ECONOMIC GROWTH AND LABOR MARKET DUALISM: A PRELIMINARY STUDY OF THE JAPANESE CASE

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January 1982
WP-82-7

Revised version of the paper presented at the Urbanization and Development Conference held at IIASA June 1-4, 1981

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FOREWORD

Roughly 1.8 billion people, 42 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates, about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policy makers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth and urbanization in many parts of the globe. Some see this trend as fostering national processes of socioeconomic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

Using a general equilibrium model, Hisanobu Shishido presents some results of comparative static and dynamic analyses that describe economic development in Japan. This historical study of Japan's development joins a collection of national case studies that are being concluded as part of the HSS Area's Population, Resources, and Growth Task.

A list of the papers in the Population, Resources, and Growth Series appears at the end of this paper.

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Chairman
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ACKNOWLEDGMENTS

I would like to thank Andrei Rogers, Chairman of the Human Settlements and Services Area, and Warren Sanderson for their encouragement and helpful comments. I also benefitted from frequent discussions with Urban Karlström.

ABSTRACT

This paper gives some preliminary results of a study of the history of Japan's economic development, using a general equilibrium model. After some aspects of Japan's historical development and the structure of the model are briefly described, comparative static and dynamic results are shown.

It is concluded that a model specification allowing for labor unemployment behaves better in replicating history than a specification assuming full employment, as in the orthodox neoclassical framework.

CONTENTS

ECONOMIC GROWTH AND LABOR MARKET DUALISM: A PRELIMINARY STUDY OF THE JAPANESE CASE

1. INTRODUCTION

Dualistic development is one of the better known features of Japan's historical economic growth. For a substantially long period of time both modern (imported) and traditional (indigenous) elements coexisted in the economy, and the latter played a significant role in the development process. (See, for example, Ohkawa 1972, Ohkawa 1980, Ohkawa and Rosovsky 1973, and Minami 1973. For a summary, see Shishido 1979, 1981.) How this dualistic growth is interrelated with the labor market, i.e., how growth affects the different labor markets and who pays for growth, is the focus of this paper. It presents some of the results of comparative static and dynamic analyses that describe this situation using a computable general equilibrium model. These analyses involve the changing of one or more parameter values, and examining the consequent divergences of the solution from the base solution. After a review of some historical aspects of Japan's urbanization and development during the period of dualistic development and after the model used is exposited, some results of the comparative static and dynamic analyses are described. Concluding observations concerning the static and dynamic features of the model are given in the last section.

Technical materials are in the Appendices. Appendices 1 and 2 describe the methods of estimating *ex ante* production parameters and the base year expected values, respectively. The Tables that appear in Appendix 3 show the results of comparative statics in percentage growth rates relative to base run values. The model itself is calibrated by using 1960 data: one of the first years for which a complete set of social accounting data is available.

2. JAPAN'S DUALISTIC DEVELOPMENT AND URBANIZATION PATTERN

If a computable general equilibrium model can be instrumental in analyzing a country's urbanization and development at all, it is through its capacity to examine *intersectoral* (rather than spatial) mobility of factors of production. This factor mobility is presumably caused by the responses of factors to differences in rates of return. The term urbanization, therefore, is conveniently assumed here to be synonymous to the shift of factors of production from primary (agriculture, fishery, and forestry) activities, to nonprimary activities. With this qualification in mind, let us look at Figure 1. This diagram shows the shares of primary and nonprimary working populations out of the total working population of Japan. There are two time periods when nonprimary or urban workers increased sharply. One is around the World War I period and the other the post-World War II period. The former roughly coincides with the beginning of the labor market dualism, which was manifested as persistent differentials in wage and productivity levels among workers (1910s), and the latter precedes the period when dualism largely disappeared (second half of the 1960s).

It is interesting to examine what was happening in the economy during these periods, and how this shift in working population occurred. The investment boom in the 1910s was initially caused by an unprecedented increase in export demand due to the outbreak of World War I. The investment was mainly carried out in modern heavy industries, which essentially used technologies with low labor-capital ratios and low elasticities of factor substitution. Consequently, the demand for new labor did not increase proportionately. The rate of turnover in these industries also decreased,

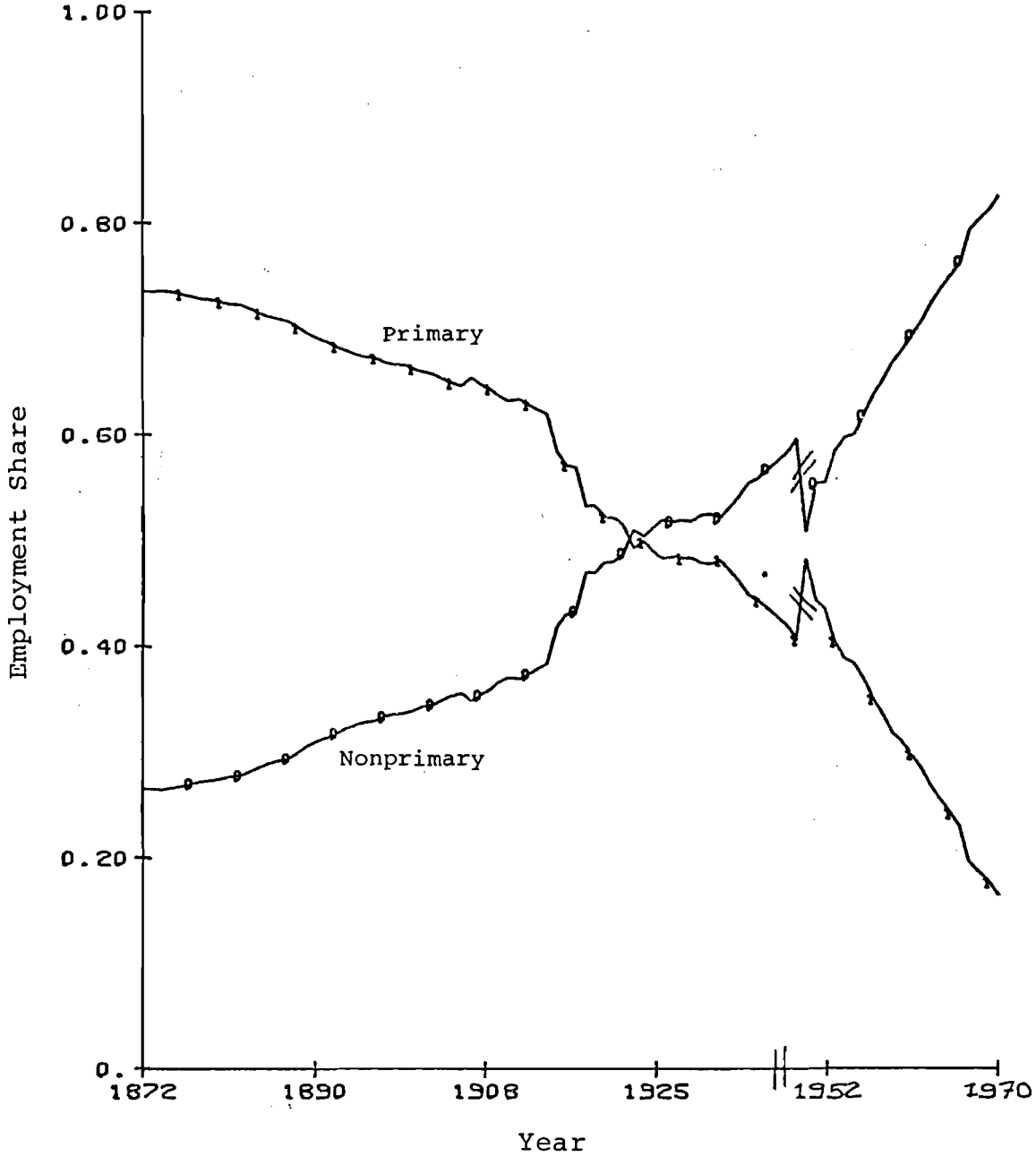

Figure 1. Shares of primary and nonprimary employment. Source: Ohkawa and Shinohara (1979).

possibly because wages in these sectors were increasing due to the desire of employers to keep the skilled labor force. Agriculture at this time, however, was going through a severe stagnation because of the lack of demand, the availability of cheaper food from foreign colonies, and the temporary exhaustion of possibilities of technical progress in a scale-neutral way.* This increased the pressure of outmigration from the rural sector. Since the modern urban sectors had limited labor absorption capacity as previously described, the only destination available for outmigrants, therefore, was the urban traditional sectors. This can be seen in Figure 2. The growth rates of traditional urban employment in 1916-1920 almost tripled (18 percent) from those of 1911-1915 (6.5 percent).

It goes without saying that in this instance, wages in these traditional sectors harldy could keep up with the price increase caused by the investment boom in the modern sectors. The distribution of income deteriorated despite (or more *because of*) the investment boom. Differential wage patterns were thus established.

The period between 1950 and 1960 saw a repetition of what happened in 1910 to 1920, in the sense that the surplus labor in the economy (especially in the traditional sectors) increased because of war repatriation. As can be seen from Figure 1, the urbanization rate in 1950 was about the same as that of 1920. The high rate of investment in the 1950s to 1960s absorbed this surplus labor fairly rapidly. Ackley and Ishi (1976) review the macroeconomic policies of Japanese government during this period. They claim that there was an insufficient amount of good quality machinery and equipment which was the constraint on economic growth. At the same time supply of skilled labor was highly elastic as long as the real wage was moderately above average income in family enterprises. Macro-government policies were carried out, therefore, in order to effectively encourage new investment. Monetary policies kept interest rates low to stimulate capital intensive private investment. The increase aggregate demand, however, deteriorated the balance of payment under a fixed exchange

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*Changes in international environments and bad weather are also considered causes of the agricultural stagnation.

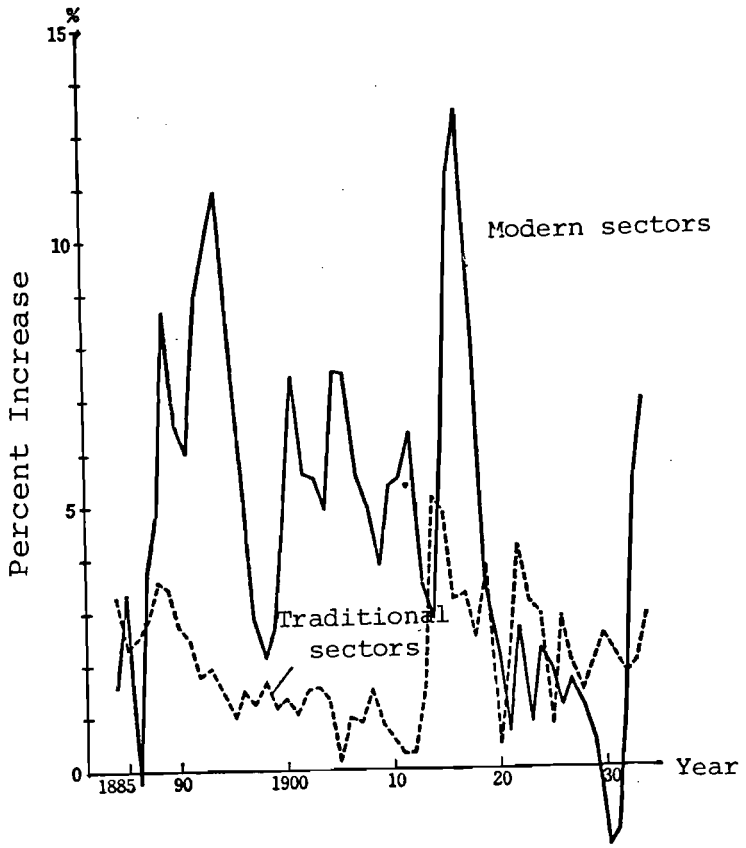

Figure 2. Growth rates of employment in modern and traditional urban sectors (three-year moving average). Source: Nakamura (1971:21).

rate in a static setting. This fact caused an occasional brake in the continued expansion of the Japanese economy.

When the balance of payments deteriorated, therefore, monetary contractions were usually employed. These were understood by everybody, however, as being temporary and did not change the growth-investment mind of the business circles at all. The same policy continued until the constraints of the labor supply began to be felt, i.e., when aggregate demand increases pushed up the real wage and also ignited inflation.

It is hoped that the comparative static results in the next section and subsequent dynamic analyses can help us understand the behaviors of these economic agents and the consequences of these behaviors.

3. THE MODEL

The model used in this analysis is essentially a simplified version of the model described in Shishido (1981). There are, however, a few changes and, for expositionary purposes, the whole system is described below.

Notations

Q	production
K	capital stock
L	labor force
Ψ	aggregate commodity of imports and domestically produced goods
w	wage rate
lc	labor cost
p	domestic price
pp	purchaser's price
pc	consumer's price
pv	value-added price
pm	import price
C	consumption demand
I	net investment demand
X	export demand
M	import
i	sector
j	sector

Sectors (subscripts i,j = 1,2,...,6)

1 modern manufacturing sector
2 traditional manufacturing sector
3 modern service sector
4 traditional service sector
5 construction sector
6 primary sectors

Vintages

Sectors 1, 2, and 3 have vintages. For example, Q_{27} means the output of sector 2, vintage 7. (For the base year, there are 8 vintages in each sector.)

Areas (subscripts u,r)

u urban
r rural

Classes (subscripts l,k)

l labor class
k capitalist class (proprietors and capital income recipients)

Production (Q)

Sectors 1,2,3, and 5 have CES production functions.

$$Q_i = A_i \left[\beta_i L_i^{\rho_i} + (1 - \beta_i) K_i^{\rho_i} \right]^{\frac{1}{\rho_i}}$$

where

A_i, β_i, and ρ_i are parameters.

The estimation method of *ex ante* and *ex post* production functions is described in Appendix 1.

Sectors 4 and 6 have production functions of the Cobb-Douglas type.

Capitol stocks (and arable land area for agriculture) are fixed period by period.

Intermediate input ratios (a_{ij}) are fixed; therefore,

$$pv_i = (1 - t_i)\ p_i - \sum_j a_{ji}\ p_j\ *$$

where

t_i is the indirect tax rate of sector i.

Labor cost

Labor cost is assumed to consist of wages and the training and hiring costs lost through quits. Then

$$lc_i = w_i + T_i \cdot q_i$$

where

T_i = training and hiring costs of sector i
q_i = quit rate of sector i, which depends on its own wages as well as wages from other sectors

Employers minimize this cost. The first order condition is

$$\frac{\delta lc_i}{\delta w_i} = 1 + T_i \frac{\delta q_i}{\delta w_i} = 0$$

For sectors 4 and 6, T_i is assumed to be zero.

Traded commodities

Sectors 1,2, and 6 have imports and exports. All imports are supposed to be competitive, and it is assumed that imports and domestically produced goods are substitutes with finite elasticities. People, therefore, consume hypothetical aggregate commodities of imports and domestically produced goods.

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* p_j = domestic price for Sectors 3, 4, and 5.
p_j = purchasers price for Sectors 1, 2, and 6.

The aggregate is formed following the tradition of Armington (1969), by a CES aggregation function Ψ.

$$\Psi_i = \gamma_i \left[\varepsilon_i M_i^{\eta_i} + (1 - \varepsilon_i) TD_i^{\eta_i} \right]^{\frac{1}{\eta}}$$

where

γ_i, ε_i, and η_i, are parameters, and

TD_i is the total domestic demand.

Then the purchaser's price of this commodity is just the cost function, i.e.,

$$pp_i = \frac{1}{\gamma_i} \left[\varepsilon_i^{\theta_i} pm_i^{1-\theta_i} + (1 - \varepsilon_i)^{\theta_i} p_i^{1-\theta_i} \right]^{\frac{1}{1-\theta_i}}$$

where

$$\theta_i = \frac{1}{1-\eta_i}$$

Import is simply

$$M_i = \left(\frac{\varepsilon_i}{1-\varepsilon_i} \right)^{\theta_i} \left(\frac{p_i}{pm_i} \right)^{\theta_i} TD_i$$

and the domestic production ratio is

$$r_i = \frac{Q_i}{\Psi_i} = \gamma_i^{\theta_i - 1} (1 - \varepsilon_i)^{\theta_i} \left(\frac{pp_i}{p_i} \right)^{\theta_i}$$

Domestic prices (p_i) are prices that clear the domestic market

$$r_i TD_i + X_i = Q_i$$

Exports are similarly specified as follows

$$X_i = C_i^x \, WT_i \left(\frac{p_i}{p_i^w} \right)^{\xi_i}$$

where

C_i^x, ξ_i are parameters

WT_i is the index of the quantity of world trade of that sector's goods

p_i^w is the world price of the good

Non-traded commodities

Service and construction sectors have no trade, but both modern and traditional services receive handling charges for externally traded goods (storage, transportation, etc.).

Consumer prices of tradeables

Prices of traded commodities are marked up by the sector and by the area. This mark-up creates an extra demand for the traditional service sector, i.e., demand for retail and wholesale services.

Therefore, consumer prices for goods of sectors 1, 2, and 6 are

$$pc_{ui} = (1 + \phi_{ui}) \, pp_i$$

$$pc_{ri} = (1 + \phi_{ri}) \, pp_i$$

where

u and r stand for urban and rural areas, respectively, and

ϕ is the mark-up rate

Consumption demand

Household consumption demands are expressed in a linear expenditure system.

Government consumption demands are treated as exogenous and business consumption demands are treated as intermediate input demands from sectors 2 and 4.

Investment

Investors instigate investing through expectation of prices and demands. They are assumed to know the *ex ante* (or blueprint) production functions. The investment demands, therefore, are

$$I_i = \left(\frac{K}{Q}\right)_i^{ef} DD_i$$

where

$\left(\frac{K}{Q}\right)_i^{ef}$ is the efficient capital output ratio with expected price vectors of sector i

DD_i is the difference between the expected demand and present supply capacity less depreciation in sector i

Expectations are formed by the difference between the actual value for the period and the previously expected value for the period multiplied by an adjustment parameter. For the base year it is assumed that prices will change at the same rate as the previous period and demands will grow at a long-term average growth rate.*

The expected demand for the next period (i.e., the one following the base period) will be the actual demand for this period (or the previous period depending on when investors were assumed to have made their decisions) multiplied by

$$\frac{g(\gamma + 1)}{g + \gamma} \quad **$$

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* This is done because there needs to be some initial value for the system of expectation formation.

** This requires the assumption that

$$g > \gamma$$

See Appendix 2.

where

g = average growth rate in the past plus 1

γ = adjustment parameter of investors (large if investors are sensitive to unexpected increase or decrease of demand)

Finally, depending on the specification chosen, these investment demands will be the actual investment or the actual investment will be amounts scaled proportionately up (down) in accordance with the amount of savings available.

Other features

Savings ratios and government variables together with other parameters are treated as exogenous.

Housing markets and urban land markets are excluded from this analysis although the full model does include these markets, and a rough trial to estimate parameters for these markets has already been made.

Market clearing

Ordinary market clearing equations close the model. Walras' Law ensures that the total savings equals the total investment,

$$PS + GS + FS = \sum_i p_k I_i$$

where

PS = private savings

GS = current government budget surplus

FS = foreign savings (= trade deficit)

p_k = price of capital goods (weighted average of prices of origin sectors of investment)

4. COMPARATIVE STATIC RESULTS

This section describes some of the 50 comparative static experiments that were carried out for the Japanese case. These comparative statics can be classified into the following seven different types:*

1. Changing the productivity of a sector
2. Changing factor substitution elasticities of production functions
3. Changing the amount of investment or saving
4. Changing the tariff rates and world demand indices
5. Changing the taste of consumers toward traditional goods
6. Changing the sector-specific training and hiring costs
7. Other specifications

Two different closures of the model are employed (see Table 1). One assumes investment to be endogenous, while the sizes of total urban and rural labor force are exogenous. This specification determines investment by the amount of savings available in the model. This is the ordinary neoclassical way of closure and is called the NC model hereafter. The second way of closing the model is to assume the nominal values of the investment as predetermined by the expectations of investors in the previous year. If we make the investment exogenous, we have to endogenize one previously exogenous variable so that the system will not be overdetermined. We have chosen to free the total urban labor force. This actually means that the labor supply is elastic in the urban area (unemployment exists) and only demands are important, i.e., the underutilization of resources, *à la* Keynes, which can be employed by increasing aggregate demand. This specification is called the FI model hereafter. Within the FI model two assumptions are made regarding wage determination. One is to assume that wage is determined by rural-urban relationships and training costs as described in section 3. The second assumption is to fix the nominal wage levels. This second specification

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*All changes are by 10 percent, except for tariffs, which are changed by 50 percent.

Table 1. A summary of the differences between the two closures.

1. NC (Neoclassical)
o Fixed total labor and capital available in each of the urban and rural areas
o Total amount of investment determined by total available savings
2. FI (Neo-Keynesian Fixed Investment)
o Aggregate demand determines the level of urban labor employment, i.e., unemployed labor exists
o Nominal amounts of investment are determined by investors' expectations during the previous period

allows one to analyze the short-run effect of inflation when wage moves with lags.

All nominal variables are deflated by relevant price indices: GDP by GDP deflators; wages as income to consumers, consumer's price index; wages as cost to employers, value-added price of own-sector goods; and the nominal value of investment by the capital good's price index.

Migration pressure* is defined by

$$\frac{\sum_i W_i \left[I_i \left(\frac{L}{K}\right)_i + q_i L_i \right]}{\sum_j \left[I_j \left(\frac{L}{K}\right)_j + q_i L_j \right]} \Big/ y_a$$

where

W_i is the nominal wage of sector i

I_i is the net investment of sector i

*In a static setting, this pressure mainly depends only on relative wages because quit rates, investment, and capital-labor ratios do not change at all or are quite rigid during the intra-period.

$\left(\frac{L}{K}\right)_i$ is the average labor-capital ratio of sector i

q_i is the quit rate of sector i

L_i is the employment of sector i

y_a is the nominal agricultural income

This is just the ratio of the weighted average of urban wages to the average agricultural income, and the weights are jobs available for migrants by new investment and quits. This specification of migration pressure comes from the framework popularized by Todaro (1969) and Harris and Todaro (1970). (For a summary, see Todaro 1975.) In this framework, internal migration is hypothesized to be explainable by rural-urban income differentials and the probability that a migrant will secure a job in the urban area. In the specification employed here, urban wages and average rural income capture the income differentials, and investment and quits capture the probability that a migrant secures a job. It is assumed, for the purpose of static analysis, that this specification reflects sufficiently the "pull" rural populations feel from the urban sectors.

This specification, however, should not be regarded as the best for explaining the migration pattern in historical Japan. Preliminary regression analyses show that wage differentials do not explain the internal migration significantly in any form. Investment in urban productive sectors, however, is a very important variable in explaining the pattern. A use of polynomially distributed-lag specifications shows that the one-year-lagged investment has a negative coefficient, and that the two-year-lagged investment has a positive coefficient. Both coefficients are extremely significant.*

This preliminary exercise seems to offer at least two testable hypotheses with regard to migration decision making. One is that an increase in urban investment induces migration because

*This specification of migration that includes the "wage differentials" is not used for the dynamic simulation for this reaction. See section 5.

farmers perceive the increase of opportunities in the urban area with a lag of two or three years. The other hypothesis is that the investment in urban areas lowers the level of the rural welfare, thus increasing the "push" factor for migration. These two hypotheses are, of course, not mutually exclusive, but if the rejection of the second hypothesis turns out to be difficult, then it gives a starting point in the inquiry, "who pays for growth in a dualistic economy?" The following comparative static results and consequent dynamic analyses try to examine this issue. Table 2 summarizes some of the major results of comparative statics; for further results see Appendix 3.

Table 2. Major results of comparative statics.

Increased Productivity in One Urban Sector
— Increased outputs of the sector
— Decreased labor employment of the sector
— Improved agricultural terms of trade (= urban traditional sectors' laborers relatively better off)
— Shift of income to urban labor
Increased Productivity in Agriculture
— Income decline in agricultural sector
— Urban traditional sectors' laborers relatively worse off
— Migration pressure increases
— Shift of income away from urban labor
— Increased real investment (FI)
— Decreased real investment (NC)
Higher Elasticity of Factor Substitution in Modern Manufacturing
— Decreased output of the sector
— Decreased wage of the sector
— Decreased labor employment of the sector
Higher Elasticity of Factor Substitution in Traditional Manufacturing
— Increased output of the sector
— Increased wage of the sector
— Increased labor employment of the sector

continued over

Table 2 continued.

High Investment (FI)

— Shift of income away from urban labor
— Decreased real wage of urban labor

High Saving (NC)

— Moderate shift of income away from labor
— Moderate increase of real wage of urban labor

Higher Exports in Modern Manufacturing

— Reduced real wage in all urban sectors
— More decrease of real wage in traditional (modern) sectors than in modern (traditional) sectors in NC (FI) closure

Higher Exports in Traditional Manufacturing

— Reduced real wage in all but traditional service sectors
— More decrease of real wage in modern sectors

Higher Tariff Rates on Manufacturing Sectors

— Increased production and employment in the sector concerned
— Real wage decrease in all urban sectors
— Increased (decreased) labor share when traditional (modern) sector has higher tariffs

Higher Tariff Rates on Agricultural Goods

— Decreased production in all urban sectors (FI)
— Decreased production only on urban consumers' products (NC)
— General but small decrease in urban real wage (except traditional service sector in FI)
— Increased labor share

Changes in Consumers' Tastes Toward Traditional Goods

— Increased labor share
— Drastically reduced migration pressure
— Increased (decreased) investment in NC (FI) closure

Higher Training Costs

— Increased real wage in the sector concerned and related sectors
— Higher (lower) urban labor share in FI (NC) closure
— Higher migration pressure

4.1. Increased Productivity

An increase of productivity in any sector in a static setting causes a decrease in the product's price, thus decreasing the employment in that sector. A crucial question is what such an increase does to the welfare of the population in general and possibly to the future path of the economy. The decrease of a product's price and the increase of its supply push up the demand for other goods. Because factors of production are less substitutable in modern sectors and because the lower the elasticity of factor substitution the lower the decrease in labor employment with fixed capital stocks, *the increase in output is higher in modern sectors*. The increase in modern manufacturing and construction output, and the consequent decrease in their prices, however, do not make laborers happy at all. Such goods are mainly capital goods, and their price decreases do not reflect changes in the price level of consumer goods. As a result the purchasing power of wage earners in many sectors actually decreases. The traditional urban sectors often escape this fate because of their assumed ties with the agriculutral sector. The agricultural sector enjoys the improvement of terms of trade due to the assumed intraperiod factor immobility. This sector's supply is fixed in each period, and an increase in the demand for agricultural goods directly results in an increase in agricultural income. Because wages in the urban traditional sectors are sensitive to agricultural income, and because agricultural income increases, the wages in urban traditional sectors tend to go up more than wages in the urban modern sectors.

An increase in productivity in urban service sectors, i.e., sectors 3 and 4, which produce largely consumer commodities, increases the consumer's purchasing power. An increase in productivity in agriculture has profound consequences. For the agricultural sector it is a typical "immiserizing growth," i.e., a supply increase while demand remains inelastic, causing income to decrease due to the decline in price. A price decrease of agricultural goods increases the demand for all other commodities—directly from an increase in consumers demand and indirectly from intermediate demands. All urban prices increase, therefore, and

wages tend to increase as well. But, again, the real wage of the two urban traditional sectors that have strong ties with rural income do not increase because of the implied increase of labor surplus in the rural area. The employers can pay workers less and yet expect little loss through increased turnovers because the employees' prospect of getting jobs in related labor markets is now worsened. Essentially the same situation occurs when agricultural sectors face cheaper imports. The supply is inelastic and their income, as well as the income of urban traditional sector wage earners, declines.

The migration pressure increases when agricultural income decreases, i.e., the increase in agricultural productivity and imports of cheaper agricultural commodities.

As stated before all wages and income in all sectors are related. Any increase in wage in one urban sector would put pressure on all other sector wages to increase. The same happens when agricultural income goes up, although the degree of relatedness with agricultural income differs by how modern the sector is. Thus, any productivity increase in any urban sector would result in a shift of income toward the labor class with the specification of wage determination employed here. The increase in the real accumulation, therefore, occurs only through capital price decrease (in the case of the productivity increase of sectors 1 and 5) or the increase in foreign savings caused by changes in terms of trade (inflation, in this case). In the case of agricultural productivity increase, however, the general decline in wage levels shift income toward capital income earners who have the higher saving propensities. This increases savings somewhat, but the general price decline reduces foreign savings by improving the balance of payments. The outcome is decreased real investment in the NC model. In the FI model, of course, the total nominal savings is fixed. This extra increase in savings comes from a more drastic shift of income toward capitalists, which increases both personal savings and government savings through high tax rates to counteract the reduction in foreign savings. Such a shift in income distribution is possible because in the FI model, employers can employ as many workers as they wish.

Employing more labor in this way increases the capital income drastically whereas in the NC model total urban labor is fixed, which constrains the reduction in wage levels. Labor is already a scarce factor of production fixed in supply by assumption in the NC model.

4.2. Elasticities of Substitution

Sensitivity analyses of changing values of elasticities of substitution result in completely different results depending on the factor intensities of the sectors involved. Increasing the substitutability between capital and labor in modern manufacturing decreases its own wage and output, whereas the opposite is true for the traditional manufacturing.* This is explained by (a) fixed capital stocks, and (b) rigid wage structure.

An increase in substitutability in modern (capital intensive) sectors, would shift the efficient production point to a higher capital intensity, if the wage-rental ratio stays constant. The capital stock is fixed, however, and there is therefore, a strong pressure to decrease the wage. But the wage structure is also rigid, determined by quit rates, training costs, and agricultural income. If there is no way for employers to reduce real wage as much as they want to, the only thing they can do is to reduce it as much as they can and adjust the employment level in such a way that the production can occur at the efficient point with the now more substitutable technology. Employment definitely declines. Furthermore, the decrease in output and income in modern manufacturing also reduces demand pressure for all other sectors. In the FI model, this results in employment decrease in all sectors, whereas in the NC model, the need to keep the total urban labor force employed requires a lower real wage rate in some sectors. This is done by increasing the price of that sector commodity.

Increasing the substitutability in the labor-intensive traditional manufacturing sector *increases* labor demand. Other sectors' prices and outputs then depend on income elasticities of

*Other results are possible depending on the parameter values chosen. The key is to find a point on the isoquant where production occurs.

consumer demand and demand for intermediate inputs. Labor share in the GDP increases in this latter case of increasing substitutability in the traditional manufacturing sector, whereas it shrinks when the same happens in the modern sector. Migration pressure increases in the first case and decreases in the second case, reflecting the sensitive reaction of agricultural income to the demand for agricultural goods.

4.3. High Investment and Saving

The analysis here involves examining the consequences of increasing growth potentials by letting the economy accumulate more capital stocks. More accumulation is realized in the FI model by simply increasing the exogenously given amount of nominal investment, whereas in the NC model a saving propensity is increased. Both deteriorate the distribution of income, in that the labor share decreases: 5.3 percent for the FI model and 2.6 percent for the NC model. In the FI model all real wage decreases, especially that of workers in mainly capital good producing sectors because the high demand for these sectors' commodities make it desirable to hire more labor. But this is done with increasingly lower wage rates because of the fixed capital assumption.

These wage declines allow employment to increase in all sectors, but migration pressure declines despite increased present employment and future job opportunities. This is the result of two factors: (1) the decline in urban real wage and (2) the increase in agricultural real income. The latter, the increase in agricultural income by increased investment, is the direct result of the fact that the data base is from 1960; Japan was already a fairly developed economy by this time with high rates of interaction among sectors. The increase in investment results in direct and indirect increases in the demand for agricultural commodities. It may be more appropriate to use data from an earlier time period for studying developing economies. In the next section, an experiment in which agriculture does not supply intermediate inputs to capital good producing sectors has

been carried out. In such a scenario, the higher amount of investment actually decreases agricultural income, thereby increasing migration pressure.

In the NC model, however, the consequences of an investment increase by similar amounts through increased saving propensities are less disconcerting. Prices in capital good producing sectors increase due to the higher demand for these commodities, but the prices of consumers' products stay relatively stable, resulting in *increasing* the real wage in all sectors in terms of consumer prices. This is possible, again, by the fact that the total number of urban workers is fixed. The wage levels do not decrease as much as they do in the scenario of the investment increase in the FI specification. As is true with all neoclassical growth scenarios, thriftiness of consumers is always a wonderful thing.

4.4. Increases in Exports

An increase in export demand, resulting from an increase in the world trade parameter (see section 3), also has differing consequences depending upon whether the sector involved is modern or not. An export increase in the modern manufacturing sector reduces the real wage of all sectors in both the FI and NC models. The magnitude of decrease is again, larger for FI solutions, for the similar reason as described in the investment increase in section 4.3. Employment increases in the FI model in all sectors except construction, which produces nontradeable capital goods. (This is misleading. The demand for construction increases in the next period because of an increase in investment caused by demand increase. It should always be remembered that we are still in the static world.) In the NC model, however, wage levels would not decrease as much, and the intersectoral reallocation of labor rather than real wage makes the system adjust to the external shock.

The increase in export demand in traditional manufacturing offers no better a picture to the urban workers; the increase in prices of traditional manufacturing commodities increases the consumer's price index drastically. The only sectors that avoid

errosion in the purchasing power of employees are urban traditional service sectors and agriculture. This is simply because agriculture supplies a large amount of intermediate inputs to traditional manufacturing. The increase in demand for the traditional manufacturing increases the demand pressure for agricultural goods, increasing the agricultural income. The agricultural income, in turn, strongly affects the wage level in urban traditional service sectors, thereby increasing the real wage of this sector's employees.

Employment and output of the modern service sector are also increased by the increase of both modern and traditional manufacturing exports. This can be viewed as a result of the interaction between intermediate and consumer demands for this sector's goods. Because the modern service sector has small intermediate input coefficients from manufacturing sectors, the impact of the latter's price increase is kept to a minimum *and* the strong demand from consumers keep the sector's own price high. Consequently, the value-added price increases in the modern service sector allowing for the increase in output and employment even in the NC model where the manufacturing sector increases its demand for labor significantly because of the increase in commodity demand in the world market.

4.5. Changes in Tariff Rates

The direct effect that an increase of a tariff rate has is the increase of the commodity's purchasing price. This causes consumer's to substitute domestically produced goods for imported goods, therefore increasing the demand for the former, thus attracting more labor into this sector. So far so good. The real question again is the implications for the whole economy and for the future. The increase in the tariff rate in the modern manufacturing sector decreases the demand for other commodities including agricultural goods. In the NC model the decrease in demand in sectors other than the modern manufacturing sector, decreases the prices. This, in turn, increases the labor cost, employment is curtailed in all of these sectors, and workers are absorbed by the modern manufacturing sector.

In the FI version consequences are more, but subtly, complicated. Modern manufacturing increases its output and employment, since it is not constrained by labor supply. The output can be increased further by hiring more labor. This both marginally increases the intermediate input demand and decreases the decline of consumer's demand for other commodities, resulting in a mixed outcome.

The increase in tariff in the traditional manufacturing sector increases the output and employment of this sector, but reduces output and employment in all other sectors, both in the FI and NC specifications. The migration pressure, however, decreases because traditional manufacturing has a higher intermediate demand for agricultural goods, which raises the level of agricultural income.

The higher tariff on agricultural demand increases the agricultural price. This would result in the decrease of consumer demand in all other sectors given the inelasticity of agricultural demand with respect to income. Thus urban sectors where consumer goods are mainly produced reduce their production.

The accumulation of capital in real terms decreases in the FI specification because of the slight price increase in capital goods, whereas in the NC model, due to the substitution effect of the labor force, the investment goods' prices do not go up when the tariff is on the consumers' commodities, resulting in a slight increase in real investment with the specific set of parameters chosen in this modeling.

4.6. Change in Consumer Taste

A change in consumer taste gives a straightforward result: an increase in general price levels, especially in the sectors where the commodities produced are favored by consumers. Note that if traditional sector goods, including agriculture, are more favored, migration pressure will decrease, and investment will be reduced in the FI model, whereas investment will increase in the NC model. This increase in investment is financed by increased foreign saving caused by a general price hike.

4.7. Change in Training Costs

An increase in training costs essentially decreases the employment level by forcing the employers to pay higher wages. This in turn increases related urban wages, thus decreasing employment in these sectors as well. In general, the output decreases in every urban sector except the urban traditional service sector, which has no training costs and little relationship with the other urban sectors. Now the labor force share of income is increased in the FI model, whereas in the NC model it is reduced. This is the opposite of what has been happening above; when there is a pressure to increase the wages, the FI model can do so by reducing the total level of employment, whereas in the NC model the fixed level of urban labor force keeps the wage level down to achieve the full employment rate.

4.8. Fixed Wage Model

Finally, one result of the experiment to fix the wage level in the FI model should be mentioned. This scenario is capable of describing a situation when the nominal wage levels are fixed by some kind of contract or by force. If a general price hike occurs in this situation, the wage earners are definitely the losers. The experiment is to let the investment increase by 10 percent, resulting in an increase in the urban labor force of 3 percent, a decline in wages of non-capital good producing sectors of approximately 1.5 percent, and a decline in capital good producing sectors by 5 percent. The income, of course, shifts toward the capital income earners. The increased investment is thus financed by increased savings from capital income as well as the increased foreign savings.

This shift of income distribution is one version of "forced savings" which, of course, is seen in the other examples (4.1 to 4.6) in a more subtle way. It is claimed by many that such an account of forced savings can often be applied to contemporary developing countries, and is therefore suitable for studies of the development process.

5. PRELIMINARY DYNAMIC ANALYSES

5.1. Instantaneous Dynamic Effects

Some dynamic effects can be inferred from the static results described in the previous section. The FI version adjusts to external and internal shocks by changing the general level of real wages of urban sectors. The NC version, on the other hand, adjusts through reallocation of labor among urban sectors.

In order to see the instantaneous* dynamic effects of different closures, three one-year period dynamic analyses with four different model closures are carried out, illustrating the effects of growth on distribution in each closure. The results are shown schematically in the four diagrams in Figure 3 using two variables: real GDP and real wage rate in the traditional manufacturing sector.

The first experiment involves an FI closure with both wages and investment nominally fixed. In this case the output grows rapidly, but naturally the real wage is reduced 10 percent by the third period, a trend that could not continue for long. In Japan there was a similar situation in the 1910s when the real wage decreased during the investment boom. This was terminated by the rice riot of 1918, which was a result of people feeling they had been unfairly treated for a long time.

In the second FI diagram, the assumption of fixed nominal wage is removed. The growth rate is slowed down a little; the decline of real wage is reduced. (In fact, the real wage increases in the fourth period analysis.) Diagrams 1 and 2 assume zero intermediate input from agriculture to capital producing sectors.**

Diagrams 3 and 4 of Figure 3 illustrate NC closures. The first specifies agricultural input to the capital good sector as

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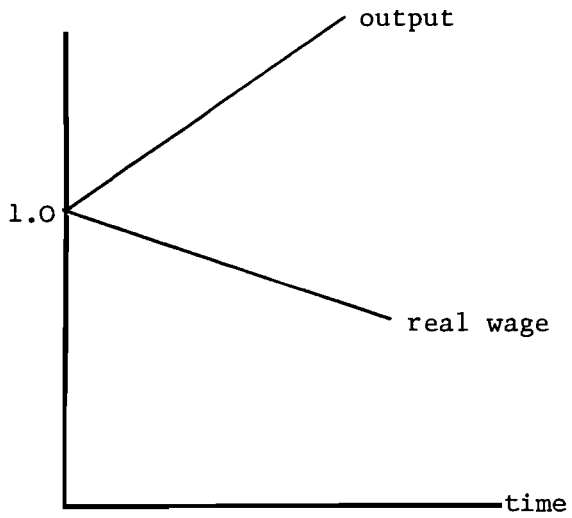
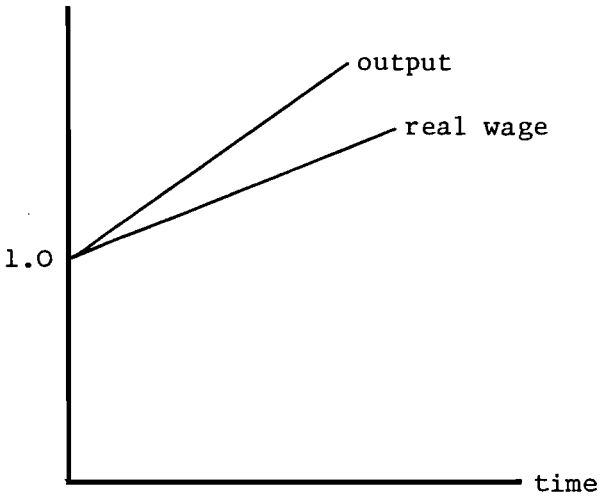
*"Instantaneous" means a short enough period of time for the many exogenous variables (foreign exchange rate, foreign prices, world demand, and government demand, etc.) to be considered more or less constant.

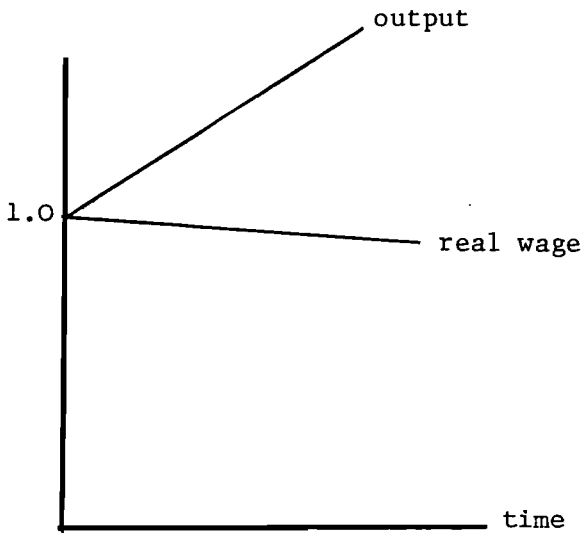
**In the earlier phase of development, the agricultural input to capital formation in urban sectors could be regarded as nil. Because of this, the use of a 1960 data base for studying less-developed economies is not appropriate.



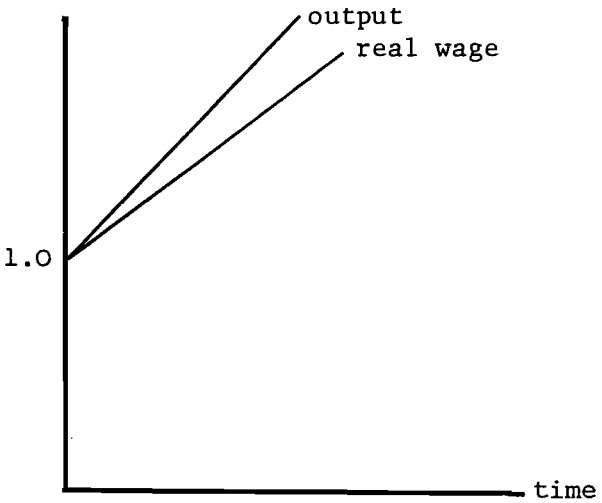
1. FI with fixed wage without agriculture/ capital goods tie



3. NC without agriculture/ capital goods tie



2. FI without fixed wage without agriculture/ capital goods tie



4. NC with agriculture/ capital goods tie

Figure 3. Instantaneous dynamic effects.

zero, whereas the second diagram uses the full 1960 input-output tables. The results are self-evident.

The higher the level of intersectoral interactions, the higher the output, and, of course, the agricultural income increases greatly with the increased demand for the sector's produce. This higher agricultural income increases the urban wages and hence the results of the diagrams. These are, of course, instantaneous effects. The long period changes the expectations of investors and producers even in the FI model, and the investment level can come down. The change of real wage at below or above output growth cannot last with the same magnitude forever in any specification. The question is, do different closures, in fact, apply at different phases of development in Japan, and, if so, which applies in which period?

5.2. Ten-Year Simulation*

Preliminary analyses of ten-year dynamic simulations have been carried out in order to at least partially answer the above question using 1960 data for the initial year. This is the period of very rapid growth in Japan. The GDP in real terms increased by 11.9 percent per annum. The "gainfully employed" in primary activities decreased by 4.17 percent per annum. The preliminary base runs give the following growth rates per annum:

		FI (%)	NC (%)
Production of	Sector 1	11.8	12.2
	Sector 2	7.4	8.2
	Sector 3	11.7	12.6
	Sector 4	5.4	6.2
	Sector 5	9.4	8.9
	Sector 6	3.8	4.9
Export of	Sector 1	19.5	20.1
	Sector 2	5.6	9.5

*Only NC and FI versions with the full 1960 input-output tables are used here for comparison.

		FI (%)	NC (%)
Import in	Sector 1	12.5	7.4
	Sector 2	17.2	14.8
	Sector 6	19.5	18.6
GDP in base year price		7.9	8.2
Labor Force	Sector 1	3.4	3.2
	Sector 2	1.4	1.2
	Sector 3	9.0	8.8
	Sector 4	4.1	2.6
	Sector 5	5.5	3.6
	Sector 6	-4.4	-4.6
Labor Share		-0.64	-0.25

The historical values that correspond exactly to these growth rates are not available. But the following historical values are for aggregations similar enough to those above for an evaluation of the models behavior.

		Historical percent per annum increase
Production of	Manufacturing	13.6
	Facilitating Industry*	10.8
	Services	8.0
	Construction	10.9
	Agriculture	2.0
Export of	Heavy Industry	20.4
	Textiles and Miscellaneous Industries	7.3
Import of	Heavy Industry Goods	14.4
	Light Industry Goods	19.8
	Agricultural Goods	14.0
	Raw Materials	11.0
GDP (in 1965 price)		11.9
Labor Force	Manufacturing	3.2
	Facilitating Industry*	3.3

*Railways, electricity, and other utilities.

Labor Force	Commerce and Service	2.8
	Construction	4.6
	Primary	-4.2
Labor Share		-0.57

It should be stated here that "migration" is specified as a function of job openings potentially available for migrants. That is,

$$M = m \cdot \sum_{i=1}^{5} \left[I_i \left(\frac{\bar{L}}{K} \right)_i + L_i \cdot q_i \right]$$

where

M is the number of migrants

m is the constant coefficient

I_i is the investment in sector i

$\left(\frac{\bar{L}}{K} \right)_i$ the labor-capital ratio of the new capital stock invested

L_i the labor force in sector i

q_i the quit rate in sector i

This means that wage differentials do not play any role at all in migration decisions because wage differentials are never significant explanatory variables of migration in regression analyses (see section 2), and, consequently, a migration specification with wage differentials would make the dynamic behavior of the model far from real. Of course, the specification that excludes wage differentials cannot apply forever if decreasing rural population pushes up the income level of the remaining rural people to a substantially higher level. It only means that at least during the period that we are interested in, wage differentials seem to have mattered very little in migrants' decision makings.

Let us now look at the behavior of the model over time. Figure 4 shows the growth rates of real GDP and urban labor share relative to the respective values of previous years in NC, FI, and historical values. The NC version (Figure 4a) has higher average growth rates of GDP but annual growth rates fall steadily. This is mainly caused by the increase in government and housing investment (taken to be exogenous for historical values) that crowds out private investment in the model. The labor share of urban income fluctuates over time although this fluctuation is less for the NC version than the historical values or the values for the FI version. There is, if anything, a slight tendency for the share to move with the GDP growth rate.

The FI version (Figure 4b), on the other hand, has oscillating GDP growth rates but no general tendency to increase or decrease. The urban labor share moves in a completely opposite direction to GDP growth rates, i.e., the higher the GDP grows, the lower the labor share becomes.

Finally, the historical values of these growth rates are shown in Figure 4c.* As can be seen from this diagram the GDP growth rates and labor share move consistently in opposite directions during the 1960-1969 period. It therefore appears, at least from a qualitative point of view, that the FI method of closing the model may be more appropriate for studying the economic growth of the time period concerned. This means that the urban sectors considered the supply of labor virtually unlimited, a result which agrees with the statement made by Ackley and Ishi (1976) that historically the urban entrepreneurs regarded the supply of quality labor as highly elastic during the decade of high economic growth.

Many dynamic sensitivity analyses have been carried out in order to further understand the dynamic behavior of the model.

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*To make the model replicate history by changing various parametric values has not been tried. This study is only qualitative because the parameters of key equations (i.e., those in the expectation formation mechanism or the wage determination mechanism) have only been guesstimated. The use of fixed input-output coefficients also contributes to the poor overall performance of the model in replicating history.

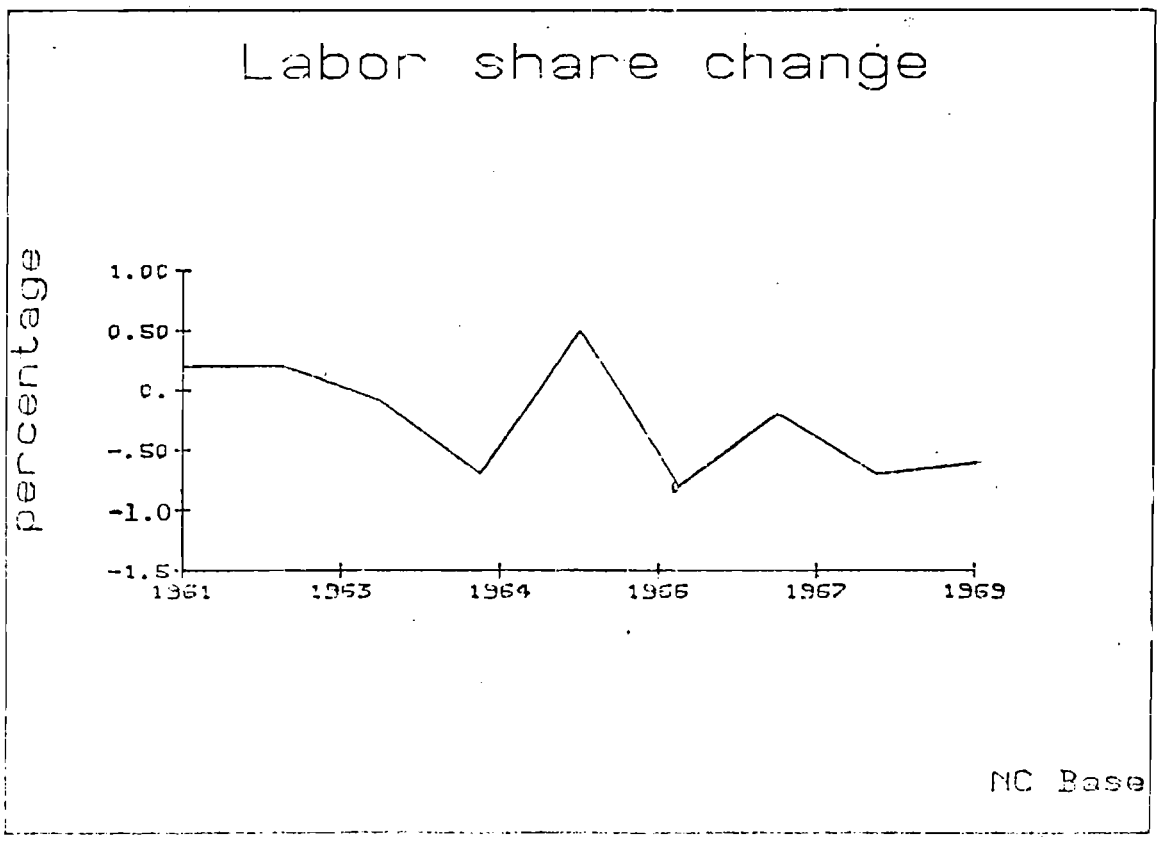
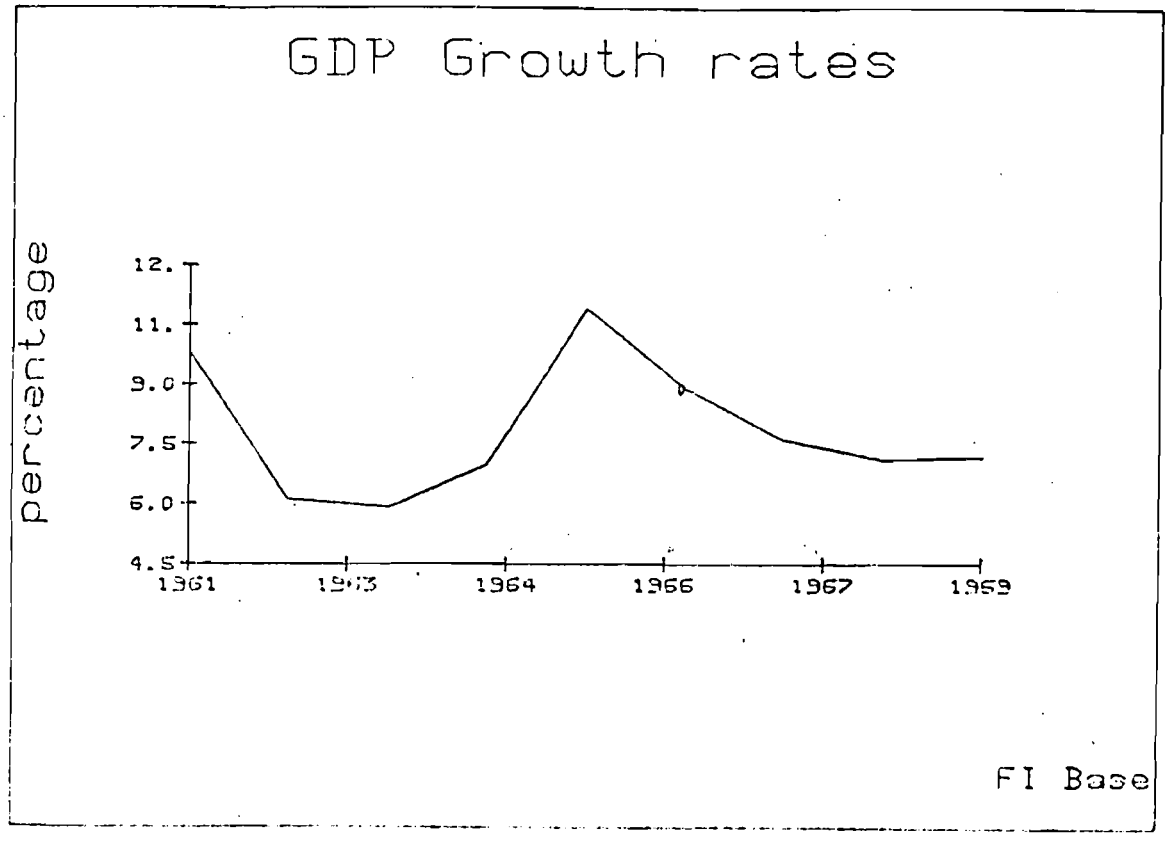


Figure 4a. GDP growth rates and changes in labor share in the NC model simulation.



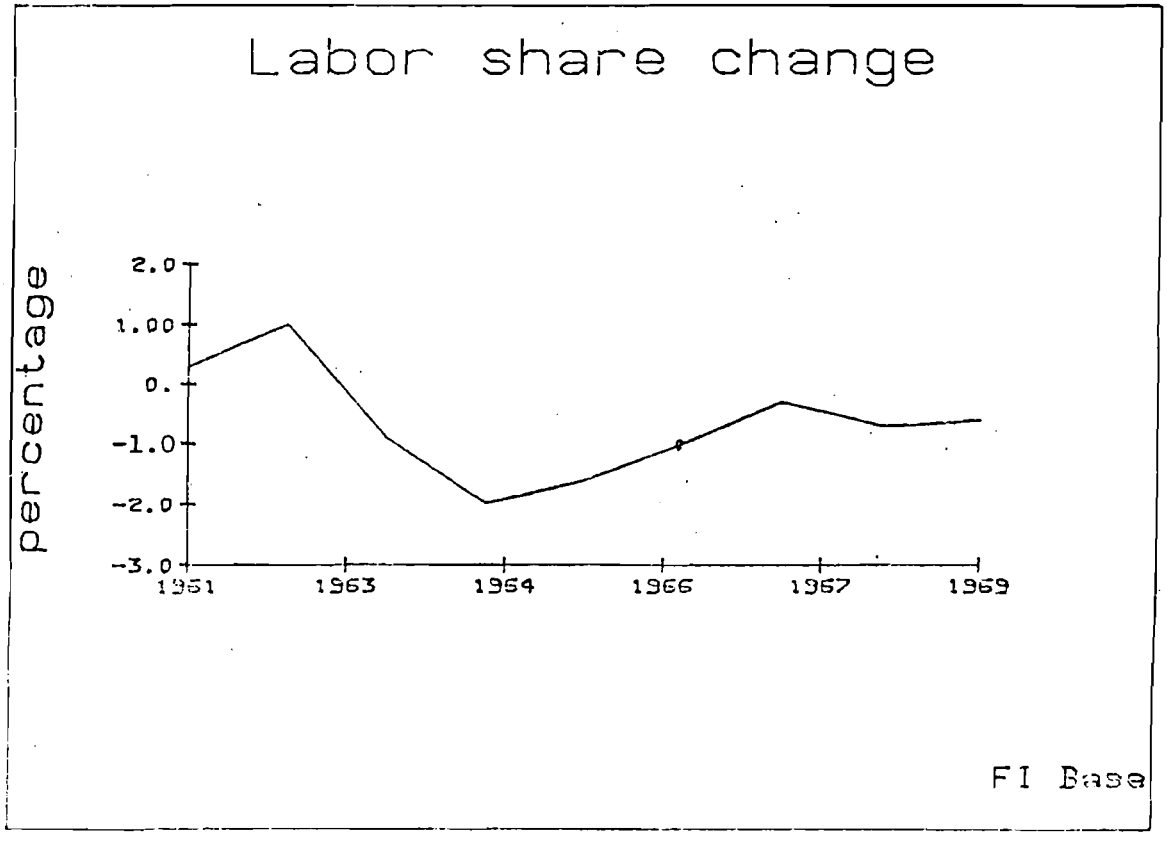
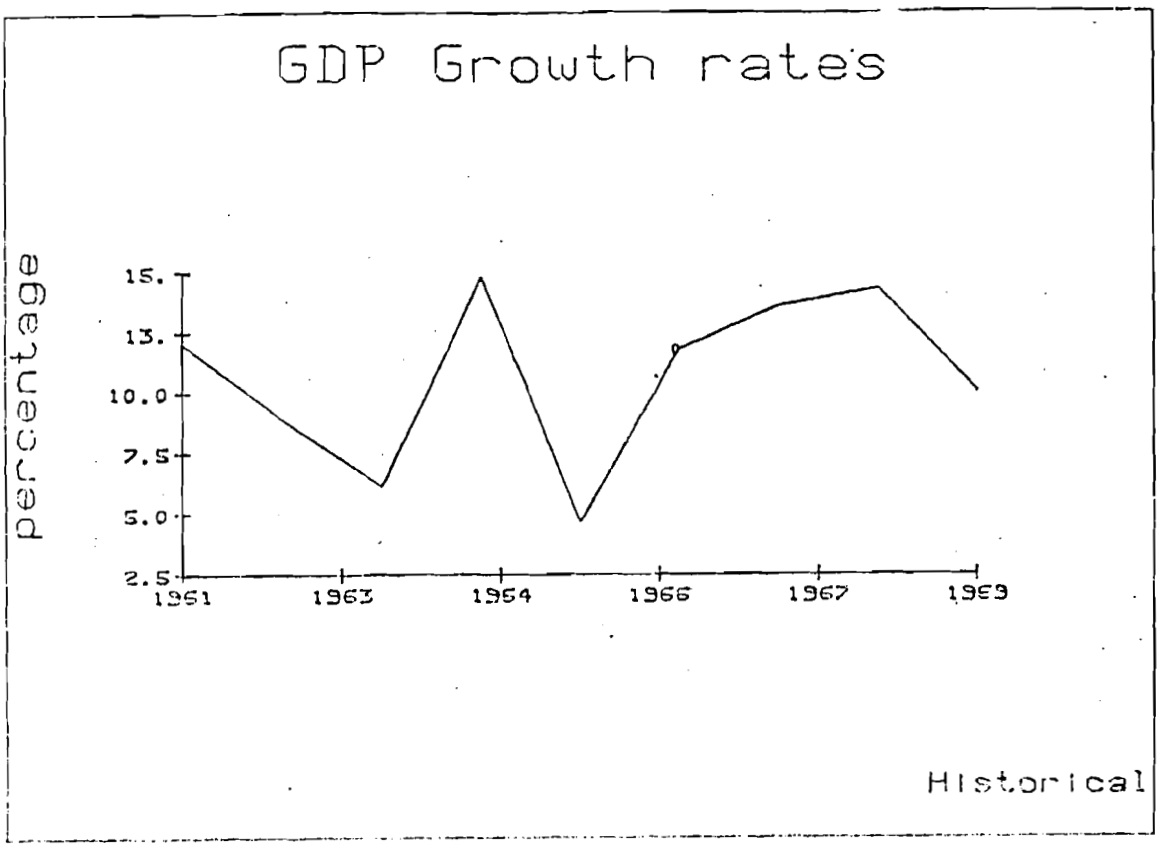


Figure 4b. GDP growth rates and changes in labor share in the FI model simulation.



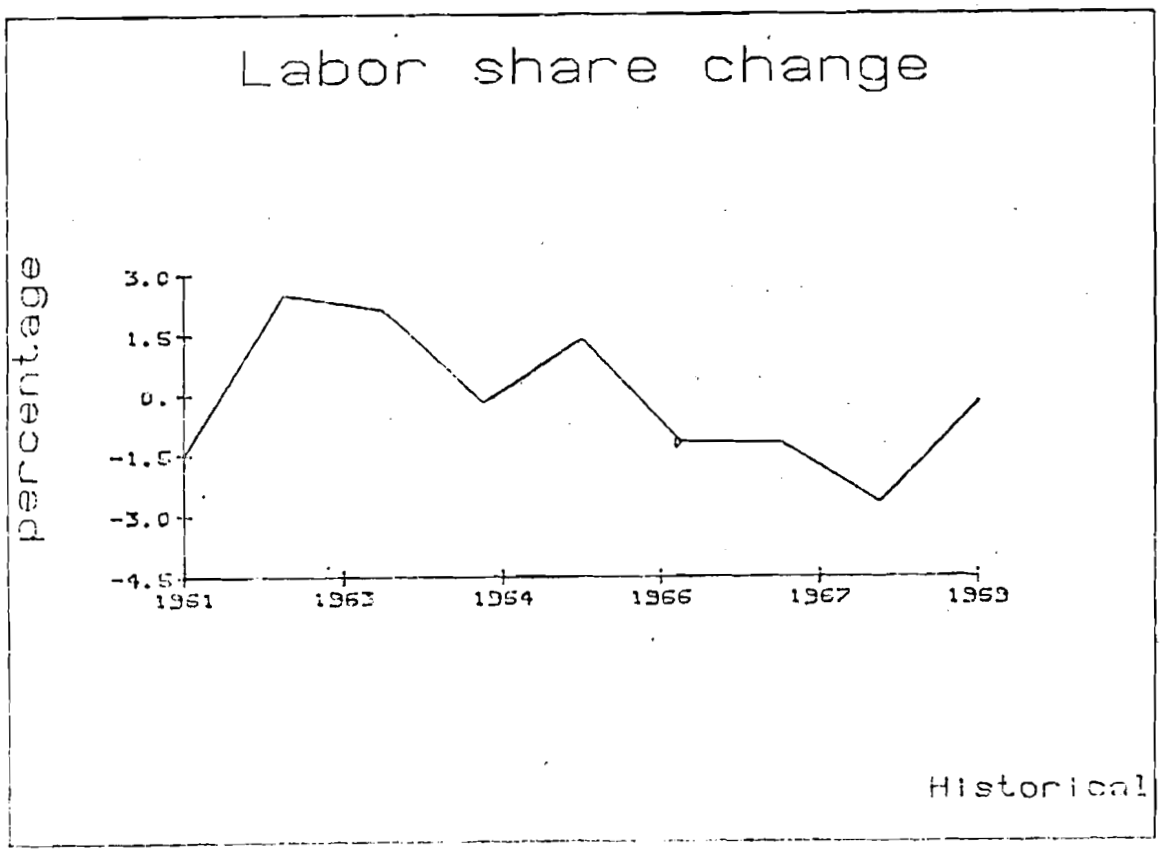


Figure 4c. GDP growth rates and changes in labor share in historical values.

Among them, four simulations are briefly described below:

(1) Lowering migration propensity by 50 percent (LMI)

(2) Increasing the world demand for sector 1 goods in 1963, 1964, and 1965 by 40 percent (HWD1)

(3) Changing consumer's subsistence minimum requirement every year (decreasing agricultural consumption and increasing sector 2 goods consumption to catch the shift of food consumption pattern from the traditional food to more modern processed food) (CTR)

(4) Lowering the saving propensity of urban labor by 10 percent (LSL)

Table 3 shows the annual average growth rates of some of the relevant variables. Major differences from the base runs are as follows:

(1) In LMI simulations, the economy grows *less* rapidly in an NC closure, and *more* rapidly in an FI closure.

(2) In HWD1 simulations, the overall growth of the economy slows down in the NC version, while the FI version shows relatively small changes in average growth rates. Stronger effects can be seen during the period (1963-1965) when the world demand increases naturally.

(3) Changes in consumption patterns from new food to processed food do not influence the overall growth rates in either the NC or the FI version, except for sector 2 whose demand is increased.

(4) In LSL simulations, FI experiences show little change, while NC experiences a slow-down of growth.

Naturally, these are results of assumptions employed in the model. However, because some of the results are, even at this macro level, counterintuitive some explanations are given in the following:

(1) The somewhat surprising behavior of the FI version* in LMI is explained by the assumption of unlimited labor supply in the urban area. Lower migration rates first increase the labor

*Past studies show that migration increases overall growth rates in general (see, for example, Yap 1976).

Table 3. Annual average growth rates (in percent) of relevant model variables.

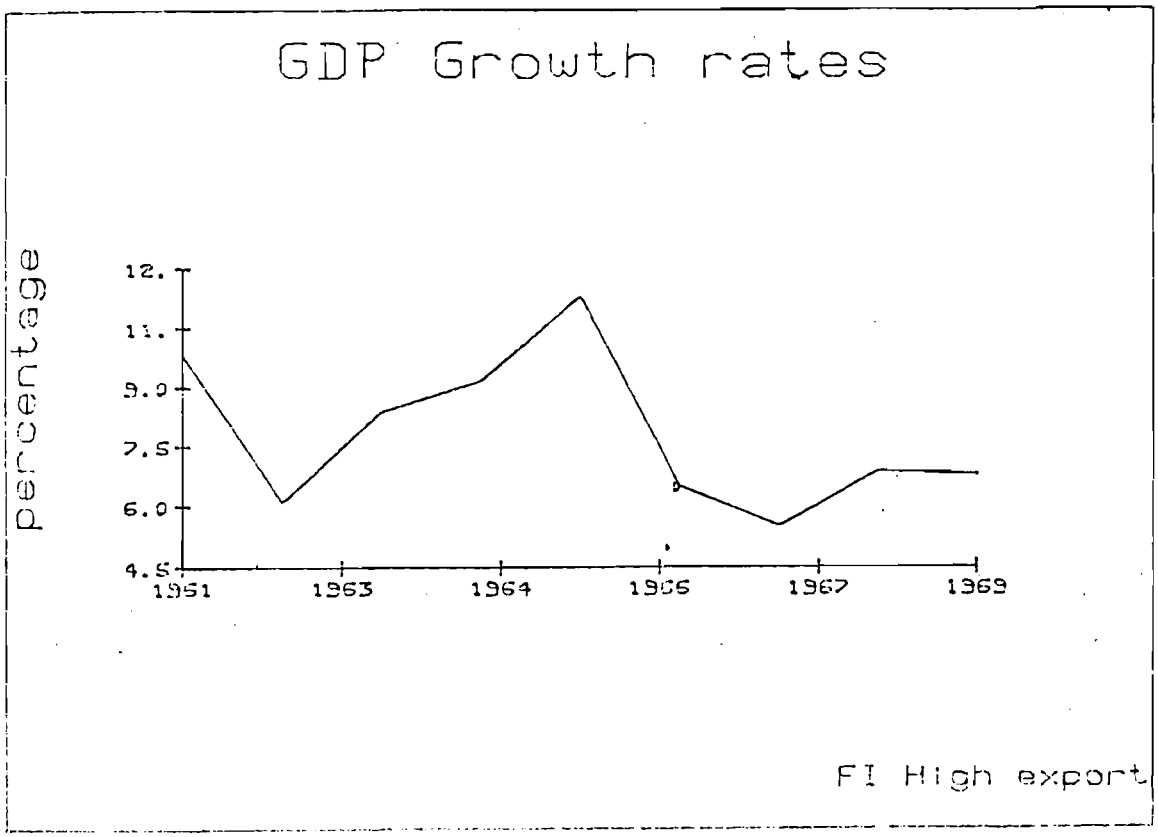
	LMI		HWD1		CTR		LSL	
	FI	NC	FI	NC	FI	NC	FI	NC
Production of sector								
1	12.7	6.9	11.7	10.9	11.8	12.2	11.7	11.9
2	8.3	6.0	7.4	7.6	8.3	9.0	7.4	8.0
3	12.5	9.0	11.7	11.8	11.2	12.1	11.7	12.4
4	6.3	3.6	5.4	5.5	5.3	6.1	5.4	6.0
5	10.2	3.5	9.3	8.0	9.4	8.9	9.5	8.6
6	5.0	3.6	3.9	4.5	3.8	4.9	3.8	4.8
Exports from sector								
1	19.4	20.6	19.0	19.8	19.1	20.1	19.0	20.0
2	7.6	14.9	6.0	10.2	5.5	9.4	5.5	9.7
Imports to sector								
1	11.6	-1.4	12.8	7.5	12.3	7.3	12.9	7.2
2	16.6	7.9	16.8	13.6	18.4	15.8	17.3	14.4
6	19.2	12.4	19.2	17.3	19.5	18.6	19.5	18.3
GDP[a]	8.7	5.5	7.8	7.6	7.7	8.1	7.8	8.1
Labor force								
1	4.3	-0.6	4.0	3.2	3.4	3.2	3.6	3.0
2	2.5	0.98	1.3	1.1	2.5	2.3	1.3	1.1
3	10.0	6.9	9.2	8.7	8.5	8.5	9.2	9.1
4	6.2	2.6	3.8	2.7	3.9	2.5	4.0	2.7
5	6.6	-1.5	5.3	3.0	5.5	3.6	5.6	3.5
6	-1.4	-0.4	-4.9	-4.1	-4.4	-4.6	-4.5	-4.4
Labor share	-0.67	-0.44	-0.60	-0.44	-0.62	-0.23	-0.64	-0.27

[a] In base year price.

force in sector 6 and this pushes down rural income per capita. The lower rural income decreases the urban wage through the mechanism of wage determination explained earlier. Employers, therefore, can hire more labor at these lower wage rates, thus increasing production. Essentially this happens whenever the rural income is lowered. There is, however, a limit to this pattern of growth: the supply of urban labor. If employment grows rapidly but migration is limited, then there is bound to be a time when the surplus urban labor (the unemployed or underemployed) is exhausted. This mechanism can then no longer work. In fact, the amount of labor employed in urban sectors exceeds the potentially available labor force, from the year 6 (1965) in this model simulation. The economy would then have to follow the NC type of development or migration would have to be increased.

(2) In order to see the effects of HWD1, it would be necessary to see the year-by-year changes in variables. For simplification we show only the GDP growth rates and the labor share growth rates of the FI and NC versions (Figure 5). It is noteworthy that the FI version (Figure 5a) grows faster with higher export demand than the base run (Figure 4b) while the NC (Figure 5b) grows more *slowly*. The higher export demand in sector 1 in NC decreases foreign saving, and hence the accumulation is lowered. This causes the migration to go down and a further decrease in economic growth. The FI version, on the other hand, reacts to the external shock in a less surprising manner. The higher foreign demand increases production and investment. Decreased foreign saving is more than compensated by the sharp shift of income away from urban labor. Forced saving through inflation is the major factor that causes this to happen. Inflation also dampens the decrease of foreign saving by decreasing growth of export. The deflationary pressure in 1966 does exactly the opposite.

(3) It is not difficult to explain almost unchanged overall economic growth patterns when consumer's subsistence minima are changed from raw food to processed food. This scenario decreases the consumer's demand for sector 6 goods, but increases the intermediate input demand for these goods from sector 2—the very sector for whose goods consumers' demand has been increased.



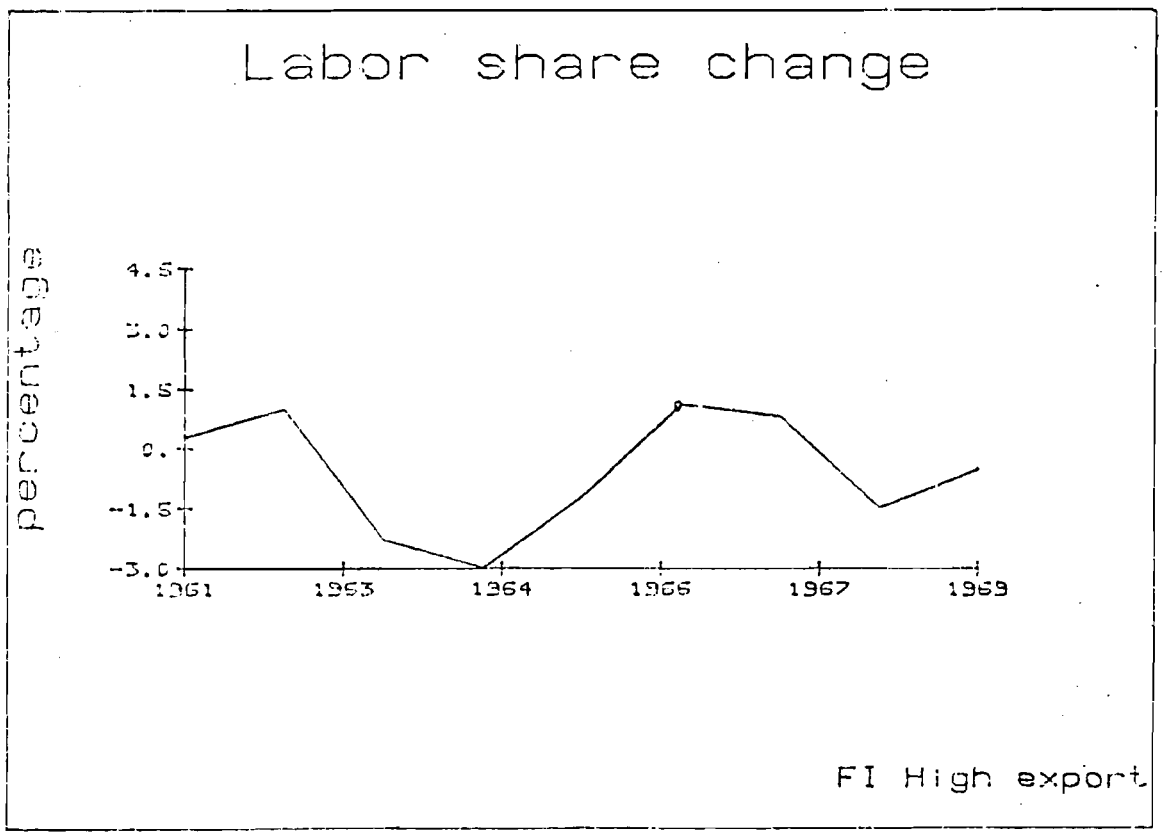
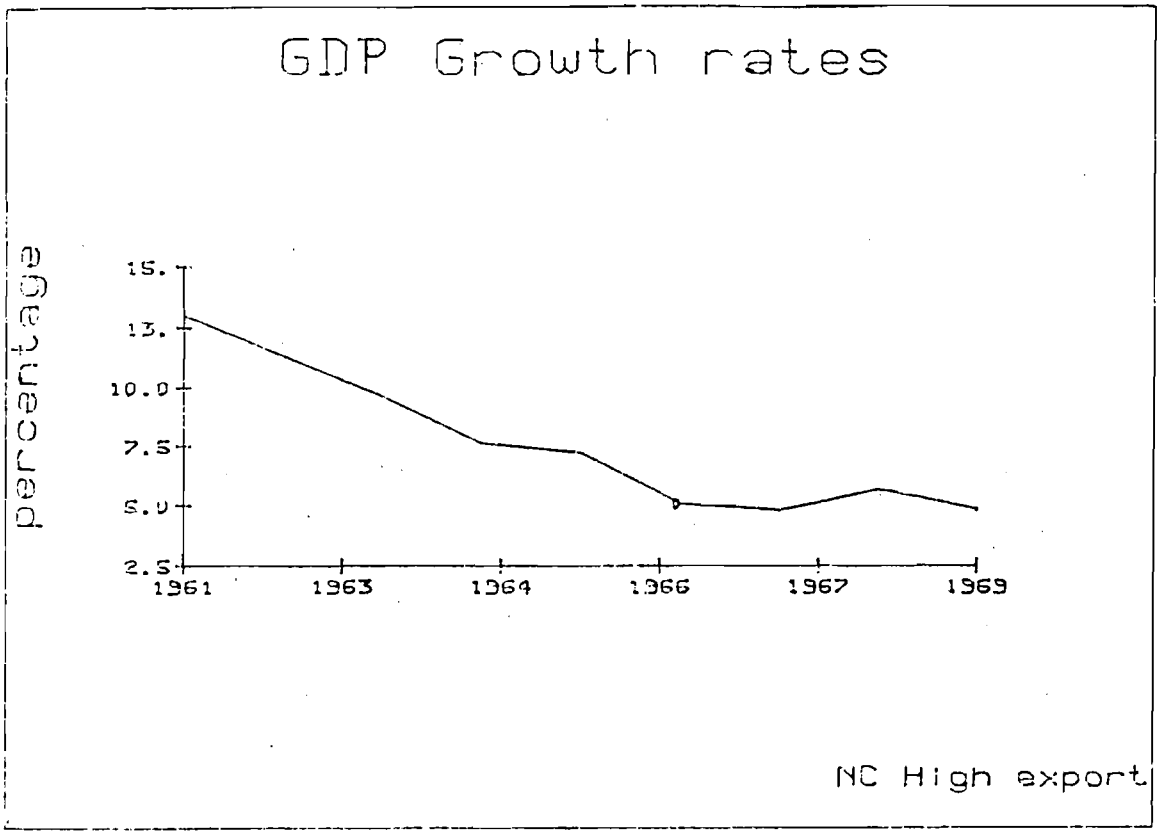


Figure 5a. GDP growth rates and changes in labor share when the amount of world trade of sector 1 goods increased in 1963-1965, FI simulation.



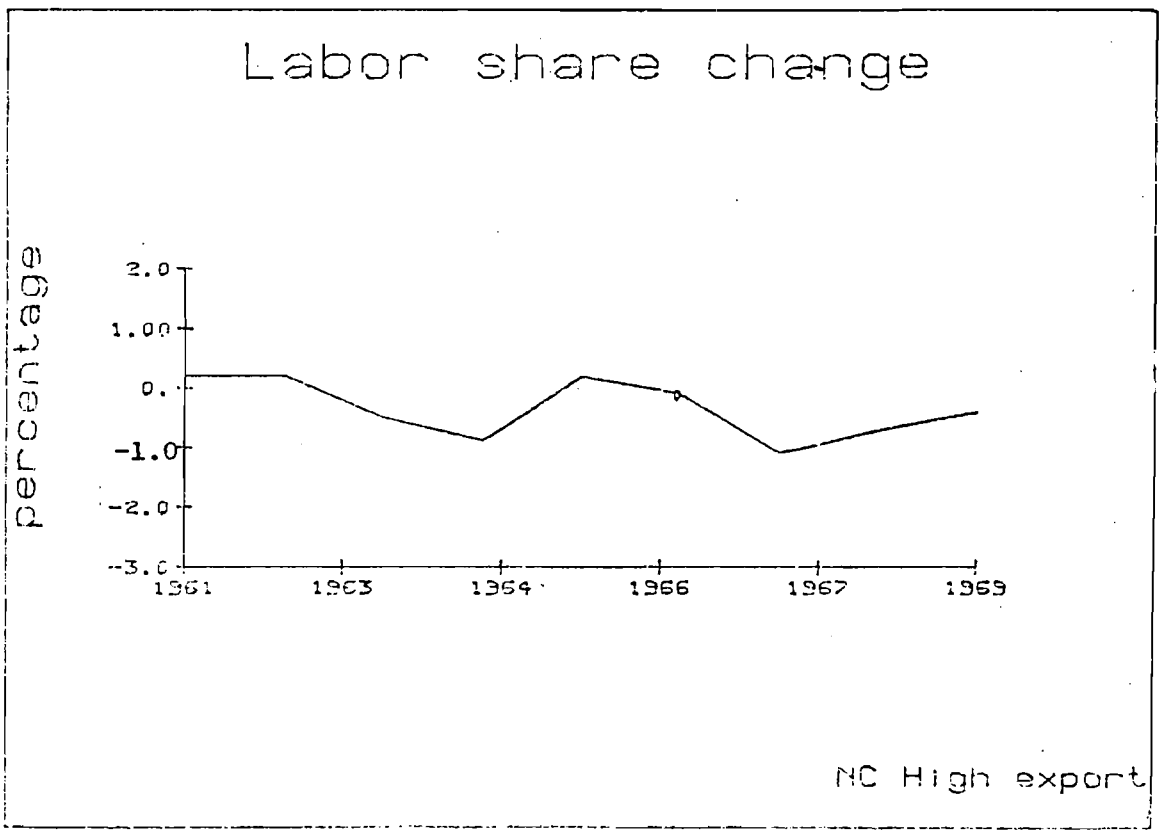


Figure 5b. GDP growth rates and changes in labor share when the amount of world trade of sector 1 goods increased in 1963-1965, NC simulation.

They compensate each other and the total demand for sector 6 goods remains almost constant. The only change, therefore, is an increase in the demand and supply of sector 2 goods.

(4) The outcome of LSL in the FI version can be explained by using the Keynesian story. When resources are underutilized (in this case urban labor resource) all that matters is the aggregate demand. The higher the demand, the higher the rate of utilization of resources. A lower saving propensity increases the consumption demand. In this simulation, growth rates look very similar to the base run, but we should notice that the base year (first-year) values of production are already higher than those of the base run.

The NC result is also as expected. It shows that frugality of population is important for an economy to grow (in the NC case). If all resources are fully utilized, less saving and higher consumption would result in an increase in prices and an accumulation decrease; which is exactly what is happening in this simulation.

6. CONCLUSIONS

The brief description of static and dynamic results in the two previous sections hardly does any justice to the complexity of the model. There are many outcomes that are more interesting if sectoral results are described in detail. But at this preliminary stage, it is better to restrict ourselves to the more aggregated results because the more disaggregated results may depend much more on chosen parameter values, whereas the aggregated results can be safely regarded as being more sensitive to the pattern of closure.

From the above analyses the following observations can be made at this stage. The first two observations are more important for the purpose of this paper.

(1) For the analysis of the Japanese economy during periods of high growth rates, it seems that closing the model in the FI specification (endogenous urban labor and investment predetermined in the previous year) does better than the NC type

(endogenous investment, full employment of all factors of production, and exogenous level of total factors available). This observation comes from the fact that the FI model replicates the *qualitative* pattern of economic growth and income distribution (see section 5.2).

(2) The degree of interrelatedness among different sectors is an important factor for determining the pattern of economic growth. For example, the level of intermediate inputs from traditional sectors to modern sectors greatly influences the level of welfare of traditional sector population in a growing economy. As a matter of fact, the less interrelated an economy is, the more growth "hurts" the traditional population (see section 5.1).

(3) A model that is built using one base year (1960) can show completely different static and, especially, dynamic reactions to external or even internal shocks when different closures are used. This is one warning to those who model an economy only using one method (e.g., neoclassical full employment model), however complicated the model may be.

(4) The "turning point" of economic development can be defined as the time when surplus labor in *both* rural and urban areas disappear. The turning point then, for the Japanese economy may not have arrived during the 1960s because the FI type of closure fits better.

(5) The "migration" pattern in Japan cannot be explained by wage differentials. The level of the urban investment is the variable which so far explains the pattern of migration both from econometric and model simulation results.

These are all tentative observations. But the way different closures produce different patterns of development, even in this largely neoclassical general equilibrium framework, is interesting and worth further research in behaviors of disaggregated agents.

APPENDIX 1: ESTIMATION OF THE *EX ANTE* PRODUCTION FUNCTION

Ex ante production functions for sectors 1, 2, and 3 have been estimated using the following method.

Available information includes the capital stock of each sector of each vintage (K_{iv}); the total labor force in each sector in the base year (L_i); the total production of each sector in the base year (Y_i), and wage and rental rates of all the necessary years in the past, including the base year.

Next, assumptions are made as to the behavior of investors and producers. Investors are assumed to know the *ex ante* production functions, and together with expectations (static or myopic) for wages and rentals, they find out the most efficient point of production and invest at that point of factor mixes.

The capital goods thus invested now have possible technical frontiers with more limited substitution possibilities which are expressed in *ex post* production functions.

The producers are then assumed to use these capital goods in such a manner as to equalize the wages for all laborers in the same sector using different vintages, i.e.,

$$p_i \frac{\delta y_{iv}}{\delta L_{iv}} = w_i \qquad \text{for all } v$$

These assumptions produce the following relationships:

given the assumed *ex ante* production function that has the CES form of

$$Y = A \left[\varepsilon L^{\rho} + (1 - \varepsilon)\ K^{\rho}\right]^{\frac{1}{\rho}}$$

where the sector subscript is suppressed.

Then the first assumption (that investors behave efficiently) will produce the following *ex post* function

$$Y_v = A_v \left[\varepsilon_v L^{\rho_v} + (1 - \varepsilon_v)\ K^{\rho_v}\right]^{\frac{1}{\rho_v}}$$

where

$$A_v = A \left[\varepsilon^{\sigma} \cdot w^e(v)^{1-\sigma} + (1-\varepsilon)^{\sigma} \cdot r^e(v)^{1-\sigma}\right]^{\frac{\sigma_v - \sigma}{(\sigma-1)(\sigma_v-1)}}$$

$$\cdot \left[\varepsilon^{\frac{\sigma}{\sigma_v}} \cdot w^e(v)^{\frac{\sigma_v-\sigma}{\sigma_v}} + (1-\varepsilon)^{\frac{\sigma}{\sigma_v}} \cdot r^e(v)^{\frac{\sigma_v-\sigma}{\sigma_v}}\right]^{\frac{\sigma_v}{\sigma_v-1}}$$

$$\varepsilon_v = \frac{\varepsilon^{\frac{\sigma}{\sigma_v}} \cdot w^e(v)^{\frac{\sigma_v-\sigma}{\sigma_v}}}{\varepsilon^{\frac{\sigma}{\sigma_v}} w^e(v)^{\frac{\sigma_v-\sigma}{\sigma_v}} + (1-\varepsilon)^{\frac{\sigma}{\sigma_v}} r^e(v)^{\frac{\sigma_v-\sigma}{\sigma_v}}}$$

where

σ, σ_v = elasticities of factor substitution

$$\sigma = \frac{1}{1-\rho}\ , \quad \sigma_v = \frac{1}{1-\rho_v}$$

$w^e(v)$, $r^e(v)$ = expected future wage and rental rates used in investment decisions for capital goods of vintage v.

Then, since we have information on capital goods of each vintage and the present wage data, labor employed for production can be expressed for each vintage as

$$L_v = \frac{K_v(1-\varepsilon_v)^{\frac{\sigma_v}{\sigma_v-1}}}{\left[(A_v \cdot \varepsilon_v)^{1-\sigma_v} w(t)^{\sigma_v-1} - \varepsilon_v\right]^{\frac{\sigma_v}{\sigma_v-1}}}$$

when

$w(t)$ is the present wage rate.

Then the production of vintage v is only

$$Y_v = A_v\left[\varepsilon_v L_v^{\rho_v} + (1-\sigma_v) K_v^{\rho_v}\right]^{\frac{1}{\rho_v}}$$

The estimates of *ex ante* production parameters and all L_v and Y_v are made by solving for each sector i and vintage v

$$Y_i - \sum_v Y_{iv}\left[A,\varepsilon,w^e(v),r^e(v),w(t),K_v\right] = 0$$

$$L_i - \sum_v L_{iv}\left[A,\varepsilon,w^e(v),r^e(v),w(t),K_v\right] = 0$$

The solution is obtained by minimizing

$$(Y_i - \sum_v Y_{iv})^2 + (L_i - \sum_v L_{iv})^2$$

This method should be compared with the estimation method of vintage (*ex post*) production functions by Goldfeld and Quandt (1972). Their method requires no behavioral assumptions, but assumes Leontief production functions and, of course, requires a sufficient number of observations.

APPENDIX 2: EXPECTATION FORMATION FOR A BASE PERIOD

The derivation of the investment, described in the text as the desired investment, is specified as

$$I_i^e = \left(\frac{K}{Q}\right)_i^{ef} \cdot DD_i$$

where

$\left(\frac{K}{Q}\right)_i^{ef}$ = the efficient capital output ratio for sector i,* and

DD_i = the difference between the expected demand and the actual supply capacity of the next period

Expected demand is specified as

$$D_i^{e\cdot t+1}(t) = \gamma \left[D_i^A(t) - D_i^{e\cdot t}(t-1)\right] + D_i^A(t)$$

---

* This is equal to $\frac{\delta C(w_i^e, r_i^e)}{\delta r_i^e}$, where $C(w_i^e, r_i^e)$ is the cost function related to the *ex ante* technology and w_i^e, r_i^e are the expected user costs of labor and capital, respectively. See Diewert (1974).

where

$D_i^{e\cdot t+1}(t)$ = the expected demand of sector i in the period t+1. This expectation is formed in period t

$D_i^A(t)$ = the actual demand for good of sector i in period t

γ = adjustment parameter

This expectation is, by substitution,

$$D_i^{e\cdot t+1}(t) = (1+\gamma)\ D_i^A(t) - \gamma(1+\gamma)\ D_i^A(t-1) + \gamma^2(1+\gamma)\ D_i^A(t-2) - \ldots = \sum_{j=0}^{\infty} (-1)^j\ \gamma^j(1+\gamma)\ D_i^A(t-j)$$

A value of expected demand is needed for the initial period because the expectation of any period depends on the demands of all past periods.* For convenience, therefore, as shown in the equation above, it can be specified that the initial value of expected demand is that of the base year and that the expectation is formed by adding another parameter, the past trend growth rate plus one, g.

Then the above equation becomes

$$D_i^{e\cdot t+1}(t) = \sum_{j=0}^{\infty} (-1)^j\ \gamma^j\ g^{-j}(1-\gamma)\ D_i^A(t)$$

This is, as in the text

$$\frac{g(1+\gamma)}{g+\gamma}\ D_i^A(t)$$

* If we are sure that $|\gamma| < 1$, then we could take the sum of a finite number of weighted past demands and approximate it as the initial value. It can be said at this stage, however, that it is uncertain whether $|\gamma| < 1$ always holds for all sectors.

provided $\frac{\gamma}{g} < 1$. Because the value of g is assumed to fall in between 1 and 1.3, this assumption is more plausible than assuming $\gamma < 1$.

APPENDIX 3: TABLES OF COMPARATIVE STATIC RESULTS

LEGEND

Sectors

Subscripts 1 - 5 denote sectors 1 - 5:

1	modern manufacturing sector
2	traditional manufacturing sector
3	modern service sector
4	traditional service sector
5	construction sector
6	primary sectors

Variables

L	labor force
Q	output
W(cost)	wage as cost to employers (wage divided by own sector value-added price)
W(income)	wage as income to earners (wage divided by consumers' price index)
Investment	Real investment (nominal investment divided by capital price index)
Migration	Migration pressure
L-share	Labor share of total value-added
Mod/Trd	Ratio of total wage earned by modern sector workers to that earned by traditional sector workers

Mod/Trd(pc)	Ratio of average per capita wage in modern sectors to that earned in traditional sectors
GDP	GDP in constant prices

Solutions

H1	10% higher productivity in sector 1
H2	10% higher productivity in sector 2
H3	10% higher productivity in sector 3
H4	10% higher productivity in sector 4
H5	10% higher productivity in sector 5
H6	10% higher productivity in sector 6
HS1	10% higher elasticity of substitution in sector 1
HS2	10% higher elasticity of substitution in sector 2
HS3	10% higher elasticity of substitution in sector 3
HR1	50% higher tariff rate in sector 1
HR2	50% higher tariff rate in sector 2
HR6	50% higher tariff rate in sector 6
HX1	10% higher world trade in sector 1 goods
HX2	10% higher world trade in sector 2 goods
HSV	10% higher saving propensity of wage earners (only NC)
HI	10% higher nominal investment (only FI)
TRC	consumers' taste more toward goods of sectors 2, 4, and 6
HC1	10% higher training cost in sector 1
HC2	10% higher training cost in sector 2

Table A3.1. NC solutions in growth rates (in percent, relative to the base solution).

Variable	H1	H2	H3	H4	H5	H6	HS1	HS2	HS3
L1	-6.4	3.2	1.5	6.3	1.8	-3.0	-0.5	-0.0	-0.3
L2	1.2	-12.8	0.7	3.3	0.55	9.1	-0.0	+0.0	-0.0
L3	1.7	2.1	-6.4	19.9	0.6	-0.3	+0.0	0.1	-1.7
L4	1.7	2.8	0.9	-10.0	9.8	2.6	0.1	+0.0	0.2
L5	0.8	5.7	0.5	9.2	-6.7	-10.4	0.4	-0.1	0.8
Q1	6.2	1.6	0.7	3.1	0.8	-1.6	-0.2	-0.1	0.1
Q2	0.6	2.0	0.4	1.8	0.3	4.8	-0.0	0.2	+0.0
Q3	1.1	1.3	5.5	3.2	0.35	-0.2	+0.0	0.1	-0.5
Q4	0.5	0.9	0.3	6.2	0.3	0.1	+0.0	+0.0	+0.0
Q5	0.5	4.1	0.3	5.6	5.3	-6.7	0.6	-0.0	0.5
W1(cost)	15.2	-2.0	-1.0	-4.0	-1.7	1.9	-0.8	+0.0	-0.2
W2(cost)	-0.5	19.4	-0.3	-1.5	-0.2	-5.6	+0.0	2.2	+0.0
W3(cost)	-1.1	-1.3	15.0	-3.3	-0.4	0.4	-0.0	2.0	-1.5
W4(csot)	-1.1	-1.8	-0.6	18.1	-0.6	-0.2	-0.1	-0.0	-0.1
W5(cost)	-0.3	-2.5	-0.2	-3.9	13.6	5.0	-0.2	+0.0	-0.4
W1(income)	-0.7	-1.6	1.6	0.1	-0.8	7.6	-0.2	0.1	-0.4
W2(income)	0.2	0.2	1.9	2.1	-0.5	3.4	-0.2	0.2	-0.3
W3(income)	-0.7	-1.5	0.2	0.1	-0.8	7.5	-0.2	0.1	-0.4
W4(income)	-0.7	1.7	2.2	3.8	-0.3	-0.2	-0.2	0.3	-0.3
W5(income)	-0.6	-1.5	1.6	0.2	-0.8	7.4	-0.2	0.1	-0.4
Investment	1.6	5.6	-8.0	14.9	4.3	-13.0	0.4	-0.1	0.9
Migration	-5.0	-8.0	-2.2	-3.4	-1.4	23.9	+0.0	-0.1	0.9
L-share	0.5	0.5	0.25	0.1	-0.1	-1.9	-0.3	0.3	-0.6
Mod/Trd	-4.4	4.2	-4.2	15.6	-0.1	0.3	-0.3	-0.2	-0.9
Mod/Trd(pc)	+0.0	-1.4	-1.8	-2.2	-0.6	5.6	0.1	-0.2	-0.3
GDP	2.3	1.4	0.8	6.8	0.2	1.0	-0.0	-0.0	+0.0

Table A3.1. continued

Variable	HR1	HR2	HR6	HX1	HX2	HSV	TRC	HC1	HC2
L1	0.8	-0.0	+0.0	0.9	-0.3	5.6	-0.8	-0.5	0.1
L2	-0.1	0.2	-0.0	-0.1	0.9	-2.0	-1.5	-0.0	-0.2
L3	-0.0	-0.0	-0.0	0.1	+0.0	-3.9	-7.6	-0.2	-0.1
L4	-0.0	-0.0	-0.0	-0.0	-0.1	-3.9	2.8	0.2	-0.1
L5	-0.8	-0.0	+0.0	-1.1	-0.5	10.2	3.1	0.5	0.7
Q1	3.3	-0.1	+0.0	0.4	-0.2	2.8	-0.5	-0.3	0.0
Q2	-0.1	0.1	-0.0	-0.1	0.5	-1.1	-0.9	-0.0	-0.1
Q3	0.0	-0.0	-0.0	+0.0	+0.0	-2.5	-4.9	-0.1	-0.0
Q4	-0.0	-0.0	-0.0	-0.0	-0.0	-1.3	0.9	0.1	-0.0
Q5	-0.5	-0.0	+0.0	-0.7	-0.3	6.3	1.9	0.3	0.4
W1(cost)	-0.5	+0.0	-0.0	-0.6	0.3	-3.7	0.7	0.5	-0.0
W2(cost)	0.1	-0.1	+0.0	+0.0	-0.4	1.0	1.3	0.1	0.3
W3(cost)	+0.0	+0.0	+0.0	-0.0	+0.0	2.7	5.5	0.2	0.1
W4(cost)	+0.0	+0.0	+0.0	+0.0	0.1	2.7	-1.8	-0.1	0.1
W5(cost)	0.4	+0.0	-0.0	0.5	0.3	-4.5	-1.3	-0.2	-0.3
W1(income)	-0.0	-0.1	-0.0	-0.0	-0.5	2.7	-2.5	1.1	-0.0
W2(income)	-0.1	-0.1	-0.0	-0.0	-0.2	1.7	-0.6	+0.0	1.0
W3(income)	-0.0	-0.1	-0.0	-0.0	-0.5	2.7	-2.5	0.5	-0.0
W4(income)	-0.1	-0.0	-0.0	-0.1	0.1	0.8	1.1	-0.1	0.7
W5(income)	-0.0	-0.1	-0.0	-0.0	-0.5	2.7	-2.5	0.2	-0.0
Investment	-0.9	0.1	+0.0	-1.1	-0.2	8.5	4.6	0.6	1.0
Migration	0.3	-0.3	-0.0	0.1	-1.7	7.7	-10.8	0.7	1.5
L-share	-0.1	+0.0	+0.0	-0.1	0.2	-0.3	1.0	-0.0	-0.2
Mod/Trd	0.5	-0.1	+0.0	9.6	-0.9	-1.5	-8.3	0.4	-0.7
Mod/Trd(pc)	-0.1	-0.1	-0.0	8.9	-0.5	-0.1	-3.6	0.8	-0.9
GDP	-0.1	-0.1	-0.0	-0.5	-0.0	+0.0	-0.7	+0.0	0.1

Table A3.2. FI solutions in growth rates (percentage relative to the base solution).

Variables	H1	H2	H3	H4	H6	HS1	HS2	HI	HR1	HR2	HR6	HX1	HX2	TRC
L	-6.3	0.1	1.7	1.1	5.6	-0.8	-0.0	3.0	1.0	-0.1	-0.0	1.4	-0.3	-3.1
L2	1.2	-13.8	0.7	1.5	12.2	-0.1	+0.0	0.9	-0.0	0.1	-0.1	0.1	0.9	-1.0
L3	1.8	0.2	-6.3	2.2	4.4	-0.1	0.1	1.6	0.1	-0.0	-0.0	0.3	+0.0	-8.8
L4	1.6	-0.4	1.0	-13.8	9.2	-0.1	+0.0	2.7	0.2	-0.1	-0.1	0.4	-0.2	1.0
L5	1.3	0.2	0.8	0.2	3.0	-0.0	-0.0	5.2	-0.3	-0.1	-0.0	-0.7	-0.5	-0.9
Q1	6.4	0.1	0.8	0.5	2.5	-0.3	-0.0	1.5	0.5	-0.0	-0.0	0.7	-0.2	-1.7
Q2	0.6	1.5	0.4	0.8	6.3	-0.1	0.2	0.4	-0.0	+0.0	-0.1	+0.0	0.4	-1.3
Q3	1.1	0.1	5.6	1.3	2.7	-0.1	0.1	0.9	0.1	-0.0	-0.0	0.2	0.0	-5.7
Q4	0.5	-0.1	0.3	4.7	2.9	-0.0	1.9	0.9	0.1	-0.0	-0.0	0.1	-0.1	0.2
Q5	0.8	0.1	0.5	0.1	1.9	-0.0	-0.0	3.2	-0.2	-0.0	-0.0	-0.2	-0.3	-0.6
W1(cost)	15.0	-0.0	-1.1	-0.7	-3.8	-0.7	+0.0	-2.0	-0.7	0.1	+0.0	-0.9	0.2	2.2
W2(cost)	-0.5	19.9	-0.3	-0.7	-6.9	+0.0	2.3	-0.4	+0.0	-0.1	0.1	-0.0	-0.4	0.8
W3(cost)	-1.2	-0.1	14.9	-1.5	-3.0	0.1	-0.0	-1.1	-0.1	+0.0	+0.0	-0.2	-0.0	6.5
W4(cost)	-1.0	0.3	-7.6	21.5	-5.7	0.1	-0.0	-1.8	-0.1	0.1	0.1	-0.3	0.1	-0.7
W5(cost)	-0.5	-0.0	-0.3	-0.0	-1.5	0.1	+0.0	-2.3	0.2	0.1	+0.0	0.2	0.3	0.5
W1(income)	-0.7	0.7	1.6	2.7	2.5	0.1	+0.0	-1.9	-0.2	-0.1	-0.0	-0.3	-0.6	-0.8
W2(income)	0.2	1.8	2.0	3.6	-0.3	+0.0	0.2	-2.3	-0.2	-0.1	-0.0	-0.2	-0.2	0.5
W3(income)	-0.7	0.7	1.6	2.7	2.4	0.1	+0.0	-1.9	-0.2	-0.1	-0.0	-0.3	-0.5	-0.8
W4(income)	1.2	3.1	2.5	4.6	-3.4	-0.0	0.4	-0.7	-0.2	-0.0	+0.0	-0.2	0.1	2.0
W5(income)	-0.6	0.7	1.7	2.7	2.3	0.1	+0.0	-1.9	-0.2	-0.1	-0.0	-0.3	-0.5	-0.8
Investment	2.8	-0.1	0.9	0.3	1.1	-0.1	-0.0	5.6	-0.5	-0.1	-0.0	-0.4	-0.3	-0.3
Migration	-5.0	-5.3	-2.2	-1.0	14.8	0.3	-0.9	-1.3	-0.0	-0.2	-0.1	-0.3	-1.7	-8.1
L-share	3.7	1.0	0.1	2.5	-3.5	-0.2	0.3	-0.5	-0.1	+0.0	+0.0	-0.1	0.2	1.0
Mod/Trd	-4.4	5.6	-4.2	7.3	-1.0	-0.2	-0.2	-0.3	0.4	-0.1	+0.0	0.4	-1.0	-8.4
Mod/Trd(pc)	-0.1	0.3	-1.8	-3.5	3.8	0.2	-0.3	-0.7	-0.1	-0.1	-0.0	-0.2	-0.6	-2.7
GDP	2.2	-0.1	0.9	0.4	4.9	-0.1	+0.0	1.2	-0.0	-0.1	-0.1	0.2	0.0	-1.7

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