made by verbal rather than written agreement. Land security was seldom granted to tenants who could not afford security deposits.

Before the implementation of the land reform, land price was about four times the amount of land rental rate during the period of 1938-1943 (Koo, 1968:79). In 1948, land price was 1.12 times that of the 1938-1943. However, lack of statistics on the growth trend of rental rates for 1938-1948 makes the comparison of land price with rental rate for 1948 impossible.

In sum, the concentration of landownership, the prevalence of landless tillers and the insecurity of tenancy made governmental intervention desirable in the land market operations.

2.2 Objectives and Justifications of the Reform

The objectives of the land reform are to create favorable tenancy conditions for land market, to redistribute farm lands from absentee landowners to the incumbent tenants, to divert investment interests from landholdings to industrial holdings, and to promote growth in both agriculture and industry.

The implementation of the land reform was based on the Principle of the Equalization of Land Rights, advocated by Dr. Sun Yat-sen, founder of the republic. He suggested that the state shall have supreme power to dispose all the unearned values increment on land caused by economic growth or by increased demand for land through growing population pressure or both. Based on this principle, the portion of land incremental value should be enjoyed by and distributed to the public instead of the landowners alone.

When the land reform was first instituted in 1949, the justifications were based more on socio-political than on economic concern. At that time, most economists and politicians voiced against the retainment of traditional land tenure systems. They were not pleased with the fact that a large number of tillers possessed no cultivated lands. They condemned the hardship which was imposed on poor farmers by landlords in most cases of land lease. There was a common fear that, if governmental intervention were absent, poor tenant farmers might end up with barely enough to survive. It was commonly sensed that whenever this condition occurred and persisted, it would result in an unstable mass of agricultural population which would, in turn, damage social order and threaten national security. Since Taiwan was and still is the only province free from the Chinese Communists' control, socio-political stability has always been the top priority that receives the government's attention. To avoid all the negative effects of the traditional land tenure system, the government was determined to implement the land reform.

2.3 Process of the Land Reform

The land reform was implemented through three sequential stages: the rent reduction; the sale of public land; and the Land-to-the-Tiller program.

2.3.1 Farmland Rent Reduction

The rent reduction act was enacted in January, 1949 and enforced in May of the same year. It set the maximum rental ceiling at 37.5 percent of the annual principal crop yield on farm lands. With a few exceptions,[1] the government appraised and determined the annual principal crop yield for most categories, grades, and areas of farm lands in 1948. The 1948 records of annual principal crop yield were used as bases for appraisal.

The rent reduction regulations state that: all extra elements beyond the legitimate rental payment have to be excluded from rental payment; lease contracts have to be in written form; and the tenancy shall be lasted for at least six years. Moreover, to protect tenure security, the incumbent tenants are provided first leasing priority unless, out of their own will, they give up the right to renew the contracts. During the lease period, landlords may not withdraw the lands from tenancy except for legally specified reasons, such as arrears in excess of two years' rental. At the end of lease period, unless for self utilization, a lessor is not allowed to terminate a lease if the lessee were willing to continue. Rental payment is required to be adjusted to a lower rate if a poor harvest were due to natural causes. The rent reduction regulations were effectively enforced due to a series of governmental intensive follow-up spot inspections and recheckings of possible violations.[2]

The rent reduction caused depreciations in land value. The decline, however, did not induce an immediate increase in the purchase of tenant lands by tenant farmers. During 1949-1952, the total area of lands transferred from landlords to tenants was merely 19,277 hectares (7 percent of the total tenant land area). Of these transferred lands, 15,839 hectares are paddyfields, 3,438 hectares are dry lands (Tang, 1954:64-65). A logical explanation for this phenomenon is that, within the years after rent reduction, most tenants were not sufficiently affluent to purchase lands.

In summary, the rent reduction lowered rental rates on tenancy, made the price of farm land depreciate, upgraded living conditions for tenants, and provided tenants with incentives to improve productivity. However, it penalized absentee landlords who owned but did not till their lands. And it threatened the livelihood of those landlords who had no other sources of income (Bao, 1951:5; Shong, 1951:131-159; Koo, 1968:50).

2.3.2 Sale of Public Land

This stage involves the sale of the public land owned by the Chinese government to the incumbent tenant farmers. The land was formerly owned by the Japanese who left for Japan from Taiwan at the end of WWII. The goals of the sale are to establish more owner-tillers and to relieve rural unemployment in Taiwan.

Before the sale started in 1948, public land area totaled 176,031 hectares; the majority of the land was already leased to farmers from the government. In some cases, subleases were also given to farmers who had already leased some public land from the government. In 1948, the government attempted to eliminate the sublease system. To do so, farmers were encouraged to form cooperatives to conduct public land leasing. However, few cooperatives were composed due to lack of capital, lack of enterpreneurship, or the irregularity of the configuration of public lands.

The initial sale of public land was suspended in 1949 and resumed in 1951. The suspension was due to the successful implementation of the rent reduction, which greatly improved farmers' livelihood and lessened the level of acute rural unemployment.

In June 1951, the "Regulations Governing the Implementation of the Sale of Public Land to Help Establish Owner-Farmers in Taiwan" was approved by the Taiwan Provincial Assembly (Koo, 1968:35). The regulations were designed to establish more owner-tillers. Based on this law, from 1951 to

1973, about 130,000 hectares of the public farm land were sold to 177,000 tenant farmers (Mao, 1980:860). Of the total sold public land, about 69,509 hectares were sold before 1958 (Koo, 1968:37). Most of the unsold public land was kept and used by the public enterprises, such as the Taiwan Sugar Corporation. The size of the public land for sale was regulated based on grades and categories. The average size of the public land purchased was a little over 0.5 hectares per tenant family (Koo, 1968:37). The price of public land was marked as 2.5 times the 1948's record of the annual main crop yield. To avoid losses possibly caused by deflation, the land price was set in physical terms. That is, rice for the payment of paddyfields and sweet potatoes for dry lands. The payment was alloted in twenty, equal, semi-annual installments, which made annual purchase allotment equal to 25 percent of the annual main crop yield. As a result of the installment plan, annual purchase allotment plus annual land taxes would keep farmers' annual financial burden within the range of 37.5 percent of the total annual main crop yield (Koo, 1968:37).

As a result of the sale of the public land, there was an increase in both the number of owner-tillers and the average size of land owned by owner-cultivators.

2.3.3 Land-to-the-Tiller

Land-to-the-Tiller was an ultimate goal of the land reform. To achieve that goal, the land-to-the-tiller act, enacted in 1953, regulates that: landholdings of absentee landlords shall be transferred to the incumbent tenant farmers; landlords can retain three hectares of medium grade paddyfields or its equivalence; and the portion of tenant land area in excess of the maximum limit shall be purchased by the government and resold to the incumbent tenants. However, such rules are not applied to the lands held and used by owner-cultivators. The resale price of land is determined at 2.5 times the 1948 record of annual main crop yield plus 4 percent interest per annum. Payment for the purchase price is allocated into twenty, equal, semi-annual allotments in rice if the purchase was of paddyfield and in sweet potatoes if the purchase was of dry land. Annual purchase allotments plus annual land taxes kept the financial burden of the land purchasers to be less than 37.5 percent of the total annual main crop yield.

Government payment for the compulsory purchase of land was made 70 percent in land bonds and 30 percent in the stocks of the four government-owned corporations. Rice bonds were paid for the purchase of paddy land; sweet potato bonds were paid for the purchase of dry land. Stocks paid for compensation were 37 percent in the Taiwan Cement Corporation, 33 per cent in the Taiwan Paper and Pulp Corporation, 13 percent in the Taiwan Agricultural and Forestry Development Corporation, and 17 percent in the Taiwan Industrial and Mining Corporation.

As a result of the implementation of the Land-to-the-Tiller program, a total 143,568 hectares of farm lands were compulsorily purchased from 106,149 landlords and resold to 195,000 tenant households. The total resale price was 1,272,000 metric tons of rice and 437,710 metric tons of sweet potatoes (Koo, 1968:45-46; Mao, 1980:860).

The program successfully increased the number of owner-tillers, lessened the level of land concentration, provided farm security through farm ownership, and provided farmers with incentives to improve productivity. During 1952- 1955, total number of farm land owners rose from 611,193 to 776,002 (Mao, 1980:863). The total area of land held by farms below 3 hectares increased from 58 to 77 percent; the total area of land held by farms over 3 hectares decreased from 42 to 23 percent (Mao, 1980:862). The proportion of owner-tillers rose from 36.1 percent in 1949 to 54.9 percent in 1953 and reached 84 percent in 1981. On the other hand, the proportion of tenant farmers declined from 38.7 percent to 21.0 percent and eventually sank to 7 percent.[3] The area of land cultivated by owners increased from 58.18 percent in 1949 to 79.04 percent in 1953 and reached 95.18 percent in 1980.[4]

Government compensation for the compulsory purchase of land was intended to transfer investment from landholdings to industrial holdings. However, the outcome of this plan was rather undesirable. After the purchase and compensation, landlords held 45.44 percent of the total value of the four government corporations. Most of the new stockholders exhibited no enthusiasm about industrial holdings. The stock retention rate was low, especially for those held by small lanlords. Landlords who did not retain the stocks either used their money in other ways or were plainly short of confidence in the stocks, even though the government provided assistances to the development of the four corporations (Koo, 1968:47-48). Little was known about how the withdrawn industrial investment was reallocated.

2.4 Factors Contributed to the Success of the Land Reform

Four key factors contributed to the success of the land reform. They are: the spot inspection system, the existent infrastructure before the reform; the small farming system; and other supplementary agricultural policies. The first factor is discussed in section 2.3.1 and is not repeated here.

2.4.1 Prereform Infrastructure

Before the land reform was initiated, infrastructure valuable to the reform already existed as a result of agricultural development during the fifty years (1895-1945) of the Japanese occupation. During that period, Japan intended to make Taiwan a major food supplier to Japan, especially of rice and sugar. The existent infrastructure directly affected the outcomes of the land reform include: the duly updated cadastral system, the expansion of cultivated land area; the effective water conservation and irrigation devices; the well-constructed roads and harbors; the multi-functional farmers' association; and the agricultural experimental research institutions. In addition, other favorable measures accomplished by the Japanese were: the unification of the system of measures and weights, and the introduction of the Chinese civil household organization--the Bao-Chia System.[5]

The cadastral system was established for the purpose of tax collection. It provided a duly investigated and surveyed record of categories, grades and areas of land, and accurate information on landownership. It was initiated in 1910-1914 after measures and weights were unified. Without its existence, the implementation of the land reform would have been hampered by delay or ineffectiveness.

The expansion of cultivated land area was ranked as the top priority in Taiwan's agricultural development under Japanese rule. In 1940, the total area of cultivated land was 860,439 hectares, more than double the total 375,909 hectares of arable land in 1901. After Taiwan was retroceded to the Chinese government in 1945, the total cultivated land area gradually increased but was always below 900,000 hectares during the years 1946-66.[6]

The expansion of cultivated land area involves both horizontal and vertical sense of expansion due to the expansion of the effective water conservation devices. Table 2.4 displays the statistics related to this subject. Vertical expansion of cultivated land took place in the form of improvements in the quality of land and a more intensive degree of land utilization. Sharp rises in both the crop and paddyfield area occurred because of a 363 percent increase in the irrigation area from 1903 to 1942.

Table 2.4
Statistics of Irrigation and Land Expansion for Selected Years

Unit: Hectare

(1) Year	(2) Irrigation Area	(3) Total Arable Land	(4) Total Paddyfields	(5) Double-Cropping Paddyfields	(6) Single-Cropping Paddyfields	(7) Total Crop Area
1901	NA	375,909	206,753	NA	NA	505,517
1903	150,456	534,157	278,190	NA	NA	NA
1905	194,223	624,501	304,908	NA	NA	685,987
1910	233,500	674,100	332,372	NA	NA	731,431
1917	287,000	720,603	320,528	201,888	118,640	827,187
1920	312,500	749,419	367,117	246,484	120,633	827,797
1930	449,500	812,116	396,670	292,120	104,550	976,396
1940	545,000	860,439	529,610	324,203	205,407	1,117,371
1942	545,092	854,462	524,533	317,117	207,416	909,148

Sources: Column (2) is cited from Y.M. Ho, Agricultural Development of Taiwan, 1903-1960. Vanderbilt University Press, Nashville, 1966, p. 93; and T.H. Lee, Capital Flows between the Agriculture and Non-agriculture in Taiwan. Bank of Taiwan, Taipei, 1972, p. 20 & 36.

Columns (3) to (6) are cited from Taiwan Agricultural Statistics, 1901-1965. JCRR, Taipei, 1966, p. 11 & 13.

Column (7) is cited from Ho, 1966, p. 50.

Water conservation includes irrigation and flood control. Although the subtropical climate makes farming possible for most seasons, the special pattern of rainfall distribution calls for improvements in both irrigation and flood control for an adequate water supply for cultivation.

Before WWII, improvements in irrigation received more attention than that of flood control. The total value of investment on irrigation in 1911-1920 was one and a half times that of 1901-1910. A greater expansion of irrigation followed in 1921-1930 because the horizontal expansion of land became less possible. The total irrigation investment during this period rose to 9 times that of 1911-1920 and 13.5 times that of 1901-1910. The government's share in irrigation investment decreased from nine tenths in 1901-1920 to one third in 1921-1930 and the civilian share of investment increased from one tenth in 1901-1920 to two thirds in 1921-1930 (Rada and Lee, 1963:37). Gradual withdrawal of the government support was resulted from the healthy agricultural development which made certainty in future harvests predictable. During the late 1930's, a rapid expansion of paddyfields, due to the expansion of irrigation, continued until the Chia-nan Irrigation System was completed in the west-central part of the island. The expansion of irrigation was interrupted by WWII.

The prewar expansion of irrigation made possible for the tremendous expansion of arable lands. Without the expansion of irrigation systems and cultivated lands, the postwar agricultural development would have been much less remarkable.

Road construction was started before the implementation of the land reform. Modernized roads and harbors provide a convenient transportation system to the postwar agricultural development. Three Japanese accomplishments on the system are summarized as follows.

First, in 1908, a main railroad system, links the north seaport--Keelung to the south seaport--Kaohsiung, was completed along the western part of the island. A large number of road branches were constantly added until 1939. The railroad formed a major portion of the postwar transportation network.

Second, from 1889 to 1910, there was a rapid growth in the number of island-wide public roads. The construction of the road system was originally designed for the Japanese military control of the island. Later, it benefited the civil transportation, distribution, and marketing of agricultural products. In 1945, the density of public roads in Taiwan ranked as the highest among all the 35 provinces of China.

Third, from 1899 to 1912, the first major harbor was constructed at Keelung. The construction of the second major harbor at Kaohsiung was initiated in 1906, but was not completed until 1950s. Keelung harbor provides services for a large volume of international exports and imports.

Both irrigation and road systems were seriously damaged by the war. Heavy expenditures were spent on the reconstruction of these systems. However, the total amount of social overhead costs saved, due to the pre-existence of these systems, was far greater than the costs of recovery and repair. The pre-existence of the systems set cornerstones for the later success of the land reform.

An equivalently important contribution was also made by the Japanese in the formation of farmers' association and agricultural experiment research institutions.

Farmers' association was initially formed in 1900. It was extended to most of the rural areas of Taiwan in later years. Farmers who associated with each other in an association are those planted the same crops or lived in the same neighborhood. It was used as media to disseminate newly acquired farming skills, to explore trade opportunities, and to promote cooperation in the distribution, marketing, storage, and financing of agricultural production. After WWII, it still functioned as usual. Moreover, its role in disseminating new technologies became more significant because of the improvements in farming technologies.

Agricultural research experiments were introduced to Taiwan long before the land reform was implemented. To make the island a major supplier to Japan's needs for rice and sugar, numerous agricultural research/experiment institutions were established. The more productive Ponlai rice was introduced to replace the less productive Chailai rice. Improvements were also made in sugarcane plantings. Fertilizer applications to sugarcane were encouraged, subsidized, disseminated, and enforced.

Research activities made great contributions to the post-reform agriculture. These activities include the improvements of seeds and cropping techniques, the experimentation of fertilizations, and blight control. High productive seed varieties were introduced for rice, sweet potatoes, peanuts, soy beans, manure greens, jute, tea, vegetables, fruits, and medical herbs. Intensive cultivation proved to be efficient for paddy rice and pineapples. Fertilizers were introduced after successful experiments in various localities. Blight control was remarkably promoted after new pesticides was introduced.

In addition, the Chinese civil household organization, known as the Bao-Chia system, was first introduced to Taiwan by the Japanese as a form of police control over the native Taiwanese. Under this system, people lived in the same neighborhood must gather frequently for social/political meetings. Although the political concern has been much less stressed under the current government's rule, the system effectively reinforced farmer association's function in the dissemination of new farming technologies.

2.4.2 Small Farm System

Before the reform, Taiwan had a high population density, scarce natural resources, and backward technologies in both agriculture and non-agriculture. To tackle these problems, the adoption of the small farm system was desirable for three reasons.

First, the system was able to absorb more labor than the consolidated land system or mechanized agriculture. During 1950-1960, the annual population growth rate of Taiwan was about 3 percent, which was one of the highest in the world. The high growth rate and high density of population created serious problems in employment and food sufficiency. Fortunately, the small farm system absorbed one third to one half of the total employment during 1950-1966. Although the proportion of agricultural employment constantly declined after 1953, actual employment kept growing until 1972.[7]

Second, the system provided more equitable opportunities in income earnings which, in turn, created a greater consumption of farm products and light industrial products. The healthy market demands for consumers' goods stimulated the growth in both agriculture and industries.

Third, compared to the consolidated land system or mechanized agriculture, the small farm system lessens the degree of the competition for the already scarce capital resources. Because the scale of the cost incurred is much larger without the use of the small farm system.

The problem of the limited area of cultivated lands and the high growth rate in agricultural population made average farm size constantly declining. Table 2.5 presents information on the decline of the average farm size for the years 1938-1979. Apparently, the land reform enhanced the trend of decline, because cultivated land became less concentrated. Table 2.6 provides detailed statistics of the average cultivated land area by farm of different size.

Although the average farm size declined after the land reform was implemented, an impressive agricultural growth continued. From 1953 to 1966, the agricultural production grew by 61.38 percent. From 1953 to 1981, it grew by 88 percent.[8] The growth occurred because small farms in Taiwan typically used a land-saving and labor-intensive mode of production.

2.4.3 Supplementary Policies

When the land reform was instituted, the government also implemented several other projects to promote the materialization of the reform. They are: the recovery and rehabilitation of the agricultural infrastructure (irrigation and drainage systems, roads, bridges, warehouses, dams, research institutions, and farmers associations); the formation of the Sino-American Joint Commission on Rural Reconstruction; the diffusion of agricultural extension services; and the demarcation of land into efficient units.

Because of the WWII's devastation and the political upheaval on the Chinese mainland, severe economic disorders were prevalent in Taiwan in the late 1940s and the early 1950s. High inflation rate, food shortages, and market-price instability made life very miserable. Food prices were 40 percent higher than the general price index during 1945-1950 (Lee, 1972:23). Under these circumstances, policies related to rural resconstruction, agricultural development, and socio-political stabilization were the top priorities in the

Table 2.5
Number of Farm Families and Area
of Cultivated Land for Selected Years

Unit: Hectare

Year	Number of Farm Families	Area of Cultivated Land	Cultivated Land Area Per Family
1938	424,525	857,806	2.021
1939	440,105	859,463	1.953
1945	500,533	816,017	1.630
1946	527,016	831,951	1.578
1950	638,062	870,633	1.364
1952	679,750	876,100	1.289
1955	732,555	873,002	1.192
1956	746,318	875,791	1.173
1957	759,234	873,263	1.150
1958	769,925	883,466	1.147
1959	780,402	877,740	1.125
1960	785,592	869,223	1.106
1961	800,835	871,759	1.089
1962	809,917	871,858	1.076
1963	824,560	872,208	1.058
1964	834,827	882,239	1.057
1965	847,242	889,563	1.050
1966	854,203	896,347	1.049
1967	868,731	902,406	1.039
1968	877,114	899,926	1.026
1969	887,112	914,863	1.031
1970	880,274	905,263	1.028
1971	879,005	902,617	1.027
1972	879,526	898,603	1.022
1973	876,565	895,621	1.022
1974	877,829	917,484	1.045
1975	867,549	917,111	1.057
1976	870,787	919,680	1.056
1977	872,509	922,778	1.057
1978	884,592	918,143	1.038
1979	898,341	915,393	1.019

Source: Taiwan Agricultural Yearbook (various years). PDAF, Taiwan.

Table 2.6
Area of Average Cultivated Land by Farm Size, 1955-1975

Size of Farm (Hectare)	Average Cultivated Land Area				
	1955	1960	1965	1970	1975
Less than 0.5	0.291 (34.4%)	0.277 (37.9%)	0.276 (37.9%)	0.272 (43.9%)	0.284 (41.7%)
0.5 - 1.0	0.804 (28.4%)	0.735 (29.1%)	0.734 (28.8%)	0.717 (27.6%)	0.730 (2.96%)
1.0 - 1.5	1.361 (16.4%)	1.230 (15.4%)	1.236 (15.0%)	1.213 (13.1%)	1.223 (14.3%)
1.5 - 2.0	1.537 (09.1%)	1.730 (08.3%)	1.732 (08.1%)	1.718 (06.9%)	1.734 (06.7%)
2.0 - 3.0	5.203 (07.8%)	2.405 (06.5%)	2.409 (06.6%)	2.404 (05.3%)	2.405 (05.1%)
3.0 - 5.0	NA NA	3.681 (02.7%)	3.669 (03.0%)	3.700 (02.5%)	3.636 (02.2%)
5.0 and More	NA NA	7.115 (00.6%)	7.310 (00.6%)	7.192 (00.7%)	6.961 (00.4%)
All Farms	1.132	0.951	0.958	0.861	0.858

Source: Table 2.6 is compiled by the author based on the data from Agricultural Census (various years). PDAF, Taiwan.

Note: The percentage of farms in each scale category is parenthesized.

government operations.

By 1952, the recovery and rehabilitation of the agricultural infrastructure were almost completed (Lee, 1972:23), which, together with the high food prices, enabled farmers to promote productivity. Around 1951-52, the agricultural production returned to its prewar peak (Ho, 1966: 17-18). The rapid agricultural growth during 1946-52 lessened the burden of food shortage.

In 1949, the Sino-American Joint Commission on Rural Reconstruction (JCRR) was formed to allocate U.S. aids appropriated to the agricultural sector. The JCRR promoted agricultural extension services, provided technical assistances in seed/fertilizer improvements, and effectively utilized financial capital for various agricultural activities.

The diffusion of agricultural extension services effectively spread new farming information. Through the services, farmers quickly acquired skills in the application of fertilizers, pesticides/insectcides, new seeds, and efficient ways of cultivation.

The demarcation of land was another project that benefited the agricultural development. The project was originally designed to mark the limits of devastated farm lands in the central part of Taiwan, which were devastated by the serious flood on August 7, 1959. It involved a total of 871 hectares of flooded farm lands. It made possible for the reclamation of the farm lands. The utilization of road, irrigation, and drainage systems became more efficient afterwards. It also greatly improved the productiveness of both land and labor.[9] A ten-year demarcation project followed in 1961 based on the early successful experiences in the demarcation. The project was well accepted by more than 98 percent of the landowners involved. It covered a total of 300,000 hectares of farm lots which were in irregular shapes.

2.5 Post-reform Progress and Development

Taiwan's economic growth/developmet during the past three decades was frequently summarized by economists into three stages: the agricultural development (1953-1965); prosperity in the import-substitutive industries (1965-1980); and development in the advanced technological industries (1980-present). This section elaborates only the growth of the first stage because of its close relations with the land reform.

During 1953-1965, the emphases of the economic plannings were: steady growth in agricultural production; food sufficiency; agricultural development; exploration of opportunities for agricultural exportation; and industrialization.

The agricultural growth/development was remarkable during 1953-1965. The production index for agriculture, fisheries, and livestock was 100 in 1952, 109.4 in 1953, and 190.3 in 1965. From 1952 to 1965, the index increased from 100 to 158.8 for agriculture, 100 to 270.6 for fisheries, and 100 to

182.3 for livestock. The statistics indicate that the agricultural production not only increased but also diversified.[10]

Food sufficiency has been continued since 1953. During 1953-1965, population growth rate was much smaller than that of the agricultural production. On an average, more people have been well fed and income distribution has been more equitable since the implementation of the land reform.

The growth of the cultivated land area and of the cropping index explains the rapid agricultural development during 1952-1965. Total cultivated land area increased from 876,100 hectares in 1952 to 889,563 hectares in 1965, while the cropping index increased from 100 in 1952 to 108.8 in 1965. The increase in the cultivated land area was a result of demarcation. The rapid growth of the cropping index shows that land expansion was more intensive than extensive.

In contrast to the rapid agricultural development, the growth of agricultural employment was slow, however. Agricultural employment was 1,792 thousand persons in 1952 and 2,017 thousand persons in 1965. The rate of agricultural employment, out of total employment, declined from 61.0 percent in 1952 to 53.7 percent in 1965.[11] The decline was resulted from the migration (from rural to urban area) due to the mushrooming of labor-intensive light industries.

The statistics on the fertilizer utilization show that improvements were made in both quantity and quality during 1952-1965.[12] The agricultural production increased through the use of existing resources and more productive farming skills.

Although the ratio of the agricultural exportation declined from 90 percent to 55 percent from 1952-55 to 1965, agricultural exports remain as a major source of income for the people of Taiwan.

In sum, the rapid agricultural development during the 1950s and 1960s was made possible by the implementation of the land reform, by the financial/economic aids from the United States and the international organizations, and by the adequate promotion of farming technologies. As a result, a wealthy and equitable economy emerges.

2.6 Summary

Before the rent reduction was implemented in 1949, due to the war's devastation, agricultural production in Taiwan reached its lowest level, which was 41.5 percent of the prewar peak in 1914. Landownership was heavily concentrated, some landlords exploited their tenants with a rental rate as high as 70 percent of the annual crop yield. The cultivated land area was insufficient to meet tenant farmers' needs. Unfair tenancy contracts, severe rural unemployment, high inflation rate, and food shortages were prevalent. Such economic disorders were further reinforced by the political upheaval in the Chinese mainland during the years 1945-49. These conditions made living extremely difficult.

After the implementation of the rent reduction, land market distortions were corrected by the strict regulations and the land redistribution programs which provided tillers and new owner-tillers with strong incentives to improve productivity. In addition, the recovery of the preexistent infrastructure, the adoption of the small farm system, and the diffusion of new farming technologies, altogether, restored and increased the agricultural productivity. As a result, agricultural production reached the prewar peak in 1951-1952. It continued to grow far beyond that level and successfully nurtured the industrial development later.

Taiwan has been frequently cited as a model of economic development. Despite its limited natural resources, high population density, and backwardness in technology in the late 1940s and 1950s, the well-designed land reform programs, the preexistent infrastructure, and the supplementary policies made Taiwan a successful case of economic development.

CHAPTER III

REVIEW OF THE LITERATURE

Chapter three presents a brief historical review of some of the important economic theories on the subjects of land, land tenure and land reform. The writings for review are highly selective regarding both authors and topics. The theories reviewed here are the thoughts of the Physiocrats, the Classical economists, and the Neoclassical or contemporary economists.

3.1 The Physiocrats

The Physiocrats were a group of mid-eighteenth century French economists who favored policies guaranteeing property-owners' rights and motivating amalgamation of small farms. They suggested these policies would be effective in spreading capitalist farming techniques to France and promoting French agricultural production.

The Physiocratic thoughts[1] were presented in "the first explicit model of an economic system" (Currie, 1981:5). This system consists of two economic sectors (agricultural and industry) and three socio-economic classes (a proprietary class, a productive class and a sterile class). The system demonstrates how money and produce circulate between the three classes. The Physiocratic model is an idealization or a model of the natural orders. Once the natural orders were adopted by a nation, the Physiocrats regarded that human behavior would be harmonized with the laws of nature.

In the Physiocratic system, the proprietary class earns rental income through leasing land to the productive class and purchases food and manufactured goods respectively from the productive class and the sterile class.

The sterile class sells manufactured goods to the other two classes and purchases food and raw materials from the productive class.

The productive class, consisting solely of cultivators, combines the use of the leased land, seeds, raw materials and manufactured goods to produce more food and raw materials. This class retains a portion of its production for self consumption and sells another portion to the sterile and the proprietary classes. The productive class pays money rents to the proprietary class and purchases manufactured goods from the sterile class.

The Physiocrats emphasized the importance of agriculture. They believed that only agricultural pursuits are productive, because agricultural production not only pays for food, raw materials, and manufactured goods necessary for production, but also generates excess wealth. Industrial pursuits, on the other hand, were thought to be non-productive because they were allegedly incapable of generating such a surplus.

The Physiocrats attributed the ability of agriculture to generate a net surplus to the contribution of permanent land investment and the abundance of nature. Permanent land investment was allegedly "incumbent on proprietors and the true basis of the claim to the privileges of proprietorship"[2] on land. In order to stimulate the proprietary class to make expenditures necessary to improve and cultivate land, the Physiocrats argued that the security of ownership of landed property and movable wealth is the essential foundation of the economic order of society.[3] To the Physiocrats, "the proprietary class was also part of the natural order of society: it was entrusted with the sacred task of providing the land which generated the net product." (Currie, 1981:7) Thus, there was no doubt that the proprietary class was entitled to the net product of agriculture in the forms of rents paid by the cultivators. Tenant farmers do not share in the net product of agriculture in the Physiocratic system, because the land would remain uncultivated, if protection of funds and products were not guarateed to those who made the advances of expenditures to improve land.

Another important Physiocratic vision is to promote the amalgamation of farms and the cost-saving capitalist farming system. The Physiocrats argued that, in the large farms worked by rich tenant farmers, "less expenditure would be required for the upkeep and repair of buildings, thus, proportionately much less cost and much more net product, [than in small ones]"[4] could be anticipated. However, the proposition of this natural order reveals an internal contradiction in the Physiocratic writings. They recognize tenant farmers' central role in the process of capital accumulation in large farms, whereas they overlook tenant farmers' entitlement to a share in the net product of agriculture. Without a share in the net product of agriculture, the income of a tenant farmer would be merely sufficient for recompensing the food and raw materials that were employed in agricultural production. Tenant farmers would be unable to save and accumulate capital.

The presence of the contradictory natural orders in the Physiocrats' writings was caused by their failure to "identify profit as a specific distributional category and as a component of the net product in the natural order."[5] The failure may have resulted from the lack of explicit differentiation between tenant farmers and hired workers within agriculture.

Due to the neglect of the existence of profit, the Physiocratic discussions were ambiguous on the possibilities of income differentials for tenant farmers and hired workers within agriculture, and of tenant farmers' receiving differential incomes based on their investment ability. Taking into account the fact that tenant farmers can also make expenditures to improve land, the Physiocratic proposition of distributing the entire net agricultural product to merely the proprietary class lacks satisfactory justification. Even worse, the Physiocratic analysis drew economists' attention to the possibility of landlords' receiving a rental income over and above the amount which is needed to recompense for their past investments to land.

The impact of the Physiocratic thoughts on the French economy was considerably insignificant.[6] However, the Physiocratic system had a profound impact on the development of Classical economic thoughts, especially on the ideas of Smith, Ricardo, and Marx. Contrary to the Physiocrats' objective, their thoughts provoked attacks on private property rights in land.

The Physiocratic view on the amalgamation of farms still received favorable attention in the recent literature of economic development (Ho, 1966:1-14), although the emphasis is shifted from its cost-saving nature to the importance of indivisibility of land investment. On the other hand, suspicions were constantly raised on the effectiveness of consolidating land-holding for large-scale agricultural development. Many studies indicated that, mechanized commercial agriculture in an under-developed economy might possibly impose competitive demand for the scarce capital, and induce serious unemploy- ment problems due to its lack of ability to absorb the abundant rural labor (Ho, 1966; Dorner, 1972).

3.2 The Classical Economists

The well-known Classical economists, Adam Smith (1723-1790), Thomas R. Malthus (1766-1834), David Ricardo (1772-1823), John S. Mill (1806-1873), and Alfred Marshall (1842-1924) and others, made great contributions to the better understandings on the structure of the agrarian economic system, the nature of rent, and land tenure system.

3.2.1 The Classical Agrarian Economic System

Adam Smith (1776) believed an agrarian economic system should be composed of three major socio-economic classes: landlords, capitalist tenant farmers, and laborers without land. In his Principles of Political Economy and Taxation, Ricardo (1821:5) laid this tripartite system as the foundation of Classical economics. In Classical economics, a sharp distinction was made between the two factors of production, labor and capital. Income payments are divided into three categories: rents to the landlords; wages to farm workers; and profits to the landlords or tenant farmers who made investments in permanent land improvements. Contrary to the Physiocrats, the Classical economists do not think the entire agricultural surplus should be distributed to the propertied class, but, instead, suggest it should be shared by both landowners and tenant farmers in the forms of rent and profit. People in each of the three classes could earn more than one type of income if they provide more than one type of service to production. Agriculture is still important for its productive ability, but, it is not the only productive sector in the economy.

On price determination, the Classical economists agreed that wages should be determined by the forces of supply and demand. However, the determination of profit and rent was not clear until Ricardo and Malthus developed the famous "theory of rent" or "Ricardian theory of rent".

3.2.2 <u>The Classical Theory of Rent</u>

Smith (1776:152) acknowledged that a higher rent might be due to a landlord because of his past efforts to improve the quality of his land. Smith (1776:247) pointed out that the existence of permanent improvements could not totally explain the existence of rent because rents were also imposed on unimproved land. He attributed the existence of rent for unimproved land to bountiful nature that, under any situation, makes the cultivation of the land possible. He also indicated that landlords could appropriate the highest proportion of the agricultural surplus if they had the power. His view on the determination of rent provided basic building blocks for the Classical theory of rent.

The definitions of "rent" and "interest and profit" have become more delineated since Malthus and Ricardo cautioned against the confused use of these terms. They defined rent as "that portion of the produce of the earth which is paid to the landlord for the use of the original and destructible power of the soil."[7] They regarded interest and profit as "a return on capital" (Currie, 1981:10). The determination of both rent and the rate of profit were considered to be made within agriculture; the rate of profit for other employment (e.g., manufacturing or commerce) was believed to follow the rate of profit in agriculture, with appropriate adjustments for risk (Ricardo, 1821).[8]

The Classical theory of rent relies on the concept of shifting the margin of cultivation and the law of diminishing marginal returns. In brief, the theory of profit and differential rents is often summarized as follows. Rent does not exist in a setting where fertile land is abundant to subsist the population. A surplus production from the land should be distributed entirely to the person who invests in permanent land improvements. Rent may be collected from fertile land when cultivation is extended to less productive land. No rent shall be generated from marginal land. The rate of profit earned from marginal land is the normal rate of profit in the agriculture. The normal rate of profit falls when cultivation is extended to land of lesser quality. Rent is the remaining residual of surplus production from land not distributed for profit. Rent increases when the normal rate of profit decreases. In the Classical theory of rent, the expansion of cultivation due to population pressure could be applied to the less fertile land or to the cultivated land. In either case, law of diminishing returns has to prevail to guarantee the origination and increase of rent (Anderson, 1968; Ricardo, 1966; Currie, 1981:11-16).

Unlike Smith (1776:247), Ricardo (1821) did not attribute the existence of rent to bountiful nature. According to Ricardo (1821:76), the true explanation for rent lay in the niggardliness of nature. Combining the highlights of the Smith and Ricardian theories of rent, Malthus suggested that both bountifulness and niggardliness of nature are necessary for explaining the existence of rent. To Malthus, rent could not have originated if land could not produce over and above the costs needed for cultivation. On the other hand, rent would never have appeared if there were plenty fertile land (Currie, 1981:13).

The classical theory of rent was commonly criticized. Richard Jones (1831:11) explains that:

> rent has usually originated in the appropriation of the soil, at a time when the bulk of people must cultivate it on such terms as they can obtain, or starve; and when their scanty capital of implements, seeds, etc., being utterly insufficient to secure their maintenance in any other occupation than that of agriculture, is chained with themselves to the land by an overpowering necessity ... the necessity is ... wholly independent of any quality of the ground they occupy, and would not be removed were the soil all equalized.

Jones' argument on the origin of rent is persuasive when it is associated with the fact that most people who were tied to the agriculture in an agrarian society possessed little or no lands, skills, and capital endowments (Dorner, 1972; Currie, 1981; Koo, 1982).

According to the theory of rent, either the origin or increase of rent would cause decreases in the normal rate of profit. If we took Jones' suggestions and considered that rent always occurs when land is scarce and when a large number of people compete for renting, the origin or increase of rent would more likely be taken from wages rather than profits. This is especially true if we recognize the problem of the scarcity of capital in agrarian economy.

3.2.3 <u>Land Tenure System and Productive Efficiency</u>

Most of the Classical economists[9] agreed to the ranking of the productive efficiency among the four land tenure systems. The owner-operator system was ranked as the most efficient, fixed rent arrangement as the second, metayage as the third, and slavery the least efficient system.

Each tenure system possesses its own unique features. Slavery was the oldest tenure system in European large estates. Under this system, slaves were employed to cultivate lands for landlords. This system was mostly criticized because landlords were generally viewed as lacking time, inclination, and ability to attend the cultivation and improvement of their lands. Slaves usually had little or no incentives to work hard because they gained little or nothing through extra effort.

The metayage system appeared later than the slave system. Under this system, landowners provided necessary land (sometimes also with capital stocks, tools, seeds, etc.) and the metayers paid a sharecropping rent to use the land for cultivation. This system was regarded as more efficient than the slave system because tenants have incentives to work harder for earning higher incomes.

The fixed rent arrangement appeared later than the metayage system. Under this system, tenants cultivated land with their own capital stocks and paid a fixed amount of rent to landlords for using land within a contracted time period. After the fixed rent is paid, tenants could keep the rest of the yields from the land. Most Classical economists agreed that the productive efficiency of the fixed rent is superior to the sharecropping arrangement.[10]

The fixed rent and the owner-operater systems were considered as equivalent in the short term. In either arrangement, the use of resources would be efficient, and the value of the marginal product of each factor would be equated to its price. On the other hand, sharecropping tenancy was regarded as inefficient. The belief was based on the argument, formalized by Marshall (1969), that an arrangement whereby the tenants pay the landowners a share of the output would act as a work determent, and the tenants would only work up to the point where the value of their share of the marginal product from each input was equated to the input price.

Fixed-rent tenancy, however, was not considered as efficient as owner-occupancy, because landlords, in the long run, tend to shift the burden of improving land to renters through raising the fixed rental payment. Renters then have little or no incentive to invest in the permanent land improvements unless they could enjoy the payoffs of the investments for a sufficiently long contractual duration.

3.2.4 Summary

The Classical economists applied the concept of shifting the margin of cultivation and the law of diminishing returns to explain the origin of rent. A priori logic reasonings made the Classical theory of rent vigorous. Increasing population and niggardliness of land were identified as the two major factors for the origin of rent. Rules are provided by the theory of rent to determine the normal rate of profit and differentiated rent on land of varying qualities. However, it does not explain why rent should be collected merely by landlords.[11] Nor does it explain why the origin of rent would be taken from profits, not from wages. The rule is not viable in the case when landlord has control over socio-economic and political levers of power due to his land ownership. Although the monopoly power of the landlord was vividly delineated by Smith as an important factor leading to the existence of obnoxiously high land rent, the market supply forces were neglected by Ricardo when he formed the Classical theory of rent.

Based on the Classical economists' viewpoints about the ranking of the productive superiority between the four tenure systems, a land market reform which aims at promoting agricultural production should give priority to setting up the owner-operators in an agrarian sector. However, the Classical economists' arguments provide no rules on how to set up more owner-operators. Whether this goal could be accomplished through redistribution of land ownership was unclear.

To support the Classical viewpoints about the ranking of the productive efficiency among the tenure systems, Spillman's findings were often cited (Koo: 1982:16). According to Spillman's study, worker's income was highest on land leased at a fixed rent arrangement, next highest on land cultivated by sharecropping tenants, and lowest under wage cultivation. But other empirical studies, Heady (1947), Cheung (1969:172), Fogel and Engerman (1977 and 1980) and others, have different findings. Heady and Cheung found that landowner's income per unit of farm land was highest on land cultivated by wage workers, next highest on land cultivated by sharecropping tenancy, and lowest on land leased at a fixed rent arrangement. Fogel and Engerman found that value of the total products was higher on the farms that employed slaves than on the self-cultivated farms in the ante-bellum South. It seems that mixed empirical findings do not always agree with the Classical viewpoint about the ranking of the efficiencies among tenure systems.

3.3 The Neoclassical Economists

In contrast to the Classical economics, Neoclassical economists, in the past, paid little attention to land and its tenure. To most of the Neoclassical economists, the determination of land rent follows the marginal productivity theory.

Nevertheless, some Neoclassical economists, such as Cheung (1969), Bardhan and Srinivasan (1971), Stiglitz (1974), Hsiao (1975), Bell and Zusman (1976 and 1980), Reid (1973 & 1977), Hallagan (1978), Bardhan (1974 & 1979), Braverman and Stiglitz (1982), have shifted their focuses on the efficiency of share tenancy. Due to the improvement of analytical methods, some literature applied the general equilibrium approach in the determination of the land reform effects.

Section 3.3.1 discusses the application of marginal productivity theory in the determination of land rent. Section 3.3.2 discusses recent thoughts of share tenancy. And section 3.3.3 reviews studies related to the impact of land reform applying the general equilibrium approach.

3.3.1 The Marginal Productivity Theory

The Neoclassical economists in the past adopted the Classical theory of rent as one of the fundamental principles for rent determination. The theory, however, was gradually replaced by the marginal productivity theory. The Neo-classical economists disputed about the necessity for making a distinction between capital embodied in land and land as an original and indestructible power of the soil.

For those Neoclassical economists who disapproved the distinction, two reasons were commonly cited. First, land, as capital, has the same nature of productive stocks. Secondly, the determination of either the profit rate or the land rent must follow the principle of the marginal productivity theory. Treating rent as a residual but not profit is inappropriate. A reward to land, as well as a reward to labor or capital, must be determined by the value of the marginal productivity. When a farmland is operated at a long-run optimal scale and the product from land is sold at a perfectly competitive market, constant returns to scale would prevail locally. Whether a rent is treated as a residual or is determined by the principle of the marginal productivity theory would refer to the same value of rent, because remunerating factor rewards, based on the marginal productivity theory, will exhaust the total production from land in the long-run optimal scale of operation.[12]

For those Neoclassical economists who were in favor of making a distinction between land and capital, a significant difference between land and capital lies in the context of tax. Without the distinction, taxation collected from land rent would discourage land improvements. With the distinction, taxation on the rent would not cause such a negative effect.

The Neoclassical economists agreed with the Classical economists on the equivalent efficiency between owner-operator and fixed rental arrangement in the short term (e.g., Schickele, 1941; Johnson, 1950; and Heady, 1947). In fact, the Neoclassical economists regarded the land tenure systems to be unrelated to the productive efficiency. A landowner may hire laborer to work on his farm. A tenant farmer may rent land for cultivation. A person may employ both laborer and land to work for him. All these options would not affect the pricing of factors and resource allocation as long as each factor is remunerated in accordance with its marginal productivity in a competitive market. Productive inefficiency was commonly regarded by the neoclassical economists as the results of imperfect competition in factor (or output) markets (Koo, 1982:32-52).

To correct productive inefficiency caused by landlord's monopoly power or land market distortions, Koo (1982:5) suggested methods for land market reform as follows:

... the necessary conditions for a land market free of monopoly or distortion are that each buyer (lessee) and seller (lesser) should be small enough to prevent any one from dictating or influencing the price (contract rent). Information about the market should be reasonably well disseminated; information should be available on possible alternative sources of supply of land as well as its current and potential uses, that is, new varieties of seeds available, farming practices, marketing channels, and sources of supply of inputs that are open to would-be buyers (lessee). The establishing of extension agents and educational programs designed to expedite dissemination of information should be included as a part of land market reform. Since land transactions require financing, lack of access to banks and financial institutions for credit to all buyers on an equal basis would contribute to market distortions. Any measures that promote and facilitate land transactions, such as written rules and regulations governing terms and duration of leases, are part of land market reform.

3.3.2 Puzzle of the Sharecropping

The neoclassical economists criticized the inadequacy of the inefficiency doctrine of sharecropping. The criticisms indicated that the doctrine was derived from the hypothesis that sharecropping tenants have alternative agricultural employment opportunities. In a society where both land and alternative agricultural employment opportunities are rare, the doctrine loses its applicability.

Based on the fact that share rents were usually higher than fixed rents, Gale Johnson (1950) questioned the adequacy of the inefficiency doctrine. Johnson suggested that three possibilities exist to induce productive efficiency in the share tenancy: a sharecropping system accompanied with the enforcement of stipulated labor inputs from tenant; a flexible lease contract which periodically reviews the performance of the tenant; and the internalization of the inputs' external opportunity costs.

Johnson's suggestion on the first possibility of productive efficiency in the share tenancy was verified by Cheung (1969). In Cheung's study, a landlord maximizes his total rental income through the control over the following three variables, number of land parcels leased out of his landholdings, share rental ratio and labor intensity on land used for sharecropping. Assume that a tenant's share has to be maintained at a level no less than his alternative earnings as a wage worker. Assume that production of sharecropping is represented by a linear homogeneous function in two variables, land area used for cultivation and stipulated labor intensity in the share tenancy. A landlord's optimal decisions are: to stipulate labor intensity from share tenancy to a level so that the value of the marginal product of the labor from sharecropping cultivation would be equal to the wage rate that a tenant can obtain at an alternative employment opportunity; and to divide landholdings into a number of parcels so that would rental earnings generated from sharecropping would equal the level of income that the landowner could receive from using the same piece of land in wage cultivation.

Cheung noted the equilibrium condition of his model is stable in the long run. When labor intensity is less in the sharecropped land, compared to that of land used for wage cultivation, landlords can maximize total rental earnings by shifting the land from sharecropping to wage cultivation. In the case when a landlord insists on a higher labor intensity on the sharecropping land, no tenants would stay as sharecroppers.

If Cheung's conclusion on the sharecropping efficiency is valid, land tenure reform aiming at eliminating sharecropping tenancy would not be needed. However, Cheung's efficiency of the share tenancy does not necessarily represent the efficient resource allocation under the Pareto conditions. Most Neoclassical economists consider that landlords with monopolistic power have control over either the share rental price or the quantity of land parcels to be leased, but they could not control both. If a landlord in Cheung's model had only control over share rental ratio but not the number of land parcels for lease, Cheung's claim on the sharecropping efficiency would be adequate only when the share rental ratio is equal to zero (Newbery, 1974:1061; Koo, 1982:21).

Newbery (1975) proved Johnson was correct in his second proposition about the possibility of sharecropping efficiency. Newbery introduced a periodical review and short-term lease into the theoretical model constructed by Bardhan and Srinivasan (1971). In this model, a landlord is assumed to use land for either wage or sharecropping cultivation. Laborer without land can use time to earn income through either sharecropping cultivation or working as a wage laborer. Assuming both landlord and laborer are maximizing utilities derived from the money income and leisure time, Bardhan and Srinivasan verified that tenant's optimal labor input level to the sharecropping cultivation would be smaller than that of the Marshallian efficient level. When periodical review and short-term lease are introduced to the Bardhan and Srinivasan′ model, tenant optimal labor input to the sharecropping cultivation should be the same as that of the Marshallian efficient level.

Hsiao (1975) suggested that the Marshallian share-cropping inefficiency is not stable when the land lease is set for a long term. Hsiao argued, when neither landlord nor tenant had a monopolistic power, the long-term contracted sharecropping landlord would be benefited from bribing tenants to exert more time and effort in cultivation. The landlord has this bribing ability, because, for the Marshallian inefficiency equilibrium, marginal product of labor would always be higher than the tenant′s alternative wage rate at the tenant′s determined labor input level. For obtaining higher rental earnings, landlord could always bribe tenant to devote more time in cultivation as long as a tenant′s time devoted to the cultivation is less than the Marshallian efficient level. After the tenant′s time devoted to the cultivation arrives at the Marshallian efficient level, landlords would not benefit from continued bribery for more tenant′s time and effort, because marginal product of labor from cultivation would be smaller than a tenant′s alternative wage earnings. When land lease is set for a long-term, landlord would eventually know the most efficient level of labor time for bribing. Thus, tenant time would be raised to an efficient level equal to that under the fixed rent arrangement.

The assumptions made by Newbery and Hsiao on the lease duration are contrary to each other. However, the sharecropping system proves able to arrive efficient resource allocation under both lease devices. This phenomenon indicates that as long as theoretical reasonings take account of landlords' awareness and care about the productive efficiency, it is possible to develop theories lending support to the doctrine of sharecropping efficiency. In sum, in cases where landlords really care about reaching productive efficiency from cultivation,[13] land tenure choices between sharecropping and fixed rent arrangements should not be crucial ingredients of land tenure reform, when the goal of the reform is merely promoting agricultural development.

Johnson's third proposition on the possibility of internalizing inputs' external opportunity costs, for sharecropping to achieve efficiency, was well elaborated by Cheung (1969); Rao (1971); Stiglitz (1974); Reid (1973 & 1977); and Hallagan (1978). Instead of proposing the equivalent efficiency between sharecropping and fixed rental arrangements, these economists built theories to defend, the globally prevalent sharecropping system as a market-determined screening device that landlords might use to differentiate between high and low achievers among potential renters. They treated sharecropping as a risk-sharing device, which is designed to attract low achievers, risk averters, or farmers with merely the endowment of their own labor. To these economists, fixed rent arrangement is restrictive and merely attractive to high achievers, risk lovers, or farmers with endowments other than their own labor. In cases where these arguments are valid, a land tenure reform involving the change of tenure system from sharecropping to fixed rent arrangement may produce new problems in land market distortions.

Most of the foregoing theories, which treat sharecropping as a screening device to differentiate high achievers from low achievers, emphasize tenants' options and their ability to choose preferred contract terms. In an agrarian economy that Jones described,[14] a large number of people search for an opportunity to rent, and, landlords can easily exert monopolistic power on the tenant market. Under this situation, it is difficult to justify why landlords would be willing to take the burden of sharing risk with tenants when most potential cultivators would agree with all the terms (such as a fixed rent requirement) that a landlord included in a contract. The theories, which treat sharecropping as a screening device, seem able to explain landlords' behavior in a tenant market where very able tenant farmers appeared, made themselves known to landlords and became the tenants that landlords desired. However, the theories could not provide explanations for the globally prevalent sharecropping, unless able farmers were in the majority. Even in the latter case, these theories did not provide rules for determining share rental price.

Various emphases of the sharecropping system contribute to better understanding of the sharecreopping's efficiency. They also imply that there is more to learn about the efficiency of other tenure systems and the sharecropping efficiency under other considerations.

In a less-developed agrarian society, rural credit and land were commonly viewed to be held by few big landowners (Lee, 1972:ch.3; Dorner, 1972; Aggarwal 1973:58; Koo, 1982:59). Under this consideration, landlords may have more control over the behavior of tenant farmers when they have power in the interlinked markets. Many studies (Bell and Zusman, 1980; Braverman and Stiglitz, 1982) associated landlord's power in the credit market with the examination of sharecropping efficiency. Braverman and Stiglitz (1982) built the most extensive theories which considered landlord's control over both credit and output markets. Landlord's power in interlinked agrarian markets may extend landlord's power to control the efficiency of resource allocation in the share tenancy. Braverman and Stiglitz (1982:713) noted that,

> ... such linkages have both distributive as well as allocative effects. Attempts to reduce the landlord's power by restricting his marketing or credit activities may ... lower agrarian output and make tenants worse off ... In the case when there is a single landlord, total agrarian output might increase, tenants could be better off, and only the landlord suffers ... simplistic models (whether competitive or non-competitive) which involve anonymous market places, homogeneous goods, and perfect monitoring of inputs are likely to be very misleading.

However, landlord's control over the interlinked markets has not been introduced to the analysis of resource allocation under the other tenure systems. A better understanding may be arrived at the efficiency of other tenure systems if the related factors bringing about the efficiency of share tenancy are also considered under alternative tenure systems.

3.3.3 Impact of Land Reform

Partial equilibrium analysis is commonly used in the existing literature on the impact of land reform.[15] Contrary to that approach, Koo (1977 & 1982) and Rosenzweig (1978) applied a general equilibrium approach to analyze the effects of land reform.

Koo traced the impact of rent reduction, based on a general equilibrium model composed of two industries (rice and potatoes) and three factors of production (labor, tenant land, and self-cultivated land). Koo (1982:86) indicated that,

> the impact of rent reduction goes further than distribution of gains and losses between monopoly landlords and tenants ... When the secondary effects are accounted for, a part of the gains goes to the nonmonopoly landlords.

Koo further assumed that: owners of tenant land receive a higher monopoly rent than owners of self-cultivated land; productive factors are fixed in supply; factor and output markets are perfectly competitive, except tenant land market is monopolistic; factor intensities and the elasticities of substitution between land and labor are the same in both industries; and consumption of goods is independent of the pattern of income distribution.

Koo's research findings lend support to the belief that rent reduction is not enforceable, since the actual changes in real income redistribution (induced by land reform) involve more agents than landlords and tenants.

Rosenzweig (1978) studied the wage effects of a redistribution of landholdings by formulating a competitive general equilibrium model which embodies labor heterogeneity and more realistic labor-supply behavior. In his model, three types of household (landless, small-farm, and large-farm) employ three factors of production (land, male labor, and female labor) to produce a homogeneous agricultural commodity. Rosenzweig assumed that each household is composed of two persons--a male and a female, each of them owns a unit of labor time. Male and female labor are imperfect substitutes in production; while labor of each sex from different households is perfectly substitutable. Besides, he also assumed: that all households are price takers, but wage rates are determined endogenously; that no land or labor is sold outside the agricultural sector; and that there are varied costs borne entirely by workers for contributing labor time on the land of other households.

Rosenzweig's study findings are generally consistent with the competitive market model. He found that "rural wage levels and a measure of landholding inequality are negatively associated, but that an equalizing land redistribution would exacerbate agricultural wage differentials between males and females" (1978:848).

Based on an assumption that the production function is linear-homogeneous, Rosenzweig (1978:854) detailed the wage effects as follows:

> (1) ...the differences between income-leisure effects in small- and large-farm households will uniquely determine the direction of the wage effects... Since the differential may be of opposite sign for males and females, it is possible that land reform could raise wage rates for one group while lowering them for another.
>
> (2) In the special case...large farms are owned by profit-maximizing absentee landlords..., wage rates of men and women will rise unambiguously; the magnitude of the rise...being a negative function of the sensitivity of demand and supply of hired labor to wage rate changes and a positive function of the magnitude of the income-leisure effects on small-farm households. In this case, the wage group benefiting most from the land reform will be that which has the greater income elasticity of leisure and the most inelastic market demand and supply curve.

Rosenzweig's study contributes to a better understanding of the wage effects of a redistribution of landholdings in the context of a heterogeneous labor force. His concluding remarks, however, do not touch on the situations in which economic activities are not limited to agriculture and production requires inputs beyond land and labor.

3.3.4 Summary

Studies by the Neoclassical or contemporary economists on land and tenure systems provide well understanding on possibilities for share tenancy to be as efficient as owner-occupancy. Theories are needed for investigating the possibilities for other tenure systems to be as efficient as owner-occupancy. Assuming equivalent efficiency is possible under all kinds of tenure systems, a land tenure reform involving shifting the tenure systems from one to another will be unnecessary when the goal of the reform is merely the promotion of agricultural development. However, the existence of allocative efficiency may never guarantee the existence of distributive equity. For a less-developed agrarian economy, distributive equality in both income and productive factors has important economic and political implications (Adelman, 1975). Even with the lack of efficient justification, land reform can be well justified based on distributive concerns.

To justify land market or tenure reform with distributive concerns based on partial equilibrium theoretical approach will probably be highly misleading. A general equilibrium approach will be more adequate for evaluating the distributive effects of a land reform. Since most planning economy needs to consider a reform's impact, not only on the agricultural sector but also on the non-agriculture sector, our study applies a general equilibrium approach incorporating a non-agricultural sector into the theoretical models to determine the effects of the rent reduction. We attempt to offer a model to examine the effects of rent reduction on wage rates, real income distribution and gross national product. The rent reduction effects are expected to differ when various possibilities of substitutions are considered among the factors of production.

CHAPTER IV

THE THEORETICAL MODELS

Chapter four presents two theoretical models to determine the economic effects of the rent reduction. Diewert's method (1974b) is followed in the formalization of the general equilibrium conditions for our basic analytical framework. Section 4.1 introduces the model whereby Diewert traces the effects of the union wage distortion. Section 4.2 describes the basic analytical framework of the two theoretical models. Models I and II are respectively presented in sections 4.3 and 4.4. Section 4.5 is a summary.

4.1 The Diewert Model

In his paper, "Unions in a General Equilibrium Model", Diewert (1974b) attempts to determine a union's equilibrium wage-employment trade-off and changes in the real incomes of various consumer groups induced by the union wage distortion. Diewert uses duality theory (between the cost and the production functions and between the utility and the expenditure functions) to derive the union's equilibrium wage-employment trade-off relationship as a function of the various distributive shares and the elasticities of substitution in production and consumption.

In Diewert's model, there are two industries (unionized and non-unionized), four factors of production (capital, white collar labor, union blue collar labor, and non-union blue collar labor), and four classes of consumers (capitalists, white collar workers, union blue collar workers, and non-union blue collar workers).

To derive the general equilibrium conditions for his model, Diewert makes use of the following assumptions: the same factor endowment is held by consumers of the same class; sale and purchase of inputs and outputs are operated in perfectly competitive markets; the total available quantity of each input is fixed and fully employed before and after the union wage promotion; and all consumers exhaust their incomes in consumption. Besides, he also assumes that the technology of each industry is represented by a constant returns to scale, concave, and non-negative production function expressed in input values; and the preferences of consumers of each class is represented by a linear homogeneous, concave, and non-decreasing utility function expressed in output values.[1] According to duality theory, the production function of each industry has a linear homogeneous, concave, non-negative, and non-decreasing unit cost function dual expressed in input prices; and the utility function of consumers of each class has a linear homogeneous, concave, and non-decreasing unit expenditure function dual expressed in output prices.

Based on the above assumptions, Diewert develops twelve equations to represent the general equilibrium of the economy. They are: four demand-equal-to-supply equations on the four input markets; two demand-equal-to-supply equations in the two output markets; two zero-profit relationships for the two industries; and four budget constraints for consumers of the four classes. The twelve equilibrium conditions are expressed in the twelve endogenous variables: four input prices, two output prices, two industry outputs, and four utility (or real income) levels for consumers of the four classes. All but one of the twelve equilibrium conditions are independent.

Diewert applies Shephard's Lemma[2] to derive aggregate demands for inputs and outputs.

Diewert uses three steps to derive the aggregate demand for an input. First, he derives the cost-minimizing input value needed by an industry for producing a unit of output, by taking the partial derivative of a unit cost function dual with respect to an input price. Second, he determines an industry's demand for an input by multiplying the cost-minimizing input value obtained from step one with the output level of an industry. Third, he determines the aggregate demand for an input by adding together the two industry's demands for the input.

Diewert uses another four steps to derive the aggregate demand for an output. First, he derives the expenditure-minimizing output value needed by a consumer for attaining a unit of utility, by taking the partial derivative of a unit expenditure function dual with respect to an output price. Second, he determines a consumer's demand for an output by multiplying the expenditure-minimizing output value obtained from step one with the maximum utility level obtainable by a consumer. Third, he determines the output value needed by a group of consumers, by multiplying a consumer's demand for an output with the total number of consumers in the same class. Fourth, he determines the aggregate demand for an output by adding together the output values needed by consumers of all the four classes.

Setting the derived aggregate demand equal to market supply, Diewert develops the demand-equal-to-supply equilibrium conditions for the input and output markets.

The four zero-profit relationships are developed based on the assumption of the competitive commodity markets. The equations state that selling price equals unit producing cost in each industry.

The four consumer budget constraints are developed based on the assumption that all consumers exhaust their incomes in consumption. The constraints state that the utility level obtainable by a consumer is determined by the input/output prices and a consumer's income and preferences.

To trace a union's equilibrium wage-employment trade- off relationship, Diewert conducts a comparative static analysis to the system of the twelve equilibrium conditions, based on a one percent reduction (from the initial equilibrium level) in the union blue collar employment induced by the union wage promotion. The displaced union workers are assumed to be employed by the non-union industry after wage is promoted for the union blue collar workers. The analysis is conducted through the normalization procedure which sets the price of the capital services equal to unity. It generates an impact vector containing valid information to determine the union's equilibrium wage-employment trade-off relationship and changes in the real incomes of various consumer groups induced by the union wage distortion.

4.2 The Analytical Framework of The Two Models

This section has six portions. Section 4.2.1 presents our assumptions and general equilibrium conditions for the analytical framework. Section 4.2.2 provides interpretations for the notations used in this study. Section 4.2.3 describes the equilibrium conditions for the three commodity markets. Section 4.2.4 describes the zero-profit relationships for the four industries. Section 4.2.5 describes the equilibrium conditions for the five input markets. Section 4.2.6 describes the budget constraints for consumers of the five classes.

4.2.1 The Assumptions and the General Equilibrium Conditions

In our analytical framework, there are two sectors (agricultural and non-agricultural), three commodities (rice, non-rice agricultural goods, and non-agricultural goods), four industries (non-agricultural, non-rice agricultural, rice produced from tenant-cultivated paddyfields, and rice produced from self-cultivated paddyfields), five factors of production (labor, capital, dry land, tenant-cultivated paddyfield, and self-cultivated paddyfield), and five classes of consumers (laborers, capitalists, dry land owner-cultivators, paddyfield landlords, and paddyfield owner-cultivators).

Seventeen equations are developed to represent the general equilibrium of the economy based on the following eleven assumptions:

1. Of the three commodities, rice is produced from tenant- and self-cultivated paddyfields, non-rice agricultural goods are produced from dry lands, no farm lands are used for the production of non-agricultural goods, and labor and capital are needed for all productions.

2. Labor and capital are two homogeneous factors of production mobile between industries.

3. The technology of each industry is characterized by a constant returns to scale, concave, and non-negative production function.

4. The sale and purchase of the inputs and outputs are operated in perfectly competitive markets.

5. The total available quantity of each input is fixed, unaffected by the implementation of the rent reduction, and fully employed before and after the rent is reduced.

6. The two types of paddyfields, tenant- and self-cultivated, initially generate the same amount of land income.

7. All paddyfields withdrawn from tenancy are used for self cultivation after the rent reduction.

8. All paddyfield owners hold the same size of lands.[3] They, however, dispose the land differently: one group uses it for tenancy, while another uses it for self cultivation.

9. Consumers of the same class possess the same factor endowment.

10. The preferences of consumers in the same class are characterized by the same linear homogeneous, concave, non-negative, and non-decreasing utility function.

11. Consumer's income is generated from his/her factor endowment and is exhausted in consumption.

The seventeen equations are: five demand-equal-to-supply equations on the input markets, three demand-equal-to-supply equations in the output markets, four zero-profit relationships for the four industries, and five budget constraints for consumers of the five classes.

4.2.2 Interpretations of the Notations

The notations used in this study are interpreted below.

w_i, where i=1,2,3,4,5, denotes the price of input i. w_1 is the amount of rent received per hectare of tenant-cultivated paddyfield, w_2 is the amount of earnings received per hectare of self-cultivated paddyfield, w_3 is the amount of wage received per standardized unit of labor services, w_4 is the amount of earnings received per standardized unit of capital services, and w_5 is the amount of earnings received per hectare of dry land.

p_N, where N=1,2,3, denotes the price of commodity N. p_1 is the price of rice, p_2 is the price of non-agricultural goods, and p_3 is the price of non-rice agricultural goods.

y_n, where n=1,2,3,4, denotes the output level of industry n. y_1 is the level of the rice output produced from tenant paddyfields, y_2 is the level of the rice output produced from self-cultivated paddyfields, y_3 is the output level of non-agricultural goods, and y_4 is the output level of non-rice agricultural goods.

x_i, where i=1,2,3,4,5, denotes the total available quantity of input i. x_1 is the total number of hectares of tenant paddyfields, x_2 is the total number of hectares of self-cultivated paddyfields, x_3 is the total amount of the quality-standardized labor services, x_4 is the total amount of the quantity-standardized capital services, and x_5 is the total number of hectares of dry lands.

n_j, where j=1,2,3,4,5, denotes the total population of consumers in class j. n_1 is the total population of paddyfield landlords, n_2 is the total population of paddyfield owner-cultivators, n_3 is the total population of laborers, n_4 is the total population of capitalists, and n_5 is the total population of dry land owners.

v^j, where j=1,2,3,4,5, is the column vector of the factor endowment held by consumers of class j. Each vector v^j contains five elements of v_i^j, where i=1,2,3,4,5. v_i^j stands for the amount of input i held by consumers of class j. v^1 contains the five factor endowment elements held by paddyfield landlords, v^2 contains those held by paddyfield owner-cultivators, v^3 contains those held by wage workers, v^4 contains those held by capitalists, and v^5 contains those held by dry land owners.

u_j, where j=1,2,3,4,5, stands for the utility (real income) level obtainable by a consumer of class j. u_1 is the utility level obtainable by a paddyfield landlord, u_2 is the utility level obtainable by a paddyfield owner-cultivator, u_3 is the utility level obtainable by a wage worker, u_4 is the utility level obtainable by a capitalist, and u_5 is the utility level obtainable by a dry land owner.

4.2.3 Commodity Market Equilibrium Conditions

We apply duality theory and Shephard's Lemma in the derivation of the commodity market equilibrium conditions.

According to duality theory, the utility function of consumers of class j has a linear homogeneous, concave, and non-decreasing unit expenditure function dual expressed in commodity prices. The unit expenditure function dual for consumers of class j, e^j, is expressed as:

$$e^j(p) = \underset{z_1,\ z_2,\ z_3,}{\text{Min}} \{ \sum_{N=1}^{3} p_N z_N : u^j(z) \geq 1 \},$$

where j = 1,2,3,4,5; N = 1,2,3; p is a column vector containing the three commodity price elements; z_j is a column vector containing the three expenditure-minimizing commodity values needed by a consumer of class j for attaining the maximum utility level that his/her income allows for.

Assuming the unit expenditure function dual is twice continuously differentiable,[4] we derive the expenditure-minimizing value of commodity N needed by a consumer of class j from the following formula:

$$z_1{}^j(u_1;p) = u_1[\partial e^j(p)/\partial p_1]; \text{ where } j = 1,2,3,4,5.$$

There are n_j individuals in the consumer class j. Therefore, the value of commodity N needed by all consumers of class j is $n_j z_N{}^j = n_j u_j[\partial e_j(p)/\partial p_N]$; the aggregate demand for commodity N is $\sum_{j=1}^{5} n_j z_N{}^j$.

Setting the derived market demand equal to market supply, we develop the demand-equal-to-supply equilibrium conditions for the three commodity markets. They are expressed by the following three formulas.

First, for rice,

$$(4.1) \qquad \sum_{j=1}^{5} u_j n_j[\partial e^j(p)/\partial p_1] = y_1 + y_2 = Y_1$$

Second, for non-agricultural goods,

$$(4.2) \qquad \sum_{j=1}^{5} u_j n_j[\partial e^j(p)/\partial p_2] = y_3 = Y_2$$

Third, for non-rice agricultural goods,

$$(4.3) \qquad \sum_{j=1}^{5} u_j n_j[\partial e^j(p)/\partial p_3] = y_4 = Y_3.$$

4.2.4 Zero-Profit Relationships for the Four Industries

The zero-profit relationships are developed for the four industries based on the assumed competitive nature of the commodity markets. The relationhips state that output's selling price is equal to unit producing cost in each industry.

According to duality theory, the production function of each industry has a linear homogeneous, concave, non-negative, and non-decreasing unit cost function dual expressed in input prices. The unit cost function dual of industry n, c^n, is expresssed as

$$c^n (w_1, w_2, w_3, w_4, w_5)$$

$$= \min_{x_1, x_2, x_3, x_4, x_5} \{ \sum_{i=1}^{5} w_i x_i : f^n(x_1, x_2, x_3, x_4, x_5) \geq 1 \},$$

where i = 1,2,3,4,5; n = 1,2,3,4.

In this study, there are four unit cost function duals. First, for the rice industry produced from the tenant-cultivated paddyfields,

$$c^1(w_1, w_3, w_4) = \mathrm{Min}_{x_1, x_3, x_4} \{ \sum_{i=1}^{5} w_i x_i : f^1(x_1, x_3, x_4) \geq 1 \}.$$

Second, for the rice industry produced from the self-cultivated paddyfields,

$$c^2(w_2, w_3, w_4) = \mathrm{Min}_{x_2, x_3, x_4} \{ \sum_{i=1}^{5} w_i x_i : f^2(x_2, x_3, x_4) \geq 1 \}.$$

Third, for the non-agricultural industry,

$$c^3(w_3, w_4) = \mathrm{Min}_{x_3, x_4} \{ \sum_{i=1}^{5} w_i x_i : f^3(x_3, x_4) \geq 1 \}.$$

Fourth, for the non-rice agricultural industry,

$$c^4(w_3, w_4, w_5) = \mathrm{Min}_{x_3, x_4, x_5} \{ \sum_{i=1}^{5} w_i x_i : f^4(x_3, x_4, x_5) \geq 1 \}.$$

With the knowledge of the unit cost function duals, we develop four zero-profit relationships. The zero-profit relationships are expressed by the following four formulas.[5] First, for the rice industry produced from the tenant-cultivated paddyfields,

(4.4)

$$p_1 = c^1(w_1, w_3, w_4) = w_1[\partial c^1(w)/\partial w_1] + w_3[\partial c^1(w)/\partial w_3] + w_4[\partial c^1(w)/\partial w_4].$$

Second, for the rice industry produced from the self-cultivated paddyfields,

(4.5)

$$p_1 = c^2(w_2, w_3, w_4) = w_2[\partial c^2(w)/\partial w_2] + w_3[\partial c^2(w)/\partial w_3] + w_4[\partial c^2(w)/\partial w_4].$$

Third, for the non-agricultural industry,

(4.6)

$$P_2=c^3(w_3,w_4)=w_3[\partial c^3(w)/\partial w_3] + w_4[\partial c^3(w)/\partial w_4].$$

Fourth, for the non-rice agricultural industry,

(4.7)

$$P_3=c^4(w_3,w_4,w_5)=w_3[\partial c^4(w)/\partial w_3]+w_4[\partial c^4(w)/\partial w_4]+w_5[\partial c^4(w)/\partial w_5].$$

4.2.5 Input Market Equilibrium Conditions

Shephard's Lemma is applied in the derivation of the input market equilibrium conditions.

Assuming that the unit cost function dual is twice continuously differentiable, we derive aggregate demands for inputs by the following five formulas:

First, for tenant-cultivated paddyfield,

$$x_1(y;w) = \sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_1].$$

Second, for self-cultivated paddyfield,

$$x_2(y;w) = \sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_2].$$

Third, for labor input,

$$x_3(y;w) = \sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_3].$$

Fourth, for capital input,

$$x_4(y;w) = \sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_4].$$

Fifth, for dry land,

$$x_5(y;w) = \sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_5].$$

In the above five formulas, y is a column vector containing the four industry output elements, w a column vector containing the five input price elements, $\partial c^n(w)/\partial w_i$ is the cost-minimizing value of input i needed by industry n for producing a unit of output, $y^n[\partial c^n(w)/\partial w_i]$ is the value of input i needed by industry n for producing y_n units of output.

Next, we figure out the market supply of input i. Each consumer of class j holds v_i^j units of input i. Multiplying v_i^j with the total population number in the consumer class j, n_j, we obtain the value of input i held by all consumers of class j. Adding together the values of input i held by all consumers of the five classes, we obtain the amount of market supply of input i, $\sum_{j=1}^{5} v_i^j n_j$.

Setting the derived market demand equal to market supply, we develop five demand-equal-to-supply equilibrium conditions for the five input markets. These conditions are expressed by the following five formulas:

First, for the tenant land market,

$$(4.8) \qquad \sum_{n=1}^{4} [\partial c^n(w)/\partial w_1]y_n = \sum_{j=1}^{5} v_1^j n_j = x_1$$

Second, for the self-cultivated paddyfield market,

$$(4.9) \qquad \sum_{n=1}^{4} [\partial c^n(w)/\partial w_2]y_n = \sum_{j=1}^{5} v_2^j n_j = x_2$$

Third, for the labor market,

$$(4.10) \qquad \sum_{n=1}^{4} [\partial c^n(w)/\partial w_3]y_n = \sum_{j=1}^{5} v_3^j n_j = x_3$$

Fourth, for the capital market,

$$(4.11) \qquad \sum_{n=1}^{4} [\partial c^n(w)/\partial w_4] y_n = \sum_{j=1}^{5} v_4{}^j n_j = x_4$$

Fifth, for the dry land market,

$$(4.12) \qquad \sum_{n=1}^{4} [\partial c^n(w)/\partial w_5] y_n = \sum_{j=1}^{5} v_5{}^j n_j = x_5$$

4.2.6 Consumer Budget Constraints

The consumer budget constraints state that the utility level obtainable by a consumer of class j is determined by input/output prices and consumer's income and preferences.

Each consumer of class j holds an identical set of factor endowment expressed as vector v^j. Let w^T stand for the transpose of the column input price vector w. The income received from the factor endowment by consumers of class j is $w^T v^j$. Dividing a consumer's income by his/her unit expenditure function dual, we determine the utility level obtainable by a consumer of class j from the following five budget contraints.

First, for paddyfield landlords,

$$(4.13) \qquad u_1 = w^T v^1/e^1(p), \text{ or } u_1 e^1(p) = w^T v^1.$$

Second, for paddyfield owner-cultivators,

$$(4.14) \qquad u_2 = w^T v^2/e^2(p), \text{ or } u_2 e^2(p) = w^T v^2.$$

Third, for wage workers,

$$(4.15) \qquad u_3 = w^T v^3/e^3(p), \text{ or } u_3 e^3(p) = w^T v^3.$$

Fourth, for capitalists,

$$(4.16) \qquad u_4 = w^T v^4/e^4(p), \text{ or } u_4 e^4(p) = w^T v^4.$$

Fifth, for dry land owners,

(4.17) $u_5 = w^T v^5/e^5(p)$, or $u_5 e^5(p) = w^T v^5$.

4.3 Model I

In model I, a system of seventeen general equilibrium conditions is formalized in the same manner as that of Diewert's model. We believe that this model can be used to determine the excess demand for tenant land induced by the rent reduction.

In model I, the general equilibrium of the economy is represented by equations (4.1) to (4.17). The seventeen equations are expressed in the same number of endogenous variables: y_1, y_2, y_3, y_4, p_1, p_2, p_3, w_1, w_2, w_3, w_4, w_5, u_1, u_2, u_3, u_4, and u_5. All but one of these equations are independent.

Rent reduction induces an increase in the area of land needed by tenant rice farmers.[6] Assume that the increased demand for tenant land will materialize through the conversion of paddyfield usage from self cultivation to tenancy after the rent is reduced. To trace the excess demand for tenant land induced by the rent reduction, we conduct a comparative static analysis to the system of the seventeen equations based on a hypothetical one percent increase (from the initial equilibrium level) in the land area used for tenancy.

The comparative static analysis is conducted through the normalization procedure which sets the price of the capital services equal to unity. In the procedure, equation (4.11) is dropped from the system and is replaced by an additional equation ($w_4 = 1$) in order to determine the values of the price variables in the system. Besides, the fourth element is also dropped from the input price vector w except when w^T is inner-producted with other variables in a multiplicative term, that is,

$$w^T = (w_1, w_2, w_3, w_5), \text{ but } w^T v^j = \sum_{i=1}^{5} w_i v_i^j.$$

The comparative static analysis generates an impact vector containing sixteen elements indicating the percentage changes in the sixteen normalized endogenous variables (except the price of the capital services which is fixed at unity) corresponding to a one percent increase in the land area used for tenancy. They are expressed as the partial derivatives of the logarithmic values of the sixteen normalized endogenous variables with respect to the logarithmic value of the area of land used for tenancy. In mathematical notations, the vector is expressed as

$$(\partial \ln p_1/\partial \ln n_1,\ \partial \ln p_2/\partial \ln n_1,\ \partial \ln p_3/\partial \ln n_1,\ \partial \ln y_1/\partial \ln n_1,$$
$$\partial \ln y_2/\partial \ln n_1,\ \partial \ln y_3/\partial \ln n_1,\ \partial \ln y_4/\partial \ln n_1,\ \partial \ln w_1/\partial \ln n_1,$$
$$\partial \ln w_2/\partial \ln n_1,\ \partial \ln w_4/\partial \ln n_1,\ \partial \ln w_5/\partial \ln n_1,\ \partial \ln u_1/\partial \ln n_1,$$
$$\partial \ln u_2/\partial \ln n_1,\ \partial \ln u_3/\partial \ln n_1,\ \partial \ln u_4/\partial \ln n_1,\ \partial \ln u_5/\partial \ln n_1).$$

The solution of the impact vector is obtained through five steps: (1) totally differentiate the sixteen normalized equations with respect to $\partial \ln p_1$, $\partial \ln p_2$, $\partial \ln p_3$, $\partial \ln y_1$, $\partial \ln y_2$, $\partial \ln y_3$, $\partial \ln y_4$, $\partial \ln w_1$, $\partial \ln w_2$, $\partial \ln w_3$, $\partial \ln w_5$, $\partial \ln u_1$, $\partial \ln u_2$, $\partial \ln u_3$, $\partial \ln u_4$, and $\partial \ln u_5$; (2) totally differentiate the system of the sixteen equations with respect to ∂lnn_1; (3) multiply the differentiated outcomes obtained from steps (1) and (2) with a constant term $1/p^{*T}Y^*$ (where p is the column output price vector, Y is a column vector containing the three elements of the commodity values, * denotes the initial equilibrium level of the variables supercribed, and $p^{*T}Y^*$ is the value of the initial gross national output measured in normalized term); (4) set the two products obtained from step three equal to each other; and (5) obtain the numerical solution of the impact vector by the equation of step (4).

The impact vector is obtained by solving the sixteen differentiated equations expressed in matrix form in the following page. Where A denotes the sixteen by sixteen coefficient matrix containing the partial derivatives obtained from the totally differentiated sixteen normalized equations with respect to ∂lnp_1, ∂lnp_2, ∂lnp_3, ∂lny_1, ∂lny_2, ∂lny_3, ∂lny_4, ∂lnw_1, ∂lnw_2, ∂lnw_3, ∂lnw_5, ∂lnu_1, ∂lnu_2, ∂lnu_3, ∂lnu_4, and ∂lnu_5; B denotes the sixteen by one coefficient matrix containing the partial derivatives obtained from the totally differentiated sixteen normalized equations with respect to lnn_1. If the inverse of matrix A exists, the impact vector equals $A^{-1}B$.

The elements of matrices A and B are expressed in the partial derivative forms in Appendix 2.1 and as functions of the various distributive shares and the elasticities of substitution in production and consumption in Appendix 2.2.

The impact vector of model I provides us with very

$$
A\begin{bmatrix}
\partial \ln p_1 \\
\partial \ln p_2 \\
\partial \ln p_3 \\
\partial \ln y_1 \\
\partial \ln y_2 \\
\partial \ln y_3 \\
\partial \ln y_4 \\
\partial \ln w_1 \\
\partial \ln w_2 \\
\partial \ln w_3 \\
\partial \ln w_5 \\
\partial \ln u_1 \\
\partial \ln u_2 \\
\partial \ln u_3 \\
\partial \ln u_4 \\
\partial \ln u_5
\end{bmatrix}
=
\begin{bmatrix}
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{j=1}^{5} \frac{\partial e^j(p^*)}{\partial p_1^*} u_j^* n_j - y_1^* - y_2^*\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{j=1}^{5} \frac{\partial e^j(p^*)}{\partial p_2^*} u_j^* n_j - y_3^*\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{j=1}^{5} \frac{\partial e^j(p^*)}{\partial p_3^*} u_j^* n_j - y_4^*\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[-p_1^* + c^1(w^*)\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[-p_1^* + c^2(w^*)\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[-p_2^* + c^3(w^*)\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[-p_3^* + c^4(w^*)\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{n=1}^{4} \frac{\partial c^n(w^*)}{\partial w_1^*} y_n^* - \sum_{j=1}^{5} v_1^j n_j\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{n=1}^{4} \frac{\partial c^n(w^*)}{\partial w_2^*} y_n^* - \sum_{j=1}^{5} v_2^j n_j\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{n=1}^{4} \frac{\partial c^n(w^*)}{\partial w_3^*} y_n^* - \sum_{j=1}^{5} v_3^j n_j\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[\sum_{n=1}^{4} \frac{\partial c^n(w^*)}{\partial w_5^*} y_n^* - \sum_{j=1}^{5} v_5^j n_j\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[e^1(p^*)u_1^* - w^{*T}v^1\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[e^2(p^*)u_2^* - w^{*T}v^2\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[e^3(p^*)u_3^* - w^{*T}v^3\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[e^4(p^*)u_4^* - w^{*T}v^4\right]\right\} \\
n_1/(p^{*T}Y^*)\left\{ d/dn_1\left[e^5(p^*)u_5^* - w^{*T}v^5\right]\right\}
\end{bmatrix}
\partial \ln n_1
$$

limited information to detect the effects of the rent reduction. The element $(\partial \ln w_1/\partial \ln n_1)$ represents the equilibrium tenant rental-acreage trade-off relationship when market <u>demand</u> forces play a dominant role in the determination of the land area used for tenancy. The inverse of this element $(\partial \ln n_1/\partial \ln w_1)$ indicates the percentage change in the land area needed by tenant farmers induced by a one percent decrease in the normalized tenant rent.

The other fifteen elements of the impact vector represent the percentage changes in the fifteen normalized endogenous variables (except the tenant rent and the price of the capital services) corresponding to a one percent increase in the land area used for tenancy. They are invalid for the examination of the rent reduction effects because cultivated land area used for tenancy practically reduced after tenant rent was lowered by the government mandate. The fact is that land usage converted from tenancy to self cultivation was more commonly practiced after the rent reduction than vice versa.

Two factors limit the comparative analysis. One is the presence of equation (4.8) as the tenant market equilibrium condition; the other is the assumed dominant feature of the tenant market <u>demand</u> forces.

Equation (4.8) states that $\sum_{n=1}^{4} y_n[\partial c^n(w)/\partial w_1] = \sum_{j=1}^{5} n^j v_1^j$.

Where aggregate demand for tenant land is described by the left-hand side of the equation and land area supplied for tenancy is described by the right-hand side of the equation;

the former contains only one element--the area of paddyfields needed by tenant rice farmers $y_1[\partial c^1(w)/\partial w_1]$, and the latter can be simplified as $n_1 v_1{}^1$ if the only group of consumers who provide lands for tenancy was the group of paddyfield landlords. With the knowledge of the values of y_1 and $v_1{}^1$, equation (4.8) is simply a function of the input prices w_1, w_3, and w_4 and the total number of paddyfield landlords n_1.

The assumed dominant tenant market demand forces renders the increase in the demand for tenant land (induced by the rent reduction) realizable. As soon as the cultivated land area needed is determined by market demand forces, the land area supplied for tenancy is also determined.

Let us use the downward-sloping curve DD in Figure 4.1 to depict the equilibrium tenant land market demand function. The slope of curve DD represents the equilibrium tenant rental-acreage trade-off relationship following a complete adjustment in production and consumption after the implementation of the rent reduction, when market <u>demand</u> forces play a dominant role in determining the size of land used for tenancy. In model I, the slope value is represented by the impact vector element $(\partial \ln w_1/\partial \ln n_1)$.

On curve DD, the initial tenant market equilibrium is reflected by point E, which is the intersection of $\ln w_1{}^{0*}$ (the logarithmic value of the initial equilibrium level of tenant rent) and $\ln n_1{}^{0*}$ (the logarithmic value of the initial equilibrium level of land size used for tenancy). When market demand forces play a dominant role in the determination of

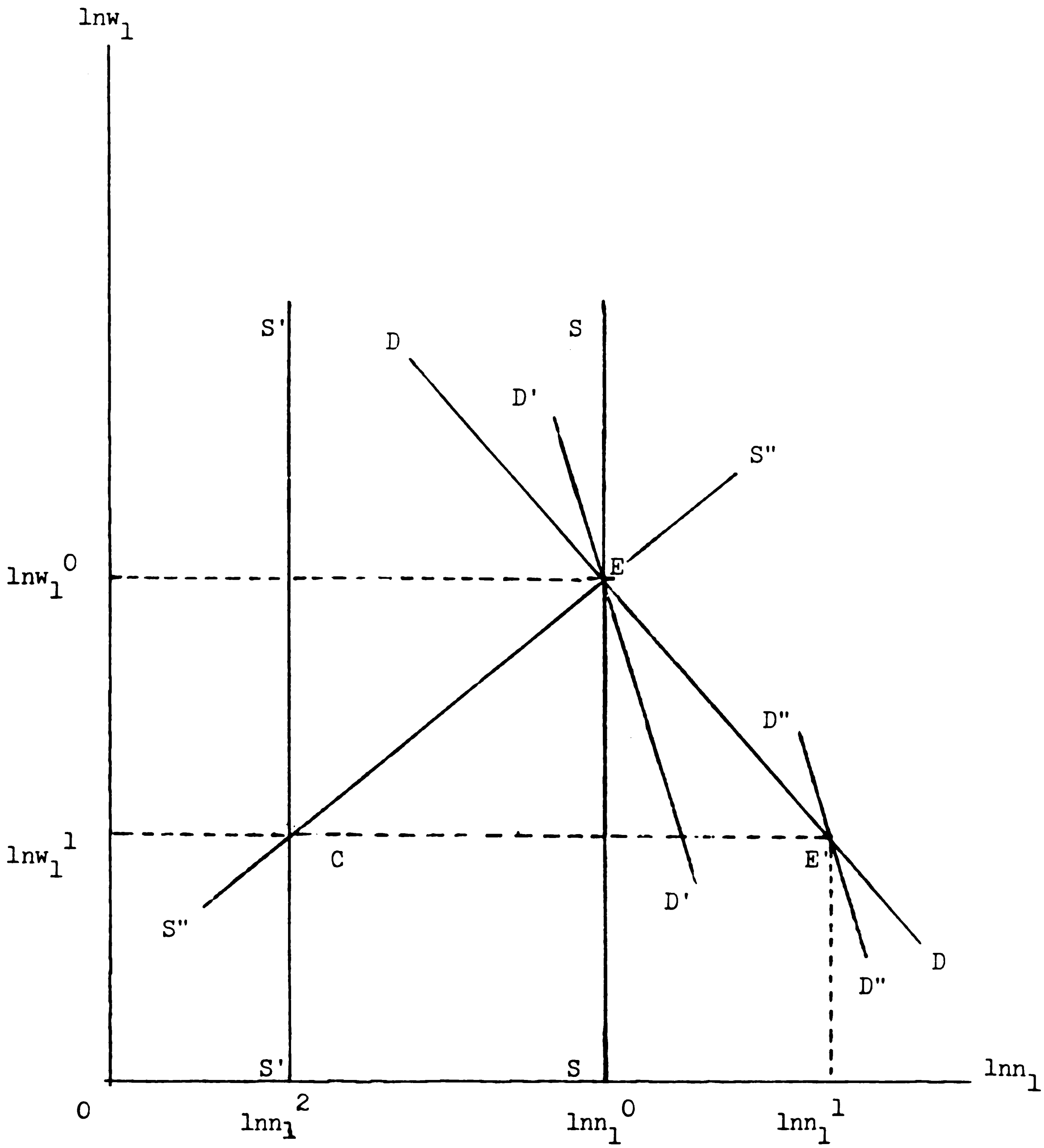

Figure 4.1 Demand and Supply Forces in the Tenant Land Market

land size used for tenancy, new tenant market equilibrium should be at point E′ after farmland rent is reduced to w_1^1. Point E′ is the intersection of $\ln w_1^1$ (the logarithmic value of the mandatory level of tenant rent) and $\ln n_1^1$ (the logarithmic value of land area needed by tenant farmers). In reality, the increase in the demand for tenant land, i.e., $(n_1^1-n_1^0)$, was practically unrealizable because land area used for tenancy was actually lower and tenant market supply forces in fact played a dominant role in determining how much land was to be supplied for tenancy.

Suppose the land area supplied for tenancy actually reduced to n_1^2. Knowing the slope value of curve DD and the area of paddyfield converted from tenancy to self cultivation $(n_1^0-n_1^2)$, we can determine that $(n_1^2-n_1^1)$ is the excess demand for tenant land induced by the rent reduction.

However, as long as equation (4.8) remains to be the tenant market equilibrium condition, the recognition of the dominant tenant market supply forces will not help us alleviate the limitations of the impact analysis.

When the total number of paddyfield landlords reduced from n_1^0 to n_1^2 after the rent reduction, new tenant market equilibrium should be at point C in Figure 4.1. Based on the right-hand side of equation (4.8), the area of land supplied for tenancy is the total population of paddyfield landlords when the value of v_1^1 is unity. The left-hand side of equation (4.8) indicates that the tenant land demand function would shift following a complete adjustment in production and consumption induced by the rent reduction. The shift in the supply side of equation (4.8) is reflected in Figure 4.1 by the shift from curve SS to curve S'S' and the shift in the demand side of equation (4.8) is reflected by the shift from curve D'D' to curve D"D". Knowing the location of the new supply curve S'S' and the new demand curve D"D" (which are the information conveyed by equation (4.8)) will not enable us to identify the new tenant market equilibrium at point C. The identification of the new tenant market equilibrium at point C is possible only if we are given the knowledge about the slope of curve S"S"; curve S"S" is the equilibrium tenant supply function, and its slope represents the equilibrium tenant rental-acreage trade-off relationship derived from a model which is able to emphasize the dominant tenant market supply forces in the determination of the land area used for tenancy induced by the rent reduction.

4.4 Model II

In Model II, we introduce a different tenant market equilibrium condition to correct the limitations presented in the impact analysis of model I. Section 4.4.1 describes the modification of the tenant market equilibrium condition. Section 4.4.2 describes model II.

4.4.1 Modification of the Tenant Market Equilibrium Condition

The modified version of the tenant market equilibrium condition is assumed to take the following form:

(4.8-MV) $\ln w_1 - a_0 \ln n_1 - k = 0.$

Where w_1 is the tenant rent per hectare of paddyfield, n_1 is the land area supplied for tenancy, k is a constant term, and a_0 is a positive slope value. We regard the equation is able to capture the dominant feature of the tenant market supply forces in the determination of the land area supplied for tenancy. Referring to Figure 4.1, equation (4.8-MV) is depicted by curve S"S".

4.4.2 Model II

Model II is composed of seventeen equations. Except for equation (4.8), all equations used in model I are still retained as the general equilibrium conditions in model II. Equation (4.8-MV) replaces equation (4.8) as the tenant market equilibrium condition. The seventeen equations are expressed by the same number of endogenous variables as those of model I. All but one of the seventeen equations are independent.

In model II, we assume that all paddyfields withdrawn from tenancy are used for self cultivation after the rent is reduced. The shift in the land usage can be expressed as $-\partial n_1 = \partial n_2$. To evaluate the effects of the rent reduction, a comparative static analysis is conducted to the system of the seventeen equations based on a hypothetical one percent decrease (from the initial equilibrium level) in the tenant paddyfield area induced by the rent reduction. The analysis is conducted through the same normalization procedure as that elaborated in model I.

Through the five similar steps introduced in model I, we obtain an impact vector for model II.

Let G denote the sixteen by sixteen coefficient matrix of the partial derivatives derived from the totally differentiated sixteen normalized equations with respect to ∂lnp_1, ∂lnp_2, ∂lnp_3, ∂lny_1, ∂lny_2, ∂lny_3, ∂lny_4, ∂lnw_1, ∂lnw_2, ∂lnw_3, ∂lnw_5, ∂lnu_1, ∂lnu_2, ∂lnu_3, ∂lnu_4, and ∂lnu_5. Let H represent the sixteen by one coefficient matrix of the partial derivatives derived from the totally differentiated sixteen normalized equations with respect to ∂lnn_1. When the inverse of matrix G exists, the impact vector equals $G^{-1}H$. In mathematical notations, the impact vector is expressed as

$$-(\partial lnp_1/\partial lnn_1,\ \partial lnp_2/\partial lnn_1,\ \partial lnp_3/\partial lnn_1,\ \partial lny_1/\partial lnn_1,$$
$$\partial lny_2/\partial lnn_1,\ \partial lny_3/\partial lnn_1,\ \partial lny_4/\partial lnn_1,\ \partial lnw_1/\partial lnn_1,$$
$$\partial lnw_2/\partial lnn_1,\ \partial lnw_3/\partial lnn_1,\ \partial lnw_5/\partial lnn_1,\ \partial lnu_1/\partial lnn_1,$$
$$\partial lnu_2/\partial lnn_1,\ \partial lnu_3/\partial lnn_1,\ \partial lnu_4/\partial lnn_1,\ \partial lnu_5/\partial lnn_1).$$

The elements of matrices G and H are expressed in the partial derivative forms in Appendix 2.1 and as functions of the various distributive shares and the elasticities of substitution in production and consumption in Appendix 2.2.

Of model II's sixteen impact vector elements, the element $-(\partial lnw_1/\partial lnn_1)$ is the negative value of the inverse of a_0--the slope of equation (4.8-MV). It reflects the rate of change in the land area supplied for tenancy following a complete adjustment in production and consumption after a one percent reduction (from the initial equilibrium level) in the tenant rent.

The other fifteen impact vector elements represent the percentage changes in the fifteen normalized endogenous variables (except for the tenant rent and the price of the capital services) corresponding to a one percent decrease (from the initial equilibrium level) in the tenant paddyfield area induced by the rent reduction. The fifteen elements provide useful information to evaluate the effects of the rent reduction on the normalized input/output prices, the industry outputs, and the real income distribution.

Model II also has limitations. First, like model I, the solution of the impact vector is an approximation based on the first-order differentiation. The approximation errs when higher-order differentiations are of non-negligible magnitude. Second, the solution of the impact vector is derived from the assumed knowledge of the equilibrium tenant land supply function. If equation (4.8-MV) bears little resemblance to the actual form of the equilibrium tenant land supply function, the validity of model II in the evaluation of the effects of the rent reduction becomes questionable.

4.5 Summary

Two theoretical models are introduced in chapter four to evaluate the impact of the rent reduction. Both models use seventeen equations to represent the general equilibrium of the economy.

Except for the tenant market equilibrium condition, the same sixteen equations are used in both models to describe the input/output market equilibrium conditions, the industry's pricing behaviors, and the consumption behaviors of consumers in different classes. Market demand forces are assumed to play a dominant role in the determination of the tenant market equilibrium condition in model I; while market supply forces are assumed to play that role in model II.

A comparative static analysis is conducted to the system of the seventeen equilibrium equations in both models. In model I, it is conducted based on a hypothetical one percent increase (from the initial equilibrium level) in the land area used for tenancy. In model II, it is conducted based on a hypothetical one percent decrease (from the initial equilibrium level) in the tenant paddyfield area induced by the rent reduction. The change in land area used for tenancy occurs, due to the assumed dominant tenant market demand forces in model I and the assumed dominant tenant market supply forces in model II.

Two impact vectors are derived from the comparative static analysis conducted in both models. The impact vector from model I provides us with information to determine the excess demand for tenant land induced by the rent reduction. The impact vector from model II renders useful information to determine the effects of the rent reduction on the input/output prices, the industry outputs, and the real income distribution.

CHAPTER V

THE NUMERICAL AND THE SENSITIVITY ANALYSIS

Chapter five interprets the results of the numerical and the sensitivity analysis conducted in the two models based on the Taiwanese data. Section 5.1 describes the data. Sections 5.2 and 5.3 respectively present the numerical and the sensitivity analysis. Section 5.4 is a summary.

5.1 Data Description

To conduct the impact analysis, data are needed on: the cultivated land area; the agricultural factor income shares; the non-agricultural factor income shares; the various distributive shares; the elasticities of substitution in production and consumption; and the slope of equation (4.8-MV)--the equilibrium tenant land supply function. These data values are described in section 5.1.1 to section 5.1.6.

5.1.1 Cultivated Land Area

The total cultivated land area, including both public and private lands, was 863,156 hectares in 1948 (Shong, 1951: 139). The lands are grouped into three categories: paddy fields used for tenant cultivation (281,221 hectares); paddy fields used for self cultivation (245,163 hectares); and dry lands (336,772 hectares) (Koo, 1968:45; 1982:121).

5.1.2 Agricultural Factor Income Shares

The agricultural factor income shares include the income shares of land, labor, and capital for the three agricultural industries (non-rice agricultural, rice produced from tenant-cultivated paddyfields, rice produced from self-cultivated paddyfields). Such data are not available and needed to be estimated. Two steps are followed in the estimation.

First, we determine the 1948 income shares of land, labor, and capital for the agricultural sector based on Lee's estimation (1972:45) for 1950-55. Lee's estimation is used because it is the nearest one to 1948 in chronological date. Lee indicates that the agricultural factor income shares were 40.15 percent for wages, 9.26 percent for interests, and 50.59 percent for land income. Multiplying these estimates with the 1948 gross agricultural output,[1] we estimate the incomes of land, labor, and capital from the agricultural sector for 1948. Table 5.1 summarizes the values and the shares of the three estimated agricultural factor incomes.[2]

Second, we figure out the income shares of land, labor, and capital for the three agricultural industries.

To estimate the 1948 land income share for the three agricultural industries, we make use of three assumptions: (1) initially, land income share was the same for the two rice industries, whether the rice was produced from publicly or privately owned paddyfields;[3] (2) land income per hectare of

Table 5.1
Factor Incomes of the Agricultural Sector, 1948

Unit: NT$1 million
1951-1956=100

	Factor Income	
Type of Factor	Value	Share (%)
Land	2,265.6	50.59%
Labor	1,798.1	40.15%
Capital	414.7	9.26%
Total	4,478.4	100.00%

Source: Compiled by the author. See section 5.1.2 of the text for detailed procedure.

of paddyfield was 2.5 times that of dry land;[4] and (3) both self- and tenant-cultivated paddyfields initially generated the same amount of income.

The statistics of the major farm products in 1948 indicate that the value of the gross rice output was NT$2,423.5 million and the value of the gross non-rice agricultural output was NT$2,054.9 million.[5] Applying the ratio of land income per hectare of paddyfield to that of dry land, the estimated land income is NT$1,803.94 million from the two rice industries and NT$461.65 million from the non-rice agricultural industry. The estimates are derived from the following procedure.

Let X_1 denote the land income share for the two rice industries and X_2 denote that for the non-rice agricultural industry. The values of X_1 and X_2 are respectively 74.4355 and 22.466 percent,[6] by solving the system of equations (5.1) and (5.2):

$$(5.1) \qquad 2423.5X_1 + 2054.9X_2 = 2265.6$$

$$(5.2) \qquad \frac{2423.5X_1}{526385} = 2.5 * \frac{2054.9X_2}{336772}$$

On the left-hand side of equation (5.1), there are two terms: the first is the total land income from the two rice industries and the second is that from the non-rice agricultural industry. The sum of these two terms equals NT$2,265.6 million, i.e., the value of the agricultural land income. Equation (5.2) indicates that land income per hectare of paddyfield was 2.5 times that of dry land. The numerator on the left-hand side of equation (5.2) is the total land income received from all paddyfields. The numerator on the right-hand side of equation (5.2) is the product of 2.5 by the total land income generated from all dry lands. The denominator on the left-hand side of equation (5.2) is the total area of paddyfields and that on the right-hand side is the total area of dry lands.

Applying the estimated values of X_1 and X_2 respectively to the gross rice and the gross non-rice-agricultural output, we estimate that NT$1,803.94 million is the total land income from the two rice industries and NT$461.65 million is the total land income from the non-rice agricultural industry. Based on the values of X_1 and X_2, we also estimate that the annual land income is NT$3,427 per hectare of paddyfield and NT$1,370.8 per hectare of dry land. Because we assume that both self- and tenant-cultivated paddyfields initially generated the same amount of land income, the estimated land income from the tenant-cultivated rice industry is NT$840.19 million and that from the owner-cultivated rice industry is NT$963.73 million.

To estimate the 1948 capital income share for the three agricultural industries, we make use of two assumptions: (1) the distribution of capital assets between the rice and the non-rice crop productions initially followed the same pattern as that of commercial fertilizers; and (2) initially, capital income share was the same for the two rice industries.[7]

The statistics of the utilization of commercial fertilizers in 1949 indicate that, 60.8 percent of the total amount of commercial fertilizers used in agriculture was applied to the rice production and 39.2 percent to the non-rice farm crops.[8] Therefore, 60.8 percent of the agricultural capital income should be attributed to the two rice industries and 39.2 percent to the non-rice agricultural industry. Of the total NT$414.7 million agricultural capital income, NT$252.14 million is from the two rice industries and NT$162.56 million is from the non-rice agricultural industry.

Since capital income share was the same for the two rice industries, of the NT$252.14 million capital income prorated to the two rice industries, NT$117.44 million should be prorated to the owner-cultivated rice industry and NT$134.71 million to the tenant-cultivated rice industry.

Based on the estimated capital incomes of the three agricultural industries, we determine that capital income share is 10.4040 percent for the two rice industries and 7.9108 percent for the non-rice agricultural industry.

To estimate the 1948 labor income share for the three agricultural industries, we make use of two assumptions: (1) the gross rice output produced from the tenant-cultivated paddyfields was 1.147 times that from the self-cultivated paddyfields; and (2) after compensating the land and capital assets used in production, the residual output from each industry is used for compensating the labor.

Based on the first assumption, we estimate that the value of the rice output is NT$1,294.75 million from the tenant-cultivated paddyfields and NT$1,128.75 from the self-cultivated paddyfields. The gross non-rice agricultural output was NT$2,054.90 million in 1948. Substracting the prorated land and capital incomes from each industry's output, we estimate the value of the labor income for the three agricultural industries: NT$171.12 million is the labor income from the owner-cultivated rice industry; NT$196.29 million is from the tenant-cultivated rice industry; and NT$1,430.69 million is from the non-rice agricultural industry.

Based on the estimated labor incomes of the three agricultural industries, we determine that labor income share is 15.1607 percent for the two rice industries and 69.6233 percent for the non-rice agricultural industry.

Columns two, three, and four of Table 5.2 summarize the values and the shares of the estimated factor incomes of the three agricultural industries.

5.1.3 Nonagricultural Factor Income Shares

The non-agricultural factor income shares include the income shares of labor and capital of the non-agricultural industry.

Three steps are followed in the estimation of the non-agricultural factor income shares. First, we estimate the non-agricultural labor income based on the derived wage-bill ratio of agricultural to non-agricultural employment. Second, we estimate the 1948 gross non-agricultural output based on the assumption that net domestic product (NDP) consisted of

Table 5.2

Estimated Agricultural and Non-agricultural Factor Incomes, 1948

Unit: N.T. million dollars 1952-1956=100

Type of Factor	Agriculture: Rice Industry: Tenant-Cultivated Paddyfield	Agriculture: Rice Industry: Self-Cultivated Paddyfield	Agriculture: Non-rice Industry	Non-Agricultural Industry
Land				
Value	963.75	840.19	461.65	NA
Percentage	74.4355%	74.4355%	22.4660%	NA
Labor				
Value	196.29	171.12	1,430.69	2,168.01
Percentage	15.1607%	15.1607%	69.6233%	27.1100%
Capital				
Value	134.71	117.44	162.56	5,828.29
Percentage	10.4040%	10.4040%	7.9108%	72.8900%
Total				
Value	1,294.75	1,128.75	2,054.90	7,996.30
Percentage	100.0000%	100.0000%	100.0000%	100.0000%

Source: Compiled by the author. See sections 5.1.2 and 5.1.3 for details.

the same proportions of agricultural and non-agricultural goods in 1948 and 1952.[9] Third, we estimate the non-agricultural capital income by deducting the estimated non-agricultural labor income from the estimated gross non-agricultural output.

To estimate the non-agricultural labor income, we assume that: agricultural and non-agricultural employment stayed at the same level in 1948 and 1949; and the wage and the working-duration differential between agricultural and non-agricultural workers were the same for 1948 and 1950-1955.[10]

In 1949, 1,733,000 persons were employed in agriculture and 1,055,000 persons in non-agriculture.[11] Intersectional differentials in both wages and annual working days existed. To estimate the wage-bill ratio of agricultural to non-agricultural employment, we have to standardize the earning ability and the working duration of the intersectional labor services.

The annual working-day ratio of agricultural to non-agricultural worker was 0.548 to 1.[12] This implies that total working days of the 1,733,000 agricultural workers are equal to those of the 972,031 non-agricultural workers.

The wage ratio of a non-agricultural to an agricultural worker, who works for the same length of time, was 1.0 to 0.9.[13] Therefore, the 1,055,000 non-agricultural workers should have received the same amount of wages as those received by the 1,172,000 agricultural workers. Based on this information, we estimate that 1.20573 is the wage-bill ratio of non-agricultural to agricultural employment. Applying the derived wage-bill ratio, we estimate that NT$2,168.01 is the 1948 non-agricultural labor income (i.e., the product of 1.20573 by the estimated NT$1,798.1 million agricultural labor income).

In 1952, 35.9 percent of NDP was generated from agriculture and 64.1 percent from non-agriculture. Applying these rates, we estimate that NT$7,996.3 million is the gross non-agricultural output because gross agricultural output was NT$4,478.4 million in 1948. Deducting the estimated NT$2,168.01 million non-agricultural labor income from the estimated gross non-agricultural output, we obtain NT$5,828.29 million as the estimated non-agricultural capital income for 1948. Based on the estimated non-agricultural labor and capital incomes, we determine that the labor income share is 27.11 percent and the capital income share is 72.89 percent.

Column five of Table 5.2 summarizes the values and the shares of the estimated non-agricultural factor incomes.

5.1.4 Various Distributive Shares

To evaluate the impact of the rent reduction, we also need the numerical values of five types of distributive shares: (1) the initial income share that consumers of class j earned through input i; (2) the initial expenditure share that consumers of class j spent on commodity N; (3) the initial national product share produced by industry n ; (4) the initial national product share possessed by a consumer of class j; and (5) the initial cost share of input i in the unit output of industry n.

The foregoing five types of distributive shares are expressed in column vector forms. Vector v^j denotes the initial factor endowment vector for consumers of class j, where j=1,2,3,4,5. Each vector v^j contains five endowment share elements v_i^j, where i=1,2,3,4,5. v_i^j denotes the initial income share that consumers of class j earned through input i. Vector D^j denotes the initial expenditure share vector for consumers of class j, where j=1,2,3,4,5. Each vector D^j contains three expenditure share elements D_N^j, where N=1,2,3. D_N^j stands for the initial expenditure share that consumers of class j spent on commodity N. Vector b contains four national product share elements b_n, where n=1,2,3,4. b_n indicates the initial national product share produced by industry n. Vector F contains five national product share elements a_j, where j=1,2,3,4,5. a_j indicates the initial national product share possessed by a consumer of class j. Vector R^n denotes the initial cost share vector, where n=1,2,3,4. Each vector R^n contains five cost share elements r_i^n, where i=1,2,3,4,5. r_i^n stands for the initial cost share of input i in the unit output of industry n.

Existing literature provides no estimates on the initial factor endowment shares for consumers of various groups. Without the loss of generality, we asssume that an individual consumer of class j initially held one unit of a specific type of productive factor. That is, each paddyfield landlord owned one hectare of tenant paddyfield, each owner-cultivator owned one hectare of either paddyfield or dry land, each wage worker owned a unit of quality-standardized labor services, and each capitalist owned N.T.$1,000.00 capital assets. Expressed in notation, the initial endowment vectors for consumers of the five classes are: $v^{1T}=(1,0,0,0,0)$; $v^{2T}=(0,1,0,0,0)$; $v^{3T}=(0,0,1,0,0)$; $v^{4T}=(0,0,0,1,0)$; and $v^{5T}=(0,0,0,0,1)$; where T denotes the transpose of a vector.

Existing literature also provides no estimates on the consumers' initial expenditure shares for 1948. Assume that all consumers had the same preferences and each initially divided his/her expenditure on the three commodities in proportion to each commodity's share of the national product. Based on the industry output values displayed in the last row of Table 5.2, the expenditure share vector for consumers of class j is determined as $D^{jT}=(0.1943,\ 0.6410,\ 0.1647)$, where $j=1,2,3,4,5$.

Vector b contains four national product share elements. b_1 is the national product share produced by the tenant-cultivated rice industry; b_2 is the share produced by the owner-cultivated rice industry; b_3 is that produced by the non-agricultural industry; and b_4 is that produced by the non-rice agricultural industry. Applying the statistics displayed in the last row of Table 5.2, vector $b^T = (0.1038,\ 0.0905,\ 0.6410,\ 0.1647)$.

To estimate the initial national product share possessed by a consumer of class j (a_j), we first determine the value of the total number of consumers in the consumer class j, n_j, and the initial national product share possessed by all consumers of class j, $n_j a_j$. We determine the value of a_j by dividing the value of $n_j a_j$ by that of n_j.

Based on the statistics displayed in Table 5.2, we determine the initial national product share possessed by all consumers of class j ($n_j a_j$): 7.7256 percent is possessed by all paddyfield landlords, 6.7352 percent by all paddyfield owner-cultivators, 31.7932 percent by all wage workers, 50.0452 percent by all capitalists, and 3.7007 percent by all dry land owners. Based on the assumed values of v_i^js, there would be 281,221 paddyfield landlords (n_1), 245,165 paddyfield owner-cultivators (n_2), 2,144,031 wage workers (n_3), 17,970,690 capitalists (n_4),[14] and 336,772 dry land owners (n_5). Dividing the value of $n_j a_j$ by that of n_j, we obtain the estimated value of a_j: a_1=0.0000274 percent; a_2=0.0000274 percent; a_3=0.0000148 percent; a_4=0.0000028 percent; and a_5=0.0000109 percent.

Table 5.2 also provides valid information to determine the numerical value of the initial cost share vector R^n. For the tenant-cultivated rice industry, R^{1T}=(0.7444, 0, 0.1516, 0.1040, 0). For the owner-cultivated rice industry, R^{2T}=(0, 0.7444, 0.1516, 0.1040, 0). For the non-agricultural industry, R^{3T}=(0, 0, 0.2711, 0.7289, 0). For the non-rice agricultural industry, R^{4T}=(0, 0, 0.6962, 0.0791, 0.2249).

5.1.5 Elasticities of Substitution in Production & Consumption

The numerical values of the elasticities of substitution (abbreviated as ES in singular form and ESs in plural form hereafter) in production are cited from Liao (1983) and Liang (1982).

Liao's and Liang's estimates are used because most estimated ESs obtained by economists, such as Lee (1972), Young (1974), Tang et al. (1981), and others, are derived based on the fitted CES and Cobb-Douglas production functions. The CES and Cobb-Douglas production functions are limited in application because they can merely generate a single value (a constant number or a unity) as the estimate of all ES terms in a type of production. Liao's and Liang's estimates are the Allen's partial elasticities of substitution[15] derived based on the fitted transcendental logarithmic cost functions. This type of ESs is the one needed for our study.

Liao (1983:59-60) estimates the ESs for the production of three types of farm products (rice, tea, and mixed crops) based on the pooled time-serial and cross-sectional cost data for the period of 1959-68. The ESs are defined in terms of five factors of production--labor, dry land, paddyfields, fixed capital assets, and variable capital assets. In our agricultural productions, labor, capital, dry land, and two types of paddyfields are defined as the factors of production. We use two sets of Liao's estimates: one is the set of ESs in the rice production from paddyfields; and another is the set of ESs in the production of mixed crops from dry lands. The first set of Liao's estimates is used as the ESs in the two rice productions; and the second is used as the ESs in the non-rice agricultural production. Except those ESs related to the fixed capital assets, all Liao's estimates are directly applied to our study.

For the two rice industries, the cross-ES is 0.8381 between land and labor, 0.1487 between land and capital, and -0.0655 between labor and capital. The estimated own-ES is -1.1503 for land, -0.3683 for labor, and -0.5753 for capital.

Let S^n denote the five by five ES matrix containing twenty-five various own- and cross-ES values in the production of industry n. Then, for the rice production from tenant-cultivated paddyfields,

$$S^1 = \begin{bmatrix} -1.11503 & 0 & 0.8381 & 0.1487 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0.8381 & 0 & -0.3683 & -0.0655 & 0 \\ 0.1487 & 0 & -0.0655 & -0.5753 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

For the rice production from self-cultivated paddy fields,

$$S^2 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & -1.1503 & 0.8381 & 0.1487 & 0 \\ 0 & 0.8381 & -0.3683 & -0.0655 & 0 \\ 0 & 0.1487 & -0.0655 & -0.5753 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

For the non-rice agricultural industry, the estimated cross-ES is 0.0486 between land and labor, -0.0864 between land and capital, and 0.9034 between labor and capital. The estimated own-ES is -13.1149 for land, -0.5630 for labor, and -0.1518 for capital. The ESs in the non-rice agricultural production is S^4.

$$S^4 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -0.5639 & 0.9034 & 0.0486 \\ 0 & 0 & 0.9034 & -0.1518 & -0.0864 \\ 0 & 0 & 0.0486 & -0.0864 & -13.1149 \end{bmatrix}$$

Liang (1982:51) estimates the ESs for the production of four sectors of economy--service, agriculture, transportation, and industry (excluding transportation), based on the annual cost data for the years 1956-76. We use the set of Liang's ESs in the production of the industrial sector as the ESs in our non-agricultural production. In Liang's estimation, the ESs are defined in terms of four factors of production--labor, capital, energy, and raw materials. In ours, the ESs are defined in terms of merely two factors of production--labor and capital. All Liang's ESs related to the inputs of labor and capital are directly applied to out study.

Thus, the cross-ES is 0.162 between labor and capital and the own-ES is -2.744 for labor and -2.581 for capital in the non-agricultural production. The ESs can be expressed by S^3.

$$S^3 = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -2.744 & 0.162 & 0 \\ 0 & 0 & 0.162 & -2.581 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

A set of assumed values are used because existing literature provides no estimates on the ESs in consumption. We choose unity as the value of the cross-ES between rice and the non-rice agricultural goods and 0.1 as the value of the cross-ES between the non-agricultural goods and rice/non-rice-agricultural goods, based on the belief that the ES between the rice and non-rice agricultural goods is relatively high and the ES between the non-agricultural goods and rice/non-rice-agricultural goods is relatively low.

Let T^j be the three by three ES matrix containing nine various own- and cross-ES values in consumption of consumers of class j, where j=1,2,3,4,5. T^j is expressed as

$$T^j = \begin{bmatrix} -0.2288 & 0.1 & 1 \\ 0.1 & -0.1844 & 0.1 \\ 1 & 0.1 & -0.2584 \end{bmatrix}$$

The diagonal elements of matrix T^j are respectively the own-ES value for rice (-0.2288), for non-rice agricultural goods (-0.1844) and for non-rice agricultural goods (-0.2584). These values are determined by solving the three independent equations expressed in matrix form in equation (5.3).

(5.3) $$T_{.m}^{j} D^{jT} = 0_3,$$

where, D^{jT} denotes the transpose of the initial expenditure share vector for consumers of class j, $T_{.m}^{j}$ is row . of matrix T^j, .=m=1,2,3, and 0_3 is a column vector containing three zero elements. Equation (5.3) is developed because substitution among commodities is restrained by a consumer's income.

5.1.6 Slope of the Equilibrium Tenant Land Supply Function

In model II, we introduce the equilibrium tenant land supply function as the tenant market equilibrium condition. The slope value of this supply function is needed for solving the impact vector of model II. This slope value, a_0, is defined as the percentage change in the land area supplied for tenancy ($\partial \ln n_1$) divided by the percentage change in the normalized tenant rent ($\partial \ln w_1$), following a complete adjustment in production and consumption induced by the rent reduction.

To estimate a_0, we assume that the adjustment in production and consumption completely occurred during the three-year period, 1949-1952. Existing literature provides no theories on how to determine the length of time which would allow the complete adjustment in production and consumption to occur. In this study, we use the three-year period based on the belief that changes in the economic variables within this period reflects more of the effects of the rent reduction. If a longer time duration were chosen, changes in the economic variables would probably reflect more of the effects of the Land-to-the-Tiller Act instituted in 1953.[16]

The percentage change in the normalized tenant rent is equal to the difference between the percentage change in the nominal tenant rent and the percentage change in the nominal price of the capital services. Compare the original 74.44 percent tenant land rental rate (estimated in section 5.1.2 of chapter 5) with the regulated 37.5 percent rental ceiling, we figure out that 49.6208 percent is the government-targeted decrease rate in the nominal tenant rent.[17] Bao (1952) suggests that the nominal rate of returns to the capital assets were stable during 1949-1952. Thus, we conclude that the percentage change in the normalized tenant rent was -49.6208 percent during 1949-1952. During the same time period, 7,080 (of the original 281,221) hectares of paddyfields were converted from tenancy to self cultivation.[18]

Therefore, the percentage change in the tenant land area is -2.5176 percent. In sum, the estimated value of a_0 is 19.7096 percent (the quotient of -49.6208 percent divided by -2.5176 percent).

5.2 The Numerical Analysis

Section 5.2 presents the impact analysis based on the solutions of the impact vectors obtained from the two theoretical models.

The last column of Tables 5.3 and 5.4 respectively displays the solution of the impact vector for models I and II. The solution of the impact vector is obtained by inserting into matrices A, B, G and H the values of the various distributive shares and the elasticities of substitution in production and consumption (estimated in section 5.1).

Row 12 of the last column of Table 5.3 shows that the equilibrium tenant rental-acreage trade-off $(-\partial \ln w_1 / \partial \ln n_1)$ has a value of -0.000483 when market demand forces play a dominant role in the determination of the land area used for tenancy. Applying the inverse of -0.000483, we estimate that the land area needed by tenant farmers would be increased by 2,070 percent following a one percent decrease in the normalized tenant rent.

Government-regulated rental ceiling targeted for a 49.6208 percent decrease in the nominal tenant rent. Since the nominal price of the capital services was stable, as a result of rent reduction, the paddyfield area needed by tenant farmers would have been increased by 102,697 percent. The area of paddyfield supplied for tenancy actually decreased by 2.5176 percent. Thus, an excess demand for tenant land would have been resulted from the increase in the demand and the decrease in the supply. The excess demand for tenant land would have been approximately one thousand twenty seven times the original land size used for tenancy.

The product of the actual 2.5176 percent decrease in the tenant land area supplied for tenancy and the numerical values of the last column of Table 5.4 provides information on the percentage changes in the sixteen normalized endogenous variables induced by the rent reduction. We summarize these changes as follows.

All normalized input prices would be decreased. Normalized land income per hectare of self-cultivated paddyfield would be decreased by 49.37 percent. Normalized tenant rent income per hectare of paddyfield would be decreased by 49.36 percent. Normalized wage income would be decreased by 26.42 percent. And normalized land income per hectare of dry land would be decreased by 4.86 percent.

Although all consumers lose in normalized income, not all of them lose in real income. Wage workers and owners of the two types of paddyfields would lose in real income while capitalists and dry land owners would gain in real income. The loss would be 19.70 percent for wage workers and 42.64 percent for paddyfield owners. The gain would be 3.78 percent for capitalists and 1.86 percent for dry land owners.

All normalized output prices would be lower and all industry outputs (except the rice output produced from tenant-cultivated paddyfields) would be decreased.

Normalized rice price would be decreased by 16.77 percent, the normalized price of the non-rice agricultural goods would be decreased by 10.59 percent, and the normalized price of the non-agricultural goods would be decreased by 2.68 percent.

The rice output produced from tenant-cultivated paddyfields would be increased by 9.63 percent, the rice output produced from self-cultivated paddyfields would be decreased by 36.03 percent, the non-agricultural output would be decreased by 10.65 percent, and the non-rice agricultural output would be decreased by 13.45 percent.

Based on the solution of the impact vector obtained from model II, we determine an industry's national product share at the new equilibrium through the following three steps.

First, we determine the percentage change in the national product share produced by industry n, by adding together the percentage changes in the output level and in the output price of industry n. The rate of change in the national product share of each industry would be: -7.14 percent for the tenant-cultivated rice industry; -52.80 percent for the owner-cultivated rice industry; -13.33 percent for the non-agricultural industry; and -24.03 percent for the non-rice agricultural industry.

Second, multiplying the above estimated rate of change with the initial national product share produced by industry n (the latter is displayed in row one of Table 5.5), the value of the output produced by industry n at the new equilibrium can be expressed as a ratio to the initial national product. The rice output produced from tenant-cultivated paddyfields is worth 9.96 percent of the initial national product, the rice output produced from self-cultivated paddyfields is worth 4.27 percent of the initial national product, the non-agricultural output is worth 55.55 percent of the initial national product, and the non-rice agricultural output is worth 12.51 percent of the initial national product. In sum, following a complete adjustment in production and consumption induced by the rent reduction, the new national product would be worth 81.97 percent of the initial national product. (Both the new and the initial national outputs are measured in normalized terms).

Third, dividing industry n's new output value as a ratio to the initial national product by the ratio of the new national product to the initial national product (i.e. 81.97%), we estimate the national product share produced by industry n at the new equilibrium. The shares are: 11.76 percent for the rice industry produced from tenant-cultivated paddyfields; 5.21 percent for the rice industry produced from self-cultivated paddyfields; 67.77 percent for the non-agricultural industry; and 15.26 percent for the non-rice agricultural industry. Row two of Table 5.5 summarizes the national product shares produced respectively by the five industries at the new equilibrium.

In sum, the value of the total national product (measured by normalized terms) would be decreased. The 9.6 percent increase in the value of the rice output from tenant-cultivated paddyfields can not offset the 26.03 percent decrease in the value of the rice output from self-cultivated paddyfields. Outputs of the other industries would also be decreased. At the new equilibrium, the non-agricultural industry and the tenant-cultivated rice industry would produce a larger portion of the national product while the owner-cultivated rice industry and the non-rice agricultural industry would produce a smaller portion of the national product.

Based on the solution of the impact vector from model II, we can also determine the real factor income shares at the new equilibrium through the following three steps.

First, we determine the rate of change in the real income share of input i, by adding together the percentage change in the total number of consumers holding input i and the percentage change in the real national income possessed by the owner of a unit of input i.[19] After the implementation of the rent reduction, the total numbers of laborers, capitalists, and dry land owners remain unchanged, but the total number of paddyfield landlords decreases and that of paddyfield owner-cultivators increases. The decrease rate in the former is 2.5176 percent and the increase rate in the latter is 2.8879 percent.[20] The solution of the impact vector from model II shows that real income per hectare of paddyfield would be decreased by 42.64 percent, real income per unit of the quality-standardized labor services would be decreased by 19.70 percent, real income per unit of the quantity-standardized capital services would be increased by 3.79 percent, and real income per hectare of dry land would be increased by 1.89 percent. Thus, the rate of changes in the various real factor income shares would be -45.16 percent for tenant-cultivated paddyfield, -39.75 percent for self-cultivated paddyfield, -19.70 percent for labor, 3.79 percent for capital, and 1.86 percent for dry land.

Second, multiplying the estimated rate of change in the real factor income share with the initial real factor income share of input i (the latter is displayed in row three of Table 5.5), the new real factor income of input i is expressible as a ratio of the initial real national income. The ratios would be 4.24 percent for tenant-cultivated paddyfield, 4.06 percent for self-cultivated paddyfield, 25.53 percent for labor, 51.95 percent for capital, and 3.77 percent for dry land. In sum, the new real national income level is 89.53 percent of the initial real national income level.

Third, dividing each input's new real factor income share as a ratio to the initial real national income by the ratio of the new real national income to the initial real national income, we determine the new real factor income shares for different inputs. They are: 4.74 percent for

Table 5.3 Percentage change in the endogenous variables due to a 1 percent decrease in the paddyfield area needed for tenancy (model I)

1	Substitution in rice production from tenant-cultivated paddyfield	High	High	High	High
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	High	High	High	High
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1/\partial \ln n_1$	0.000517	0.000358	0.000166	0.000128
6	$-\partial \ln p_2/\partial \ln n_1$	0.000129	0.000080	0.000107	0.000067
7	$-\partial \ln p_3/\partial \ln n_1$	-0.000556	-0.000251	-0.000450	-0.000206
8	$-\partial \ln y_1/\partial \ln n_1$	-0.999209	-0.999497	-1.000147	-1.000119
9	$-\partial \ln y_2/\partial \ln n_1$	1.146222	1.146512	1.147381	1.147285
10	$-\partial \ln y_3/\partial \ln n_1$	0.000171	0.000105	0.000175	0.000113
11	$-\partial \ln y_4/\partial \ln n_1$	0.000317	0.000197	0.000250	0.000160
12	$-\partial \ln w_1/\partial \ln n_1$	0.001298	0.000933	0.000197	0.000200
13	$-\partial \ln w_2/\partial \ln n_1$	-0.000457	-0.000151	0.000817	0.000703
14	$-\partial \ln w_3/\partial \ln n_1$	0.000482	0.000298	0.000401	0.000251
15	$-\partial \ln w_5/\partial \ln n_1$	0.000221	0.000074	0.000179	0.000060
16	$-\partial \ln u_1/\partial \ln n_1$	0.001206	0.000854	0.000164	0.000166
17	$-\partial \ln u_2/\partial \ln n_1$	-0.000549	-0.000231	0.000791	0.000669
18	$-\partial \ln u_3/\partial \ln n_1$	0.000391	0.000219	0.000374	0.000217
19	$-\partial \ln u_4/\partial \ln n_1$	-0.000001	-0.000017	0.000002	-0.000011
20	$-\partial \ln u_5/\partial \ln n_1$	0.000130	-0.000005	0.000153	0.000026

Table 5.3 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	High	High	High	High
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	Low	Low	Low	Low
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1/\partial \ln n_1$	0.027200	0.000783	0.001648	0.001374
6	$-\partial \ln p_2/\partial \ln n_1$	0.002700	0.000068	0.000514	0.000099
7	$-\partial \ln p_3/\partial \ln n_1$	-0.035017	-0.000644	-0.006413	-0.000908
8	$-\partial \ln y_1/\partial \ln n_1$	-0.949426	-0.998695	-1.000752	-0.997307
9	$-\partial \ln y_2/\partial \ln n_1$	1.102440	1.145862	1.151692	1.144275
10	$-\partial \ln y_3/\partial \ln n_1$	0.012717	0.000318	0.002764	0.000392
11	$-\partial \ln y_4/\partial \ln n_1$	0.020032	0.000506	0.003524	0.000703
12	$-\partial \ln w_1/\partial \ln n_1$	0.063827	0.001939	0.000279	0.003610
13	$-\partial \ln w_2/\partial \ln n_1$	-0.046313	-0.000829	0.005947	-0.002797
14	$-\partial \ln w_3/\partial \ln n_1$	0.030275	0.000761	0.005758	0.001107
15	$-\partial \ln w_5/\partial \ln n_1$	0.013938	0.000189	0.002554	0.000265
16	$-\partial \ln u_1/\partial \ln n_1$	0.062578	0.001849	0.000686	0.003429
17	$-\partial \ln u_2/\partial \ln n_1$	-0.047561	-0.000918	0.006354	-0.002978
18	$-\partial \ln u_3/\partial \ln n_1$	0.029026	0.000671	0.006165	0.000926
19	$-\partial \ln u_4/\partial \ln n_1$	0.003508	0.000047	0.000695	0.000060
20	$-\partial \ln u_5/\partial \ln n_1$	0.012690	0.000100	0.002961	0.000084

Table 5.3 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	Low	Low	Low	Low
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	High	High	High	High
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1 / \partial \ln n_1$	0.000212	0.000167	0.000120	0.000091
6	$-\partial \ln p_2 / \partial \ln n_1$	0.000075	0.000052	0.000101	0.000062
7	$-\partial \ln p_3 / \partial \ln n_1$	-0.000342	-0.000182	-0.000424	-0.000194
8	$-\partial \ln y_1 / \partial \ln n_1$	-0.999147	-0.999357	-0.999893	-0.001000
9	$-\partial \ln y_2 / \partial \ln n_1$	1.146165	1.146375	1.147095	1.147056
10	$-\partial \ln y_3 / \partial \ln n_1$	0.000135	0.000098	0.000172	0.000113
11	$-\partial \ln y_4 / \partial \ln n_1$	0.000206	0.000148	0.000236	0.000152
12	$-\partial \ln w_1 / \partial \ln n_1$	0.001339	0.001082	0.000484	0.000436
13	$-\partial \ln w_2 / \partial \ln n_1$	-0.000560	-0.000330	0.000484	0.000436
14	$-\partial \ln w_3 / \partial \ln n_1$	0.000280	0.000196	0.000377	0.000233
15	$-\partial \ln w_5 / \partial \ln n_1$	0.000136	0.000055	0.000169	0.000057
16	$-\partial \ln u_1 / \partial \ln n_1$	0.001306	0.001046	0.000466	0.000410
17	$-\partial \ln u_2 / \partial \ln n_1$	-0.000593	-0.000366	0.000466	0.000410
18	$-\partial \ln u_3 / \partial \ln n_1$	0.000247	0.000160	0.000359	0.000208
19	$-\partial \ln u_4 / \partial \ln n_1$	0.000004	-0.000007	0.000003	-0.000010
20	$-\partial \ln u_5 / \partial \ln n_1$	0.000103	0.000019	0.000151	0.000031

Table 5.3 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	Low	Low	Low	Low	Taiwan
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low	Taiwan
3	Substitution in nonagricultural production	Low	Low	Low	Low	Taiwan
4	Substitution in non-rice agricultural production	High	Low	High	Low	Taiwan
5	$-\partial \ln p_1/\partial \ln n_1$	0.000522	0.000265	0.001469	0.000165	0.000165
6	$-\partial \ln p_2/\partial \ln n_1$	0.000073	0.000032	0.000594	0.000050	0.000026
7	$-\partial \ln p_3/\partial \ln n_1$	-0.000993	-0.000333	-0.007385	-0.000458	0.000105
8	$-\partial \ln y_1/\partial \ln n_1$	-0.997683	-0.998887	-0.998184	-0.999803	-0.999878
9	$-\partial \ln y_2/\partial \ln n_1$	1.144868	1.145979	1.149506	1.147206	1.147067
10	$-\partial \ln y_3/\partial \ln n_1$	0.000430	0.000197	0.003236	0.000288	0.000105
11	$-\partial \ln y_4/\partial \ln n_1$	0.000593	0.000269	0.004037	0.000353	0.000132
12	$-\partial \ln w_1/\partial \ln n_1$	0.003129	0.001655	0.003411	0.000616	0.000483
13	$-\partial \ln w_2/\partial \ln n_1$	-0.001979	-0.000762	0.003411	0.000616	0.000483
14	$-\partial \ln w_3/\partial \ln n_1$	0.000821	0.000363	0.006663	0.000563	0.000261
15	$-\partial \ln w_5/\partial \ln n_1$	0.000395	0.000100	0.002941	0.000133	0.000048
16	$-\partial \ln u_1/\partial \ln n_1$	0.003144	0.001638	0.003960	0.000627	0.000417
17	$-\partial \ln u_2/\partial \ln n_1$	-0.001964	-0.000780	0.003961	0.000627	0.000417
18	$-\partial \ln u_3/\partial \ln n_1$	0.000836	0.000346	0.007213	0.000574	0.000195
19	$-\partial \ln u_4/\partial \ln n_1$	0.000106	0.000029	0.000807	0.000040	-0.000037
20	$-\partial \ln u_5/\partial \ln n_1$	0.000410	0.000082	0.003491	0.000144	-0.000018

Note: Please see sections 5.2 and 5.3 of the text for calculation procedures.

Table 5.4 Percentage change in the endogenous variables due to a 1 percent decrease in the paddyfield area supplied for tenancy (model II)

1	Substitution in rice production from tenant-cultivated paddyfield	High	High	High	High
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	High	High	High	High
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1/\partial \ln n_1$	-7.803158	-7.523368	-16.858903	-12.407865
6	$-\partial \ln p_2/\partial \ln n_1$	-1.940352	-1.665420	-10.838842	-6.465097
7	$-\partial \ln p_3/\partial \ln n_1$	8.389856	5.276421	45.699181	20.003285
8	$-\partial \ln y_1/\partial \ln n_1$	-9.282740	-6.461847	38.525608	34.026359
9	$-\partial \ln y_2/\partial \ln n_1$	8.093826	4.730266	-69.771588	-57.136490
10	$-\partial \ln y_3/\partial \ln n_1$	-2.577536	-2.207953	-17.791852	-11.014358
11	$-\partial \ln y_4/\partial \ln n_1$	-4.790999	-4.138601	-25.413244	-15.543379
12	$-\partial \ln w_1/\partial \ln n_1$	-19.607843	-19.607843	-19.607843	-19.607843
13	$-\partial \ln w_2/\partial \ln n_1$	6.826684	3.080867	-83.539584	-68.493919
14	$-\partial \ln w_3/\partial \ln n_1$	-7.266302	-6.236726	-40.589679	-24.210735
15	$-\partial \ln w_5/\partial \ln n_1$	-3.339437	-1.550354	-18.196671	-5.841267
16	$-\partial \ln u_1/\partial \ln n_1$	-18.229698	-17.947514	-16.911035	-16.347358
17	$-\partial \ln u_2/\partial \ln n_1$	8.204732	4.741109	-80.843006	-65.233577
18	$-\partial \ln u_3/\partial \ln n_1$	-5.888189	-4.576428	-37.892936	-20.950291
19	$-\partial \ln u_4/\partial \ln n_1$	0.013584	0.344696	-0.251335	1.090698
20	$-\partial \ln u_5/\partial \ln n_1$	1.961437	0.109836	-15.500230	-2.581043

Table 5.4 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	High	High	High	High
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	Low	Low	Low	Low
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1/\partial \ln n_1$	-8.355800	-7.914850	-114.672762	-20.032102
6	$-\partial \ln p_2/\partial \ln n_1$	-0.829448	-0.684729	-35.722405	-4.661581
7	$-\partial \ln p_3/\partial \ln n_1$	10.757000	6.512352	446.143769	42.499484
8	$-\partial \ln y_1/\partial \ln n_1$	-16.461107	-11.735122	68.237703	32.709896
9	$-\partial \ln y_2/\partial \ln n_1$	14.737521	9.436550	-347.434397	-78.779301
10	$-\partial \ln y_3/\partial \ln n_1$	-3.906619	-3.219978	-192.319036	-25.948878
11	$-\partial \ln y_4/\partial \ln n_1$	-6.153921	-5.113251	-245.217173	-32.810164
12	$-\partial \ln w_1/\partial \ln n_1$	-19.607843	-19.607843	-19.607843	-19.607843
13	$-\partial \ln w_2/\partial \ln n_1$	14.225414	8.322005	-414.175838	-94.265818
14	$-\partial \ln w_3/\partial \ln n_1$	-9.299918	-7.677306	-400.525833	-52.266454
15	$-\partial \ln w_5/\partial \ln n_1$	-4.281524	-1.914801	-177.676328	-12.357593
16	$-\partial \ln u_1/\partial \ln n_1$	-19.224270	-18.703623	-47.907942	-19.727087
17	$-\partial \ln u_2/\partial \ln n_1$	14.608868	9.226121	-442.478214	-94.385373
18	$-\partial \ln u_3/\partial \ln n_1$	-8.916380	-6.773121	-428.826284	-52.385773
19	$-\partial \ln u_4/\partial \ln n_1$	-1.077635	-0.476878	-48.353260	-3.622319
20	$-\partial \ln u_5/\partial \ln n_1$	-3.898093	-1.010717	-205.978485	-12.477197

Table 5.4 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	Low	Low	Low	Low
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low
3	Substitution in nonagricultural production	High	High	High	High
4	Substitution in non-rice agricultural production	High	Low	High	Low
5	$-\partial \ln p_1/\partial \ln n_1$	-3.107266	-3.021001	-4.826581	-4.088398
6	$-\partial \ln p_2/\partial \ln n_1$	-1.089437	-0.941775	-4.032453	-2.768877
7	$-\partial \ln p_3/\partial \ln n_1$	4.993105	3.295438	17.057443	8.686305
8	$-\partial \ln y_1/\partial \ln n_1$	-9.921567	-8.252472	4.395739	5.994882
9	$-\partial \ln y_2/\partial \ln n_1$	8.717308	6.726385	-15.414558	-15.486211
10	$-\partial \ln y_3/\partial \ln n_1$	-1.980025	-1.785442	-6.933091	-5.054490
11	$-\partial \ln y_4/\partial \ln n_1$	-3.016707	-2.679915	-9.519029	-6.786891
12	$-\partial \ln w_1/\partial \ln n_1$	-19.607843	-19.607843	-19.607843	-19.607843
13	$-\partial \ln w_2/\partial \ln n_1$	8.118971	5.891793	-19.608154	-19.608081
14	$-\partial \ln w_3/\partial \ln n_1$	-4.079764	-3.526793	-15.100881	-10.368992
15	$-\partial \ln w_5/\partial \ln n_1$	-1.985747	-0.991839	-6.791659	-2.545764
16	$-\partial \ln u_1/\partial \ln n_1$	-19.128122	-18.959931	-18.894573	-18.469235
17	$-\partial \ln u_2/\partial \ln n_1$	8.598652	6.539669	-18.894592	-18.469521
18	$-\partial \ln u_3/\partial \ln n_1$	-3.600055	-2.878892	-14.387621	-9.230396
19	$-\partial \ln u_4/\partial \ln n_1$	-0.063655	0.119622	-0.130758	0.423664
20	$-\partial \ln u_5/\partial \ln n_1$	-1.506086	-0.343985	-6.078501	-1.407247

Table 5.4 (Continued)

1	Substitution in rice production from tenant-cultivated paddyfield	Low	Low	Low	Low	Taiwan
2	Substitution in rice production from self-cultivated paddyfield	High	High	Low	Low	Taiwan
3	Substitution in nonagricultural production	Low	Low	Low	Low	Taiwan
4	Substitution in non-rice agricultural production	High	Low	High	Low	Taiwan
5	$-\partial \ln p_1/\partial \ln n_1$	-3.271486	-3.139803	-8.437839	-5.243456	-6.661820
6	$-\partial \ln p_2/\partial \ln n_1$	-0.457757	-0.382471	-3.411442	-1.585163	-1.064583
7	$-\partial \ln p_3/\partial \ln n_1$	6.212439	3.944064	42.399418	14.479560	-4.204989
8	$-\partial \ln y_1/\partial \ln n_1$	-13.987242	-11.293098	-10.033816	0.424041	3.825517
9	$-\partial \ln y_2/\partial \ln n_1$	12.507389	9.468230	-15.064028	-15.374094	-14.309828
10	$-\partial \ln y_3/\partial \ln n_1$	-2.693064	-2.338426	-18.578833	-9.126672	-4.229892
11	$-\partial \ln y_4/\partial \ln n_1$	-3.715276	-3.189996	-23.178834	-11.187201	-5.340704
12	$-\partial \ln w_1/\partial \ln n_1$	-19.607843	-19.607843	-19.607843	-19.607843	-19.607843
13	$-\partial \ln w_2/\partial \ln n_1$	12.358806	8.959002	-19.608508	-19.608194	-19.608013
14	$-\partial \ln w_3/\partial \ln n_1$	-5.132446	-4.288330	-38.249681	-17.773123	-10.494556
15	$-\partial \ln w_5/\partial \ln n_1$	-2.471059	-1.182751	-16.886796	-4.212404	-1.931048
16	$-\partial \ln u_1/\partial \ln n_1$	-19.701942	-19.402187	-22.764755	-19.957703	-16.938471
17	$-\partial \ln u_2/\partial \ln n_1$	12.264656	9.164614	-22.765608	-19.958142	-16.938697
18	$-\partial \ln u_3/\partial \ln n_1$	-5.226557	-4.082687	-41.406615	-18.123000	-7.825215
19	$-\partial \ln u_4/\partial \ln n_1$	-0.666195	-3.434121	-4.632460	-12.667978	1.504399
20	$-\partial \ln u_5/\partial \ln n_1$	-2.565213	-9.771490	-20.043863	-4.562360	0.738201

Note: Please see sections 5.2 and 5.3 of the text for calculation procedure.

Table 5.5
Industry Output and Real Factor Income Share Before and After the Implementation of the Rent Reduction

	Industry Output Share				
	Rice Industry from Tenant-Cultivated Paddyfields	Rice Industry from Owner-Cultivated Paddyfields	Non-Agricultural Industry	Non-rice Agricultural Industry	Total
Before Rent Reduction	10.38%	9.05%	64.10%	16.47%	100%
After Rent Reduction	11.76%	5.21%	67.77%	15.26%	100%

	Real Factor Income Share					
	Tenant-Cultivated Paddyfield	Self-Cultivated Paddyfield	Labor	Capital	Dry Land	Total
Before Rent Reduction	7.73%	6.74%	31.79%	50.05%	3.70%	100%
After Rent Reduction	4.74%	4.51%	28.52%	58.03%	4.21%	100%

Source: compiled by the author based on the information displayed in tables 5.2 and 5.4 of this study.

tenant-cultivated paddyfield, 4.53 percent for self-cultivated paddyfield, 28.51 percent for labor, 58.01 percent for capital, and 4.21 percent for dry land. Row four of Table 5.5. summarizes these new real factor income shares.

As a result of the rent reduction, the real factor income share decrease for labor and for both types of paddyfields but increases for capital and dry land. The rate of increase of the real capital income share is much larger than that of the real dry land income share.

5.3 The Sensitivity Analysis

Section 5.3 interprets the results of the sensitivity test.

In the sensitivity analysis, we test how the solution of the impact vector from the two models would be changed when we alter the magnitude of the cross-ESs in production. Two sets of assumed values are alternately assigned to the cross-ESs in the production of the four industries. One set contains the cross-ES values of 1 (high values) and another the values of 0.1 (low values). No attempts are made to test the sensitivity of the impact analysis to the magnitude of the own-ESs in production and the ESs in consumption.

The results of the sensitivity test are displayed in the first sixteen columns of Table 5.3 (for model I) and Table 5.4 (for model II). In both tables, the notations H and L respectively indicate that the values of 1s and the values of 0.1s are assigned as the cross-ES values in the designated production.

Based on the numerical values displayed in row 12 of Table 5.3, we learn that the excess demand for tenant land would be larger when the cross-ESs are high in both the non-agricultural production and the rice production from tenant-cultivated paddyfields while low in both the non-rice agricultural production and the rice production from self-cultivated paddyfields. The size of the excess demand for tenant land is very sensitive too the magnitude of the cross-ESs in the non-rice agricultural production, when the non-agricultural production and the rice production from tenant-cultivated paddyfields have high cross-ES values while the rice production from self-cultivated paddyfields has low cross-ES values.

The numerical value of the impact term $\partial \ln w_1/\partial \ln n_1$, displayed in row 12 of Table 5.4, always equals -19.607843. As long as the slope value is predetermined for the equilibrium tenant land supply function, the magnitude of the cross-ESs in production would not affect the tenant rental-acreage trade-off relationship (which is the inverse of the estimated slope value of equation (4.8)).

Percentage changes in the other normalized input prices vary when the magnitude of the cross-ESs changes in production.

Normalized land income per hectare of self-cultivated paddyfield varies in different direction when the magnitude of the cross-ESs changes from a low to a high value in the rice production from self-cultivated paddyfields. The normalized land income would be increased when the cross-ESs have a high value, and would be decreased when the cross-ESs have a low value.

Normalized wage rate and normalized land income per hectare of dry land would always be decreased no matter how we vary the magnitude of the cross-ESs in production.

The rate of change in normalized land income per hectare of paddyfield is the same for both types of paddyfields when values of the cross-ESs are low in both rice productions. They are different when values of the cross-ESs are high in both rice productions.

The rate of change would be different in normalized wage rate, in normalized land income per hectare of dry land, and in normalized income per hectare of self-cultivated paddyfield when we change the magnitude of the cross-ESs in different productions.

With the high (low) cross-ES values in the rice production from self-cultivated paddyfields, normalized income would be increased (decreased) for paddyfield owner-cultivators and decreased (increased) for wage workers and dry land owners.

With the high (low) cross-ES values in the rice production from tenant-cultivated paddyfields, normalized income would be increased by a smaller (larger) rate and decreased by a larger (smaller) rate for paddyfield owner-cultivators and normalized income would be decreased by a larger (smaller) rate for wage workers and dry land owners.

When the cross-ES values are high (low) in the non-agricultural production, the rate of gains or losses in the normalized income would be smaller (larger) for wage workers, dry land owners, and paddyfield owner-cultivators.

When the cross-ES values are high (low) in the non-rice agricultural production, normalized income gains or losses would be larger (smaller) for wage workers, dry land owners, and paddyfield owner-cultivators.

The magnitude of the cross-ESs would also affect the real income level obtainable by consumers in the same manner as it affects the normalized income obtainable by consumers. Capitalists and dry land owners would possibly gain in real income while wage workers and owners of both types of paddyfields would possibly lose.

The real income level obtainable by capitalists would rise when the high value is assigned to the cross-ESs in the non-agricultural production and when the low value is assigned to the cross-ESs in the non-rice agricultural production. The rate of gain for capitalists is higher (lower) when the cross-ES values are high (low) in the rice production from tenant-cultivated paddyfields and when these values are low (high) in the rice production from self-cultivated paddyfields. When the values assigned to the cross-ES terms differ from the values stated above, capitalists would possibly lose in real income.

Paddyfield owner-cultivators would gain (lose) in real income when the cross-ES values are high (low) in the rice production from self-cultivated paddyfields. The rate of gain (loss) is larger (smaller) when the cross-ES values are low (high) in the non-agricultural production, low (high) in the rice production from tenant-cultivated paddyfields, and high (low) in the non-rice agricultural production.

The magnitude of the cross-ESs in production would affect the size of the decrease rate in the real income levels obtainable by landlords, wage workers, and dry land owners. When the ES values are high (low) in the rice production from tenant-cultivated paddyfields, the decrease rate would be smaller (larger) for landlords and larger (smaller) for wage workers and dry land owners. When the ES values are high (low) in the rice production from self-cultivated paddyfields, the decrease rate would be larger (smaller) for the owners of both tenant and dry lands, but smaller (larger) for wage workers. When the ES values are high (low) in the non-agricultural production, the decrease rate would be smaller (larger) for wage workers and the owners of tenant and dry lands. When the ES values are high (low) in the non-rice agricultural production, the decrease rate would be larger (smaller) for consumers in the above three classes.

The rate of change in the industry output varies when the magnitude of the cross-ESs changes in different productions. All industry outputs, except for the rice output from tenant-cultivated paddyfields, would decrease no matter how values are changed for the cross-ES terms.

When the cross-ES values are high (low) in the rice production from self-cultivated paddyfields, the rice output would be decreased (increased) from tenant-cultivated paddyfields and increased (decreased) from self-cultivated paddyfields. The decrease rate is smaller (larger) for both non-agricultural and non-rice agricultural outputs.

When the cross-ES values are high (low) in the rice production from tenant-cultivated paddyfields, the rate of change would be larger (smaller) for the rice output from tenant-cultivated paddyfields; the rice output from self-cultivated paddyfields would be increased by a smaller (larger) rate or decreased by a larger (smaller) rate. The decrease rate would be larger (smaller) for both non-agricultural and non-rice agricultural outputs.

When the cross-ES values are high (low) in the non-agricultural production, industry's output would vary by a smaller (larger) rate. On the other hand, when the cross-ES values are high (low) in the non-rice agricultural production, industry's output would vary by a larger (smaller) rate.

The rate of changes in normalized commodity prices differ when the magnitude of the cross-ESs varies in different productions.

When the cross-ES values are high (low) in the rice production from tenant-cultivated paddyfields, all normalized commodity prices would change by a larger (smaller) rate. When the cross-ES values are high (low) in the rice production from self-cultivated paddyfields, all normalized commodity prices would change by a smaller (larger) rate. When the cross-ES values are high (low) in the non-agricultural production, rice would have a lower normalized price, non-rice agricultural goods would have a smaller (larger) rate of increase and non-agricultural goods would have a larger (smaller) rate of decrease in the normalized price. When the cross-ES values are high (low) in the non-rice agricultural production, all normalized commodity prices would change by a smaller (larger) rate.

5.4 Summary

Chapter five describes the estimated values of the various distributive shares and the elasticities of substitution in production and consumption for the Taiwanese economy. It then presents the results of the numerical and the sensitivity analysis derived based the Taiwanese data.

The numerical analysis generates two important conclusions. First, the rent reduction would reduce the real income levels obtainable by paddyfield landlords, wage workers and paddyfield owner-cultivators, while raise that obtainable by capitalists and dry land owners. Second, the gross national product would decrease as a result of the rent reduction.

The above rent reduction effects were obtained based on the assumption that consumers of each class possess only one unit of a single type of productive factor as endowment. The imposition of this assumption will not affect the validity of this analysis in the prediction of the real income redistribution effects of the rent reduction. For example, for a landlord who initially holds a hectare of paddyfield and also N.T.$1,000.00 capital assets as the endowment, the real income level obtainable by him/her would be decreased by a smaller rate compared to that obtainable by landlords who initially possess but one hectare of paddyfield as the endowment, because our impact analysis suggests that there is real income gain in the capital holdings. In the case that a landowner also holds labor as endowment, the real income level obtainable by him/her would be decreased by a much larger rate compared to that obtainable by landowners who initially possess no labor as the additional endowment, because our impact analysis suggests that there is real income loss in the labor holding.

Prior to the rent reduction, tenant land market distortions probably prevailed in Taiwan because of the heavy concentration in landholdings, the keen competition for chances to lease land, and the people's reliance on agriculture for living. Even if tenant rent were determined in a perfectly competitive market, the land rental could have been set at an unreasonably high rate by landlords due to the great demand in the tenant land market.

We may assume that the paddyfield markets were initially perfectly competitive, however, rental income per hectare of tenant-cultivated paddyfield was much higher than land income per hectare of self-cultivated paddyfield. If the tenant market conditions were consistent with these assumptions, and that the other input/output markets were perfectly competitive before the implementation of the rent reduction. Our findings from the impact analysis provide valid information for predicting the rent reduction effects in this case. As a result of rent reduction, gross national output would be decreased, real income levels would be higher for capitalists and dry land owners while lower for wage workers and owners of both types of paddyfields. Although real income would be decreased for owners of both types of paddyfields, the exact amount of real income loss would be much larger for paddyfield landlords compared to that for paddyfield owner-cultivators.

In contrast with the above assumptions, we may instead assume that the capital and tenant land markets were initially imperfectly competitive and that market demand forces did not play a dominant role in the other input/output markets. When the pre-existent input/output market conditions were consistent with these assumptions, the examination of the rent reduction effects must be based on the analytical framework(s) able to capture these features.

A sensitivity test is conducted to the impact analysis by varying the magnitude of the cross-elasticities of substitution in production. The results from the test suggest that the rent reduction effects would be different when we vary the magnitude of the cross-elasticities of substitution in production. Gross national product and the real income of consumers would be decreased at a larger (smaller) rate when the values of the cross-elasticities of substitution are high (low) in the non-rice agricultural production and in the rice production from tenant-cultivated paddyfields and low (high) in the non-agricultural production and in the rice production from self-cultivated paddyfields.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Farmland rent reduction in Taiwan was designed to redistribute income from landlords to tenants, provide tenants with incentives to improve productivity, and promote agricultural development. Whether these goals were achieved needs a thorough examination through the general equilibrium analysis. It is believed that the immediate effects of rent reduction do not endure, because they induce the occurrence of secondary effects after adjustments are made in production and consumption.

Two theoretical models were constructed to examine the impact of the rent reduction, based on a framework of two sectors, three commodities, four industries, five factors of production and five classes of consumers. In the analysis, we assume that all factor and commodity markets are initially perfectly competitive and that tenant- and self-cultivated paddyfields initially receive the same amount of land income.

Model I is composed of seventeen equilibrium conditions. They are: five demand-equal-to-supply equations on the factor markets; three demand-equal-to-supply equations in the commodity markets; four zero-profit relationships for the four industries; and five budget constraints for consumers of the five classes. Market demand forces are assumed to play a dominant role in the determination of all factor/commodity market equilibrium conditions.

Except the tenant market equilibrium condition, all equilibrium conditions appear in the same forms in both models. An equilibrium tenant land supply function is introduced as the tenant market equilibrium condition in model II. This approach is adopted based on the belief that it is able to better capture the dominant feature of the tenant market supply forces in the determination of land size used for tenancy after rent is lowered by the government mandate.

From model I, we derive an impact vector through a comparative static analysis based on a hypothetical one percent increase (from the initial equilibrium level) in the land area used for tenancy. The impact vector provides us with information to determine the excess demand for tenant land after rent is reduced. Based on the Taiwanese data, when the target rate of decrease occurs on tenant rent, excess demand for tenant land would be one thousand twenty seven times the original size of land supplied for tenancy.

From model II, an impact vector is obtained through a comparative static analysis based on a one percent decrease (from the initial equilibrium level) in the land area supplied for tenancy induced by the rent reduction. The impact vector provides us with information to determine the secondary effects of the rent reduction on the normalized input/output prices, the industry outputs, and the real income distribution. The results of the impact analysis based on the Taiwanese data suggest that, as a result of the rent reduction, gross national product and real incomes for wage workers and owners of both types of paddyfields would decrease, and real incomes for capitalists and dry land owners would slightly increase.

The findings of our impact analysis are generally consistent with the competitive market model. They suggest that inefficient production and resource allocation would be resulted from the rent reduction policy which renders tenant rent deviated from the competitive-market-determined level. At the same time, our findings suggest that a rent reduction program, able to draw rent closer to the competitive-market-determined level, can always promote efficiency in production and resource allocation.

The effects of the rent reduction should not be deducted simply based on the findings of our impact analysis. Prior to the land reform in Taiwan, tenant market distortions existed, landholdings were highly concentrated, and landless farmers competed for tenancy as a means of livelihood. Thus, the assumptions on the perfectly competitive tenant market and on the equivalent earnings from both types of paddyfields are not compatible with the reality.

Suppose markets for both tenant- and self-cultivated paddyfields were initially perfectly competitive, but tenant rent was much higher than earnings received from the self-cultivated paddyfields. The impact analysis derived from model II still provides us with valid guidelines to determine the effects of the rent reduction on the normalized input/output prices, the industry outputs, and the real income distribution. Though the rate of decrease in real income is the same for landlords and owner-cultivators of paddyfield in this situation, the amount of decrease in real income would be much larger for the landlords compared to that of the owner-cultivators.

Suppose markets for both capital and tenant-cultivated paddyfields were initially non-competitive and the dominant assumption on the market demand forces fails to depict the input/output market condition(s). Alternative model(s) should be formalized to capture these changes in order to trace the economic effects of the rent reduction.

For all the merits they entail, both models I and II have limitations. First, the solutions of both impact vectors are approximated based on the first-order differentiation. They err when higher-order differentiations are of non-negligible magnitude. Second, the parameter of the equilibrium tenant land supply function in model II is estimated based on the actual rate of changes occurred on the normalized tenant rent and the area of land supplied for tenancy during the three-year period after the implementation of the rent reduction. The three-year period is chosen based on the belief that the secondary effects of rent reduction completely occurred during that period. The choice, however, lacks any theoretical support from existing literature.

In the sensitivity analysis we show that outcomes of our findings are varied, depending on the magnitude of the cross-elasticities of substitution in different productions.

When low values are assigned to the cross-elasticities of substitution in the rice production from tenant-cultivated paddyfields, wage workers and owners of self-cultivated paddyfields would lose less in real income, whereas landlords, capitalists, and dry land owners would lose more (or gain less) in real income.

When low values are assigned to the cross-elasticities of substitution in the rice production from self-cultivated land, landlords would lose less in real income, whereas the other groups of consumers would lose more (or gain less) in real income.

When low values are assigned to the cross-elasticities of substutition in the non-agricultural production, paddyfield owner-cultivators would lose less in real income, whereas the other groups of consumers would lose more (or gain less) in real income.

When low values are assigned to the cross-elasticities of substitution in the non-rice agricultural production, landlords, wage workers, and capitalists would gain less (or lose more) in real income, whereas dry land owners and paddyfield owner-cultivators would lose more (or gain less) in real income.

Policymakers who intend to use rent reduction as a means to redistribute income should take into account the sensitivity of the income redistribution effects. Our sensitivity analysis suggest that real income distribution after the rent reduction would be less (more) equalized when low (high) values occur on the cross-elasticities of substitution in the non-agricultural and the self-cultivated rice production and when high (low) values occur on the cross-elasticities of substitution in the tenant-cultivated rice and the non-rice agricultural production.

The sensitivity test conducted in this study has limitations. It merely reflects the sensitivity of the impact analysis to the varied feature of complementarity in production because values of the cross-elasticities of substitution were set within the range of positive numbers (from 0.1 to 1). If a wider range of values, i.e., values covering both positive and negative numbers, were included, the test would produce information to detect the sensitivity of the impact analysis to the varied feature of substitution in production.

NOTES

CHAPTER II

1 Land rent was still negotiated and set by landlords and tenants on some lands. Most of these lands were used to produce special crops such as tea, fruit, citronella, etc. Rentals were rarely high on such lands before the rent reduction was implemented. See A.Y.C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan, Praeger, New York, 1968, p. 30.

2 Ibid., pp. 32-3. After the rent reduction was implemented, a total of 34,867 violating cases were discovered and duly corrected.

3 Data are cited from Y.K. Mao, "Land Reform and Agricultural Development in Taiwan", in C.M. Ho and T.S. Yu (eds.), Agricultural Development in China, Japan, and Korea, Academia Sinica, Taipei, 1980, p. 861 and Taiwan Statistical Data Book, 1982, Council for Economic Planning and Development, Executive Yuan, Taipei, p. 57.

4 These figures are estimated based on the data displayed in Table 2.3 of this study.

5 For a brief but adequate description of the Bao-Chia system see G.W. Barclay, Colonial Development and Population in Taiwan, Princeton University Press, New Jersey, 1954, pp. 50-52.

6 Taiwan Statistical Data Book, 1982, p. 56.

7 Ibid., p. 58.

8 Ibid., p. 52.

9 The Development of Taiwan, 1945-1962, Taiwan Provincial Information Services, Taichung, 1962, pp. VI and 6-7.

10 Taiwan Statistical Data Book, 1982, pp. 61-65.

11 Ibid., pages 16 & 58.

12 Ibid., p. 66.

CHAPTER III

1 The Physiocratic thoughts are well presented in J.M. Currie, The Economic Theory of Agricultural Land Tenure,

Cambridge, 1981, pp. 4-9, and R.L. Meek, "Physiocracy and Classicism in Britain" Economic Journal, 1951, 61: 26-47.

2 The excerpt is originally from Baudeau, cited from C. Gide and C. Rist A History of Economic Doctrines, London, 1945, p. 42.

3 The excerpt is quoted in Currie, p. 7.

4 Ibid., p. 9.

5 Ibid.

6 Ibid. Following the French revolution, land tenure reform extended peasants' property rights to land, which led to further fragmentation of farms.

7 D. Ricardo, The Principle of Political Economy and Taxation 3rd edn., London, 1821, Chapter II.

8 Currie, p. 170, fn. 15. Currie states that "... In the 1815 Essay, Ricardo ... did envisage rates (of profit) elsewhere as being determined in the agricultural sector ... although Ricardo never stated this explicitly" and "It is worth noting that Malthus had disputed Ricardo's initial theory, contending that the agricultural rate of profit no more than regulates the rates of profit elsewhere, than the rates of profit in other trade regulate the rate of profit in agriculture."

9 Ricardo was the only exception who gave no heed to alternative tenure system. Ricardo, 1821, chapter II.

10 An exceptional case is James S. Mills. Mills was very cautious about the superiority of the fix rent system than the sharecropping arrangement in terms of productive efficiency. His attitude toward the sharecropping inefficiency doctrine was strongly affected by Sismondi's praises of the operation of metayage system in Italy. For details, see M.G. Qubria and R. Rashid, "Puzzle of the Sharecropping" World Development, 1984, 12: 103-14, and Currie, p. 26.

11 According to Currie, p. 22, "one of the 'offshoots' of Classical economics...(is) the popular movement associated with Henry George. In Progress and Poverty, first published in 1879, George launched a vehement attack on private property in land, blaming such rights for virtually all the maladies afflicting society. His remedy was the appropriation by the state of ground rent through taxation ... he did not wish to tax improvements to the land; he advocated taxing pure ground rent only."

12 E.S. Mills and B.W. Hamilton, Urban Economics, 3rd edn.,

Scott, Foresman and Co., Glenview, Illinois, 1984, pp.70-73.

13 It is difficult to explain why landlords should not care about productive efficiency of the cultivation if land income is the only source of their income.

14 R. Jones, An Essay on the Distribution of Wealth and on the Sources of Taxation, J. Murray, London, 1831, p. 11.

15 For works related to this subject, please see A.Y.C. Koo, Land Market Distortion and Tenure Reform, Iowa State University press, 1982, and P. Dorner, Land Reform and Economic Development, Penguin, England, 1972.

CHAPTER IV

1 Diewert's assumptions on the consumer's preferences are very restrictive because they imply that all consumer income elasticities of demand are unity, which contradicts Engel's Law. see W.E. Diewert, "Unions in a General Equilibrium Model", in Canadian Journal of Economics, 1974, 7:479. Diewert indicates that the assumption will lead "to a well-defined interpretation of changes in a given consumer's utility or real income level. An increase in a given comsumer's utility level of λ percent going from an initial comsumption point to another new compsumption point is equivalent to an increase in his consumption vector by λ percent. However, ... this does not imply that we can cardinally compare utility changes between different consumers."

2 Shephard's lemma states that the partial derivative of a unit cost function dual (a unit expenditure function dual) with respect to an input price (an output price) is the cost-minimizing input value (expenditure-minimzing output value) needed by an industry (a consumer) for producing (attaining) a unit of output (utility). For details, see R.M. Shephard, Cost and Production Functions, Princeton University Press, 1953, p. 11; P.A. Samuelson, Foundation of Economic Analysis, Harvard University Press, 1947; and H.R. Varian, Microeconomic Analysis, Norton, New York, 1978, p. 51.

3 There are advantages in assuming that paddyfield landlords and owner-cultvators initially hold an identical factor endowment. The relaxation of this assumption is at the cost of adding one more class of paddyfield owner-cultivators into the consumer classes. The added class of paddyfield owners is the converted paddyfield owner-cultivators who withdraw lands from tenancy to self cultivation after the implementation of the rent reduction. The initial factor endowment held by this

class of consumers is identical to that held by the continued paddyfield landlords but is different from that held by the continued paddyfield owner-cultivators.

4 Based on the assumption that the unit cost/expenditure function duals are twice continuously differentiable, the impact vectors derived from our two theoretical models would be expressible as functions of the various distributive shares and the elasticities of substitution in production and consumption.

5 In equations (4.4)-(4.7), the second equality are developed based on the Euler's Theorem. For a brief and accurate description of the Euler's Theorem see J.M. Henderson and R.E. Quandt, Microeconomic Theory: A Mathematical Approach, 3rd edn., McGraw-Hill, New York, 1980, pp. 107-10.

6 This proposition is made based on the fact that the conditional factor demand curve derived from the assumed production function (or the unit cost function dual) should be downward-sloping. For a brief proof, see H.R. Varian, Microeconomic Analysis, Norton, New York, 1978, pp. 30-34.

CHAPTER V

1 The 1948 gross agricultural output is displayed in Table 1 of Appendix 1.

2 Agricultural land income share in 1948 might actually be larger than that for the years of 1950-55, due to the implementation of the rent reduction policy in 1949.

3 A 25 percent of the annual main crop yield was set by authorities as the uniform rental rate for all public land leases. Frequently practiced subleases resulted in the dominance of market forces in the determination of actual rental rate for public land lease. For a detailed report on this point, see A.Y.C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan, Praeger, New York, 1968, p. 45.

4 A.Y.C. Koo, Land Market Distortion and Tenure Reform, Iowa State University Press, Ames, 1982, p. 121, fn. 5. Koo reports that the actual rental payment ratio of paddyfield to dry land was 2.5 for both public and private land leases. The authority-determined 25 percent rental rate was merely able to be exerted on the public dry land leases to the national proprietary enterprises. The same findings were also reported in T.S. Shong, "Land Distribution in Taiwan", in T. T. Bao (ed.) The Cabinet Rent Reduction Report, Chinese Research

Institute of Land Economics, Taipei, 1951, p. 139.

[5] The relevant data are displayed in Table 1 of Appendix 1.

[6] The estimated two rental rates--74.4355% from paddyfields and 23.466% from dry lands, well reflect the actual rental rates recorded for the years 1938-1945. Rental rate was 85% on paddyfields before the year of 1938 but was decreased after 1938 due to the enactment of the Japanese rental ceiling regulations. See T.H. Lee Intersectional Capital Flows in the Economic Development of Taiwan, 1895-1960, Bank of Taiwan, Taipei, 1972, p. 63.

[7] Rice farmers, produced from either self- or tenant-cultivated paddyfields, applied the same portion of produces to compensate for the capital assets used in production. Z.T. Hwang The Economics of Rice Farmers in Taiwan, Bank of Taiwan, Taipei, 1959.

[8] The distribution of commercial fertilizers in 1949 is displayed in Table 8 of Appendix 1.

[9] This assumption is adopted because information on the distribution of the net domestic product are not available at earlier dates.

[10] The adoption of this assumption is due to the unavailabilty of data on the wage and working duration differentials between agricultural and non-agricultural workers at earlier dates.

[11] The relevant data are displayed in Table 7 of Appendix 1.

[12] Ibid.

[13] The relevant data are displayed in Table 9 of Appendix 1.

[14] The annual rate of returns to the capital assets was 34.8% during the years 1950-55. See Lee, p. 45. Applying this rate of returns to the estimated total capital income displayed in Table 5.2 of chapter 5, we learn that the estimated total capital assets is worth NT$17,970.69 million in 1948. Assume that each capitalist possesses NT$1,000.00 of capital assets as endowment, total population of capitalists is 17,970,690.

[15] H. Uzawa, "Production Functions with Constant Elasticities of Substitution", in Review of Economic Studies 1962, 29: 291-99. The Allen's partial elasticities of substitution can be expressed as a function of the unit cost function dual of an industry's production function, the dual function's first-order differentiations, and the dual function's second-order differentiations:

$$S_{rt}^{n} = \frac{c^{n} * c_{rt}^{n}}{c_{r}^{n} * c_{t}^{n}} \qquad (1)$$

$$S_{rr}^{n} = \frac{c^{n} * c_{rr}^{n}}{c_{r}^{n}} \qquad (2)$$

In the above equations,

$$c_r^n = \partial c^n / \partial p_r \ ,$$

$$c_t^n = \partial c^n / \partial p_t \ ,$$

$$c_{rt}^n = \frac{\partial c^n}{\partial p_r \, \partial p_t},$$

where c^n is the unit cost function dual for the production function of industry n, S_{rt}^n is the elasticity of substitution between inputs r and t in the production of industry n, * is a notation of multiplication, r=t=1,2,3,4,5, and n=1,2,3,4.

16 The enactment of the "Land-to-the-Tiller" program resulted in a 51 percent reduction in the land area supplied for tenancy and resulted in the 143,568 (out of the total 281,221) hectares of tenant-cultivated paddyfields purchased by the government and resold to the incumbent tenant farmers.

17 According to the rent reduction regulations, the 37.5 percent rental ceiling should be measured based on the main crop yield from land in the 1948 record. Rent reduction would have incurred a decrease of more than 49.62 percent in the tenant rent if the prereform rental rate were set based on all crop yields from land.

18 Data on the size of land converted from tenancy to self cultivation for 1949-1952 are cited from Statistical Abstract: 1982, Taipei: The Ministry of Interior, 1983, p.113.

19 Initial real income distribution among the different factors of production has the same pattern as that of the initial nominal income distribution based on the assumption that each consumer diviides his/her expenditures on the three commodities in proportion to the commodity's share of the initial national product.

20 The increase rate in the self-cultivated paddyfield area is obtained, by dividing the increment of 7,080 hectares in the self-cultivated paddyfield area by the initial total 245,163 hectares of the self-cultivated paddyfield area.

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APPENDIX I

DATA SOURCES

Table A.1
Production of Major Farm Products, 1948

Unit: N.T.$ million

Item	Value	Gross Output*
	1952-1956 Price	
Rice Production	2,588.0	2,423.5
Non-rice Production		
Total	2,453.8	2,054.9
Sweet Potato	593.2	296.6
Peanut	169.6	157.8
Sugar Cane	351.8	-----
Tea	96.8	-----
Vegetable	-----	240.5
Fruits	-----	270.8
Livestock & Poultry	-----	387.0
Others	1,242.4	702.2
Total Production	5,041.8	4,478.4

Source: Y.M. Ho, Agricultural Development of Taiwan, 1903-1960. Vanderbilt University Press, Nashville, 1966, pp. 22-24, 135-148, and 153-154.

Note: *Gross output is defined as gross products after deducting seeds and feeds.

Tabel A.2
Area of Cultivated Land by
Owner-cultivator and Tenant, 1948

Unit: Hectare

Total Cultivated Land Area	863,157
Owner-Cultivated Land Area	502,153
Paddyfield Area	245,164
Dry Land Area	256,989
Tenant Land Area	361,004
Paddyfield Area	281,221
Dry Land Area	79,783

Source: T.S. Shong, "Land Distribution in Taiwan", in T.T. Bao (ed.), The Cabinet Rent Reduction Report. Chinese Research Institute of Land Economics, Taipei, 1951, p. 139 & 149.

Table A.3
Area of Cultivated Land Owned by Public and Private, 1948

Unit: Hectare

(1) Total Cultivated Land Area	863,157
(2) Private Land Area	687,126
Paddyfield Area	454,418
Dry land Area	232,708
(3) Public Land Area	176,031
Paddyfield Area	71,967
Dry land Area	104,064
(4) Public Land Area Cultivated by Public Enterprises	71,631
(5) Public Land Area Cultivated by Civilian Tenants	104,400

Sources: (1), (2), and (3) are cited from T.S. Shong, "Land Reform in Taiwan", in T.T. Bao (ed.), The Cabinet Rent Reduction Report. Chinese Research Institute of Land Economics, Taipei, 1951, p. 138, Table 7.

(4) and (5) are cited from Bao, 1951, p. 13.

Table A.4
Area of Private Land
by Owner-cultivator and Tenant, 1949

Unit: Hectare

Owner-Cultivated Area	430,522
Tenant-Cultivated Area	256,604
Total Private Land Area	687,126

Source: T.T. Bao (ed.), The Cabinet Rent Reduction Report. Chinese Research Institute of Land Economics, 1951, Taipei, p. 1 and p. 13.

Table A.5
Distribution of Landlords by Size of Land
Sold Under the Land-to-the-Tiller Program

Size of Land Sold (in hectare)	Number of Landlords	Paddy Field	Dry Land	Total
Less than 0.5	27,668 (26.08%)	11,582 (9.52%)	2,353 (10.67%)	13,935 (9.70%)
0.5-less than 1.0	24,519 (23.12%)	19,142 (15.74%)	3,012 (13.67%)	22,154 (15.43%)
1.0-less than 1.5	15,451 (14.56%)	15,459 (12.74%)	2,358 (10.70%)	17,817 (12.41%)
1.5-less than 2.0	9,757 (9.20%)	11,534 (9.49%)	1,813 (8.22%)	13,347 (9.29%)
2.0-less than 3.0	11,039 (10.40%)	15,520 (12.76%)	2,521 (11.44%)	18,041 (12.56%)
3.0-higher	17,615 (16.61%)	48,298 (39.73%)	9,976 (45.27%)	58,274 (40.58%)
Total	106,049 (100%)	121,535 (100%)	22,033 (100%)	143,568 (100%)

Source: Anthony Y.C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan. Praeger, N.Y., 1968, p. 46, Table 12.

Table A.6
Utilization of Paddyfield, 1948

Cropping Pattern	Area (in hectare)
Double-Cropping Paddyfield	314,989
Single-Cropping Paddyfield	211,345
First Crop	18,326
Second Crop	193,069
Total Paddyfield	526,334

Source: Taiwan Agricultural Statistics, 1901-65. The Rural Economic Division, JCRR, Taipei, 1966, p. 13.

Table A.7
Employment, Wage Index, and Annual Working-Day Index of Agricultural and Nonagricultural Worker in Selected Years

Item	Statistics
(1) Employment, 1949 (in 1,000 persons)	
Total Employment	2,828
Agricultural Employment	1,773
Nonagricultural Employment	1,055
(2) Wage Index, 1950-1955	
Agricultural Worker	0.900
Nonagricultural Worker	1.000
(3) Annual Working-Day Index, 1953	
Agricultural Worker	0.548
Nonagricultural Worker	1.000

Sources: (1) Anthony Y.C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan. Praeger, New York, 1968, p. 139.

(2) T.H. Lee, Capital Flows between Agriculture & Non-Agriculture in Taiwan. Bank of Taiwan, Taipei, 1972, p. 54, note 8; and C.T. Shih, "Wage Differential and Labor Mobility between Agriculture and Non-Agriculture: A Two-Way Analysis", in The Proceedings on the Conference of Taiwan's Human Resources. Academia Sinica, Taipei, 1979, pp. 381-418.

(3) Shih, 1979, p. 413.

Table A.8
Percentage Distribution of Commercial Fertilizers, 1949

Type of Crop	Percentage of Fertilizers used in the Crop
Rice	60.8
Sugar Cane	37.7
Sweet Potato	0.4
Wheat	0.8
Other Crops	0.3
Total	100.0

Source: Y.M. Ho, Agricultural Development of Taiwan, 1903-60. Vanderbilt University Press, Nashville, 1966, p. 58.

Table A.9
Origin of Net Domestic Product and
Gross Domestic Capital Formation, 1952

Item	Value (NT $ million) 1952=100	Percentage
(1) Net Domestic Product	14,572	100.0
Agriculture	5,233	35.9
Nonagriculture	9,339	64.1
(2) Gross Domestic Capital Formation	2,643	100.0
Agriculture	592	22.4
Nonagriculture	2,051	77.6
U.S. Aid	1,057	40.0

Sources: (1) Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, pp. 33-34.

(2) Ibid., pp. 39-40, and 47-48.

Table A.10
Composition of Gross Domestic Capital Formation, 1952

	Value (in N.T.$ million) 1952=100	Percentage
Gross Domestic Capital Formation	2,643	100.00
Fixed Capital Formation	1,940	73.40
Agriculture	470	17.78
Nonagriculture	1,470	55.62
Increase in Stock	703	26.60
Agriculture	122	4.62
Nonagriculture	581	21.98

Source: Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, pp. 41-44.

Table A.11
Factor Income Shares in Agricultural Sector, 1950-55

Type of Factor	Income Share
Land	50.59%
Labor	40.15%
Capital	9.26%

Source: T.H. Lee, Capital Flows between Agriculture and Nonagriculture in Taiwan. Bank of Taiwan, Taipei, 1972, p. 45, Table 25.

Table A.12
Price Index of Rice, Agricultural Products and General Products for 1948, 1949, 1952, and 1952-1956

Unit: Percentage

Type of Index	1948	1949	1952	1952-56
Rice	21,295.46	21.28	77.12	100
Agricultural Products	24,470.58	26.23	79.28	100
General Products	17,790.91	30.73	84.71	100

Sources: Data on rice are cited from Y.M. Ho, Agricultural Development of Taiwan, 1903-1960. Vanderbilt University Press, Nashville, 1966, p. 136.

Agricultural products include rice and other agricultural goods. Data on these products are cited from Y.M. Ho, 1966, p. 154.

General products include agricultural and non-agricultural goods. Data on these products are cited from A.Y.C. Koo, The Role of Land Reform in Economic Development: A Case Study of Taiwan. Praeger, New York, 1968, p. 135.

Table A.13
Origin of Net Domestic Product, 1952-1981

Unit: %

Year	Total Net Domestic Product	Agriculture	Non-agriculture		
				Industry	
			Subtotal	Subtotal	Manufacturing
1952	100.0	35.9	64.1	18.0	10.9
1953	100.0	38.3	61.7	17.7	11.3
1954	100.0	31.7	68.3	22.2	14.5
1955	100.0	32.9	67.1	21.1	13.8
1956	100.0	31.6	68.4	22.4	14.5
1957	100.0	31.7	68.3	23.9	15.7
1958	100.0	31.0	69.0	23.9	15.5
1959	100.0	30.4	69.6	25.7	17.7
1960	100.0	32.8	67.2	24.9	16.8
1961	100.0	31.4	68.6	25.0	17.0
1962	100.0	29.2	70.8	25.7	17.0
1963	100.0	26.7	73.3	28.2	19.7
1964	100.0	28.2	71.8	28.9	20.9
1965	100.0	27.3	72.7	28.6	20.1
1966	100.0	26.2	73.8	28.8	20.3
1967	100.0	23.8	77.2	30.8	22.2
1968	100.0	22.0	78.0	32.5	24.1
1969	100.0	18.8	81.2	34.6	26.3
1970	100.0	17.9	82.1	34.7	26.4
1971	100.0	14.9	85.1	36.9	28.9
1972	100.0	14.1	85.9	40.4	32.4
1973	100.0	14.1	85.9	43.8	36.3
1974	100.0	14.5	85.5	41.2	32.7
1975	100.0	14.9	85.1	39.2	29.3
1976	100.0	13.4	86.6	42.7	32.5
1977	100.0	12.5	87.5	43.7	32.9
1978	100.0	11.3	88.7	45.5	34.5
1979	100.0	10.4	89.6	45.7	34.9
1980	100.0	9.3	90.7	45.3	34.0
1981	100.0	8.7	91.3	44.5	32.7

Source: Taiwan Statistical Data Book, Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, p. 34.

Table A.14
Agricultural Production--Index Number, 1952-1981

Unit: %

Year	General Index	Agriculture	Forestry	Fisheries	Livestock
1952	100.0	100.0	100.0	100.0	100.0
1953	109.4	108.5	102.0	102.8	123.7
1954	111.9	109.3	107.8	122.5	125.8
1955	112.4	107.8	113.5	141.5	130.5
1956	121.0	116.9	107.1	152.1	139.5
1957	129.6	123.5	124.1	167.6	155.8
1958	138.3	130.4	142.0	171.8	174.7
1959	140.7	130.0	182.0	183.1	173.2
1960	142.6	132.1	188.8	190.8	167.4
1961	155.3	141.9	215.3	219.7	185.3
1962	159.3	143.8	220.6	228.2	201.1
1963	159.6	141.9	219.8	245.8	206.3
1964	178.7	159.6	271.6	267.6	218.9
1965	190.3	172.3	277.3	278.2	225.3
1966	196.5	175.1	255.7	319.7	250.0
1967	208.9	182.2	260.4	362.0	285.8
1968	223.2	190.3	274.7	445.8	307.9
1969	218.9	181.6	259.0	480.3	327.7
1970	230.7	190.7	270.8	510.6	354.7
1971	231.8	188.6	284.1	533.1	363.7
1972	236.9	190.1	265.1	564.1	400.0
1973	243.4	189.0	251.6	622.5	547.4
1974	248.0	200.2	232.4	595.1	433.7
1975	245.0	194.9	212.4	655.6	419.5
1976	269.5	211.4	204.1	704.2	526.3
1977	280.3	215.4	166.1	768.3	598.4
1978	275.2	205.1	160.8	793.0	624.2
1979	289.8	212.3	144.5	863.4	692.1
1980	286.9	207.7	135.3	885.8	692.8
1981	285.2	204.0	126.5	885.8	717.7

Source: Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, p. 54.

Table A.15
Selected Indicators of Taiwan Economy, 1952-1981

Year	Population	GNP	Per Capita GNP	Agricultural Production	Industrial Production
		Index (Base: 1952=100)			
1952	100.0	100.0	100.0	100.0	100.0
1953	103.8	109.3	105.8	109.4	125.0
1954	107.6	119.8	112.0	111.9	132.5
1955	117.7	129.5	116.7	112.4	150.0
1956	115.5	136.6	118.8	121.0	155.0
1957	119.2	146.5	123.5	129.6	175.0
1958	123.5	156.2	127.5	138.3	190.0
1959	128.3	168.3	133.0	140.7	212.5
1960	132.8	179.1	137.2	142.6	242.5
1961	137.2	191.4	142.0	155.3	280.0
1962	141.6	206.4	148.7	159.3	302.5
1963	146.2	225.7	157.9	159.6	330.0
1964	150.8	253.5	172.2	178.7	400.0
1965	155.4	281.4	185.9	190.3	465.0
1966	159.9	306.8	197.3	196.5	537.5
1967	163.6	339.2	212.8	208.9	627.5
1968	167.9	369.9	226.6	223.2	767.5
1969	176.4	403.2	241.5	218.9	920.0
1970	180.6	448.7	263.1	230.7	1,105.0
1971	184.5	506.6	291.1	231.8	1,377.5
1972	188.1	574.0	323.8	236.9	1,670.0
1973	191.5	647.6	358.5	243.4	1,940.0
1974	195.0	654.8	356.0	248.0	1,852.5
1975	198.7	682.6	364.4	245.0	2,010.0
1976	203.1	774.6	405.2	269.5	2,500.0
1977	206.9	851.0	463.3	280.3	2,825.0
1978	210.8	968.8	487.5	275.2	3,531.3
1979	210.5	1,047.1	516.8	289.8	3,817.2
1980	219.0	1,116.2	540.4	286.9	4,107.4
1981	223.1	1,117.7	560.1	285.2	4,279.9

Source: Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, p.1 & 4.

Table A.16
Agricultural Population by Tenant and Type of Owner for Selected Years

Unit: 1,000 persons

End of Year	Total		Percentage		
	Number	As % of Total Population	Full Owner	Part Owner	Tenant
1945	NA	NA	29.8	29.5	40.7
1949	NA	NA	36.1	25.2	38.7
1952	4,257	52.4	38.0	26.0	36.0
1953	4,382	51.9	55.0	24.0	21.0
1954	4,489	51.3	57.0	24.0	19.0
1955	4,603	50.7	59.0	23.0	18.0
1960	5,373	49.8	64.0	22.0	14.0
1965	5,739	45.4	67.0	20.0	13.0
1970	5,997	40.9	77.0	13.0	10.0
1975	5,598	34.7	82.0	9.0	9.0
1979	5,639	32.3	85.0	7.0	8.0
1980	5,288	29.7	82.0	11.0	7.0
1981	4,964	27.4	84.0	9.0	7.0

Sources: Data for the years before 1952 are cited from Y.K. Mao, "Land Reform and Agricultural Development in Taiwan", in C.M. Ho and T.S. Yu (eds.) Agricultural Development in China, Japan and Korea. Academia Sinica, Taipei, 1980, p. 861.

Data for 1952 and the later years are cited from Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, p. 57.

Table A.17
Agricultural and Nonagricultural Employment, 1952-1981

End of Year	Total Employment: Number (1,000 persons)	Total Employment: As % of Total Population	Percentage of Employment in: Agriculture	Percentage of Employment in: Nonagriculture
1952	2,936	36.1	61.0	39.0
1953	2,954	35.0	61.3	38.7
1954	3,000	34.3	60.4	39.6
1955	3,026	33.3	59.9	40.1
1956	3,015	32.1	59.9	40.1
1957	3,110	32.1	58.2	41.8
1958	3,178	31.7	57.1	42.9
1959	3,272	31.5	56.6	43.4
1960	3,344	31.1	56.1	43.9
1961	3,429	30.9	55.8	44.2
1962	3,504	30.4	55.3	44.7
1963	3,617	30.4	54.5	45.5
1964	3,710	30.3	54.2	45.8
1965	3,755	29.7	53.7	46.3
1966	3,870	29.8	53.0	47.0
1967	4,130	31.1	49.4	50.6
1968	4,337	31.8	49.4	50.6
1969	4,942	34.5	45.0	55.0
1970	5,053	34.4	44.5	55.5
1971	5,440	36.3	42.3	57.7
1972	5,812	38.0	39.9	60.1
1973	6,091	39.1	37.2	62.8
1974	6,254	39.5	36.9	63.1
1975	6,466	40.0	36.6	63.4
1976	6,837	41.4	34.6	65.4
1977	7,040	41.9	33.8	66.2
1978	7,374	43.0	31.8	68.2
1979	7,703	44.1	29.7	70.3
1980	7,795	43.8	28.3	71.7
1981	8,150	44.9	28.0	72.0

Source: Taiwan Statistical Data Book. Council for Economic Planning and Development, Executive Yuan, Taipei, 1982, pp. 8-9.

Notes: Total employment refers to workers age 12 and older before 1967. Since 1967, only workers aged 15 and over have been covered by employment surveys.

Data on agricultural employment do not include the employment of forestry and fisheries before 1967. Since 1967, the employment of forestry and fisheries have been included.

Data on nonagricultural employment include servicemen for 1967 and thereafter.

APPENDIX II

ELEMENTS IN THE IMPACT VECTORS

Appendix 2 presents the elements of matrices A, B, G, and H. These elements are first presented in partial derivative form; and then transformed into functions of the various distributive shares and the elasticities of substitution in consumption and production. Notation $A_{n.}^T$ stands for the transpose of the nth column of matrix A, where n=1,2, ... ,16. $G_{n.}^T$ stands for the transpose of the nth column of matrix G, where n=1,2, ... ,16. B^T and H^T respectively stand for the transpose of matrices B and H. All notations in section 1 are interpreted in chapter four; all notations in section 2 are interpreted in sections 5.1.4 to 5.1.6 of chapter five.

1. Elements of Impact Vectors in Partial Derivative Form

$$A_{1.}^{T} = \frac{p_1^*}{p^{*T}y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^{*2}} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^* \partial p_2^*} u_j^* n_j, \right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^* \partial p_3^*} u_j^* n_j, -1, -1, 0, 0, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_1^*} u_1^*,$$

$$\left. \frac{\partial e^2(p^*)}{\partial p_1^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_1^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_1^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_1^*} u_5^* \right]$$

$$A_{2.}^{T} = \frac{p_2^*}{p^{*T}y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_2^* \partial p_1^*} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_2^{*2}} u_j^* n_j, \right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_2^* \partial p_3^*} u_j^* n_j, 0, 0, -1, 0, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_2^*} u_1^*,$$

$$\left. \frac{\partial e^2(p^*)}{\partial p_2^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_2^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_2^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_2^*} u_5^* \right]$$

$$A_{3.}^{T} = \frac{p_3^*}{p^{*T}y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_3^* \partial p_1^*} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_3^* \partial p_2^*} u_j^* n_j, \right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_3^{*2}} u_j^* n_j, 0, 0, 0, -1, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_3^*} u_1^*,$$

$$\left. \frac{\partial e^2(p^*)}{\partial p_3^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_3^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_3^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_3^*} u_5^* \right]$$

$$A_{4.}^{T} = \frac{y_1^*}{p^{*T}y^*} \left[-1, 0, 0, 0, 0, 0, 0, \frac{\partial c^1(w^*)}{\partial w_1^*}, 0, \frac{\partial c^1(w^*)}{\partial w_3^*}, \right.$$

$0, 0, 0, 0, 0, 0]$

$$A_{5.}^{T} = \frac{y_2^*}{p^{*T}y^*} [-1, 0, 0, 0, 0, 0, 0, 0, \frac{\partial c^2(w^*)}{\partial w_2^*}, \frac{\partial c^2(w^*)}{\partial w_3^*},$$

$0, 0, 0, 0, 0, 0]$

$$A_{6.}^{T} = \frac{y_3^*}{p^{*T}y^*} [0, -1, 0, 0, 0, 0, 0, 0, 0, \frac{\partial c^3(w^*)}{\partial w_3^*},$$

$0, 0, 0, 0, 0, 0]$

$$A_{7.}^{T} = \frac{y_4^*}{p^{*T}y^*} [0, 0, -1, 0, 0, 0, 0, 0, 0, \frac{\partial c^4(w^*)}{\partial w_3^*}, \frac{\partial c^4(w^*)}{\partial w_5^*},$$

$0, 0, 0, 0, 0]$

$$A_{8.}^{T} = \frac{w_1^*}{p^{*T}y^*} [0, 0, 0, \frac{\partial c^1(w^*)}{\partial w_1^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^1(w^*)}{\partial w_1^* \partial w_i^*}, 0, 0, 0,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^{*2}} y_n^*, \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_2^*} y_n^*, \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_3^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_5^*} y_n^*, -v_1^1, 0, 0, 0, 0]$$

$$A_{9.}^{T} = \frac{w_2^*}{p^{*T}y^*} [0, 0, 0, 0, \frac{\partial^2 c^2(w^*)}{\partial w_2^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^2(w^*)}{\partial w_2^* \partial w_i^*}, 0, 0,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_2^*} y_n^*, \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_2^{*2}} y_n^*, \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^* \partial w_2^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^* \partial w_2^*} y_n^*,\ 0,\ -v_2^2,\ 0,\ 0,\ 0]$$

$$A_{10.}{}^T = \frac{w_3^*}{p^{*T}Y^*} [0,\ 0,\ 0,\ \frac{\partial c^1(w^*)}{\partial w_3^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^1(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^2(w^*)}{\partial w_3^*} +$$

$$\sum_{i=1}^{5} w_i^* \frac{\partial^2 c^2(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^3(w^*)}{\partial w_3^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^3(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^4(w^*)}{\partial w_3^*} +$$

$$\sum_{i=1}^{5} w_i^* \frac{\partial^2 c^4(w^*)}{\partial w_3^* \partial w_i^*},\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_3^*} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_2^* \partial w_3^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^{*2}} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^* \partial w_3^*} y_n^*,\ 0,\ 0,\ -v_3^3,\ 0,\ 0]$$

$$A_{11.}{}^T = \frac{w_5^*}{p^{*T}Y^*} [0,\ 0,\ 0,\ 0,\ 0,\ 0,\ \frac{\partial c^4(w^*)}{\partial w_5^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^4(w^*)}{\partial w_5^* \partial w_i^*},$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_5^*} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_2^* \partial w_5^*} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^* \partial w_5^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^{*2}} y_n^*,\ 0,\ 0,\ 0,\ 0,\ -v_5^5]$$

$$A_{12.}{}^T = \frac{u_1^*}{p^{*T}Y^*} [\frac{\partial e^1(p^*)}{\partial p_1^*} n_1,\ \frac{\partial e^1(p^*)}{\partial p_2^*} n_1,\ \frac{\partial e^1(p^*)}{\partial p_3^*} n_1,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ e^1(p^*),\ 0,\ 0,\ 0,\ 0]$$

$$A_{13.}{}^T = \frac{u_2^*}{p^{*T}Y^*} [\frac{\partial e^2(p^*)}{\partial p_1^*} n_2,\ \frac{\partial e^2(p^*)}{\partial p_2^*} n_2,\ \frac{\partial e^2(p^*)}{\partial p_3^*} n_2,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$0, 0, 0, 0, e^2(p^*), 0, 0, 0]$

$$A_{14.}^T = \frac{u_3^*}{p^{*T}Y^*} \left[\frac{\partial e^3(p^*)}{\partial p_1^*} n_3, \frac{\partial e^3(p^*)}{\partial p_2^*} n_3, \frac{\partial e^3(p^*)}{\partial p_3^*} n_3, 0, 0, 0, 0, 0,\right.$$

$0, 0, 0, 0, 0, e^3(p^*), 0, 0]$

$$A_{15.}^T = \frac{u_4^*}{p^{*T}Y^*} \left[\frac{\partial e^4(p^*)}{\partial p_1^*} n_4, \frac{\partial e^4(p^*)}{\partial p_2^*} n_4, \frac{\partial e^4(p^*)}{\partial p_3^*} n_4, 0, 0, 0, 0, 0,\right.$$

$0, 0, 0, 0, 0, 0, e^4(p^*), 0]$

$$A_{16.}^T = \frac{u_5^*}{p^{*T}Y^*} \left[\frac{\partial e^5(p^*)}{\partial p_1^*} n_5, \frac{\partial e^5(p^*)}{\partial p_2^*} n_5, \frac{\partial e^5(p^*)}{\partial p_3^*} n_5, 0, 0, 0, 0, 0,\right.$$

$0, 0, 0, 0, 0, 0, 0, e^5(p^*)]$

$$B^T = \frac{n_1}{p^{*T}Y^*} \left[\frac{\partial e^1(p^*)}{\partial p_1^*} u_1^* - \frac{\partial e^2(p^*)}{\partial p_1^*} u_2^*, \frac{\partial e^1(p^*)}{\partial p_2^*} u_1^* - \frac{\partial e^2(p^*)}{\partial p_2^*} u_2^*,\right.$$

$$\frac{\partial e^1(p^*)}{\partial p_3^*} u_1^* - \frac{\partial e^2(p^*)}{\partial p_3^*} u_2^*, 0, 0, 0, 0, -v_1^1, +v_2^2, 0, 0, 0$$

$0, 0, 0, 0]$

$$G_{1.}^T = \frac{p_1^*}{p^{*T}Y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^{*2}} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^* \partial p_2^*} u_j^* n_j,\right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_1^* \partial p_3^*} u_j^* n_j, -1, -1, 0, 0, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_1^*} u_1^*,$$

$$\left.\frac{\partial e^2(p^*)}{\partial p_1^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_1^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_1^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_1^*} u_5^*\right]$$

$$G_{2.}{}^{T} = \frac{p_2^*}{p^{*T}y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_2^* \partial p_1^*} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial {p_2^*}^2} u_j^* n_j, \right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_2^* \partial p_3^*} u_j^* n_j, 0, 0, -1, 0, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_2^*} u_1^*,$$

$$\left. \frac{\partial e^2(p^*)}{\partial p_2^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_2^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_2^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_2^*} u_5^* \right]$$

$$G_{3.}{}^{T} = \frac{p_3^*}{p^{*T}y^*} \left[\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_3^* \partial p_1^*} u_j^* n_j, \sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial p_3^* \partial p_2^*} u_j^* n_j, \right.$$

$$\sum_{j=1}^{5} \frac{\partial^2 e^j(p^*)}{\partial {p_3^*}^2} u_j^* n_j, 0, 0, 0, -1, 0, 0, 0, 0, \frac{\partial e^1(p^*)}{\partial p_3^*} u_1^*,$$

$$\left. \frac{\partial e^2(p^*)}{\partial p_3^*} u_2^*, \frac{\partial e^3(p^*)}{\partial p_3^*} u_3^*, \frac{\partial e^4(p^*)}{\partial p_3^*} u_4^*, \frac{\partial e^5(p^*)}{\partial p_3^*} u_5^* \right]$$

$$G_{4.}{}^{T} = \frac{y_1^*}{p^{*T}y^*} \left[-1, 0, 0, 0, 0, 0, 0, 0, 0, \frac{\partial c^1(w^*)}{\partial w_3^*}, \right.$$

$$\left. 0, 0, 0, 0, 0, 0 \right]$$

$$G_{5.}{}^{T} = \frac{y_2^*}{p^{*T}y^*} \left[-1, 0, 0, 0, 0, 0, 0, 0, \frac{\partial c^2(w^*)}{\partial w_2^*}, \frac{\partial c^2(w^*)}{\partial w_3^*}, \right.$$

$$\left. 0, 0, 0, 0, 0, 0 \right]$$

$$G_{6.}{}^{T} = \frac{y_3^*}{p^{*T}y^*} \left[0, -1, 0, 0, 0, 0, 0, 0, 0, \frac{\partial c^3(w^*)}{\partial w_3^*}, \right.$$

$$\left. 0, 0, 0, 0, 0, 0 \right]$$

$$G_{7.}^{T} = \frac{y_4^*}{p^{*T}y^*} [0,\ 0,\ -1,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ \frac{\partial c^4(w^*)}{\partial w_3^*},\ \frac{\partial c^4(w^*)}{\partial w_5^*},$$

$$0,\ 0,\ 0,\ 0,\ 0]$$

$$G_{8.}^{T} = \frac{w_1^*}{p^{*T}y^*} [0,\ 0,\ 0,\ \frac{\partial c^1(w^*)}{\partial w_1^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^1(w^*)}{\partial w_1^* \partial w_i^*},\ 0,\ 0,\ 0,$$

$$\frac{1}{w_1^*},\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_2^*} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_3^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_1^* \partial w_5^*} y_n^*,\ -v_1^1,\ 0,\ 0,\ 0,\ 0]$$

$$G_{9.}^{T} = \frac{w_2^*}{p^{*T}y^*} [0,\ 0,\ 0,\ 0,\ \frac{\partial^2 c^2(w^*)}{\partial w_2^{*2}} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^2(w^*)}{\partial w_2^* \partial w_i^*},\ 0,\ 0,$$

$$0,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_2^{*2}} y_n^*,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^* \partial w_2^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^* \partial w_2^*} y_n^*,\ 0,\ -v_2^2,\ 0,\ 0,\ 0]$$

$$G_{10.}^{T} = \frac{w_3^*}{p^{*T}y^*} [0,\ 0,\ 0,\ \frac{\partial c^1(w^*)}{\partial w_3^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^1(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^2(w^*)}{\partial w_3^*} +$$

$$\sum_{i=1}^{5} w_i^* \frac{\partial^2 c^2(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^3(w^*)}{\partial w_3^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^3(w^*)}{\partial w_3^* \partial w_i^*},\ \frac{\partial c^4(w^*)}{\partial w_3^*} +$$

$$\sum_{i=1}^{5} w_i^* \frac{\partial^2 c^4(w^*)}{\partial w_3^* \partial w_i^*},\ 0,\ \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^* \partial w_2^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^{*2}} y_n^*, \quad \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^* \partial w_3^*} y_n^*, 0, 0, -v_3^3, 0, 0]$$

$$G_{11.}^T = \frac{w_5^*}{p^{*T}y^*} [0, 0, 0, 0, 0, 0, \frac{\partial c^4(w^*)}{\partial w_5^*} + \sum_{i=1}^{5} w_i^* \frac{\partial^2 c^4(w^*)}{\partial w_5^* \partial w_i^*},$$

$$0, \quad \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_2^* \partial w_5^*} y_n^*, \quad \sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_3^* \partial w_5^*} y_n^*,$$

$$\sum_{n=1}^{4} \frac{\partial^2 c^n(w^*)}{\partial w_5^{*2}} y_n^*, 0, 0, 0, 0, -v_5^5]$$

$$G_{12.}^T = \frac{u_1^*}{p^{*T}y^*} [\frac{\partial e^1(p^*)}{\partial p_1^*} n_1, \frac{\partial e^1(p^*)}{\partial p_2^*} n_1, \frac{\partial e^1(p^*)}{\partial p_3^*} n_1, 0, 0, 0, 0, 0,$$

$$0, 0, 0, e^1(p^*), 0, 0, 0, 0]$$

$$G_{13.}^T = \frac{u_2^*}{p^{*T}y^*} [\frac{\partial e^2(p^*)}{\partial p_1^*} n_2, \frac{\partial e^2(p^*)}{\partial p_2^*} n_2, \frac{\partial e^2(p^*)}{\partial p_3^*} n_2, 0, 0, 0, 0, 0,$$

$$0, 0, 0, 0, e^2(p^*), 0, 0, 0]$$

$$G_{14.}^T = \frac{u_3^*}{p^{*T}y^*} [\frac{\partial e^3(p^*)}{\partial p_1^*} n_3, \frac{\partial e^3(p^*)}{\partial p_2^*} n_3, \frac{\partial e^3(p^*)}{\partial p_3^*} n_3, 0, 0, 0, 0, 0,$$

$$0, 0, 0, 0, 0, e^3(p^*), 0, 0]$$

$$G_{15.}^T = \frac{u_4^*}{p^{*T}y^*} [\frac{\partial e^4(p^*)}{\partial p_1^*} n_4, \frac{\partial e^4(p^*)}{\partial p_2^*} n_4, \frac{\partial e^4(p^*)}{\partial p_3^*} n_4, 0, 0, 0, 0, 0,$$

$$0, 0, 0, 0, 0, 0, e^4(p^*), 0]$$

$$G_{16.}{}^T = \frac{u_5*}{p*^TY*}\left[\frac{\partial e^5(p*)}{\partial p_1*} n_5, \frac{\partial e^5(p*)}{\partial p_2*} n_5, \frac{\partial e^5(p*)}{\partial p_3*} n_5, 0, 0, 0, 0, 0,\right.$$

$$\left. 0, 0, 0, 0, 0, 0, 0, e^5(p*)\right]$$

$$H^T = \frac{n_1}{p*^TY*}\left[\frac{\partial e^1(p*)}{\partial p_1*} u_1* - \frac{\partial e^2(p*)}{\partial p_1*} u_2*, \frac{\partial e^1(p*)}{\partial p_2*} u_1* - \frac{\partial e^2(p*)}{\partial p_2*} u_2*,\right.$$

$$\frac{\partial e^1(p*)}{\partial p_3*} u_1* - \frac{\partial e^2(p*)}{\partial p_3*} u_2*, 0, 0, 0, 0, \frac{-a_0}{n_1}, +v_2{}^2, 0, 0, 0$$

$$\left. 0, 0, 0, 0\right]$$

2. <u>Elements of Impact Vectors Expressed as Functions of the Various Distributive Shares and the Elasticities of Substitution in Production and Consumption</u>

To transform elements of impact vectors from partial derivative forms into functions of the various distributive shares and the elasticities of substitution in production and consumption, we multiply $p_1{}^*$ through the first row of matrices A, B, G, and H; $p_2{}^*$ through the second row; $p_3{}^*$ through the third row; $y_1{}^*$ through the fourth row; $y_2{}^*$ through the fifth row; $y_3{}^*$ through the sixth row; $y_4{}^*$ through the seventh row; $w_1{}^*$ through the eighth row; $w_2{}^*$ through the ninth row; $w_3{}^*$ through the tenth row; $w_5{}^*$ through the eleventh row; $u_1{}^*$ through the twelfth row; $u_2{}^*$ through the thirteenth row; $u_3{}^*$ through the fourteenth row; $u_4{}^*$ through the fifteenth row; and $u_5{}^*$ through the sixteenth row.

$$A_{1.}{}^T = \left[\sum_{j=1}^{5} n_j a_j D_1{}^j T_{11}{}^j D_1{}^j, \sum_{j=1}^{5} n_j a_j D_1{}^j T_{12}{}^j D_2{}^j,\right.$$

$$\sum_{j=1}^{5} n_j a_j D_1{}^j T_{13}{}^j D_3{}^j,\ -b_1,\ -b_2,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$$n_1 a_1 D_1{}^1,\ n_2 a_2 D_1{}^2,\ n_3 a_3 D_1{}^3,\ n_4 a_4 D_1{}^4,\ n_5 a_5 D_1{}^5]$$

$$A_{2.}{}^T = [\sum_{j=1}^{5} n_j a_j D_2{}^j T_{21}{}^j D_1{}^j,\ \sum_{j=1}^{5} n_j a_j D_2{}^j T_{22}{}^j D_2{}^j,$$

$$\sum_{j=1}^{5} n_j a_j D_2{}^j T_{23}{}^j D_3{}^j,\ 0,\ 0,\ -b_3,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$$n_1 a_1 D_2{}^1,\ n_2 a_2 D_2{}^2,\ n_3 a_3 D_2{}^3,\ n_4 a_4 D_2{}^4,\ n_5 a_5 D_2{}^5]$$

$$A_{3.}{}^T = [\sum_{j=1}^{5} n_j a_j D_3{}^j T_{31}{}^j D_1{}^j,\ \sum_{j=1}^{5} n_j a_j D_3{}^j T_{32}{}^j D_2{}^j,$$

$$\sum_{j=1}^{5} n_j a_j D_3{}^j T_{33}{}^j D_3{}^j,\ 0,\ 0,\ 0,\ -b_4,\ 0,\ 0,\ 0,\ 0,$$

$$n_1 a_1 D_3{}^1,\ n_2 a_2 D_3{}^2,\ n_3 a_3 D_3{}^3,\ n_4 a_4 D_3{}^4,\ n_5 a_5 D_3{}^5]$$

$$A_{4.}{}^T = [\ -b_1,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ b_1 r_1{}^1,\ 0,\ b_1 r_3{}^1,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0]$$

$$A_{5.}{}^T = [\ -b_2,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ b_2 r_2{}^2,\ b_2 r_3{}^2,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0]$$

$$A_{6.}{}^T = [\ 0,\ -b_3,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ b_3 r_3{}^3,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0]$$

$$A_{7.}{}^T = [\ 0,\ 0,\ -b_4,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ b_4 r_3{}^4,\ b_4 r_5{}^4,$$

$0, 0, 0, 0, 0]$

$$A_{8.}^{T} = [\ 0, 0, 0, b_1 r_1{}^1 + b_1 \sum_{i=1}^{5} r_i{}^1 s_{i1}{}^1 r_1{}^1, 0, 0, 0,$$

$$\sum_{n=1}^{4} b_n r_1{}^n s_{11}{}^n r_1{}^n, \sum_{n=1}^{4} b_n r_1{}^n s_{12}{}^n r_2{}^n,$$

$$\sum_{n=1}^{4} b_n r_1{}^n s_{13}{}^n r_3{}^n, \sum_{n=1}^{4} b_n r_1{}^n s_{15}{}^n r_5{}^n,$$

$$-n_1 a_1 E_1{}^1, 0, 0, 0, 0]$$

$$A_{9.}^{T} = [\ 0, 0, 0, 0, b_2 r_2{}^2 + b_2 \sum_{i=1}^{5} r_i{}^2 s_{i2}{}^2 r_2{}^2, 0, 0,$$

$$\sum_{n=1}^{4} b_n r_1{}^n s_{12}{}^n r_2{}^n, \sum_{n=1}^{4} b_n r_2{}^n s_{22}{}^n r_2{}^n,$$

$$\sum_{n=1}^{4} b_n r_2{}^n s_{23}{}^n r_3{}^n, \sum_{n=1}^{4} b_n r_2{}^n s_{25}{}^n r_5{}^n,$$

$$0, -n_2 a_2 E_2{}^2, 0, 0, 0]$$

$$A_{10.}^{T} = [\ 0, 0, 0, b_1 r_3{}^1 + b_1 \sum_{i=1}^{5} r_i{}^1 s_{i3}{}^1 r_3{}^1,$$

$$b_2 r_3{}^2 + b_2 \sum_{i=1}^{5} r_i{}^2 s_{i3}{}^2 r_3{}^2, b_3 r_3{}^3 +$$

$$b_3 \sum_{i=1}^{5} r_i{}^3 s_{i3}{}^3 r_3{}^3, b_4 r_3{}^4 + b_4 \sum_{i=1}^{5} r_i{}^4 s_{i3}{}^4 r_3{}^4,$$

$$\sum_{n=1}^{4} b_n r_1{}^n S_{13}{}^n r_3{}^n, \quad \sum_{n=1}^{4} b_n r_2{}^n S_{23}{}^n r_3{}^n,$$

$$\sum_{n=1}^{4} b_n r_3{}^n S_{33}{}^n r_3{}^n, \quad \sum_{n=1}^{4} b_n r_3{}^n S_{35}{}^n r_5{}^n,$$

$$0,\ 0,\ -n_3 a_3 E_3{}^3,\ 0,\ 0]$$

$$A_{11.}{}^T = [\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ b_4 r_5{}^4 + b_4 \sum_{i=1}^{5} r_i{}^4 S_{i5}{}^4 r_5{}^4,$$

$$\sum_{n=1}^{4} b_n r_1{}^n S_{15}{}^n r_5{}^n, \quad \sum_{n=1}^{4} b_n r_2{}^n S_{25}{}^n r_5{}^n,$$

$$\sum_{n=1}^{4} b_n r_3{}^n S_{35}{}^n r_5{}^n, \quad \sum_{n=1}^{4} b_n r_5{}^n S_{55}{}^n r_5{}^n,$$

$$0,\ 0,\ 0,\ 0,\ -n_5 a_5 E_5{}^5]$$

$$A_{12.}{}^T = [\ a_1 D_1{}^1 n_1,\ a_1 D_2{}^1 n_1,\ a_1 D_3{}^1 n_1,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ n_1 a_1,\ 0,\ 0,\ 0,\ 0]$$

$$A_{13.}{}^T = [\ a_2 D_1{}^2 n_2,\ a_2 D_2{}^2 n_2,\ a_2 D_3{}^2 n_2,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0,\ n_2 a_2,\ 0,\ 0,\ 0]$$

$$A_{14.}{}^T = [\ a_3 D_1{}^3 n_3,\ a_3 D_2{}^3 n_3,\ a_3 D_3{}^3 n_3,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_3 a_3,\ 0,\ 0]$$

$$A_{15.}{}^T = [\ a_4 D_1{}^4 n_4,\ a_4 D_2{}^4 n_4,\ a_4 D_3{}^4 n_4,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_4 a_4,\ 0]$$

$$A_{16.}^T = [\ a_{5}D_1{}^5 n_5,\ a_5 D_2{}^5 n_5,\ a_5 D_3{}^5 n_5,\ 0,\ 0,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_5 a_5]$$

$$B^T = [\ (a_1 D_1{}^1 - a_2 D_1{}^2) n_1,\ (a_1 D_2{}^1 - a_2 D_2{}^2) n_1,\ (a_1 D_3{}^1 -$$

$$a_2 D_3{}^2) n_1,\ 0,\ 0,\ 0,\ 0,\ -n_1 a_1 E_1{}^1,\ n_1 a_2 E_2{}^2,\ 0,\ 0,$$

$$0,\ 0,\ 0,\ 0,\ 0]$$

$$G_{1.}^T = [\sum_{j=1}^{5} n_j a_j D_1{}^j T_{11}{}^j D_1{}^j,\ \sum_{j=1}^{5} n_j a_j D_1{}^j T_{12}{}^j D_2{}^j,$$

$$\sum_{j=1}^{5} n_j a_j D_1{}^j T_{13}{}^j D_3{}^j,\ -b_1,\ -b_2,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$$n_1 a_1 D_1{}^1,\ n_2 a_2 D_1{}^2,\ n_3 a_3 D_1{}^3,\ n_4 a_4 D_1{}^4,\ n_5 a_5 D_1{}^5]$$

$$G_{2.}^T = [\sum_{j=1}^{5} n_j a_j D_2{}^j T_{21}{}^j D_1{}^j,\ \sum_{j=1}^{5} n_j a_j D_2{}^j T_{22}{}^j D_2{}^j,$$

$$\sum_{j=1}^{5} n_j a_j D_2{}^j T_{23}{}^j D_3{}^j,\ 0,\ 0,\ -b_3,\ 0,\ 0,\ 0,\ 0,\ 0,$$

$$n_1 a_1 D_2{}^1,\ n_2 a_2 D_2{}^2,\ n_3 a_3 D_2{}^3,\ n_4 a_4 D_2{}^4,\ n_5 a_5 D_2{}^5]$$

$$G_{3.}^T = [\sum_{j=1}^{5} n_j a_j D_3{}^j T_{31}{}^j D_1{}^j,\ \sum_{j=1}^{5} n_j a_j D_3{}^j T_{32}{}^j D_2{}^j,$$

$$\sum_{j=1}^{5} n_j a_j D_3{}^j T_{33}{}^j D_3{}^j,\ 0,\ 0,\ 0,\ -b_4,\ 0,\ 0,\ 0,\ 0,$$

$n_1a_1D_3{}^1$, $n_2a_2D_3{}^2$, $n_3a_3D_3{}^3$, $n_4a_4D_3{}^4$, $n_5a_5D_3{}^5$]

$G_{4.}{}^T$ = [$-b_1$, 0, 0, 0, 0, 0, 0, 0, 0, $b_1r_3{}^1$, 0,

0, 0, 0, 0, 0]

$G_{5.}{}^T$ = [$-b_2$, 0, 0, 0, 0, 0, 0, 0, $b_2r_2{}^2$, $b_2r_3{}^2$, 0,

0, 0, 0, 0, 0]

$G_{6.}{}^T$ = [0, $-b_3$, 0, 0, 0, 0, 0, 0, 0, $b_3r_3{}^3$, 0,

0, 0, 0, 0, 0]

$G_{7.}{}^T$ = [0, 0, $-b_4$, 0, 0, 0, 0, 0, 0, $b_4r_3{}^4$, $b_4r_5{}^4$,

0, 0, 0, 0, 0]

$G_{8.}{}^T$ = [0, 0, 0, $b_1r_1{}^1 + b_1 \sum_{i=1}^{5} r_i{}^1S_{i1}{}^1r_1{}^1$, 0, 0, 0,

a_1, $\sum_{n=1}^{4} b_nr_1{}^nS_{12}{}^nr_2{}^n$,

$\sum_{n=1}^{4} b_nr_1{}^nS_{13}{}^nr_3{}^n$, $\sum_{n=1}^{4} b_nr_1{}^nS_{15}{}^nr_5{}^n$,

$-n_1a_1E_1{}^1$, 0, 0, 0, 0]

$G_{9.}{}^T$ = [0, 0, 0, 0, $b_2r_2{}^2 + b_2 \sum_{i=1}^{5} r_i{}^2S_{i2}{}^2r_2{}^2$, 0, 0,

0, $\sum_{n=1}^{4} b_nr_2{}^nS_{22}{}^nr_2{}^n$,

$$\sum_{n=1}^{4} b_n r_2{}^n S_{23}{}^n r_3{}^n, \sum_{n=1}^{4} b_n r_2{}^n S_{25}{}^n r_5{}^n,$$

$$0, -n_{2}a_{2}E_{2}{}^{2}, 0, 0, 0]$$

$$G_{10.}{}^T = [\ 0, 0, 0, b_1 r_3{}^1 + b_1 \sum_{i=1}^{5} r_i{}^1 S_{i3}{}^1 r_3{}^1,$$

$$b_2 r_3{}^2 + b_2 \sum_{i=1}^{5} r_i{}^2 S_{i3}{}^2 r_3{}^2, b_3 r_3{}^3 +$$

$$b_3 \sum_{i=1}^{5} r_i{}^3 S_{i3}{}^3 r_3{}^3, b_4 r_3{}^4 + b_4 \sum_{i=1}^{5} r_i{}^4 S_{i3}{}^4 r_3{}^4,$$

$$0, \sum_{n=1}^{4} b_n r_2{}^n S_{23}{}^n r_3{}^n,$$

$$\sum_{n=1}^{4} b_n r_3{}^n S_{33}{}^n r_3{}^n, \sum_{n=1}^{4} b_n r_3{}^n S_{35}{}^n r_5{}^n,$$

$$0, 0, -n_{3}a_{3}E_{3}{}^{3}, 0, 0]$$

$$G_{11.}{}^T = [\ 0, 0, 0, 0, 0, 0, b_4 r_5{}^4 + b_4 \sum_{i=1}^{5} r_i{}^4 S_{i5}{}^4 r_5{}^4,$$

$$0, \sum_{n=1}^{4} b_n r_2{}^n S_{25}{}^n r_5{}^n,$$

$$\sum_{n=1}^{4} b_n r_3{}^n S_{35}{}^n r_5{}^n, \sum_{n=1}^{4} b_n r_5{}^n S_{55}{}^n r_5{}^n,$$

$$0, 0, 0, 0, -n_{5}a_{5}E_{5}{}^{5}]$$

$G_{12.}{}^T = [\ a_1D_1{}^1n_1,\ a_1D_2{}^1n_1,\ a_1D_3{}^1n_1,\ 0,\ 0,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ n_1a_1,\ 0,\ 0,\ 0,\ 0]$

$G_{13.}{}^T = [\ a_2D_1{}^2n_2,\ a_2D_2{}^2n_2,\ a_2D_3{}^2n_2,\ 0,\ 0,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ 0,\ n_2a_2,\ 0,\ 0,\ 0]$

$G_{14.}{}^T = [\ a_3D_1{}^3n_3,\ a_3D_2{}^3n_3,\ a_3D_3{}^3n_3,\ 0,\ 0,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_3a_3,\ 0,\ 0]$

$G_{15.}{}^T = [\ a_4D_1{}^4n_4,\ a_4D_2{}^4n_4,\ a_4D_3{}^4n_4,\ 0,\ 0,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_4a_4,\ 0]$

$G_{16.}{}^T = [\ a_5D_1{}^5n_5,\ a_5D_2{}^5n_5,\ a_5D_3{}^5n_5,\ 0,\ 0,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ 0,\ n_5a_5]$

$H^T = [\ (a_1D_1{}^1 - a_2D_1{}^2)n_1,\ (a_1D_2{}^1 - a_2D_2{}^2)n_1,\ (a_1D_3{}^1 -$

$a_2D_3{}^2)n_1,\ 0,\ 0,\ 0,\ 0,\ -a_0a_1,\ n_1a_2E_2{}^2,\ 0,\ 0,$

$0,\ 0,\ 0,\ 0,\ 0]$

Appendix III

The Computer Program for the Comparative Static Analysis

Mr. Kim Harbaugh at the Antioch Computer Center kindly shared the following program with me. This program is useful for obtaining the numerical solution of the impact vector $A^{-1}B$ (for model I) and $G^{-1}H$ (for model II) through the use of scientific subroutine package.

```
      DOUBLE PRECISION A(16,16), B(16), COMMEN(20)
      OPEN(UNIT=3,TYPE='OLD',NAME='MATRIX.DAT',DISPOSE='KEEP')
      IDISK=3
      IOUT=6
      IN=5
      KS=1

      WRITE(5,100)
      READ(IN,101)
      WRITE(5,108)
      READ(IN,109) COMMEN
      WRITE(IOUT,110)N, COMMEN
      DO 10  J=1,N
      READ(IDISK,102) (A(I,J),I=1,N)
10    CONTINUE
      READ(IDISK,102) (B(I),I=1,N)
      WRITE(IOUT,103)
      DO 20 J=1,N
      WRITE(IOUT,104) (A(I,J),I=1,N)
20    CONTINUE
      WRITE(IOUT,105)
      WRITE(IOUT,104) (B(I),I=1,N)
      CALL DSIMQ(A,B,N,KS)
C
      IF(KS .EQ. 1) WRITE(IOUT,106)
      WRITE(IOUT,107)
      WRITE(IOUT,111)(I,B(I),I=1,N)
      STOP
C
100   FORMAT(1HO,'ENTER N'/)
101   FORMAT(I2)
102   FORMAT(3F10,6,F30.10)
103   FORMAT(1HO,'------------------A-------------------'//)
104   FORMAT(1X,3F15.6,F30.10)
105   FORMAT(1HO,'------------------B-------------------'//)
106   FORMAT(1HO,'----- SINGULAR -----'//)
107   FORMAT(1HO,'------------------x-------------------'//)
108   FORMAT(1HO,'ENTER COMMENTS'/)
109   FORMAT(20A4)
110   FORMAT(1HO,'N = ',1X,I2,/1HO,'COMMENTS',/1HO,20A4//)
111   FORMAT(1X,I2,2X,E30.10)
      END
```