

DEVELOPMENT, STRUCTURAL CHANGE AND URBANIZATION:
EXPLORATIONS WITH A DYNAMIC THREE SECTOR GENERAL
EQUILIBRIUM MODEL APPLIED TO INDIA
1951-1984

Rakesh Mohan

A DISSERTATION
PRESENTED TO THE
FACULTY OF PRINCETON UNIVERSITY
IN CANDIDACY FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY

RECOMMENDED FOR ACCEPTANCE BY THE
DEPARTMENT OF
ECONOMICS

May, 1977

5-13-77

To my Mother, Satya

who did not live to see the
fruits of my endeavors and
to my Father, Ratish Mohan

ABSTRACT

This study investigates the process of economic growth that is now being experienced by poor countries and pays special attention to the phenomenon of urbanization. A non-linear, three sector, two region wage and price endogenous dynamic general equilibrium model (called DYNURB) is developed. Agriculture is based entirely in the rural region with industry and services in the urban region. The special features of DYNURB include the explicit specification of the service sector (usually neglected in such studies), of transportation and of biased technical change in each sector. Labor and capital are mobile between sectors and regions and earn their marginal product. There is no unemployment of factors. International trade is neglected so the model depicts a large closed economy and is tuned and validated with Indian data.

DYNURB is tuned for India in 1951 and simulated to 1984 -- for 33 years. It traces actual Indian development remarkably well despite its theoretical purity in structure. Simulation results are compared with actual growth in output; trends in population and urbanization; changes in sectoral output and labor shares; the rate of capital accumulation; behavior of prices and wages; technical change and sources of growth. The simulation shows that the transfer of labor from rural to urban areas is as much to service sector occupations as to industrial occupations and therefore demonstrates the necessity of studying

structural change in at least a 3-sector context. It also highlights the importance of demand in the development process. Attempts are made to disentangle cause and effect in the growth process by conducting a host of sensitivity tests with DYNURB. The model behaves much like a buffalo: not much happens when parameters are changed within reasonable ranges.

The summary result of the study may be stated thus: rapid agricultural productivity growth, relatively slow service productivity growth, high rates of investment and Engel demand effects combine to produce a continuing increase of urbanization levels, albeit in a logistic manner, as development proceeds.

PREFACE

This dissertation is an attempt to bring together a diverse set of topics which have interested me for a number of years. As an engineer turned economist, the role of technical change in economic development has been something which has always intrigued me. My work (with Robert Evenson) on the productivity of research and extension in agriculture in India reflects this interest. Recently, I have been more concerned with problems of cities. So this study was originally motivated by the question: "Are cities a necessary concomitant of economic growth?" It has ended up being a more general development study though specially concerned with the phenomenon of urbanization with technical change thrown in for good measure.

My intellectual debts are many: Lloyd Reynolds introduced me to development economics; Janos Kornai taught me a healthy disrespect of "standard neo-classical" economics before it was too late; Arnold Harberger educated me to believe that the practice of elegant economics is not necessarily divorced from reality. I am particularly grateful to Robert Evenson and John Lewis for enabling me to appreciate various aspects of Indian economic growth and for making possible various field visits to India. My vague notions of technical change have been sharpened considerably by Robert Evenson, as has my ability to digest numbers and to appreciate the complexity

of agricultural production. Edwin Mills bears the responsibility for introducing me to cities and then inspiring this dissertation by asking the question, "Is there a limit to urbanization?" Sherman Robinson is equally responsible for this dissertation by making me believe that computers are there to be used. I bear a special debt of gratitude to both of them for giving me their time generously much beyond the call of duty and encouraging me at many low times in the process of this work. Thanks are also due to Kemal Dervis for reading the thesis carefully and providing useful comments. My intellectual debt to him is obvious in the text.

Suman Bery is responsible for careful and remarkably quick editing and proof-reading -- as well as for any remaining errors. The support and friendship as well as the provocative intellectual stimulation of Surjit Bhalla and Clas Wihlborg made the four years at Princeton seem somewhat less.

The ambience of the Elm Club did much to expedite the production of this thesis and all other work I did at Princeton. Thanks are due to Mrs. Dorothy Rieger and Gerri Kavanagh for helping in this.

Finally, I have been amazed by the skill, diligence and speed of Betty Kaminski in typing the manuscript and assisting in its production. I must bear responsibility for ruining many of her weekends. She has been assisted ably by

Jeanne Carlucci. I am grateful to both for making possible a relatively quick ending to this whole endeavor.

Financial support for this research was provided from a grant to the Princeton University Economics Department from the Sloan Foundation and from the Income Distribution Project of the Research Program in Development Studies at Princeton.

TABLE OF CONTENTS

	Page #
ABSTRACT	iv
PREFACE	vi
1. Introduction: Urbanization in the Context of Economic Development	1
2. Genesis of the Model	11
2.1 Economy Wide Models	13
2.2 The Service Sector	39
2.3 Technical Change	48
2.4 Summary	60
3. DYNURB: Mathematical Specification of the Model	63
3.1 Production Conditions	65
3.2 Net Prices - Intermediate Goods and Transportation Costs	71
3.3 Factor Demand	72
3.4 The Savings Function	77
3.5 The Demand System	78
3.6 Investment Demand	88
3.7 Factor Employment	89
3.8 Material Balance Equations	89
3.9 Price Normalization	90
3.10 Dynamic Equations	91
3.11 Summary of DYNURB	95
4. Preparing DYNURB for Simulation: Model Solution and Parameters	106
4.1 Model Solution	106
4.2 Choice of Parameters and Initial Conditions	116
4.3 List of Chosen Parameters and Initial Conditions	151

TABLE OF CONTENTS (Cont'd)

	Page #
5. India in the Year 1984: A Simulation of DYNURB	154
5.1 A Stagnant Economy: India 1860 to 1950	155
5.2 Growth of Output	158
5.3 Population and Urbanization	162
5.4 Structural Change in the Developing Economy	167
5.5 Capital Accumulation	176
5.6 Behaviour of Prices	181
5.7 Consumption Behaviour	191
5.8 Technical Change and Sources of Growth	195
5.9 Summary	200
6. India in the Year 1984: What Could be Sensitivity Tests with DYNURB	203
6.2 Population Growth	206
6.3 Changes in Demand Patterns	216
6.4 Changes in Savings Behaviour	230
6.5 Wage Equalization	242
6.6 Increase in Transport Costs	247
6.7 Appropriate Technology: The Relevance of the Elasticity of Substitution	252
6.8 Factor Augmentation, Bias and Technical Change	261
7. Toward a Dynamic Theory of Urbanization: Directions for Further Research	270
APPENDIX	280
BIBLIOGRAPHY	299

1. Introduction: Urbanization in the Context of Economic Development.

This work was begun with the objective of studying the process of urbanization and to probe the structural causes thereof. Urbanization has been a process experienced to some degree by almost all countries but is still not well understood. It has been more pronounced during the last century and a half - during the period that Kuznets has aptly dubbed the era of 'modern economic growth'. The process has intensified in more recent times. Thus urbanization is thought to be inextricably linked with the structural changes that accompany economic development. This study seeks to illuminate these links. The primary purpose of constructing the model developed here was to explore the urbanization process occurring in an economy over time. In fact, urbanization emerges more as a by-product rather than as the central theme of the model. The study has therefore become more of an inquiry into the development process as a whole rather than a special study of urbanization.

Economists have yet to develop specific ideas on what makes particular economic activities characteristically urban, except for the association of agriculture with rural areas and industry with urban areas. Despite the difficulties of grafting spatial concerns onto economic models,

one is still forced to resort to familiar economic growth and development stylizations. This is done with knowledge that severe compromises will be required to squeeze the phenomenon of urbanization out of such models. These methodological antecedents are presented in the next chapter while these introductory remarks are more concerned with urbanization per se, and with the approaches traditionally adopted to study it. Urbanization has received an increased degree of attention from governments and other policy makers in recent years. The reason for this concern is the extremely rapid rate of urbanization that occurred in most parts of the world over the last thirty years. In particular, the growth rate of many Latin American, African and some Asian cities has been truly explosive. The populations of most cities in less developed countries (LDCs) have been growing at the rate of 3 to 7 percent per year. Even during the period of rapid urbanization in Europe, rates of population growth in cities were on the order of 1 to 2.5 percent per year. It is then not surprising that the current phenomenon of rapid urbanization is viewed with some trepidation.

Before proceeding further, a distinction must be drawn between the growth of large cities and that of urbanization as a whole. Much of the present concern is focused on the problems arising from the rapid growth

of large cities. This study, however, is not concerned with these problems and views urbanization merely as the shift of people from rural to urban areas in general. The level of urbanization is then the proportion of urban population in total population. Its rate of growth is the growth of this proportion. The growth rate of urban population then indicates the growth of urbanization only when it is greater than overall population growth. What is sought to be studied here therefore is the long-term process in which there is a shift of people from rural habitation to urban habitation and the structural causes thereof.

As documented by Brian J.L. Berry (1973), although cities have always existed, their growth rate must have been extremely small until the industrial revolution. The current pattern of habitation in developed countries, where a larger proportion of people live in urban areas than in rural areas, is a pattern which is historically unprecedented. Surprisingly, there have been relatively few studies of the causes of urbanization and there is little agreement on the nature of the relationship between levels of development and urbanization.

Attempts have been made to associate levels of industrialization (percent of labor force in industry or share of industrial product) and urbanization. Hoselitz (1957) set off a debate by asserting that many LDCs are currently "over-urbanized" since they have smaller proportions of labor force in industry than was the case in European countries in the last century when they were at similar levels of urbanization. In so doing, Hoselitz implicitly asserts a linear relationship between the levels of industrialization and urbanization. The other consequence of his assertion is that current urbanization is being caused more by rural push rather than urban pull. Sovani (1962) and Kamerschen (1969) have both questioned this implication and have found little correlation between levels of urbanization and indices of rural push. In refuting his over-urbanization thesis, they separately find that the levels of urbanization and industrialization are more closely correlated in LDCs now and in rich countries in the last century, than in rich countries now.

These studies have been valuable in providing some insights into the related phenomena of economic development, industrialization and urbanization but the basic assumptions of their methodology need to be questioned. Urbanization is essentially a dynamic phenomenon. Thus, if there is a connection between industrialization, development and urbanization, it should ideally be studied in a dynamic framework within the context of one system. Doing a cross-country analysis - as

was done by Hoselitz (1957) and Davis and Golden (1954) -- involves the assumption that the current cross-section of different levels of development replicates the historical process of the system under investigation. An associated problem with such cross-section analysis is that political entities, i.e. nation-states are usually taken as the appropriate data points. Thus a country as large as India is one data point as is a country as small as Kuwait. The implicit assumption is then that nation states form self-contained economic geographical systems. This may not be the case at all except in large systems such as Brazil, the United States, Russia, China and India. Such analysis would be improved if attempts were made to group together certain sets of geographically contiguous countries which can then more reasonably be regarded as self-contained systems. A third problem with cross-section analysis is that linear relations of some kind are usually posited -- particularly if linear regression analysis is used. If, however, (a) the relationship between industrialization and urbanization is non-linear and (b) the trend of urbanization in a system is non-linear, e.g. logistic, linear analysis clearly gives misleading results. Since there is a logical limit (100 percent) to the level of urbanization, its trend of growth is likely to be asymptotic and probably logistic like many other growth series (Price, 1975). If this is the case, it is not surprising that Kamerschen finds that the level of correlation between industrialization and urbanization is low for rich countries now.

The fourth problem is a consequence of the assumption that the historical process can be captured by observing co-existing different levels now. This implies that the process undergone in the last century was similar to that now. That this may be erroneous and that the current LDC experience is quite different, needs some elaboration. A primary factor is that the overall population growth rate is much higher than ever before. The growth rate of cities is high without migration. Technical change in agriculture which raises farm productivity has to provide for the growing rural population in addition to the burgeoning urban population. In times when overall population growth rates were less than 0.5 percent, a 3 percent growth in agricultural productivity was tremendous. The second major difference from the European experience is the coexistence of high and low technology in LDC cities. High population growth and technological growth makes it possible to have cities with a multimillion population at low levels of income. This was just not possible in the last century. The sewage disposal, water supply and transport problems of a city of 8 million are qualitatively different from those of a city of half a million, which was the size of major Western cities at similar income levels. The third major difference may be the decline in relative prices of transportation and communication. There are, therefore, reasonable a priori expectations that the current urbanization experience of LDCs may well be different from the historical European experience.

The foregoing is an attempt to show that cross section cross-country analyses of urbanization though valuable in themselves are not like to yield the causes of urbanization.

In a recent paper, Pandey (1977) attempts to overcome some of these shortcomings by studying Indian urbanization and regarding its 18 states as data points. He refutes the rural pressure theory; finds that industrialization alone explains about half the variation in urbanization between the states; and that urbanization has a high negative association with technical change in agriculture. The last result is somewhat surprising but his study also suffers from some of the shortcomings outlined above. Regarding Indian states as self-contained units with no interaction between them is even less justified than considering a cross-section of different countries.¹ Secondly, he only looks at the 1971 census and is therefore looking at a static cross-section while attempting to explain a dynamic phenomenon. He does eliminate intercultural and other systemic differences by considering the Indian experience only.

The contention of this study is that explanations of long-term trends of urbanization and of its relationship with

¹See, Mohan (1974), for one method of dealing with inter-state interactions -- but in the context of agricultural productivity differences.

economic development and industrialization will more likely be found if the performance of a system is studied over time. The ideal way of doing this would be:

- i) to catalogue the different sets of activities which take place in urban and rural areas.
- ii) to investigate if there are underlying differences in the conduct of these activities. One example of "underlying differences" is the existence of different production functions in urban and rural areas.
- iii) to identify the above differences and model the production structure of each area.
- iv) to model the demand side of the economy and devise methods for achieving a static equilibrium (or rules for existence of disequilibrium).
- v) to model the growth of the economy, i.e. find rules for investment, population growth, etc.
- vi) Simulate the system thus created and investigate the effects of different assumptions on urbanization.

Before discussing the feasibility of doing such an investigation, the implications of such a scheme need to be spelled out:

- (a) Urbanization is being regarded as primarily an economic process;¹
- (b) It is being seen as an integral part of the development process. Thus the process of urbanization is seen as a result of the interaction of a set of complex forces in a general equilibrium (or general disequilibrium) framework.

¹See B.J.L. Berry (1973) for "non-economic" reasons for existence of cities in "pre-industrial" times.

The causes of urbanization being sought are therefore not regarded as being simple. The answer is expected to be the type: A, B, C, D, E, etc. interact together in certain constellations to produce an X level of urbanization; rather than A produces X (e.g., rural pressure produces urbanization).

- (c) While the schema may be general enough to be applied to different systems, it is not expected that specific levels of appropriate urbanization can be prescribed for each level of industrialization or development. There can, however, be notions of appropriate levels within the context of specific systems.

In the schema given above, (i) and (ii) are the most difficult since they involve the interaction of spatial and production theory. In this study, it is assumed that industrial and service activities are exclusively based in urban areas and agricultural activities in rural areas. Each activity has a different production function in accordance with (iii) above, so a sharp distinction is made between the patterns of urban and rural production activities. Chapter 3 gives some justification for these choices. It is, however, recognized that this study fails as most others, to supply answers to the question: Why do industrial and service activities primarily base themselves in urban areas? The study does advance understanding of urbanization by considering the service sector explicitly and getting away from the industrialization emphasis of many past studies of urbanization. This may be regarded as

one of the major differences between the urbanization phenomena of the last century and the current LDC experience.

Plan of the Study

The next chapter provides the antecedents of the model that is developed in this study. Chapter 3 specifies all the relations used in the model and justifications for each. Chapter 4 describes the solution procedure used and the choice of parameters and initial conditions. Chapter 5 presents the results of the simulation of the model and validates its usefulness by comparing its results with actual magnitudes for India. Chapter 6 reports the results of sensitivity tests giving insights into the processes of urbanization development. Chapter 7 presents the main conclusions of the study and its shortcomings and suggests how some of these may be removed.

2. Genesis of the Model

The model developed in this study is a non-linear, three-sector, two-region, wage and price endogenous dynamic general equilibrium model (henceforth called DYNURB). The three sectors are agriculture, industry and services, with agriculture being exclusively based in rural areas and the other two exclusively in urban areas. Consumption of all three goods takes place in both regions and capital and labour are mobile between sectors and regions. Transportation is an intermediate good which is used whenever goods are transferred across regions. The special features of the model include the specification of transportation and that of a service sector -- which is characteristically neglected in most such models. Particular attention is paid to the specification of technical change which is seen as primarily capital and labour augmenting. The model also allows for completely exogenous (or 'manna from heaven' type) technical change. The model neglects international trade and can therefore be seen to depict a large economy in which trade is unimportant. India is an obvious example and the model is tuned and validated with Indian data. The mathematical formulation of the model is given in the next chapter.

This chapter reviews some of the literature that has influenced this model and isolates those features which assist in an understanding of the structural forces underlying urbanization. The review is organized according to the following

topics:

- a. Economy wide models relevant to this study.
- b. Studies of the service sector.
- c. Concepts of technical change and their formulation.

In reviewing the economic growth/development literature, a curious dichotomy is found in models that explain or trace structural changes in economies over time. On the one hand, there are the highly stylized one and two sector models and on the other, there are the detailed multi-sector models of the planning variety. While the variety within these is immense -- some of which will be described shortly -- there appears to be little in terms of size between these two classes. Though it is surprising that there has not been much investigation in this respect, there are good reasons for it. The smaller models are primarily intended to provide basic analytical insights. Mathematically, it becomes difficult to derive analytical results as soon as two-sectors are increased into three. Thus three sectors are often regarded as equivalent to 'n'. The large models have derived from the practical planning concerns of the centrally planned economies, and more lately, of the less developed economies. Given their interest in practicality, the number of sectors has to be large to give any results that are relevant for policy implementation.

It may be stated at the outset, that the model developed here bears the most resemblance to the work of Kelley, Williamson and Cheetham (1972) (henceforth referred to as KWC) and

Kelley and Williamson (1974) (referred to as KW2). It is also related to Yamaguchi (1973) on the one hand, and in its computation and modelling philosophy, to Johansen (1974), Adelman and Robinson (1976), Dervis (1973) and Fakhruddin Ahmed (1974).

2.1 Economy Wide Models

The approaches of this study were foreseen in large part by earlier non-mathematical theorists. Prominent among three sector analyses, were those by (as reported by Johansen (1974)), Colin Clark (1951), Allan G. B. Fisher (1935), S.G. Triantis (1954) and Harvey Leibenstein (1957). Johansen relates their main conclusion to be:

"...that which is shown by careful generalization of available facts to be the most important concomitant of economic progress, namely the movement of working population from agriculture to manufacture and from manufacture to commerce and services" (Johansen (1974) p. 9).

(quoting Colin Clark (1951) p. 395)

This is borne out by this study except for the progression from agriculture to manufacture to services. The processes described here involve labour transfers from agriculture to manufacture and services simultaneously.

Colin Clark predicted that the terms of trade of primary industries vis-a-vis other industries would tend to

improve, whereas he saw no reason to expect great changes in relative price between the products of secondary and tertiary industries. This is another result which this study confirms.

Among the main assumptions used to explain the structural changes between the three sectors were (as related by Johansen (1974)):

1. Income elasticity of demand for primary goods is low as compared with secondary and tertiary goods, that for the last, being the highest. This is built into DYNURB's demand system but with income elasticities being the same for secondary and tertiary goods.
2. Primary, Secondary and Tertiary production are not equally capital intensive, with tertiary production requiring the least and secondary production requiring the most capital. This is not supported by empirical evidence: the tertiary sector could indeed be the most capital intensive.
3. The rate of technical progress in the tertiary sector is slow relative to the other sectors. This study utilizes this assumption.
4. The input-output structure requires secondary industries to take large intermediate inputs and the tertiary sectors the least. Most input-output tables bear this out.

These comments indicate the extent of intuition and observation used by early analysts. A study such as this

serves to confirm many of their assumptions and conclusions while giving them a more precise theoretical basis in the shape of a mathematical model.

2.11 Two Sector Models

The vast dual economy literature spawned by the seminal work of W. Arthur Lewis (1954) is reviewed exhaustively and competently by Kelley, Williamson and Cheetham (1972), and thus need not be repeated here. DYNURB is clearly in the dual economy tradition in that it has two regions where people behave differently. Wages in DYNURB, however, are determined as labour's marginal product. There is no surplus labour but there is a structural difference between urban and rural wages which is never narrowed. Urban and rural consumers have different demand functions.

The Kelley-Williamson-Cheetham Model (1972)

KWC combine growth theory, general equilibrium analysis and quantitative economic history to develop a dual economy model. They attempt to simulate the Japanese economy in the period 1880-1915 by way of illustration. Their model is an agriculture-nonagriculture model though it is often left unclear whether non-agriculture refers only to manufacturing

or to all of non-agriculture. The main features of their model are noted below: (a summary of the KWC model is presented in Table 2.1).

- i) Production: The KWC model employs constant elasticity of substitution (CES) production functions in both sectors with the elasticity (σ) assumed to be less than unity in industry and more than unity in agriculture. There is no land in the production of agriculture. A later version (Kelley and Williamson (1974) - KW2) includes land as a factor but the production function used is then Cobb-Douglas. The technology is labour saving in industry and labour using in agriculture.
- ii) Demand: The KWC model uses the Stone Linear Expenditure System with different parameters for urban and rural consumers. A minimum amount of food is assumed to be consumed before income is allocated to other goods.
- iii) Technical Change: All technical change is factor augmenting and both capital and labour are homogeneous across sectors. Thus the rate of factor augmentation is the same in both sectors.
- iv) Savings: A classical savings function is utilized i.e., only capitalists save. All wage income is consumed.
- v) Factor Markets: Wages and capital rentals are fully equalized across sectors. The advanced disequilibrium version of the same model does allow for wage differences between the two sectors.

Table 2.1: Summary of KWC ModelStatic EquationsProduction

$$1. \quad Q_i(t) = A_i \{ \gamma_i (x K_i(t))^{-\rho} \} + (1-\gamma_i) (y L_i(t)^{-\rho})^{-1/\rho} \quad i=1,2$$

Worker and Capitalist Demand

$$2. \quad \frac{D_{ij}(t)}{L_j(t)} = \beta_{ij} y w(t) + (1-\beta_{ij}) \gamma \quad j=1,2$$

$$3. \quad \frac{D_{2j}(t)}{L_j(t)} = \frac{\beta_{2j}}{P(t)} (\bar{y} w(t) - \gamma) \quad \beta_{ij} + \beta_{2j} = 1$$

$$4. \quad C_1(t) = \beta_{11} (1-s) r(t) x K + (1-\beta_{11}) \gamma$$

$$5. \quad C_2(t) = \frac{\beta_{21}}{P(t)} \{ (1-s) r(t) x K - \gamma \}$$

$$6. \quad I(t) = \frac{s}{P(t)} x \bar{K} r(t)$$

Factor Demand

$$7. \quad w_1(t) = F_L^1 \quad w_1 = w_2$$

$$8. \quad w_2(t) = P(t) F_L^2$$

$$9. \quad r_1(t) = F_K^1 \quad r_1 = r_2$$

$$10. \quad r_2(t) = P(t) F_K^2$$

Table 2.1 (cont)Employment

$$11. \quad K = K_1(t) + K_2(t)$$

$$12. \quad L = L_1(t) + L_2(t)$$

Market Balancing

$$13. \quad X_1(t) = D_{11}(t) + D_{12}(t) + C_1(t)$$

$$14. \quad X_2(t) = D_{21}(t) + D_{22}(t) + C_2(t)$$

$Q_i(t)$ - output

$K_i(t)$ - capital

$L_i(t)$ - labour force,

$w_i(t)$ - wage rate

$r_i(t)$ - rental of capital

$P(t)$ - relative price of industrial goods

$D_{ij}(t)$ - workers demand for good i in sector j

$C_i(t)$ - capitalists demand for good i

$I(t)$ - gross investments.

$i = 1$ - industry/urban

$i = 2$ - agriculture/rural.

Dynamic Equations

$$x(t) = x_0 e^{\lambda_K t} \quad - \quad \text{capital augmentation rate}$$

$$y(t) = y_0 e^{\lambda_L t} \quad - \quad \text{labour augmentation rate}$$

Table 2.1 (cont)

$$\dot{K}(t) = I(t) - \delta K(t)$$

$$\dot{L}(t) = [n_1 u(t) + n_2 (1 - u(t))]$$

u - level of urbanization

n_1 - rate of urban natural population growth rate

n_2 - rural natural population growth rate

δ - rate of capital depreciation

I - investment.

The KWC model is really an elaboration of the Jorgenson (1961) dual economy model. The difference is mainly a) that capital is allowed as an input in agriculture and the C.E.S. production function is used and b) that consumers are divided into capitalists and workers.

While the KWC model is probably the most carefully formulated two-sector dual economy model, it suffers from a number of shortcomings which DYNURB is designed to overcome:

- i. In studying structural changes over time and urbanization in particular, regarding the non-agriculture sector to be exclusively industrial masks much of the structural change taking place. It is the contention of this study that it is essential to take account of the service sector when investigating such changes. Thus DYNURB has 3 sectors while maintaining the dual economy tradition in two regions.
- ii. KWC do not distinguish between population and labour force. While this does not affect the supply side, it does distort the demand side since people outside the labour force do demand products. This is particularly important in considering the subsistence good component in the KWC demand system. Differing labour force and population growth rates cannot be taken account of. DYNURB distinguishes population from labour force by postulating a worker participation ratio (WPR). Since this is kept constant, labour and population growth rates are the same in

DYNURB too. However, this can easily be modified by making WPR time variant. This has not been done in this study because a more elaborate population sub-model is planned for a later version of DYNURB.

iii. KWC equalize wages and rents among sectors.

Wages are always higher in urban relative to rural areas and that there is no tendency for this gap to be narrow. Data on capital rents are less easy to interpret. DYNURB allows fixed sector wage and rent differentials although rents are equalized in its simulation.

iv. KWC do not allow wage earners to save.

Although a higher proportion of income from capital is saved than that from labour (e.g., in Houthakker (1965)), the large proportion of self employed in poor countries makes this distinction less valid. This is particularly important in the large agricultural sector. DYNURB allows both workers and capitalists to save and at different rates in different sectors. In the simulation, however, workers and capitalists save equally.

- v. KWC assume that the rate of factor augmentation is the same in both sectors. This is unreasonable since the evidence suggests that, for example, the education level of the labour force changes at different rates in the urban and rural sectors. This is something of a conundrum since the assumption of a homogeneous labour force requires that it augment itself at the same rate in both sectors. One solution is to distinguish between different skills in the labour force -- as done by Adelman and Robinson (1976). This, however, complicates the model and is really not necessary at the present level of aggregation. DYNURB allows for different rates of factor augmentation and suggests an interpretation consistent with the factor homogeneity assumption.
- vi. KWC omit land in the production of agriculture. It is difficult to understand how they can maintain this along with the assumption that capital goods are produced in the industrial sector only. Land cannot then be subsumed under capital. KW2 rectifies this of course but then uses a Cobb-Douglas production function for agriculture. DYNURB includes land and livestock in the agriculture production function which is specified as a variant of the C.E.S. and Cobb-Douglas functions.

- vii. KWC do not allow for intermediate goods. This can be justified in a completely dual economy but not in an economy undergoing rapid development where the input-output matrix becomes more dense and therefore has an effect on the production structure.
- viii. One last criticism of KWC is less a shortcoming of the model but more of its use in simulation. KWC simulate their model for 50 years and for an economy with a rapid rate of growth. It is unreasonable to expect constant parameters to be valid for as long a period and particularly in a rapidly growing economy. This, of course, is a problem common to all simulation models limiting their usefulness. DYNURB suffers from the same problem but is not simulated for more than 35 years.

Thus, while DYNURB derives its basic structure from KWC, it attempts to improve on their model -- in particular, to study the trend of urbanization in a low income economy.

The Yamaguchi Model (Yamaguchi, 1973)

Mitoshi Yamaguchi (1973, 1974) and Yamaguchi and Hans Binswanger (1974, 1975) (Y and B) develop a model to study the long term history of the Japanese economy from 1880 to 1965. (The model is summarized in Table 2.2). Their main criticisms of KWC are

- i) the failure in KWC to distinguish between population and labour force;
- ii) the augmentation of capital and labour at the same rate in both sectors.
This makes it impossible to measure the effect of technical change in agriculture on the rest of the economy;
- iii) the equalization of rents and wages across sectors which is contrary to evidence.

The objectives of Y and B are somewhat different. Their model is not primarily a simulation model and not really a theoretical tool. They are much more interested in tracing Japanese economic history from 1880 to 1965 and particularly in investigating

the effects of population growth and technical change on real income growth. They do this by estimating parameters for every decade and run the model on these parameters. As Table 2.2 indicates, the following are the main exogenous variables:

- i) rate of technical change in each sector
- ii) rate of population growth
- iii) rate of labour force growth
- iv) rate of total capital formulation.

The following variables are then determined endogenously.

- i) real per capita income
- ii) total labour and capital in each sector
- iii) terms of trade.

Thus, Y and B meet their main criticism (i), (ii), outlined above, by making labour force and population grow differently according to estimated real rates; by making technical change different in each sector, again exogenously. While they allow for non-equalization of wages and rentals in their theoretical model, they equalize them in their empirical work.

The Y and B model is rather simple but adequate for its concerns. By using Cobb-Douglas production functions and a log-log demand function, it is a linear model, dynamically. Thus, as outlined in Table 2.2, it can be run over time very simply to isolate the effects of changes in each exogenous

Table 2.2: Summary of Yamaguchi ModelThe Static ModelProduction

$$(1) \quad Q_i = T_i L_i^{\alpha_i} K_i^{\beta_i} \quad i=1,2$$

1. Agriculture 2 - non ag

$$(2) \quad L = L_1 + L_2$$

$$K = K_1 + K_2$$

Factor Markets

$$(3) \quad w_i = \alpha P_i \frac{Q_i}{L_i} \quad i=1,2$$

$$(4) \quad r_i = \beta P_i \frac{Q_i}{K_i} \quad i=1,2$$

$$(5) \quad w_1 = m_w w_2 \quad \text{factor mobility condition}$$

$$(6) \quad r_1 = r_2$$

Agric. Demand Function

$$(7) \quad Q_{1D} = a. \text{ Pop. } P^n E^\epsilon$$

$$(8) \quad P_1 Q_1 + P_2 Q_2 = P' \text{ Pop. } E$$

P_i - sectoral output prices, $P = P_1/P_2$, P' - price level

w_i, r_i - sectoral wage, rental rates

T_i - sectoral level of technical efficiency

Pop - population

Table 2.2 (cont)

E	- real per capita income
m_w	- sectoral proportional wage differential
a	- ag. demand shifter
η, ϵ	- ag. price and income elasticity
α_i, β_i	- output elasticity of labour and capital

The Dynamic Model

The dynamic model can be written

$$A X = b ,$$

where

$$A \cdot 8 \times 8, \quad x \cdot 8 \times 1, \quad b \cdot 8 \times 1$$

$$(x') = (\dot{Q}_1, \dot{Q}_2, \dot{K}_1, \dot{K}_2, \dot{L}_1, \dot{L}_2, \dot{P}, \dot{E})$$

and b has all exogenous parameters, such as:

$$\dot{a}, \dot{pop}, \dot{T}_1, \dot{T}_2, \dot{L}, \dot{K}, \dot{P} .$$

The inverse of A gives "growth rate multipliers" for the variables in x . Thus the effects of changes in the elements in b on the variables in x are found directly.

variable analytically. It is therefore an appealing model. As always, this is obtained at a cost of neglect of some complexity. The use of Cobb-Douglas production functions, for example, eliminates the possibility of bias in technical change. One other shortcoming not discussed by Y and B relates to their use of different parameters in every decade. They do not discuss the effects of these abrupt switches in parameters on the operation of the model. As mentioned earlier, a model can be run for as long a period by changing parameters periodically. This should, however, be done in some smooth way to eliminate the effects of shocks.

Y and B's main contribution is in the investigation of the effect of population change on real per capita income growth and that of technical change in agriculture. They conclude that Japan was fortunate to have low rates of population growth in the Meiji era. The negative demand effects of population growth on per capita income always outweigh its positive effect through the resulting increase in labour supply. DYNURB tends to confirm this finding. They also find that the net negative effect increases over time. They find that the effect of technical change in agriculture was very important in early economic development and less so in later stages. This is not surprising with the relative increase of the non-agriculture sector in later stages. Technical change in agriculture was stable over time while that in non-agriculture fluctuated significantly.

One other two sector model worth mentioning here is the Tolley-Smidt (1964) model. This is reviewed in detail by Yamaguchi (1975). Indeed the Y and B model is derived from it. It was designed to investigate the effect of technical change in agriculture on the growth of the U.S. economy from 1930 to 1960. The main difference between the two models is that everything in Tolley-Smidt is in per capita terms and the population effect is therefore subtracted out. Moreover, it is inconsistent in that per capita income is regarded as exogenous when it really is endogenous to the model.

2.12 Planning Models

Although DYNURB has derived much from the general line of evolution of multi-sector, economy-wide planning models starting from Johansen (1974)¹ it needs to be distinguished sharply in its aims and philosophy. Dervis (1973) provides, perhaps, the most lucid review of the principles of these models. It is best to quote his definition:

"...we define as Johansen type models, planning models that postulate sectoral neo-classical production functions and price-responsive demand functions, linked around an input-output matrix in a Walrasian general equilibrium model that endogenously determined quantities and prices.

A Johansen type model, as defined above, is determinate and generates a solution without the need for optimization. Perhaps more correctly,

¹Johansen's first model was developed in 1960. 1974 is the date of a later edition of his book.

the burden of optimization is placed on the agents of the system (i.e., firms and households), not on a central objective function. In Walrasian spirit, these agents are independently optimizing and this, under the usual convexity assumptions, is known to imply an efficient outcome."

(Dervis (1973), p. 15)

According to this definition, DYNURB is a classical Johansen-type model. However, Dervis continues:

"By operating on pre-determined instrument variables, the planner can, however, affect the system and steer it in a desired direction. In general, the system has the form:

$$F(Y, Z) = 0,$$

where Y are endogenous and Z the controllable variables, with F a vector valued non-linear function."

(Dervis (1973), p. 16)

DYNURB is a positive model in that it has no controllable variables. It is designed to study the process of economic development over time in a market economy but has no "policy" variables. It does, of course, have a vector Z of exogenous variables but these are interpreted as parameters of the economic system and not as controllable variables. This is a distinction of degree and not of kind. Technically, there is no difference between an exogenous variable that is controllable and one that is a parameter. It is a difference in approach and interpretation. Clearly, one can think of

government policies which affect the parameters used in DYNURB. Controllable variables are thought of as more direct policy variables that governments can manipulate. As a corollary, one thinks of policy variables in the short term context and of system parameters in the long term -- though, as mentioned earlier, the long term cannot be too long! Thus the maximum time horizon in Johansen-type models is about 10 years. DYNURB is run for 30 years.

An exhaustive review of Johansen-type models and other planning models is provided by Taylor and Manne (1975). Here only Dervis (1973), Adelman and Robinson (1976) and F. Ahmed (1974) are reviewed since they are Princeton products and have therefore influenced DYNURB the most.

Dervis (1973)

Dervis provides the first -- and perhaps the only -- model which has capital distinguished by sector of origin and destination and which imposes intertemporal equilibrium on capital markets. It is a twelve-sector model run for 10 years on Turkish data from 1972 to 1981. It is solved for inter-temporal equilibrium and therefore has to assume perfect foresight. It is not decomposable in time and has to be solved simultaneously for all time periods. Apart from this major difference, DYNURB is distinguished from Dervis in the following ways:

- i) Dervis uses Cobb-Douglas production functions, though he does experiment with C.E.S. functions.

- ii) Dervis allows foreign trade -- intermediate goods and capital goods are linked by fixed coefficients while consumption goods imports are exogenous.
- iii) With 12 sectors and the production of capital from more than one sector, it is necessary to assume a fixed composition of capital (and labour) in each sector. DYNURB has only one K-good producing sector.
- iv) The Demand equations are of the Stone linear expenditure system but with no subsistence bound on consumption. This makes the income elasticity of demand for all goods equal to unity.
- v) Wages are equalized across sectors except that there is a constant rural/urban wage differential -- an assumption retained in DYNURB. Although wage is set equal to marginal product in each sector, it is given exogenously in the initial period and then made to grow at a given exogenous rate. Wage determination is completely endogenous in DYNURB.
- vi) Dervis allows for capital gains during each period.
- vii) Capital grows exogenously at a constant growth rate specified. This is in lieu of a savings function. DYNURB has a savings function so capital also grows endogenously. Since the savings parameter is specified exogenously, growth of capital cannot be regarded as completely endogenous.

Thus DYNURB and Dervis differ mainly in the specification of exogenous growth rates of wages and capital, aside from the detailed elaboration of the composition of capital. This reflects the difference in approach alluded to earlier. While

Dervis is interested in investigating the effects of a central planning agency manipulating wage rates and capital growth, DYNURB is a positive model which merely tries to simulate a developing market economy. Though the Dervis model is more complex and larger in size, DYNURB is (to use an Adelman-Robinson (1976) phrase) "more comprehensive in its degree of closure", i.e., has more endogenous variables.

Fakhruddin Ahmed (1974)

Ahmed's is also a dynamic general equilibrium multi-sector model with a neoclassical production system as well as a price responsive demand system. It is developed to investigate and model migration and employment in Bangladesh and is run over a period of ten years -- 1973 to 1983. The model has 7 sectors and distinguishes capital by sector of origin. It is solved sequentially for every time period and then allowed to grow. Some of Ahmed's concerns are similar to those of this study. He is mainly concerned with rural/urban migration and resulting urban unemployment. While rural/urban labour movements are a central part of DYNURB, these are viewed as long term movements and there is no unemployment. Ahmed is interested in short term disequilibrium phenomena. Other major points of difference are outlined:

- i) Ahmed uses Cobb-Douglas production functions. Moreover, he allows each sector to produce in both regions -- rural and urban. This is clearly a more realistic assumption than the one in DYNURB. Ahmed also has an underlying input-output intermediate goods framework.
- ii) Labour Market: Ahmed has 2 markets for each factor -- rural and urban. In the labour market, the rural wage rate is set equal to labour's marginal product. In the urban market, wage is fixed exogenously and labour hired until its marginal product is equal to the fixed wage rate. This grows at a predetermined rate. Thus urban unemployment can result.
- iii) Capital: As in Dervis, total investment is determined exogenously and capital grows at a given rate. Capital is immobile between regions but can move within a region. Rentals, however, are not equalized even within a region. A constant proportion between rates of return in various sectors is assumed.
- iv) Demand: Ahmed's system is similar to Dervis with fixed budget shares for each good. The consumption coefficients are allowed to change over time.
- v) Foreign Trade is permitted, but is exogenously specified.
- vi) Migration: Since Ahmed's primary concern is with migration, he has an explicit migration function. Migration is a function of the relative difference between the expected urban wage and the rural wage. This is distinguished from Harris-Todaro (1970) in that theirs is a function of the absolute difference

between the expected urban wage and rural wage. Migration in DYNURB is determined by the need to maintain the given urban/rural wage differential. The net migration resulting is thus a general equilibrium result. The difference, again, is a result of different time horizons: DYNURB is long term while Ahmed's model is short term. Ahmed accounts for time lags in information and does not view migration as sufficiently quick to bring about equilibrium in each period.

As with Dervis, Ahmed's model has somewhat different objectives from those of DYNURB. It includes many more realistic assumptions, e.g. differing capital rentals across sectors, and consequently needs more exogenous information. It therefore also departs from more neo-classical general equilibrium assumptions than Dervis and DYNURB -- in particular, there are severe restrictions on factor mobility. Ahmed's model is similar to Dervis in that it also exogenously specifies urban wage rates and capital levels and growth -- again a reflection of concern with policy instruments.

Adelman-Robinson (1976) [A-R]

The Adelman-Robinson model is, perhaps, the most disaggregated and elaborate of the Johansen-type models. Indeed, it is too complex and large to be adequately reviewed here. Thus only a few comments of relevance to DYNURB will be offered. A-R are concerned with the investigation of income distribution

effects of different development paths. Thus, detailed specification is extended to the household sector, the skill composition of labour and size class of firms. Moreover, the financial sector is modelled as well. In their basic formulation, two essential differences stand out:

- i) Demand: A-R use a log-log specification.
- ii) Production: Production in agriculture is defined by a C.E.S. function, in manufacturing sectors by Cobb-Douglas functions and in services by either fixed coefficients, Cobb Douglas Functions or unspecified. All service sectors are also not profit maximizing. One curious assumption is that the elasticity of substitution between capital and labour in agriculture is assumed to be low. The opposite is the case in most other studies.

A-R model the South Korean economy and run the model for 9 years. It also is thus a short-run model. It is too complex to be run for a longer period since the number of parameters to be estimated is too large for repeated estimation. One of the costs of disaggregation is that a larger proportion of parameters can be expected to change over time. To give some idea of its level of disaggregation: the model has 29 producing sectors, each with firms distinguished by size; labour is classified into skill categories in addition to two categories of self-employed and five groups of farmers.

Thus the A-R model and DYNURB stand at the opposite poles of disaggregation and size. Paradoxically, though, they are somewhat similar in their degree of complexity. Complexity, here, is viewed as some index of the intensity of interrelations in the economy. To use their own phrase, once again, the two models are similar in their degree of closure -- more variables are endogenous in both than any of the other models discussed. As such, their solution techniques are similar -- indeed DYNURB's solution technique was derived directly from A-R.

In closing this section on economy wide models, it is worth mentioning the work of Kendrick and Taylor (1969) since theirs is a 4-sector model with services as one sector.

Kendrick-Taylor (1969) (K-T)

Kendrick-Taylor develop a 4-sector model to maximize a welfare function over a thirty year period subject to constraints in the form of distribution relations, production functions, absorptive capacity functions, foreign exchange constraints, initial and terminal capital stock and foreign debt constraints. As such, its philosophy is clearly different from the "Johansen-type" models described above but is similar in size and time horizon to DYNURB. Their 4 sectors are 1) agriculture and mining, 2) heavy industry, 3) light industry, 4) services. Once again, differences

and similarities with DYNURB may be pointed out:

- i) Production functions used are C.E.S. functions. As in DYNURB they assume a relatively high elasticity of substitution in agriculture and a low rate of technical change in services. They also assume a low elasticity of substitution for services which is not the case in DYNURB.
- ii) Capital: K-T assume that there are absorptive capacity constraints so that capacity expansion is relatively difficult in agriculture, less difficult in light industry and relatively easy in heavy industry. In addition, as in many other models, capital growth rates are specified exogenously. Here, even sectoral capital growth rates are specified.
- iii) Foreign Trade is allowed but is exogenously determined.

Thus the K-T model is much simpler in structure than DYNURB though similar in scope. It has quite different objectives -- once again it is designed to be a planning model albeit at a rather aggregated level. Its main relevance to DYNURB is its specification of a C.E.S. production function for services. It appears to be the only other model that has done this.

2.2 The Service Sector

The service sector can be called the step-child of economists. Dual economy models which have so dominated development thinking have characteristically concentrated on industrialization to the neglect of employment in the service sector. Even multi-sector models like those of Dervis and Adelman-Robinson are much more concerned with the behaviour of the manufacturing sector. Indeed, Adelman-Robinson regard the personal services sector as a residual and do not even attempt to model the production functions of the other service sectors. There does not appear to be even one estimation of a production function of the service sector in the literature. It has been argued that the service sector is so variegated that it really does not mean much to model it. The outputs are difficult to measure. While there is some merit in this argument, the outputs of the service sector may not be more difficult to define and aggregate than the millions of products of the industrial sector.

Before proceeding, it is worth defining the components of the service sector. It includes:

- Retail and wholesale trade
- Banking and insurance
- Real estate
- Government
- Education and health
- Personal, professional, business and repair services.

In general, "service industries may be thought of as providing a service rather than a tangible, material commodity." (Deakin and George (1965) p. 16). There is some disagreement on whether transport and communications should be included in the manufacturing or service sector. This study agrees with Fuchs: "Transport, communications and public utilities have often been classified as services, but we have excluded them from our study of the service sector because in their use of physical capital and the nature of their production processes they appear to have more in common with some of the goods industries than with services." (Fuchs (1968)).

Any classification is necessarily arbitrary at the margin so it is not worth giving any further justification for this choice.

It is obvious from a perusal of the sectors comprising the service sector that they are characteristically urban activities except for some services and trade. Furthermore, activities such as education, health, banking and insurance, real estate and housing, government, are those which become progressively more significant with rising per capita income. Thus a neglect of such activities ignores an essential part of the development and urbanization process. This cannot be stated too strongly and may be regarded as one of the central points of this study.

To give precision to this point, Table 2.3 reproduces a table from J.A. Dowie (1966). It shows the magnitude -- in developed countries -- of a sector that is often neglected by economists.

Table 2.3: Sector Shares of Gross Product, Manpower and Capital Formation

1959-61 (percentage)

	<u>Goods</u>	<u>Services</u>
<u>Gross Product</u>		
Australia	57.4	42.6
U.S.	43.2	56.8
U.K.	52.8	47.2
<u>Manpower</u>		
Australia	52.2	47.8
U.S.	38.3	61.7
U.K.	54.5	45.5
<u>Fixed Capital Formation</u>		
Australia	41.4	58.6
U.S.	33.2	66.8
U.K.	43.5	56.5

SOURCE: J.A. Dowie (1966), p. 538, Table 1.

Note: The service sector includes transport and communications in this study.

Having established the importance of the service sector, what follows is a review of studies of the sector to outline its characteristics. Victor Fuchs' (1968) study of the service economy in the U.S. is probably the most systematic study of the sector, though Stigler (1956) was earlier. Unfortunately, there is even less information for the less developed countries.

Fuchs' main points may be summarized as follows:

i) The share of the service sector in total employment rose from 40% to 55% in the period 1929 to 1967 in the U.S. During the same period, the share of service output remained virtually constant. This implies that output/man grew slowly relative to other sectors. The increase in quality/man was most rapid in industry. This finding supports the need for different factor augmentation rates in each sector -- as suggested in the last section. Industry underwent more rapid change in total technical change.

ii) Women, part-timers and self-employed held about 50% of all jobs in the service sector. This probably applies at least as importantly to LDCS and has major implications for the pattern of urban employment.

iii) The service sector includes a large component of non-profit institutions -- government, education and health. This fact

is often used as an argument against the modelling of profit-maximizing behaviour for this sector.

iv) One of the major defects in the national income accounts is that output in some industries is estimated from employment data. This, of course, is most serious in the evaluation of output for the government sector.

v) Within the service economy, Fuchs found that employment was positively correlated with productivity changes. If this is true in general, the rapid rate of employment increase in government is an indication of increase in productivity as well.

vi) Services are more location specific and wages differ more by location than in manufacturing.

The treatment of the service sector in DYNURB is educated by all these findings: in particular, a slower rate of technical change is assumed than in manufacturing. Government is treated no differently from other sectors and is included in the service production function.

Marimont (1969) elaborates on the problem of measuring output for service industries. The national accounts system calculates changes in output by deflating value output by price changes. These are more difficult to do for the service

sector where unit measures are less specific. Gorman (1968), in an interesting paper, shows that the use of different concepts in the measurement of real output of banks gives quite different results. If the concept used is liquidity (interest foregone by depositors) then output rose by only $2\frac{1}{2}\%$ a year in U.S. banks from 1948 to 1966. If, on the other hand, a measure of transactions is used (service rendered by banks in transactions) then the growth over the same period is 7% a year. This merely illustrates some of the difficulties inherent in the measurement of service output.

In another innovative paper, Schwartzman (1969) discusses the problems in measuring the output of retail trade. He argues that a retailer really offers a variety of services: delivery, credit, help in obtaining items, advice in selection of goods, variety in goods, processing, judgement of quality, and so on.

He argues that the mere measurement of the value of outturn is misleading since different changes take place in each of the variety of services indicated above. For example, in the U.S., while there was an increase in constant dollar sales/man hr. from 1929 to 1963, it was accompanied by a decline in the quantity of service/transaction and a large increase in the average size of transaction. He therefore concludes that there was a decrease in the quantity of service per dollar of sales, i.e., a negative productivity change according to one interpretation.

Fuch's finding of a low rate of technical change in services and a corresponding increase in relative prices is supported for Canada by Weston (1969), for Britain by Deakin and George (1965) and for Australia by Dowie (1966). It is therefore justified to regard it as a general finding. One other general finding is that the incremental capital-output ratio is higher for the service industries. On the demand side, it appears that there is no identifiable increase of the share of services with rise in incomes, relative to manufacturing. This would indicate roughly similar income elasticities of demand for products of the two sectors. DYNURB incorporates this conclusion in its demand system.

Discussions of the service sector in less developed countries are hard to find. One exception is Katouzian (1970). He discusses the conclusion of Colin Clark and Allan Fisher (mentioned in the last section) that employment first moves from agriculture to industry and then to services as income rises. He points out that the shares of the service sector in LDCS are not that different from the developed countries. He illuminates the problem by a 3-way classification of services:

- i) New Services: These include education, medical services and entertainment which are highly related to increases in per capita income.
- ii) Complementary Services: These are those services which go hand in hand with industry: banking, finance, wholesale and retail trade, and are thus complementary factors to urbanization.

- iii) Old Services: These include various kinds of personal services like domestic servants which decline with growth of industrialization.

Katouzian underlines the importance of the service sector in LDCS even at low levels of incomes. The increased contemporary role of government is one reason for this importance.

The link between the development of the service sector and urbanization is explored by Gur Ofer (1976) in a study of the service sector in socialist countries. Ofer finds that all socialist countries have a less than estimated urbanization level as would be expected from market economies at similar GNP levels. Their accent on heavy industry and the Marxist bias against the service sector have produced a correspondingly small service sector. This is strong support for the argument made in this study.

Ofer offers one other significant idea on the phenomenon of urbanization. He finds that the socialist countries use more labour-intensive techniques in agriculture and more capital-intensive techniques in manufacturing (as compared with similar market economies.) He suggests that this may be because a socialist system can better measure the entire social cost of urbanization, i.e., including negative externalities, and therefore economize on it. This is an interesting explanation for the use of overly capital-intensive techniques used in manufacturing in LDCS.

The main ideas reviewed in this section on the service sector may be summarized as follows:

- i) The service sector is too important both in terms of output share and employment to be neglected in a study of development and urbanization. This is particularly so in this era when even low-income countries have large service sectors.
- ii) The rate of change of quality of labour is lower in services as compared with that in manufacturing.
- iii) The rate of total technical change is likewise smaller in the service sector. One word of caution is necessary here. Dhrymes (1963) found this difference to be very small (1.71% a year for manufacturing, 1.61% a year for services) and the difference not to be significant statistically.
- iv) The problems of measurement of the output of services are immense. Thus conclusions on measurement of productivity change have to be made with circumspection.

The specification of the service sector in DYNURB has been influenced by all these findings.

2.3 Technical Change

The formulation and measurement of technical change has long been a problem in economic models. The ideal would be to make technical change endogenous so that economic activities themselves can be seen to be influencing the rate of technological progress. These processes, however, are still little understood or, expressed somewhat differently, the production function of technical change itself is yet to be convincingly specified. This section reviews some of the literature relevant to the specification of technical change in DYNURB. Issues discussed are, 1) the choice of production function as it affects technical change; ii) the neutrality of technical progress; iii) the question of factor embodiment as one view of technical change; and iv) the possibilities of specifying endogenous technical change.

2.31 Choice of Production Function

The most lucid discussion on the theory and measurement of technical change is probably that by Murray Brown (1966) which has since been updated by Nadiri (1970).¹ To begin with, it is useful to clarify what is meant by technical change in economics.²

¹Also see Hahn and Matthews (1964) and Kennedy and Thirlwall (1972) for excellent reviews of the technical change literature.

²The following discussion closely follows Murray Brown (1966) pp. 13-38.

"The production function expresses the way in which outputs are produced by inputs, and the way inputs cooperate with each other in varying proportions to produce any given output. These relations between outputs and inputs and between the inputs themselves are determined by the technology that rules at any given time. The technology is embedded in the production function and can be expressed in terms of it."

(Brown (1966), p. 12)

This is the problem at issue. Factor productivity measures are often based on the production function

$$Q = A F(K, L) \quad (2.1)$$

which gives as a measure of the rate of technical change

$$\frac{\dot{A}}{A} = \frac{\dot{Q}}{Q} - \left[\frac{A L F_L}{Q} \cdot \frac{\dot{L}}{L} + \frac{A K F_K}{Q} \cdot \frac{\dot{K}}{K} \right], \quad (2.2)$$

where Q is output,

K and L are the inputs,

A the "level of efficiency" or scale parameter.

$\dot{X}$ refers to $\frac{dX}{dt}$, and F_L and F_K are partial derivatives of Q with respect to L and K respectively.

From this it is clear that the rate of technical or productivity change depends on i) the form of the production function which determines F_L and F_K , ii) measurement of

L and K, iii) the importance of variables other than K and L that are omitted.¹

The characteristics of a production function can be thought to have 4 components:

- i) Efficiency of the Technology: This is represented by A in (2.1) above. For a given level of inputs the amount of output is determined by the level of A. The larger it is, the larger the output.
- ii) Degree of Economies of Scale: This is represented in (2.1) by the degree of homogeneity of $F(K,L)$. If a proportional increase in the inputs results in output increased by a larger proportion, the function is homogeneous of degree greater than 1 and vice versa.
- iii) The Capital Intensity of a Technology: Degrees of capital intensity are reflected in the size of the labour-capital ratios for given relative factor prices. For a given marginal product of labour, the marginal product of capital is more for a more capital intensive technology.

¹This discussion closely follows Nadiri (1970), p. 1140.

- iv) The Elasticity of Substitution: This is an index of the ease with which capital can be substituted for labour in a production process. The index is

$$\sigma = \frac{(dK/dL)}{K/L} \cdot \frac{F_L/F_K}{dF_L/dF_K} , \quad (2.3)$$

i.e., the elasticity of substitution relates the proportional change in the relative factor inputs to a proportional change in the marginal rate of substitution between labour and capital. Where price is equal to the marginal product the marginal rate of substitution is the relative factor price ratio. It may also be thought of as a measure of the similarity of factors: $\sigma = 0$ implies that factors are completely dissimilar, $\sigma = \text{infinity}$ implies that the factors are identical. Clearly the form of F affects the behaviour of σ .¹

If the Cobb-Douglas Production Function

$$Q = A K^\alpha L^\beta \quad (2.4)$$

is chosen to represent the production process -- with the exponents α and β chosen to be constant -- then the characteristics (iii) and (iv) above are lost. A constant proportion

¹The above is taken from Brown (1966), pp. 12-20.

α/β implies a constant capital intensity of production and the function has an elasticity of substitution equal to unity. Moreover, $\alpha + \beta$ determines the degree of homogeneity of the production function, usually, of course taken to be 1.

It is because of these limitations that the constant elasticity of substitution function (the C.E.S.) function is used in DYNURB:

$$Q = A\{\gamma K^{(\sigma-1)/\sigma} + (1-\gamma)L^{(\sigma-1)/\sigma}\}^{v\sigma/(\sigma-1)} \quad (2.5)$$

where Q, A, K, L, σ are as before, γ is the capital intensity parameter and v is the degree of homogeneity or economies of scale parameter. $v = 1$ makes the function homogeneous of degree 1.

This permits the variation of σ and therefore allows a more complex modeling of technical change. It is however, recognized here that the empirical identification of these characteristics is not easy, even impossible because of their inherent interrelatedness. The justification for their use, despite this caveat, is the possibility of a wider ranging theoretical investigation.

2.32 Neutrality of Technical Progress

Having defined the components of technical progress as viewed through the production function, their implications can now be discussed. Again to quote Brown (p. 20):

"A neutral change neither saves nor uses labour, it is one which produces a parallel shift of the production relation itself, but does not affect the marginal rate of substitution of labour for capital. A non-neutral change alters the shape of the production function and can be either labour-saving (capital using) or capital-saving (labour using)."

A neutral technical change is caused by changes in A and in the degree of economies of scale v . A non-neutral change is caused by changes in σ and γ (in equation 2.5) i.e., the elasticity of substitution and the capital intensity. Changes in A and v merely shift the production function, while changes in σ and γ alter its shape thereby altering the marginal rate of substitution. Thus the Cobb-Douglas function can only be used to measure neutral technical change. Increases in A or the presence of economies of scale merely increase the level of output produced by the same level of inputs.

An increase in capital intensity is always labour saving because the marginal product of capital is increased relative to that of labour. Thus an increase in γ produces a capital using technical change.

A change in σ produces an ambiguous result. When capital is increasing faster than labour, a rise in σ raises

the marginal product of capital relative to that of labour and the technical change is therefore labour-saving (or capital using). The converse is true if labour increases faster than capital.

The effect of a change in σ on output is illustrated in Figure 2.1. Q and Q' are isoquants with Q having the smaller elasticity of substitution. If K and L grow at the same rate along $(\frac{K}{L})_0$, Q and Q' technologies give the same rate of change in output. If K grows faster than L

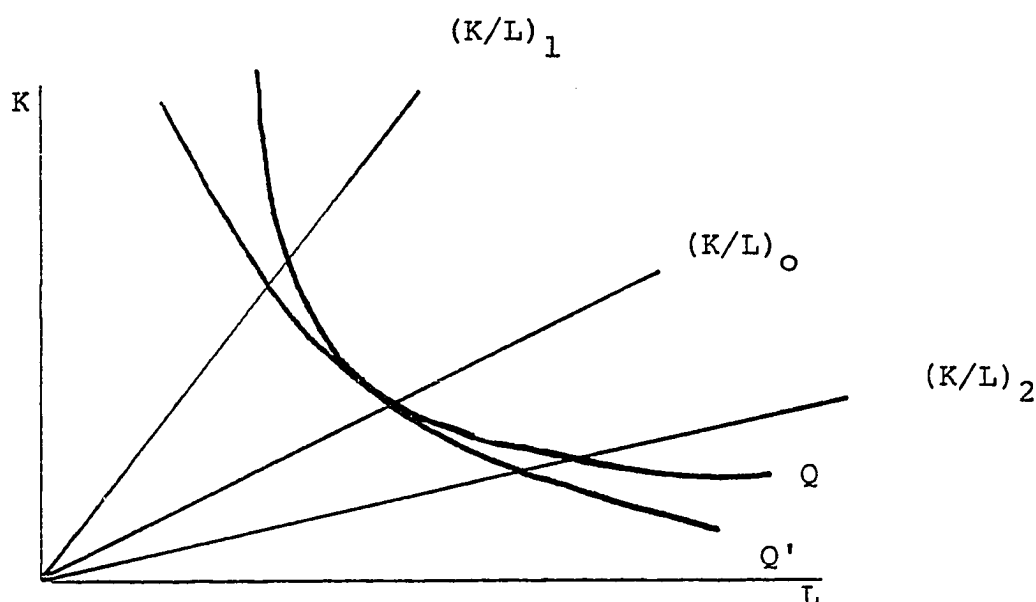


Figure 2.1

(from Brown (1966) p. 25)

along $(\frac{K}{L})_1$ or if L grows faster than K along $(\frac{K}{L})_2$ the Q' technology always gives a larger rate of output. Thus, if K and L grow at different rates, a larger elasticity of substitution always results in an increased rate of output growth.

A last clarificatory note is necessary in this section on the neutrality of technical progress. Although the bias of technical change is defined according to changes in the marginal rate of substitution, there are differing views on what is kept constant. In this study the Hicks definition of bias is always used:

Technical change is labour saving, neutral or capital saving according as

$$\left(\frac{\partial (F_K/F_L)}{\partial t} \right)_{\substack{K/L \\ \text{const.}}} \begin{matrix} > \\ < \end{matrix} 0 . \quad (2.6)$$

The question of bias in technical change has been discussed and clarified in some detail above because the terms "capital-saving", "labour-saving" are often used rather loosely in the development context.

2.33 The Embodiment/Vintage Question

Much of the debate concerning technical change has been on its measurement. Ever since Solow's earliest work (Solow, 1957) which attributed almost 2/3 of U.S. GNP growth to the unexplained residual $(\frac{\dot{A}}{A})$, there have been attempts to reduce this residual by measuring inputs better. On the

one hand is the work by Jorgenson and Griliches (1967) which takes the view that all technical change can be explained by errors or omissions in the measurement of inputs. Another is the further work by Solow himself as in Solow (1959) emphasizing a different view of capital. According to this view, technical change is embodied in different vintages of capital and should therefore not be viewed as disembodied as in the $\left(\frac{\dot{A}}{A}\right)$ calculation. Nelson (1964) gives more empirical weight to this view. The other line of argument asserts that -- and this is similar to Jorgenson and Griliches -- viewing K and L as the only inputs is erroneous. The correct approach is to disaggregate K and L and to question the validity of aggregation. This, of course, is the Cambridge capital theory view.

This study does not enter into any of these controversies and takes an eclectic view of the matter. Both capital and labour are assumed to improve in quality over time and this may be represented thus:

$$Q = A F (xK, yL) \quad , \quad (2.7)$$

where x and y are the coefficients of factor augmentation. (This is also the view taken by KWC). This is seen to subsume the vintage, factor heterogeneity and errors in measurement arguments. Each of these views require that different

factors are summed up, each with a different weight. Thus, in the vintage argument, new capital is more efficient than old and therefore each unit has greater weight than the old. By assuming factor augmentation this increase in quality of new capital (or labour) is seen to increase the quality of the aggregate. Similarly, if it is asserted that different factors have different qualities, the factor augmentation interpretation is merely saying that each improves in quality over time and the rate of change of the weighted sum is given by y and x . Lastly, y and x could also be seen as measuring the errors in measurement that Jorgenson and Griliches talk about.

One of the consequences of this formulation is that the direction of technical change depends on y, x and σ . The bias is

$$B = \left(\frac{dy}{y} - \frac{dx}{x} \right) \cdot \left(\frac{1-\sigma}{\sigma} \right) \quad . \quad (2.8)$$

(Nadiri, (1970),
p. 1143)

Embodiment is distinguished in the literature from the augmentation effect. All quality changes in an aggregate can be subsumed by an index of factor augmentation, while embodiment only refers to quality changes that appear in new factors. Thus, embodiment of technical change in capital could even produce labour augmenting technical change.

Problems of measurement arise because there is no obvious natural unit for measuring capital as there is one for labour. While this is true, the variety of skills, age, sex, etc. is large enough for measurement of labour to be similarly difficult.

2.34 Endogenous Technical Change

While various distinctions have been made to describe different kinds of technical change, it must be recognized that many of these are highly interdependent. Thus, σ itself, depends on the kinds of technical change that occur: innovations, for example, can make the substitution of capital for labour easier. As shown, the bias of technical change depends jointly on factor augmentation and σ . Some of these problems would be eased if there was a production function for technical change itself.

Conceptually, Kennedy (1964), Syed Ahmad (1964) and others, have suggested the innovation possibilities frontier. John Conlisk (1969) has included an "endogenously positioned" technical change frontier in a neo-classical growth model. Factor augmenting technical change provides a convenient device for illustrating this frontier:

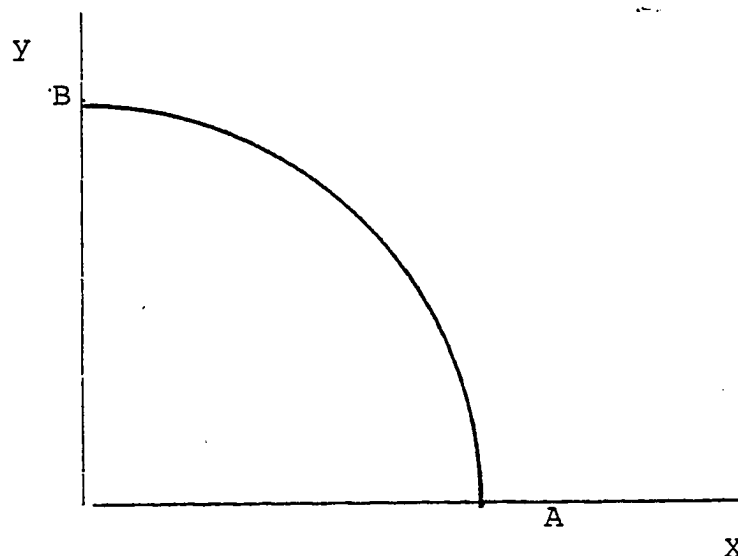


Figure 2.2: Technical Change Frontier

The idea is that an economy, or a sector, faces a constraint AB which defines the set of innovation possibilities.

Each of the axes can be interpreted as measuring the coefficients of factor augmentation. As suggested by Conlisk (1969), "In choosing a point on this curve, the model economy decides how much it wishes to stress growth in capital versus growth in labour," (p. 350) i.e., it chooses the bias of its technical change. Thus y and x could be seen to be determined by

$$H(y,x) = G(K,L) \quad , \quad (2.9)$$

i.e., y and x could be results of production decisions themselves. These decisions are price responsive -- when

entrepreneurs anticipate a relative increase in real wages, they will, in the short run, substitute capital for labour and then, presumably with a lag, attempt to find labour saving innovations. This is done by allocation of resources to activities such as research and development.

The formulation of factor augmenting technical change is therefore seen as one which at least conceptually can be made endogenous.

There have been attempts to model the research and development production function but there is yet no agreement on how it can be formulated for aggregative economy-wide models. Thus, in DYNURB, technical change is regarded as potentially endogenous but has been modeled as factor augmenting in a C.E.S. production function framework to provide for maximum flexibility.

2.4 Summary

This chapter has reviewed three strands of the literature which are particularly relevant to the development of DYNURB:

- (a) Economy wide models
- (b) The Service Sector
- (c) Technical Change.

The review has attempted to show that the traditional two-sector models are inadequate for a study of urbanization since the service sector is vital to urbanization process. The expansion to a larger number of sectors necessitates estimation of more parameters which are then also more likely to change over time. Therefore, since urbanization is a long term process, a model investigating the underlying structural changes involved needs to be one adequate for long term simulation. Thus DYNURB is designed as a 3-sector model incorporating the service sector and yet not being too large to simulate over a long period of time.

Different views and formulations of technical change have been reviewed to clarify the notions that have been used in DYNURB. The use of C.E.S. functions and factor augmenting technical change in DYNURB has been justified in this context.

To conclude, the special features of DYNURB may be summarized:

- i) The Service sector is modeled explicitly.
- ii) DYNURB is a three sector model attempting to find a mean between 2-sector models which miss some essentials and n-sector models which are too disaggregated for long term simulation.
- iii) DYNURB has a higher degree of closure than most models.
- iv) DYNURB distinguishes between the labour force and population.

- v) DYNURB does not assume a classical savings function as is done in many other models. This lends realism in acknowledging the existence of a large self-employed sector in poor economies.
- vi) Modelling a savings function is an improvement over exogenous specification of capital growth rates.
- vii) The modelling of technical change is almost the most flexible possible short of endogenously induced changes.

3. DYNURB: Mathematical Specification of the Model

DYNURB -- The model developed in this study is a non-linear, three-sector, two region, wage and price endogenous dynamic general equilibrium model in the Johansen tradition. It is developed to study the basic structural changes that produce urbanization as a low-income economy develops to higher income levels over time. The model in its present form is for a closed economy and is designed to reflect the Indian economy in particular over a 30 year period starting in 1951, i.e., the period after Indian independence. It is therefore seen as a long term model. The model solves recursively over time -- it finds an equilibrium for a period, then grows, and then again for the next period. Such a process may be characterized as "lurching equilibrium" as aptly expressed (though in a slightly different sense) by Adelman-Robinson. It is recognized that this does not reflect reality where the adjustment process takes time and capital and labor are not perfectly mobile. The justification for ignoring this is that in a long term context, factors may be regarded as more mobile. Thus the model is wrong in that it finds an equilibrium for every period but is probably not too misleading in showing trends over an extended period of time.

This chapter describes all the equations that comprise the model with justifications for the particular forms used.

The sectoral division according to Indian national accounts classification is as follows:

1. Agriculture Sector:

- 1.1 Agriculture
- 1.2 Forestry and logging
- 1.3 Fishing

2. Industrial Sector:

- 2.1 Mining
- 2.2 Manufacturing
- 2.3 Construction
- 2.4 Electricity, gas and water
- 2.5 Transport and communication

3. Service Sector:

- 3.1 Wholesale and Retail Trade
- 3.2 Hotels and Restaurants
- 3.3 Banking and Insurance
- 3.4 Real Estate, ownership of dwellings
and business services
- 3.5 Public Administration and Defense
- 3.6 Other Services.

Agricultural production is regarded as taking place exclusively in the rural region. Industry and services are exclusively based in the urban region. Thus only rural workers can work in agriculture and urban workers in industry and services. A shift of employment from agriculture to industry and services implies a shift of population from the

rural to the urban region. This transfer is costless. Similarly capital is perfectly mobile between sectors and regions. The justification of this sector location is that the vast majority of urban employment in India is in industry and services while that of rural employment is in agriculture. This is shown in Table 3.1.

The components of the model follow. t is the time subscript. I or i is the sector subscript ranging from 1 to 3. Sector 1 is agriculture, Sector 2, industry and Sector 3, services. J or j is the region subscript, 1 for the rural region and 2 for the urban region. The model has no financial sector so all magnitudes are real and in initial period values.

3.1 Production Conditions:

Value added in DYNURB is created through production functions, but it has an underlying inter-industry input-output structure for intermediate goods. All production functions are homogeneous of degree 1, i.e., exhibit constant returns to scale.

Agriculture:

The agriculture production function has four factors: capital (K_1), and labor (L_1) which combine with a constant elasticity of substitution σ_1 ; this joint input then combines with land (LAND) and livestock (LVSTK) according to a Cobb-Douglas production function with constant exponents (shares). Agricultural

Table 3.1
Distribution of Workers by Sector and
Region: India, 1961.

<u>Category</u>	Rural (percent)	Urban (per cent)
1. cultivator	60.3	6.6
2. agricultural laborer	18.9	3.5
3. other primary	2.8	2.5
Sector 1	82.0	12.6
4. Household Industry	6.1	7.9
5. Other Manufacturing	1.5	21.0
6. Construction	0.7	3.7
7. Transport and Communication	0.5	8.0
Sector 2	8.8	40.6
8. Trade and Commerce	2.1	16.3
9. Other Services	7.1	30.6
Sector 3	9.2	46.9
Total	100.0	100.0

Source: Ashish Bose (1973). p. 305.

output:

$$Q_1(t) = LAND(t)^{ALPH} LVSTK(t)^{GAM} \left[B_1 \left\{ \gamma_1 \{x_1(t) K_1(t)\}^{(\sigma_1-1)/\sigma_1} + (1-\gamma_1) \{y_1(t) L_1(t)\}^{(\sigma_1-1)/\sigma_1} \right\}^{\sigma_1/(\sigma_1-1)} \right]^{BET} \quad 3.1$$

where

ALPH, GAM, BET are shares of LAND, LVSTK and of the combined labour and capital input.

γ_1 is the capital intensity parameter

B_1 is the scaling parameter (it is included in the CES part of the function for programming convenience).

$x_1(t)$, $y_1(t)$ are the factor augmenting coefficients of capital and labor respectively.

The above are all exogenously given. LAND and LVSTK are specific to agriculture while K and L are free to move to other sectors. This is the reason for treating them differently, and allowing greater flexibility in the substitution between capital and labor.

Industry and Services:

$$Q_i(t) = B_i [\gamma_i \{x_i(t) K_i(t)\}^{(\sigma_i-1)/\sigma_i} + (1-\gamma_i) \{y_i(t) L_i(t)\}^{(\sigma_i-1)/\sigma_i}]^{\sigma_i/(\sigma_i-1)} \quad i = 2,3 \quad 3.2$$

All the symbols here are as defined above with i assuming the

values 2,3 for industry and services, respectively.

[For the purpose of running simulation experiments, each of the production functions can also be specified as Cobb-Douglas functions:¹

$$Q_i(t) = A_i \text{ LAND}^{\text{ALPH}} \text{ LVSTK}^{\text{GAM}} (x_i(t) K_i(t))^{\text{EXPK}_i} (y_i(t) L_i(t))^{\text{EXPL}_i} \quad (3.1a)$$

and

$$Q_i(t) = A_i (x_i(t) K_i(t))^{\text{EXPK}_i} (y_i(t) L_i(t))^{\text{EXPL}_i} \quad (3.2a)$$

$$i = 2,3$$

where

EXPK_i , EXPL_i are shares of capital and labor.

These functions have to be used whenever $\sigma = 1$ in simulation experiments.]

The use of CES functions was justified in the last chapter. A few more comments on their use need to be offered here.

It is obvious that the use of CES functions permits σ to be different in each sector. This can be regarded as another feature that distinguishes one sector from another. The assumption of a low σ in the industrial sector is partly to reflect the problem of latecomers to the development process. Countries entering the relatively rapid development process in the 20th century are at an advantage as well as a disadvantage. On the one hand the availability of advanced technology makes it possible

¹Although CES functions can be shown to subsume Cobb-Douglas functions, for purposes of computation they have to be specified separately.

for them to jump many intermediate stages. On the other hand, since much of this technology is then imported it may not reflect the factor proportions of the LDCs. Yet, choice of technique is limited because of world market pressures as well as by the domination of information/education/technology by the advanced countries. This is then one more reason for the use of CES production functions in this study.

The next comment is in the nature of a caveat. Stated baldly, evidence on the existence of stable σ 's being significantly different from 1 is scanty. In a survey of empirical studies based on the CES function, Nerlove's [1967] main conclusion was that results were inconclusive: 'Even slight variations in the period or concepts tend to produce drastically different estimates of the elasticity. While there seems little rhyme or reason for most of these differences, a number of possible sources of bias exist and may account for at least some of these differences.' (Nerlove [1967], p. 58). He also identifies simultaneous equation difficulties as another source of the estimation problems. In a subsequent study Zarembka (1970) concludes that "There is no significant evidence that the elasticity of substitution at the two-digit level departs from unity using either behavioral equation or direct estimation. The explanation may be that the elasticity is a 'second order' parameter in production functions for which most bodies of data are not able to provide precise estimates." (Zarembka [1970])

p. 52). His own estimates lie on both sides of unity. In another review paper -- this for CES estimates in LDCs -- Bruton [1972] reaches similar conclusions. He finds estimates covering a whole range of different industries and countries to be as low as 0.2 or 0.3 and as high as 2. In general, time series estimates are found to be lower than cross section estimates. In an attempt to reconcile different estimates, Berndt [1976] identifies the following as sources of error:

- cyclical changes in capacity utilization
- measurement errors
- systematic variation of input prices with product prices
- embodied and disembodied technical change

After accounting for many of these errors by the use of different estimation techniques, Berndt's estimates lie in the narrow range between 1.15 and 1.25. Clague [1969] on the other hand, in a study based on industry data from Peru finds $\sigma < 0.5$ in almost all cases.

Thus one cannot but fail to conclude that the estimation of CES functions still has some way to go. It is with this knowledge that CES functions are still used in DYNURB to facilitate wider experiments and to make possible quantitative ideas of the effects of different assumptions.

3.2 Net Prices - Intermediate Goods and Transportation Costs

If the input-output coefficients are denoted by a_{ij} - the amount of good i required to produce one unit of good j - the standard net price equation would be given by

$$PSTAR_{it} = P_{it} - \sum_{j=1}^3 a_{ji} P_{jt} \quad (3.3a)$$

where $PSTAR_{it}$ is the price net of intermediate costs and P_{it} is the seller's price, all at time t .

In DYNURB, however, transport is included as an additional intermediate good. Whenever a commodity is transferred from one region to another it is deemed to incur intermediate transport costs. Thus, when the agriculture sector uses 1 unit of good 2 as an intermediate good, it also uses a_T units of transport. Since, in DYNURB transport is produced by the industry sector, this additional demand is always produced by sector 2. The net price equations then become non-linear in a_{ij} and a_T and highly 'irregular' in structure. In the following resulting net price equations,

P_{ij} is the price of good i in region j

$PSTAR_{ij}$ is the net price of good i in sector j

(For net prices $i=j$ since net prices have no relevance outside their own region)

$j=1$ is rural, $j=2$ is urban.

$$PSTAR_{11} = P_{11} - [a_{11} P_{11} + a_{21} (1+a_T) P_{22} + a_{31} (a_T P_{22} + P_{32})]$$

$$PSTAR_{22} = P_{22} - [a_{12} P_{11} + a_{22} P_{22} + a_{12} a_T P_{22} + a_{32} P_{32}]$$

$$PSTAR_{33} = P_{32} - [a_{13} P_{11} + a_{23} P_{22} + a_{13} a_T P_{22} + a_{33} P_{32}] \quad (3.3b)$$

P_{ij} and $PSTAR_{ii}$ have time subscripts also but have been omitted here for convenience. Note that the price of transport, being an industrial good, is P_{22} .

a_T -- the transport coefficient -- could alternatively be regarded as rural/urban, urban/rural friction costs which result in additional usage of sector 2 transport type goods. It has been added here in this rather irregular fashion as the simplest way to simulate transport cost effects. It adds a further spatial dimension to DYNURB -- albeit in a rather imperfect fashion. This inclusion facilitates experimentation with different transport costs.

3.3 Factor Demand

Returns to factors in DYNURB are equal to their marginal value products. Thus factors are demanded until their marginal products equal their wages or rentals. The wage and rental equations are

Labor:

i) Agriculture: Because of the composite agriculture production function,

$$W_1(t) = PSTAR_{11}(t) (1 - \gamma_1) B_1^{(\sigma_1 - 1)/\sigma_1} \left(\frac{QT(t)}{Y_1(t)L_1(t)} \right)^{1/\sigma_1} \cdot^{BET} \left(\frac{Q_1(t)}{QT(t)} \right)^{1/\sigma_1} \quad (3.4)$$

where

$$QT(t) = B_1 [\gamma_1 \{x_1(t) K_1(t)\}^{(\sigma_1-1)/\sigma_1} + (1-\gamma_1) \{y_1(t) L_1(t)\}^{(\sigma_1-1)/\sigma_1}]^{\sigma_1/(\sigma_1-1)} \quad (3.5)$$

i.e., the CES part of the production function

and $W_1(t)$ is wages of labor in agriculture.

ii) Industry and Services:

$$W_i(t) = PSTAR_{ii}(t) (1-\gamma_i) \beta_i^{(\sigma_i-1)/\sigma_i} \left[\frac{Q_i(t)}{y_i(t)L_i(t)} \right]^{1/\sigma_i} \quad (3.6)$$

$W_i(t)$ is wage of labor in sector i . $i = 2, 3$.

Capital:

These are similar to expressions above.

i) Agriculture:

$$R_1(t) = PSTAR_{11}(t) \cdot \gamma_1 \cdot B_1^{(\sigma_1-1)/\sigma_1} \left[\frac{QT(t)}{x_1(t)K_1(t)} \right]^{1/\sigma_1} \cdot BET \left[\frac{Q_1(t)}{QT(t)} \right]^{1/\sigma_1} \quad (3.7)$$

where R_1 is the capital rental.

ii) Industry and Services:

$$R_i(t) = PSTAR_{ii}(t) \gamma_i B_i^{(\sigma_i-1)/\sigma_i} \left[\frac{Q_i(t)}{x_i(t)K_i(t)} \right]^{1/\sigma_i} \quad i = 2, 3 \quad (3.8)$$

where $R_i(t)$ is the capital rental in sector i .

The wages and rentals given above are for the efficiency units. Those for the augmented units or "actual" units are

$$W_i^*(t) = y_i(t) W_i(t) \quad (3.9)$$

and

$$R_i^*(t) = x_i(t) R_i(t) \quad (3.10)$$

$W_i^*(t)$ then is the wage per person in sector i at time t and $R_i^*(t)$ that for the corresponding augmented unit of capital. A word on interpretation is necessary here.

Since $y_i(t)$ and $x_i(t)$ are allowed to take different values in different sectors, the factor homogeneity assumption comes into question. What is assumed here is that the efficiency units are homogeneous. Different augmentation rates imply that because of sector characteristics one sector requires more efficient factors than another. For example, it is not unreasonable to assume that the industrial sector has, on average a more educated labour force than the agriculture sector and that the level of education/skill even increases faster in it. As mentioned in the last chapter, the index of labour used in the model is really some weighted sum of the variety of skill and education levels that exist in the labour force. It can then be interpreted that in the example given above only the higher quality members of the agriculture labor force move to the industry sector (according to the market situation). These members "possess" higher than average efficiency units in the agriculture sector. It is in this way that it can be consistently maintained that efficiency units of a factor are homogeneous as well as perfectly mobile and are augmented at different rates

in different sectors. The appropriate equalizing (within the given wage structure outlined next) is then for the returns to the efficiency units of the factors. Thus, if it is sought to equalize wages across all sectors what is equalized is the wage per efficiency unit. The wage per person, or augmented unit, may well be different. This interpretation therefore conveniently maintains factor homogeneity and mobility along with different rates of technical change in factor quality.

Land and Livestock

These are only in sector 1 and the Cobb-Douglas marginal product functions give their marginal returns:

$$\text{RENT}(t) = \text{PSTAR}_{11}(t) \cdot \text{ALPH} \cdot \frac{Q_1(t)}{\text{LAND}(t)} \quad (3.11)$$

$$\text{RLVSTK}(t) = \text{PSTAR}_{11}(t) \cdot \text{GAM} \cdot \frac{Q_1(t)}{\text{LVSTK}(t)} \quad (3.12)$$

where RENT is return per unit of land and RLVSTK the return per unit livestock.

Inter-Region Wage and Rental Structure

There is ample evidence that urban and rural earnings differ for the same skill and that there is no tendency for this gap to be closed. Reasons for this are not entirely clear but a few may be offered.

- i) different wages may reflect different costs of living. Dwelling rents, transport costs, etc., are all substantially higher in urban areas.

- ii) within the same professional or craft category, there may be differences in skill and education.
- iii) persons with similar skills could be under-utilized in rural areas due to deficiencies in demand.

Such reasons, significant as they are, are really not convincing enough to account for all the differences which have been observed, for instance, in India:

<u>Profession</u>	<u>Rural Earnings as Percent of Urban</u>
Doctors	50.7
Lawyers	47.0
Engineers	50.0
Barbers	55.1
<u>Priests</u>	<u>51.6</u>
Average	50.2

Source: M. Mukherjee (1969), p. 429.

The small range 47-55 percent is remarkable and indicates some systematic economic forces at work. Such figures are also commonly found in other countries.

DYNURB takes these differences for granted as an element of reality and makes provision for their imposition on the wage and rental structure. Moreover, if there is any reason to believe that returns to capital are higher in one sector than another, this is provided for as well. Thus

$$W_i(t) = \theta_i W_1(t) \quad (3.13)$$

$$R_i(t) = \phi_i R_1(t) \quad i = 1, 2, 3 \quad (3.14)$$

where θ_i , ϕ_i are parameters. Note that these differences are imposed on the wages of efficiency units. Wages per person therefore can differ even more.

Note also that within this imposed structure the payments to factors are still equal to their marginal product. If $\theta_{2,3} > 0$, then the labor efficiency units produce more in the urban region than their rural counterparts even though they are identical.

3.4 The Savings Function

This has also been designed for maximum flexibility, DYNURB permits different savings rates out of labor and capital income as well as different saving rates for each sector.

Labor income in each sector is

$$YLAB_i(t) = y_i(t) W_i(t) L_i(t) \quad i = 1, 2, 3 \quad (3.15)$$

Property income in the agriculture sector is

$$YCAP_1(t) = x_1(t) R_1(t) K_1(t) + RENT(t) \cdot LAND(t) + RLVSTK(t) \cdot LVSTK(t) \quad (3.16)$$

and property income in the other 2 sectors

$$YCAP_i(t) = x_i(t) R_i(t) K_i(t) \quad i = 2, 3 \quad (3.17)$$

The total savings from factor incomes in each sector are then

$$YSAVE_i(t) = SLAB_i(t) \cdot YLAB_i(t) + SCAP_i(t) \cdot YCAP_i(t) \quad i = 1, 2, 3 \quad (3.18)$$

where $SLAB_i(t)$ is the proportion of income saved from labor income and

$SCAP_i(t)$ the proportion from capital income in sector i . This form subsumes the Kaldor or classical savings function when $SLAB_i = 0$ $i = 1, 2, 3$.

As mentioned in the last chapter, Houthakker (1965) provides evidence for the assumption that labour income is saved at a different rate from capital income. This is also supported by Bhalla (1976) in a study on rural savings in India drawing on a country-wide sample of rural households. Panikar (1970) and the study by the National Council for Applied Economic Research (1965) provide evidence that rural and urban savings rates are different.

One reason for the rejection of the Kaldorian savings function in this study is the large component of self-employed in a poor economy. In India, for example, according to the national accounts statistics, about 50 percent of all factor income originates as income of self-employed (Government of India (1976) p. xxxi). This obviously blurs the distinction between capital and labor income -- for purposes of determining the savings rates.

3.5 The Demand System

The Demand System used is the Stone Linear Expenditure System. Income after savings, or disposable income in sector i is

$$YCONS_i(t) = (1 - SLAB_i(t)) YLAB_i(t) + (1 - SCAP_i(t)) YCAP_i(t) \quad i = 1, 2, 3 \quad (3.19)$$

The total population associated with labor in each sector is

$$POP_i(t) = L_i(t) / WPR_i \quad (3.20)$$

where WPR_i is the worker participation ratio. These are different for the urban and rural regions. Thus

$$WPR_2 = WPR_3 \neq WPR_1$$

In general, a larger proportion of women and children appear to work in rural areas. DYNURB therefore distinguishes between members of the labor force and the total population. As will be evident shortly, this is important for the demand side of the model.

The Stone system for DYNURB is written

$$D_{ij}(t) = \frac{\beta_{ij}}{P_{ij}(t)} \left[YCONS_j(t) - \sum_{k=1}^3 P_{kj}(t) \cdot FMIN_k(t) \cdot POP_j(t) \right] + FMIN_i(t) \cdot POP_j(t) \quad (3.21)$$

$$i = 1, 2, 3$$

$$j = 1, 2, 3$$

$$\sum_{i=1}^3 \beta_{ij} = 1, \beta_{i2} = \beta_{i3}, \quad i = 1, 2, 3 \quad 0 < \beta_{ij} < 1 \text{ for all } i, j$$

and the function is not defined when

$$YCONS_j(t) < \sum_{k=1}^3 P_{kj}(t) FMIN_k(t) \cdot POP_j(t)$$

$D_{ij}(t)$ is the total quantity of good i demanded from income generated in sector j . β_{ij} is the marginal budget share devoted to good i from discretionary income in sector j .

$P_{ij}(t)$ is the price of good i in sector j . Here

$$P_{12} = P_{13} = P_{11} (1 + a_T)$$

$$P_{21} = P_{22} (1 + a_T)$$

$$P_{31} = P_{33} (1 + a_T)$$

The price difference between regions is attributed to transport costs as for intermediate goods whenever a good has to be transported outside its own region. The industry and service sectors being both in the urban region

$$P_{23} = P_{22}$$

$$P_{32} = P_{33}$$

Note that this causes additional demand for transport, i.e., that for good 2. $FMIN_i(t)$ is the minimum amount of good i required by an individual for subsistence purposes. Stone regards the expenditures on these as committed expenditures which can be interpreted somewhat differently from subsistence. In DYNURB

$$FMIN_2 = FMIN_3 = 0$$

i.e., only food -- the agricultural good is regarded as necessary for subsistence. $FMIN_i$ is allowed to change over time in DYNURB.

[Note: The standard form of the Stone System is written in terms of the demand for good i by an individual

$$q_i = \gamma_i + \frac{\beta_i}{p_i} \left(y - \sum_{j=1}^n p_j \gamma_j \right)$$

where γ_i is the minimum quantity of good i necessary for subsistence, p_i is the price of good i and y is the individual's income. The term inside the parentheses is income available

after committed expenditures and may be called discretionary income. β_i is the marginal budget share of good i from discretionary income. This demand system is consistent with the individual's utility function

$$U = \sum_{i=1}^n \beta_i \log (q_i - \gamma_i)$$

(see Goldberger (1967) for derivation)].

If disposable income is less than the minimum required subsistence bundle

$$\sum_{k=1}^3 P_{kj} \cdot FMIN_k(t) POP_j(t)$$

then the demand function is not defined. There is one other problem with (3.21) as formulated. To be consistent with the interpretation of $FMIN$, as subsistence requirements, savings should be taken only from discretionary income. This can, of course, be done easily but is not done here for practical reasons:

- i) The estimation of the savings parameters from standard national income accounts and household surveys is then made difficult.
- ii) Since the demand function is used in the aggregated form it is reasonable to expect that this misspecification will not be too significant practically.¹

¹KWC do not allow savings from labour. Their capitalist consumers also save out of total income and not only discretionary income.

The use of the Stone system is convenient for DYNURB's purposes but presents some problems as well. Pros and cons are enumerated below.

i) Unlike other demand systems, the Stone system is consistent with an underlying utility function, the Stone-Geary utility function outlined above. It can therefore be stated that each consumer in DYNURB allocates expenditures so as to maximize his utility function. Every individual in a sector has an identical utility function. In DYNURB, urban consumers in the two urban sectors are identical in their tastes but their tastes differ from those of rural consumers. Thus,

$$B_{i2} = B_{i3} \neq B_{i1} \quad i = 1, 2, 3$$

ii) Aggregation. As shown by Goldberger (1967), individual demand functions in the Stone system aggregate perfectly if all individuals have the same utility function. Demand functions can therefore be aggregated over each sector in DYNURB. This is particularly useful here because of the role of FMIN - the individual subsistence requirements - and the pooling of labour and capital income. This combined income supports members of the labour force and their dependents. Individual demand functions are therefore not meaningful to write while aggregate functions are. Thus the aggregation property of Stone's system is necessary to DYNURB and the form used in 3.21 is the appropriate one.

iii) Income Elasticity of Demand: The Stone system can exhibit "Engel Effects" easily, i.e. the proportion of income spent on food can be shown to be declining over time with that on other commodities rising. These effects in the Stone system depend on the existence and magnitude of the FMIN. The income elasticity of demand for good i by consumers in sector j is

$$\eta_{ij}(t) = \frac{\partial[D_{ij}(t)]}{\partial[YCONS_j(t)]} \cdot \frac{YCONS_j(t)}{D_{ij}(t)} \quad (3.22)$$

Now

$$\frac{\partial[D_{ij}(t)]}{\partial[YCONS_j(t)]} \Rightarrow \frac{B_{ij}}{P_{ij}(t)} \quad (3.23)$$

($YCONS_j(t)$ is used in lieu of income because of the pooling of income from 2 sources)

Consider 2 cases:

i) $FMIN_i = 0$ and ii) $FMIN_i \neq 0$

when $FMIN_i = 0$

$$D_{ij}(t) = \frac{B_{ij}}{P_{ij}(t)} \left[YCONS_j(t) - \sum_{k=1}^3 P_{kj}(t) \cdot POP_j(t) FMIN_k(t) \right]$$

Therefore (from 3.22, 3.23 and the above),

$$\eta_{ij}(t) = \frac{YCONS_j(t)}{YCONS_j(t) - \sum_{k=1}^3 P_{kj}(t) POP_j(t) FMIN_k(t)} \quad (3.24)$$

The term in the denominator is positive and less than the numerator, hence

$$\underline{n_{ij}(t) > 1 \quad \text{when } FMIN_i = 0}$$

When $FMIN_i \neq 0$ the numerator in (3.22) becomes

$$\frac{\beta_{ij}}{P_{ij}(t)} \cdot YCONS_j(t)$$

and the denominator is

$$D_{ij}(t) = \frac{\beta_{ij}}{P_{ij}(t)} \left(YCONS_j(t) - \sum_{k=1}^3 P_{kj} FMIN_k(t) POP_j(t) \right) + FMIN_i(t) POP_j(t)$$

If $FMIN_k = 0$, all $k \neq i$

$$D_{ij}(t) = \frac{\beta_{ij}}{P_{ij}(t)} [YCONS_j(t)] + (1 - \beta_{ij}) \cdot FMIN_i(t) \cdot POP_j(t)$$

$$\text{i.e. } n_{ij}(t) = \frac{\beta_{ij} YCONS_j(t)}{\beta_{ij} YCONS_j(t) + (1 - \beta_{ij}) \cdot P_{ij}(t) \cdot FMIN_i(t) \cdot POP_j(t)} \quad (3.25)$$

$$1 - \beta_{ij} > 0$$

hence $\underline{n_{ij}(t) < 1, \text{ for } FMIN_i \neq 0 \text{ and } FMIN_k = 0, \text{ all } k \neq i}$

If, however, $FMIN_k \neq 0$

$$n_{ij}(t) = \frac{\beta_{ij} \cdot YCONS_j(t)}{\beta_{ij} YCONS_j(t) - POP_j(t) \left(\beta_{ij} \sum_{k=1}^3 P_{kj}(t) FMIN_k(t) - P_{ij} FMIN_i(t) \right)}$$

then, $\eta_{ij}(t) < 1$ if

$$P_{ij} FMIN_i(t) > \beta_{ij} \sum_{k=1}^3 P_{kj}(t) FMIN_k(t)$$

or if

$$P_{ij} (1 - \beta_{ij}) FMIN_i(t) > \beta_{ij} \sum_{\substack{k=1 \\ k \neq i}}^3 P_{kj}(t) FMIN_k(t) \quad (3.26)$$

This clearly depends on the relative magnitudes of $FMIN_i(t)$ and $FMIN_k(t)$. In DYNURB, $FMIN_1(t) > 0$

$$\text{while } FMIN_2(t) = FMIN_3(t) = 0$$

hence (3.24) and (3.25) hold and

$$\eta_{1j}(t) < 1 \quad (3.27)$$

$$\eta_{2j}(t) = \eta_{3j}(t) > 1 \quad (3.28)$$

Despite the uncertainty in (3.26), in a low income economy, even if $FMIN_2$ and $FMIN_3$ are non-zero, they can be expected to be substantially less than $FMIN_1$ and (3.26) can be expected to hold. Then (3.29) and (3.28) will still hold except that $\eta_{2j}(t)$ and $\eta_{3j}(t)$ will not necessarily be equal.

Now consider (3.24) and (3.25) again. Note that as income increases in both cases η_{ij} tends towards 1. When subsistence expenditures become small compared to income, income elasticity of demand for all goods tends towards unity in the Stone System. This is an undesirable feature of this system. While $\eta_{1j} < 1$ is particularly suitable for DYNURB

its tendency to increase towards unity as income rises is less so. In fact, the available evidence would suggest that it decreases with increasing income. As long as $\eta_{ij} < 1$, though, the share of food expenditure in the total continues to decline.

iv) Constancy of Parameters: One other problem in the system as formulated is that the β_{ij} 's are constant. Stone and Brown (1966) get good results for Britain by changing them with time:

$$\beta_{ij}(t) = \beta_{ij}(0) + bt$$

where b is a constant.

This appears to be a rather arbitrary way of making this change with little theoretical justification. For lack of suitable evidence therefore, the β_{ij} 's are kept constant over time in DYNURB.

v) Constant Budget Shares: As a corollary to the comments in (iii) above, one of the consequences of $\eta_{ij} \rightarrow 1$ is that all commodities get almost constant budget shares at high incomes. This problem is less severe in DYNURB since it is only concerned with low income countries in their early stages of development.

vi) Price Sensitivity: One other attraction of the Stone demand system is that it makes the commodity demands price responsive:

$$\frac{\partial D_{ij}}{\partial P_{ij}} = - \frac{\beta_{ij}}{P_{ij}^2} \left(YCONS_j - \sum_{k=1}^3 P_{kj} \cdot FMIN_k \cdot POP_j \right) - \frac{\beta_{ij}}{P_{ij}} \cdot FMIN_i$$

(omitting the time subscripts for convenience). The own price elasticity of demand is then

$$\begin{aligned} P_{\eta_{ij}} &= \frac{\partial D_{ij}}{\partial P_{ij}} \cdot \frac{P_{ij}}{D_{ij}} \\ &= - \left[\frac{\beta_{ij}}{P_{ij}} \right] \frac{\left(YCONS_j - \sum_{k=1}^3 P_{kj} \cdot FMIN_k \cdot POP_j \right) + \beta_{ij} \cdot FMIN_i \cdot POP_j}{\frac{\beta_{ij}}{P_{ij}} \left(YCONS_j - \sum_{k=1}^3 P_{kj} \cdot FMIN_k \cdot POP_j \right) + FMIN_i \cdot POP_j} \end{aligned} \quad (3.29)$$

If $FMIN_i = 0$

$$P_{\eta_{ij}} = -1$$

and if $FMIN_i \neq 0$, since $0 < \beta_{ij} < 1$ $0 > P_{\eta_{ij}} > -1$.

Thus demand is less price responsive for goods that have a subsistence component.

Cross price elasticity

$$= \frac{\partial D_{ij}}{\partial P_{kj}} \cdot \frac{P_{kj}}{D_{ij}}$$

$$= - \frac{\beta_{ij}}{P_{ij}} \cdot FMIN_k \cdot \frac{P_{kj}}{D_{ij}}$$

$$< 0 \text{ for } FMIN_k > 0$$

$$\text{and } = 0 \text{ for } FMIN_k = 0$$

i.e. as the price of a subsistence good increases, demand for other good decreases.

Price changes of non-subsistence goods do not affect other demands.

vii) Parameter Estimates: There do not appear to be any Stone system estimates for the Indian economy. This is one of the drawbacks of using this system. Estimates for DYNURB are therefore partly judgmental - in particular those for $FMIN_i$.

To summarize, the Stone system is an appropriate one to use for a low income economy since it adequately reflects the Engel curve effects of a declining budget share for food. It may not be an adequate system for higher income economies.

3.6 Investment Demand

The demand for investment goods is, ex post, equivalent to the total savings in the economy. Investment goods, i.e. capital, are produced by the industrial sector¹ only in DYNURB. The demand for gross investment

$$DINV(t) = \frac{1}{P_{22}(t)} \sum_{i=1}^3 YSAVE_i(t) \quad (3.30)$$

¹The industrial sector includes construction as well as machinery and equipment.

3.7 Factor Employment

Total capital and total labour are fixed for each period. For full employment

$$KTOT(t) = K_1(t) + K_2(t) + K_3(t) \quad (3.31)$$

and $LTOT(t) = L_1(t) + L_2(t) + L_3(t) \quad (3.32)$

where $KTOT(t)$ and $LTOT(t)$ are total capital and labour respectively.

Total urban population is

$$URBPOP(t) = POP_2(t) + POP_3(t) \quad (3.33)$$

and rural population is

$$RURPOP(t) = POP_1(t) \quad (3.34)$$

Total urban labour is

$$URBL(t) = L_2(t) + L_3(t) \quad (3.35)$$

and rural labour is

$$RURL(t) = L_1(t) \quad (3.36)$$

3.8 Material Balance Equations

$$Q_1(t) = D_{11}(t) + D_{12}(t) + D_{13}(t) + \sum_j a_{1j} Q_j$$

$$Q_2(t) = D_{21}(t) + D_{22}(t) + D_{23}(t) + D_{INV}(t) \\ + \sum_j a_{2j} Q_j + D_{TRAN}(t)$$

$$Q_3(t) = D_{31}(t) + D_{32}(t) + D_{33}(t) + \sum_j a_{3j} Q_j \quad (3.37)$$

Q_1, Q_2, Q_3 , are total supplies which have to be exhausted by total demands. Demands for each good are the sum of consumer demand and intermediate goods demand except for sector 2. This sector also supplies investment demand and transport demand $DTRAN(t)$.

$$\begin{aligned} DTRAN(t) = & a_T (D_{21}(t) + D_{12}(t) + D_{13}(t) + D_{31}(t)) \\ & + a_T (a_{21} + a_{31}) Q_1(t) + a_T (a_{12}) Q_2(t) \\ & + a_T (a_{13}) Q_3(t) \end{aligned} \quad (3.38)$$

The first line is the demand for transportation because of transportation of consumer goods and the rest are intermediate good demands.

3.9 Price Normalization

Prices are normalized in every period on base period production weights. Thus

$$\sum_i s_i P_{ii}(t) = 1.0 \quad (3.39)$$

$$\text{where} \quad s_i = \frac{Q_i(1)}{\sum Q_i(1)} \quad (3.40)$$

With no money in DYNURB this price normalization is necessary in every period. There are only relative price changes, the weighted sum remaining constant over time.

This concludes the description of the static economy.

3.10 Dynamic Equations

After an equilibrium solution is found for a period, the economy is allowed to grow. This mainly involves the growth of factors and technical change.

i) Technical Change:

Labour in each sector is augmented at a constant rate every year. These rates may vary for different sectors:

$$y_i(t+1) = y_i(t) (1+\lambda_{i1}) \quad (3.41)$$

$$x_i(t+1) = x_i(t) (1+\lambda_{i2}) \quad (3.42)$$

$$\lambda_{ij} > 0 \quad i = 1, 2, 3.$$

Furthermore, DYNURB also provides exogenous neutral technical change - of the 'manna from heaven' type. Thus

$$B_i(t+1) = B_i(t) (1+GB_i) \quad (3.43)$$

where B_i is the scaling parameter in each production function.

ii) Growth of Labour:

DYNURB follows the KWC specification of different natural growth rates of population in the rural and urban areas. Thus

$$URBL(t+1) = URBL(t) (1+GURB(t)) \quad (3.44)$$

$$\text{and} \quad RURL(t+1) = RURL(t) (1+GRUR(t)) \quad (3.45)$$

where GURB and GRUR are the rates of natural population

increase in urban and rural areas respectively. DYNURB makes provision for $GURB(t)$ and $GRUR(t)$ to vary over time but does not do so in simulation.

In a recent paper, McIntosh (1975) advances the following main reasons for lower fertility rates in urban areas

- i) Urban people spend more on education
 - ii) Children are more of a burden because of overcrowding
- He provides convincing evidence that natural population growth rates are indeed less in urban areas relative to rural areas.

In line with the model's long term philosophy, people are assumed to change their behavior instantly on moving between regions. This goes for consumption tastes as well as reproduction rates. It would be desirable to introduce some lags in this process. These have been neglected since they are regarded as second-order effects in the long term.

(3.44) and (3.45) describe a rather primitive population sub-model. One of the major extensions of DYNURB is intended to be one with a more sophisticated population model. This would trace the age profile and the labour/population relation more realistically.

Total labour is

$$LTOT(t+1) = URBL(t+1) + RURL(t+1) \quad (3.46)$$

iii) Growth of Capital

Total capital depreciates at a constant rate δ and is increased by gross investment $DINV$. Thus,

$$KTOT(t+1) = KTOT(t) + DINV(t) - \delta \cdot KTOT(t) \quad (3.47)$$

iv) Other Factors

The other factors in the agriculture production function, Land and Livestock, are allowed to grow at an exogenously specified constant growth rate. DYNURB is not concerned with their behavior and merely makes them grow to reflect realistic magnitudes. This growth should ideally be a result of investment. This cannot be permitted in DYNURB because investment goods are produced by Sector 2. If capital was distinguished by sector of origin, land and livestock increments could be regarded as resulting from investment in agricultural goods. This is omitted in the interests of simplicity and resulting distortions are probably minimal.

$$LAND(t+1) = LAND(t) (1+GLAND) \quad (3.48)$$

$$LVSTK(t+1) = LVSTK(t) (1+GLVSTK) \quad (3.49)$$

where $GLAND$ and $GLVSTK$ are the relevant constant growth rates.

v) Savings

Savings are generally observed to grow with increases in incomes as development programs. This can probably be

accounted for by the role of minimum subsistence demands in peoples' consumption and savings functions. This was mentioned in the discussion of the Stone system. In DYNURB because savings are specified to take precedence over subsistence demands, they have to be made to grow exogenously:

$$SLAB_i(t+1) = SLAB_i(t) (1+GSLAB_i) \quad (3.50)$$

$$SCAP_i(t+1) = SCAP_i(t) (1+GSCAP_i) \quad i = 1,2,3. \quad (3.51)$$

where

$GSLAB_i$ and the $GSCAP_i$ are the relevant growth rates in the proportion saved from labour and capital income respectively.

Lastly, DYNURB allows growth in the minimum subsistence requirements though it does not use this in simulation.

$$FMIN_i(t+1) = FMIN_i(t) (1+GFMIN_i) \quad (3.52)$$

where $GFMIN_i$ is the growth rate in the minimum subsistence requirement of good i .

This concludes the specification of the dynamic equations.

3.11 Summary of DYNURB

All the equations in DYNURB are now listed together.

The Static Model

1. Production Functions

$$Q_1(t) = \text{LAND}(t)^{\text{ALPH}} \cdot \text{LIVSTK}(t)^{\text{GAM}} \left[B_1 \left\{ \gamma_1 \{x_1(t) K_1(t)\}^{(\sigma_1-1)/\sigma_1} + (1-\gamma_1) \{y_1(t) L_1(t)\}^{(\sigma_1-1)/\sigma_1} \right\}^{(\sigma_1/\sigma_1-1)} \right]^{\text{BET}} \quad (3.1)$$

$$Q_i(t) = B_i \left[\gamma_i \{x_i(t) K_i(t)\}^{\frac{\sigma_i-1}{\sigma_i}} + (1-\gamma_i) \{y_i(t) L_i(t)\}^{\frac{\sigma_i-1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i-1}} \quad i = 2, 3. \quad n \text{ equations} \quad (3.2)$$

2. Net Price Equations:

(Time subscripts on P_{ij} and PSTAR_{ij} omitted).

$$\begin{aligned} \text{PSTAR}_{11} &= P_{11} - \left[a_{11}P_{11} + a_{21}(1+a_T)P_{22} + a_{31}(a_TP_{22} + P_{32}) \right] \\ \text{PSTAR}_{22} &= P_{22} - \left[a_{12}P_{11} + a_{22}P_{22} + a_{12}a_TP_{22} + a_{32}P_{32} \right] \\ \text{PSTAR}_{33} &= P_{33} - \left[a_{13}P_{11} + a_{23}P_{22} + a_{13}a_TP_{22} + a_{33}P_{32} \right] \end{aligned} \quad (3.3b)$$

n equations

3. Factor Demand:

Labour Wages:

$$W_1(t) = \text{PSTAR}_{11}(t) (1-\gamma_1) B_1^{(\sigma_1-1)\sigma_1} \left(\frac{QT}{y_1(t)L_1(t)} \right)^{1/\sigma_1} \cdot \text{BET} \left(\frac{Q_1(t)}{QT(t)} \right)^{1/\sigma_1} \quad (3.4)$$

$$\left[QT(t) = B_1 \left[\gamma_1 \left\{ x_1(t) K_1(t) \right\}^{(\sigma_1-1)/\sigma_1} + (1-\gamma_1) \left\{ y_1(t) L_1(t) \right\}^{\frac{\sigma_1-1}{\sigma_1}} \right]^{\frac{\sigma_1}{\sigma_1-1}} \right] \quad (3.5)$$

$$W_i(t) = \text{PSTAR}_{ii}(t) (1-\gamma_i) B_i^{\frac{\sigma_i-1}{\sigma_i}} \left\{ \frac{Q_i(t)}{y_i(t)L_i(t)} \right\}^{1/\sigma_i} \quad (3.6)$$

 $i = 2, 3$

n equations

Capital Rentals:

$$R_1(t) = \text{PSTAR}_{11}(t) \cdot \gamma_1 \cdot B_1^{\frac{\sigma_1-1}{\sigma_1}} \left(\frac{QT(t)}{x_1(t)K_1(t)} \right)^{1/\sigma_1} \cdot \text{BET} \left(\frac{Q_1(t)}{QT(t)} \right)^{1/\sigma_1} \quad (3.7)$$

$$R_i(t) = \text{PSTAR}_{ii}(t) \cdot \gamma_i \cdot B_i^{\frac{\sigma_i-1}{\sigma_i}} \left(\frac{Q_i(t)}{x_i(t)k_i(t)} \right)^{1/\sigma_i} \quad (3.8)$$

 $i = 2, 3$

n equations

Land and Livestock Returns:

$$\text{RENT}(t) = \text{PSTAR}_{11}(t) \cdot \text{ALPH} \frac{Q_1(t)}{\text{LAND}(t)} \quad (3.11)$$

$$\text{RLVSTK}(t) = \text{PSTAR}_{11}(t) \cdot \text{GAM} \cdot \frac{Q_1(t)}{\text{LVSTK}(t)} \quad (3.12)$$

2 equations

Wage and Rental Structure:

$$W_i(t) = \theta_i W_1(t) \quad (3.13)$$

$$R_i(t) = \phi_i R_1(t) \quad i = 2, 3 \quad (3.14)$$

4 equations

4. Savings:

$$\text{YLAB}_i(t) = Y_i(t) W_i(t) L_i(t) \quad i = 1, 2, 3 \quad (3.15)$$

$$\begin{aligned} \text{YCAP}_1(t) &= X_1(t) R_1(t) K_1(t) + \text{RENT}(t) \cdot \text{LAND}(t) \\ &+ \text{RLVSTK}(t) \cdot \text{LVSTK}(t) \end{aligned} \quad (3.16)$$

$$\text{YCAP}_i(t) = X_i(t) R_i(t) K_i(t) \quad i = 2, 3 \quad (3.17)$$

(income from labour and capital)

n equations

$$YSAVE_i(t) = SLAB_i(t) \cdot YLAB_i(t) + SCAP_i(t) \cdot YCAP_i(t) \quad (3.18)$$

$i = 1, 2, 3$ n equations
(income saved)

5. The Demand System.

$$YCONS_i(t) = (1 - SLAB_i(t)) \cdot YLAB_i(t) + (1 - SCAP_i(t)) \cdot YCAP_i(t) \quad (3.19)$$

$i = 1, 2, 3.$
(disposable income) n equations

$$POP_i(t) = L_i(t) / WPR_i \quad (3.20)$$

$i = 1, 2, 3.$ n equations
(population)

$$D_{ij}(t) = \frac{\beta_{ij}}{P_{ij}(t)} \left[YCONS_j(t) - \sum_{k=1}^3 P_{kj}(t) \cdot FMIN_k(t) \cdot POP_j(t) \right] + FMIN_i(t) \cdot POP_j(t) \quad (3.21)$$

$i = 1, 2, 3$ n^2 equations
 $j = 1, 2, 3$
(demand for good i in sector j)

$$P_{12} = P_{13}$$

$$P_{22} = P_{23}$$

$$P_{32} = P_{33}$$

$$P_{12} = P_{11}(1+a_T)$$

$$P_{21} = P_{22}(1+a_T)$$

$$P_{31} = P_{33}(1+a_T)$$

2 n equations

(price equations)

6. Investment Demand

$$DINV(t) = \frac{1}{P_{22}(t)} \sum_{i=1}^3 YSAVE_i(t) \quad (3.30)$$

1 equation

7. Factor Employment

$$KTOT(t) = K_1(t) + K_2(t) + K_3(t) \quad (3.31)$$

$$LTOT(t) = L_1(t) + L_2(t) + L_3(t) \quad (3.32)$$

2 equations

$$URBPOP(t) = POP_2(t) + POP_3(t) \quad (3.33)$$

$$RURPOP(t) = POP_1(t) \quad (3.34)$$

$$\text{URBL}(t) = L_2(t) + L_3(t) \quad (3.35)$$

$$\text{RURL}(t) = L_1(t) \quad (3.36)$$

4 equations

(regional population and labour)

8. Material Balances

$$Q_1(t) = D_{11}(t) + D_{12}(t) + D_{13}(t) + \sum_j a_{1j} Q_j$$

$$Q_2(t) = D_{21}(t) + D_{22}(t) + D_{23}(t) + \text{DINV}(t) \\ + \sum_j a_{2j} Q_j + \text{DTRAN}(t)$$

$$Q_3(t) = D_{31}(t) + D_{32}(t) + D_{33}(t) + \sum_j a_{3j} Q_j \quad (3.37)$$

n equations

$$\text{DTRAN}(t) = a_T(D_{21}(t) + D_{12}(t) + D_{13}(t) + D_{31}(t)) \\ + a_T(a_{21} + a_{31}) Q_1(t) + a_T a_{12} Q_2(t) \\ + a_T a_{13} Q_3(t) \quad (3.38)$$

1 equation

9. Price Normalization:

$$\sum_i S_i P_{ii}(t) = 1.0 \quad (3.39)$$

1 equation

$$s_i = \frac{Q_i(1)}{\sum Q_i(1)} \quad i = 1, 2, 3. \quad n \text{ equations} \quad (3.40)$$

10. Dynamic Equations:

Technical change

$$y_i(t+1) = y_i(t) (1 + \lambda_{i1}) \quad (3.41)$$

$$x_i(t+1) = x_i(t) (1 + \lambda_{i2}) \quad (3.42)$$

$$B_i(t+1) = B_i(t) (1 + GB_i) \quad (3.43)$$

3n equations

(The t subscript on B_i is omitted in the static model)

Growth of Labour

$$URBL(t+1) = URBL(t) (1 + GURB(t)) \quad (3.44)$$

$$RURL(t+1) = RURL(t) (1 + GRUR(t)) \quad (3.45)$$

$$LTOT(t+1) = URBL(t+1) + RURL(t+1) \quad (3.46)$$

3 equations

Growth of Capital

$$KTOT(t+1) = KTOT(t) + DINV(t) - \delta KTOT(t) \quad (3.47)$$

1 equation

Other Factors

$$\text{LAND}(t+1) = \text{LAND}(t) (1+\text{GLAND}) \quad (3.48)$$

$$\text{LVSTK}(t+1) = \text{LVSTK}(t) (1+\text{GLVSTK}) \quad (3.49)$$

2 equations

Savings

$$\text{SLAB}_i(t+1) = \text{SLAB}_i(t) (1+\text{GSLAB}_i) \quad (3.50)$$

$$\text{SCAP}_i(t+1) = \text{SCAP}_i(t) (1+\text{GSCAP}_i) \quad (3.51)$$

$$\text{FMIN}_i(t+1) = \text{FMIN}_i(t) (1+\text{GFMIN}_i) \quad (3.52)$$

3 equations

Now, in the static model, there are $13n + n^2 + 15$ equations. With $n=3$, this is 63 equations. Walras' Law can be assumed to operate, making one demand equation redundant. Hence the static model has 62 independent equations.

List of Endogenous Variables.

1.	$Q_i(t)$	n	Sectoral outputs.
2.	$K_i(t)$	n	Sectoral capital stocks
3.	$L_i(t)$	n	Sectoral labour force
4.	$P_{ij}(t)$	n^2	Prices of commodities
5.	$\text{PSTAR}_{ii}(t)$	n	Net Prices
6.	$W_i(t)$	n	Wages
7.	$R_i(t)$	n	Capital Rentals
8.	$\text{RENT}(t)$	1	Land rent
9.	$\text{RLVSTK}(t)$	1	Return to Livestock

10.	$YSAVE_i(t)$	n	Sectoral savings
11.	$YCONS_i(t)$	n	Sectoral disposable income
12.	$YCAP_i(t)$	n	Sectoral property income
13.	$YLAB_i(t)$	n	Sectoral labour income
14.	$POP_i(t)$	n	Sectoral population
15.	$D_{ij}(t)$	n^2	Sectoral commodity demand
16.	$DINV(t)$	1	Investment demand
17.	S_i	n	Price weights
18.	$URBPOP(t)$	1	Urban population
19.	$RURPOP(t)$	1	Rural population
20.	$URBL(t)$	1	Urban Labour
21.	$RURL(t)$	1	Rural labour
22.	$DTRAN(t)$	1	Transport demand

There are $12n + 2n^2 + 8 = 62$ endogenous variables, which equal the number of independent equations in the static model.

List of Exogenous Variables and Parameters

1.	$KTOT(1)$	1	Initial Capital Stock
2.	$LTOT(1)$	1	Initial Labour Force
3.	$LAND(1)$	1	Initial Land Endowment
4.	$LVSTK(1)$	1	Initial Livestock
5.	$y_i(1)$	n	Initial Sectoral labour quality
6.	$X_i(1)$	n	Initial sectoral capital quality
7.	$B_i(1)$	n	Production Function Scaling Parameter
8.	γ_i	n	Sectoral capital intensity parameter

9.	σ_i	n	Sectoral elasticity of substitution
10.	ALPH	1	Share of Land in Agriculture
11.	GAM	1	Share of LVSTK in Agriculture
12.	BET	1	Share of Labour & capital in agriculture
13.	$EXPK_i$	n	Share of capital in Cobb-Douglas functions
14.	$EXPL_i$	n	Share of labour in Cobb-Douglas functions
15.	A_i	n	Cobb-Douglas Scaling Parameter
16.	a_{ij}	n^2	Input-output coefficients
17.	a_T	1	Transport coefficient
18.	θ_i	n	Wage differentials
19.	ϕ_i	n	Rental differentials
20.	$SLAB_i(1)$	n	Initial saving rate from sectoral L income
21.	$SCAP_i(1)$	n	Initial saving rate from sectoral K income
22.	$GSLAB_i$	n	Growth rate in labour saving coefficient
23.	$GSCAP_i$	n	Growth rate in capital saving coefficient
24.	WPR_i	n	Sectoral (regional) worker participation ratio
25.	β_{ij}	n^2	Marginal budget shares by region
26.	$FMIN_i$	n	Minimum subsistence levels
27.	λ_{i1}	n	Labour augmenting rates

28.	λ_{i2}	n	Capital augmenting rates
29.	GB_i	n	Neutral technical change rates
30.	GURB	1	Natural growth rate of urban labour
31.	GRUR	1	Natural growth rate of rural labour
32.	δ	1	Rate of capital depreciation
33.	GLAND	1	Rate of land increase
34.	GLVSTK	1	Rate of Livestock increase
35.	$GFMIN_i$	n	Rate of increase in $FMIN_i$

There are $20n + 2n^2 + 13 = 91$ numbers required to run a simulation of DYNURB. This is a relatively small set of data to run a simulation model

4. Preparing DYNURB for Simulation:

Model Solution and Parameters

This chapter presents the procedure for solving DYNURB and the selection of parameter values and initial conditions to reflect the progress of the Indian economy from the year 1951. The first section provides an outline of the solution technique while the second gives information on choice of parameters and initial conditions. The next chapter will give the results of simulation along with actual values for the Indian economy wherever possible.

4.1 Model Solution

At the end of the last chapter it was shown that the number of equations in DYNURB is equal to the number of endogenous variables in the static model. This provides assurance that a solution is feasible. With neoclassical production functions and the demand system used, it is reasonable to expect that a unique solution exists for the model. This study does not investigate the existence properties of the model, nor its stability properties any further. However, given that there is more than one consumer, the theoretical probability of non-uniqueness exists. Practically, it is likely that the solution is, indeed, unique since various initial conditions were found to lead to the same solution.

As Johansen type general equilibrium models go, it is obvious from Chapter 2 that DYNURB is a model which is relatively small in size though rich in complexity. Dervis (1973) outlines three approaches to the computation of model equilibrium:

- i) The Scarf approach is based on a systematic search in the price-simplex for a vector, that (approximately) maps into itself.' This utilizes the existence proofs based on fixed point theorems.
- ii) The Walrasian approach uses Walras' model of the workings of a market system. It gropes for the equilibrium market clearing quantities by adjusting prices in response to excess demands.
- iii) The Direct approach finds a solution to the set of simultaneous equations representing the general equilibrium economic system. This is usually done by iterative methods such as the Gauss-Seidel method.

Details of these methods are not given here since they are adequately dealt with by Dervis (1973), chapter 4, and Adelman-Robinson (1976), chapter 5. The latter have a fairly exhaustive discussion of various solution strategies and of their adequacy for different types of models. Here only an outline of the solution algorithm will be given.

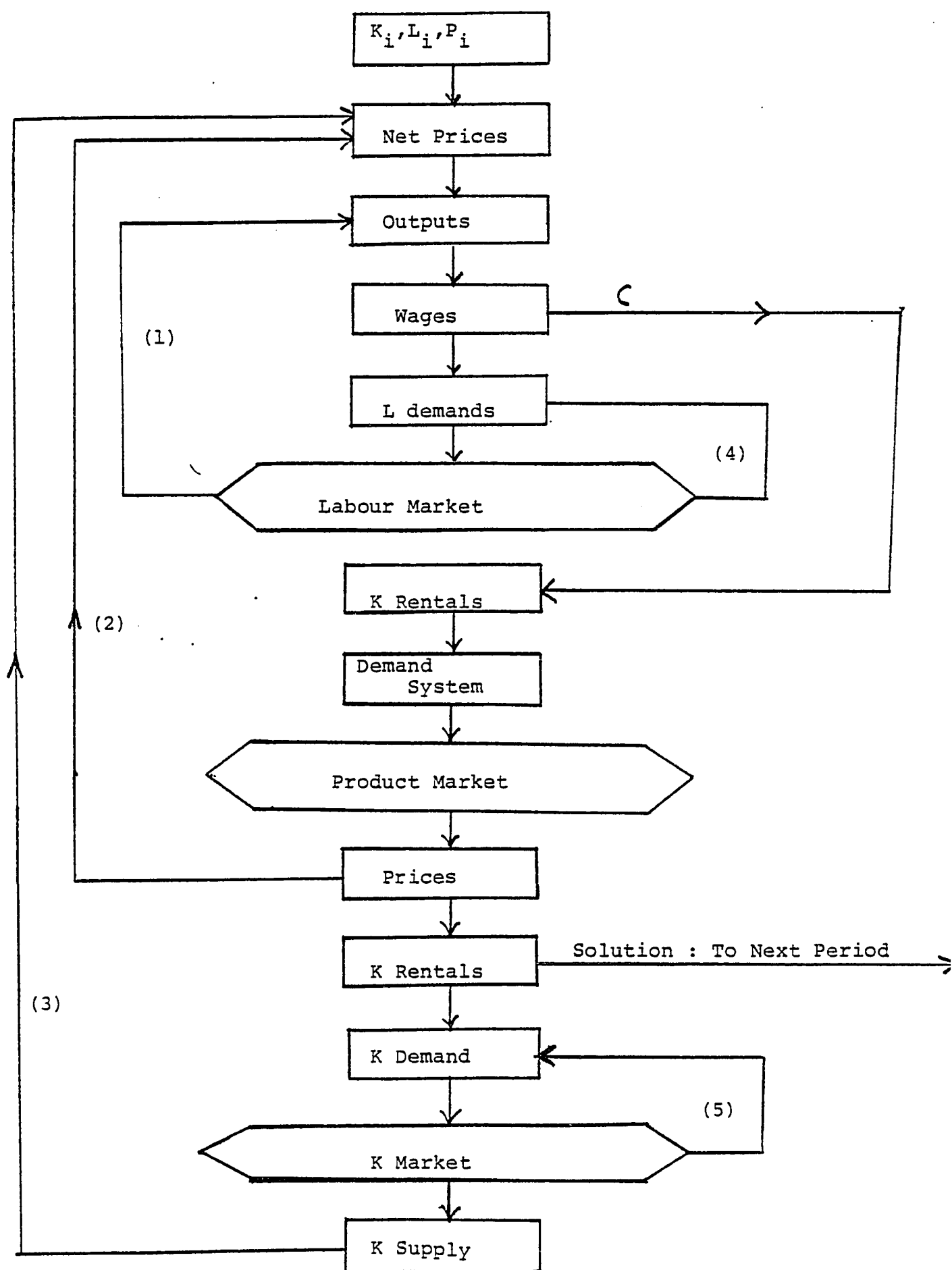
In Adelman-Robinson terms, the strategy used to solve DYNURB is the 'product-market' strategy. Dervis and F.Ahmed (1974) used factor market strategies. DYNURB faces one problem not encountered by any of the above. They all fixed capital allocations before solving for labour markets (or vice versa as in Dervis) and product markets. In DYNURB wages

and rentals and therefore capital and labour allocations have to be determined simultaneously. With constant returns to scale production functions the long run supply curve is flat. Thus, if one sector is more profitable at one level of production, it is so at all levels. If it is attempted to find equilibrium wages and rentals simultaneously, there is a tendency for all resources to shift to the most profitable sector. One resource therefore has to be made 'less mobile' -- in this case capital -- to be able to find the solution. The solution technique outlined below is therefore somewhat different from Dervis, A-R and Ahmed. It is most similar to A-R, who also use a product market strategy, but are able to fix capital stocks by firm before solving the labour market.

Solution Procedure:

Fig. 4.1 illustrates the solution technique used to solve DYNURB.

In summary, a set of initial prices are assumed along with a set of labour and capital allocations by sector. Total labour and capital stocks are fixed for the period. The labour market is then solved for market clearing wages as if capital allocations were fixed. Given resulting factor incomes, product demands are calculated along with intermediate demands and investment. Excess demand equations are formed and prices changed in response. The labour market is then solved again followed by the product market until a set of market clearing wages and product prices are found -



all the while acting as if capital allocations were fixed. It is only then that an excess demand capital equation is formed and capital rentals changed accordingly resulting in a revised allocation of capital. This allocation is then treated as fixed and the whole process repeated until a final solution is reached in which all markets: the labour market, the goods markets and the capital market are all in equilibrium and give a set of solution wages, rentals and prices. Associated with these are sectoral capital and labour allocations and outputs. Thus the model essentially solves 5 markets: the markets for labour and capital and the markets for the 3 goods. The efficiency labour and capital are homogeneous and have a given intersectoral wage structure. Each is therefore regarded as an economy-wide market. The solution technique can be regarded as simulating a market economy: capital is 'less mobile' than labour and prices adjust in response to excess demands. As mentioned earlier, if labour and capital are made equally mobile, i.e., solved simultaneously, the constant returns to scale nature of the production function shifts all production to one sector. Capital is therefore 'artificially' fixed for the solution of the labour and goods markets.

The above is now described in somewhat greater detail.

i) The Labour Market: Given an initial allocation of prices,

labour and capital, sectoral outputs are calculated and then the corresponding wages according to marginal product. The wage structure is then imposed on a weighted mean of the wages and corresponding labour demand found. There is a difficulty here since the functions used are C.E.S. functions and it is difficult to find an explicit equation for labour demand - although a polynomial expression can be derived. Here the marginal product equation is used directly in a Gauss-Seidel iteration. Given the wage, labour demands are calculated. These are resubstituted to give revised outputs and wages until the process converges to give the labour demands consistent with the outputs and imposed wage structure along with the equality of wages to marginal product in each sector. The excess demand for labour equation is then formed with sum of labour demands and the labour supply fixed for the period. A simple market solution algorithm is then used. This algorithm is the same for all the markets, and is therefore outlined generally.¹ The excess demand equation for a good X (or factor) may be written

$$ED_x = X_D - X_S$$

This is associated with a price P which is then altered to PN in response. If

¹This was developed with Sherman Robinson's guidance.

- i) $ED_x > \epsilon, \quad PN > P$
- ii) $ED_x < -\epsilon, \quad PN < P$
- iii) $-\epsilon < ED_x < \epsilon \quad PN = P$

where ϵ is a small positive number

The rule for the change is

$$PN = P(1+DP)$$

where $DP = DAMP \left(\frac{ED}{XS} \right)$

DAMP merely damps the change in price response to excess demand. DP is constrained to be less than 10% to guard against wild fluctuations. In the solution of DYNURB, DAMP is set at 0.3 for all the markets. Solution was also tried for DAMP = 0.6. While a solution in an individual market was speeded up, the number of iterations required to solve all the markets increased. $\epsilon = 0.002$, i.e. excess demand or supply may be no more than 0.2 percent.

Labour demands are recalculated in order to equate the new wage in each sector (obeying the imposed wage structure). This is done until labour demands and supply satisfy the convergence criterion ϵ . This is loop 4 in Fig. 4.1. Convergence is usually reached in less than 5 iterations of this loop. The new labour allocations are used to recalculate outputs and wages and the process repeated (loop 1) until change in wage in each sector from previous iteration is less

than about 0.05 percent. [The convergence criterion is .0001 in absolute terms where W_1 is in the order of 0.2 to 0.3]. In this way convergence criteria are applied to both quantity and price (wage) changes. Convergence is usually reached in less than 5 iterations.

ii) The Product Market: The labour market having been solved and with the initial capital allocation, capital rentals are calculated and then all factor incomes. Commodity demands, intermediate demand (including the demand for transport) and investment demand comprise total demand for each of the three goods. The procedure outlined above is used to alter prices in response to excess demands in each market. This is done as if each market is independent: i.e., the Jacobian is treated as if it is diagonal. This is clearly incorrect but is adequate for a model as small as this. Changed prices are normalized according to base year production weights (Eqn. 3.39, 3.40).

The labour market is then solved again with the changed prices which is followed by another product market simulation. This is loop 2 in Fig. 4.1. This is repeated until the product markets clear, along with the labour market. This solution is usually reached in less than 5 iterations of loop 2. More than 10 iterations are seldom required.

iii) The Capital Market: Given the labour and product

market equilibrium at fixed capital allocations, capital demands are re-calculated based on the imposed rental structure (here rentals are equalized across all sectors). Rentals are changed by the same algorithm as outlined above and capital allocation re-calculated until total capital demanded and supplied are within the 0.2 percent convergence criterion (loop 5). The new capital allocations are then used to solve the labour and product markets again until all the markets - labour, products and capital - are simultaneously in equilibrium. This is loop 3 in Fig. 4.1. The convergence criterion used here is that change in rental (in the outer loop 3) should be no more than about 0.1 percent (this is in absolute terms: 0.0001 where rentals are in the order of 0.1). This convergence usually takes place in about 10-15 iterations of loop 3.

A note of caution is in order here. The most convergence difficulty is found in loop 3. The reason is the one mentioned earlier. Changes in capital allocation between iterations should not be too large to violate the 'as if' fixed capital fiction. In some simulations, it may be necessary to change capital allocations less than that required by the rental = marginal product of capital condition in loop 5.¹ In the simulations of India, reported in this

¹This was found to be a problem in a later attempted simulation of Korea.

study, this was not found to be a significant problem. It clearly depends on the price elasticity of demand for capital.

iv) Growth of the Economy: After the solution to a period is found, the economy grows according to equations (3.41) to (3.52). Sectoral factor allocations are made to grow at the overall factor growth rate to provide initial values for the next period.

This concludes the outline of the solution technique.

DYNURB was simulated on the Princeton University IBM 360/91 computer. The program takes about 25 seconds to compile at a cost of about \$10. It solves for 35 periods in less than 5 seconds at a cost of less than \$2. It is therefore relatively cheap to run and each experiment can therefore be performed at low cost. The total cost of developing the program, debugging it, solving the model and performing experiments with it was about \$1800. This could, perhaps, have been reduced to about \$1500 if debugging were more efficient. These figures are given so that any benefits derived from such an exercise can be weighed against the costs incurred.

In the context of a low income country, the cost of such models is not inconsiderable. Expansion of

the model to a greater number of sectors or labour classifications etc. would be correspondingly expensive. DYNURB is programmed to make expansion up to 5 sectors quite easy. Solution technique would probably have to be changed and the full Jacobian accounted for in a further expansion.

4.2 Choice of Parameters and Initial Conditions

Ideally, the parameters used in a model such as DYNURB should be estimated from data. This is not done here partly because of time constraints and partly because the model is regarded more as a theoretical exercise rather than an empirical one. One of the advantages of a small model is that plausible parameter values can be educated guesses without causing significant errors. In the case of some parameters it is not even unreasonable to 'estimate' them by trial and error. Some idea of the effects of possible errors in parameter values is also gained by sensitivity tests which are reported in Chapter 6. Gaining a knowledge of the sensitivity of an economy to structural changes, i.e. changes in parameter values, is indeed, one of the objectives of this study.

The parameter values used in the model are now provided along with explanations of their derivation. Initial values of some endogenous variables are also necessary and these are reported as well.

4.21 Production Parameters: The production parameters needed are the

- B_i - scaling parameters
- σ_i - elasticity of substitution
- γ_i - capital intensity parameters

and ALPH, BET and GAM, the factor output elasticities or shares in the agricultural sector. Since there are no studies estimating the required C.E.S. production function parameters they have to be approximated from indirect information as detailed below:

Factor Shares: For C.E.S. functions, with the assumption of constant returns to scale and profit maximization, it is easy to show that

$$\frac{rK}{wL} = \frac{\gamma}{1-\gamma} \left(\frac{K}{L} \right)^{(\sigma-1)/\sigma} \quad (4.1)$$

Thus γ can be calculated from information on factor shares and capital-labour ratios in each sector.

There do not appear to be many studies on the estimation of aggregate production functions for India, except those for the agriculture sector. Those that exist are usually estimates of the Cobb-Douglas production function. For the manufacturing sector there are a few early studies, Murti and Sastri (1957) Tewari (1951), Dutt (1955) and Bhatia (1954) and an unpublished later study, Evenson-Oomen (1974) which attempted to estimate

a C.E.S. function and only reported preliminary tentative findings. Murti and Sastry's study was based on cross section data on individual firms while the others were based on industrial aggregates. The exponent for labour varied from about 0.53 to 0.77 in these studies with the lower figure coming from the cross section data. With the usual assumptions, these estimates should also correspond to the labour share in the sector. According to national income accounts, in the organized sector, labour share accounted from 65 to 70 percent of income between 1960 and 1974 (G.O.I, 1976, p. xxxi). The sectors in DYNURB, however, include organized and unorganized parts of the economy. The latter, of course, include a large proportion of the self-employed. It is assumed here that in such enterprises the imputed factor shares are not significantly different from the rest of the economy, though they could tend to have somewhat larger labour shares. The service sector includes the whole public administration and defence sector and so labour share can be assumed to be somewhat higher. Thus in DYNURB, assumed factor shares are:

	Labour	Capital
Industry	0.60	0.40
Services	0.70	0.30

For agriculture, Evenson and Jha (1973) report factor shares for each state for 1960 and 1971. They fall in the following

ranges (excluding outliers)

Labour	0.40	to	0.68
Capital	0.01	to	0.10
Land	0.20	to	0.40
Livestock	0.04	to	0.18

Clearly each has a large range because of different factor endowments between states. In general, land share tends to rise over time while that of livestock declines. In DYNURB, the factor shares in agriculture are chosen to be:

Labour	0.55	i.e.	BET = 0.62
Capital	0.07		
Land	0.33		ALPH = 0.33
Livestock	0.05		GAM = 0.05

Evenson-Jha include fertilizer as a factor when the correct interpretation of it would be as an intermediate input. This causes some error in their estimates. The value of GAM assumed is on the low side because of its observed tendency to decline over time.

σ_1 - The Elasticity of Substitution: It was remarked in the last chapter that the estimates of σ differ widely over industries, over time and over countries. It is therefore difficult to provide good justification for any values used. However, there appears to be general agreement that the

elasticity of substitution between labour and capital is greater in the agriculture sector than in the manufacturing sector. One of the reasons is that many of the manufacturing techniques used in these countries were designed in the developed countries. Thus for any particular purpose there are a limited set of technology choices possible at any time. The changes in K/L ratios in response to factor price changes would therefore be necessarily limited. The vast literature on labour absorption in manufacturing - reviewed for example in Morawetz (1974) - in low income countries is really concerned with the elasticity of substitution, although such concern is usually expressed as concern for labour employment. Thus, in this study, σ_2 , the elasticity of substitution in industry, is assumed to be relatively low and set at 0.6. This value is supported by the Evenson-Oomen study - tentative though it is.

Kelley-Williamson-Cheetham (1972) assert σ_1 (agriculture) to be 1.5 and Kelley-Williamson (1974) later use a Cobb-Douglas function for Meiji-Japan. The many studies on Indian agriculture e.g. Evenson-Jha (1973) also assume the Cobb-Douglas function. Since agricultural techniques are usually more indigenous than those in manufacturing and have adapted over a long period of time to local conditions, these techniques may be regarded as more appropriate for local, relative-factor price changes. The techniques of agricultural production change more with country or agro-climate region

than techniques, say, in manufacturing. This would suggest that such techniques are more adaptable or flexible. Hence σ_1 here is set at 1.2 - a figure between those used in the two Kelley-Williamson studies.

Since the production function for services has never really been estimated, σ_3 is purely notional. The service sector includes such diverse sectors as housing and real estate on the one hand and personal services on the other. The former consists almost entirely of capital services while the latter of labour. The service sector is also more economy specific than manufacturing. But because of the presence of capital dominated sectors such as real estate, it is postulated here that the overall elasticity of substitution in services is less than that in agriculture. Hence $\sigma_2 < \sigma_3 < \sigma_1$, and σ_3 is specifically set at 0.8.

The values of σ_1 , σ_2 , σ_3 postulated in this study are compared with those used in a few selected studies in Table 4.1. (overleaf).

Table 4.1 Elasticities of Substitution in Selected Studies

	<u>Agriculture</u>	<u>Industry</u>	<u>Services</u>
1. DYNURB	1.2	0.6	0.8
2. Dervis (1973) (CES variant)	1.0	.7, .85, .8, .92, .65, .89, .4, .5, .6	0.9, 0.86
3. KWC (1972)	1.5	0.5	
4. K-W (1974)	1.0	0.8	
5. Kendrick-Taylor (1972)	1.2	0.9, 0.9	0.6

Note: (1) Dervis' industrial sectors are mining, food and tobacco products, textiles, light manufacturing, heavy manufacturing, transport equipment, energy, transport and communication and construction. His service sectors are trade and services.

(2) K-T's industrial sectors are light manufacturing and heavy manufacturing.

From the factor shares and the σ_i and with the chosen initial conditions, the production parameters used in the basic simulation of DYNURB are:

Table 4.2 Production Function Parameters

		B_i	γ_i	σ_i	Shares	
					L	K
1.	Agriculture	0.3821 (0.5457)	0.1363	1.2	0.55	0.07
2.	Industry	1.0339 (1.0960)	0.5385	0.6	0.60	0.40
3.	Services	0.7568 (0.7520)	0.3444	0.8	0.70	0.30

Note: (1) Figures in parenthesis are for the corresponding Cobb-Douglas specifications.

(2) In agriculture, ALPH (Land Share) = 0.33,
GAM (LVSTK share) = 0.05, BET = 0.62.

4.22 Input Output Table

The input-output table used in DYNURB is derived from the 32 sector modified I.S.I (Indian Statistical Institute) input - output table for 1960-61 (as reported in Eckaus and Parikh (1968)). The sectoral aggregation is given in Table 4.3. The resulting input-output table used in DYNURB is given in Table 4.4.

Table 4.3 Sectoral Aggregation for Input Output Table

<u>DYNURB Sectors</u>	<u>ISI Sectors</u>
1. Agriculture	11 Plantations 12 Animal Husbandry 15 Food grains 18 Other Agriculture 21 Forestry Products
2. Industry	1. Construction, urban 2. Construction, rural 3. Electrical equipment 4. Transport Equipment 5. Non electrical equipment 6. Iron and Steel 7. Iron-Ore 8. Cement 9. Other metals 10. Other minerals 12. Leather & leather products 14. Food Industries 16. Cotton and other textiles 17. Jute textiles 19. Chemical fertilizers 20. Glass and non-metallic minerals 22. Motor Transport 23. Petroleum products 24. Crude oil 25. Rubber products 26. Synthetic Rubber 27. Chemicals 28. Railways 29. Electricity 30. Coal and coke.
3. Services	31. Housing 32. Others.

Note: The I.S.I. input-output table is given as table 3.2 in Eckaus-Parikh (1968)

Table 4.4 Input-Output Table Used in DYNURB

	1 Agriculture	2 Industry	3 Services
1. Agriculture	0.08	0.19	0.14
2. Industry	0.03	0.30	0.03
3. Services	0.003	0.070	0.004

Source: Aggregation according to Table 4.3 of Table 3.2
in Eckaus-Parikh (1968) p. 38.

The value of a_T - the transport coefficient is set at 0.005 in accordance with the transport coefficient in the I.S.I. table.

4.23 Demand Parameters:

As with the production side there are no estimates of the demand system used in this study. The Stone Linear Expenditure system does not appear to have been estimated for India. There are, however, many consumption studies with different approaches like NCAER(1967), D.B. Gupta (1973), and B.M. Desai (1972). Most of such consumption studies are based on either the Government of India annual National Sample Surveys (N.S.S.) or the occasional NCAER surveys. Table 4.5 gives some results from Desai. The results in

Table 4.5 Consumption Pattern in India

A. Rural

1	2	3	4	5	6	7	8	9	10	11
Decile	Rs/per cap/month Approx.Monthly Exp.	Foodgrains η MPE APE			Milk η MPE APE			Clothing η MPE APE		
1,2	8.93	.93	.60	.64	2.81	.07	.02	2.48	.06	.02
3	13.14	.72	.43	.60	2.19	.09	.04	2.17	.08	.04
4,5	17.80	.60	.32	.54	1.85	.11	.06	2.00	.11	.05
6,7,8	24.13	.51	.24	.47	1.60	.12	.07	1.87	.13	.07
9	30.71	.46	.19	.41	1.45	.12	.08	1.80	.16	.09
9 to 9.5	41.89	.40	.14	.35	1.30	.12	.09	1.72	.19	.11
9.5 to 10.	85.84	.33	.07	.22	1.09	.12	.10	1.62	.29	.18
Mean	24.43	.52	.24		1.59	.12		1.87	.14	
<u>B. Urban</u>										

1	2	3	4	5	6	7	8	9	10	11
1,2	As above	.92	.50	.54	2.29	.09	.04	4.41	.02	.01
3		.61	.30	.49	1.83	.11	.06	3.25	.05	.02
4,5		.44	.18	.42	1.57	.12	.08	2.61	.08	.03
6,7,8		.31	.11	.35	1.38	.12	.09	2.14	.09	.04
9		.23	.07	.29	1.27	.12	.10	1.85	.10	.06
9 to 9.5		.16	.04	.23	1.16	.12	.10	1.57	.11	.07
9.5 to 10.		.05	.01	.12	1.00	.11	.11	1.18	.10	.09
Mean		.30	.11		1.38	.12		2.12	.09	

Notes: (1) MPE - Marginal propensity to spend
 APE - Average propensity to spend
 η - Expenditure elasticity of Demand

(2) The Monthly expenditures given in column 2 are all India averages - urban and rural are therefore somewhat different.

Source: B.M. Desai (1972) Table 3, p.15.

Gupta (1973) are similar. Note from table 4.5 that

- 1) Income or expenditure elasticity of demand for food grains is much greater in rural areas than in urban areas, and declines with income in both areas. The marginal propensity to expend (MPE) is also correspondingly greater.
- 2) The average propensity to expend (APE) or average budget shares of food grains declines with income indicating some subsistence minimum.
- 3) The income elasticity of demand for clothing declines with income while the marginal propensity to expend increases. This would be in accordance with the Stone system where clothing would be a non-subsistence good.
- 4) The MPE for clothing is higher in rural areas than in urban. This is probably explained by lower incomes in rural areas and the availability of a wider variety of goods in urban areas. In addition, expenses on service essentials like housing are liable to be greater in urban areas.
- 5) The mean figures are in close accord with those for the 6th, 7th and 8th deciles. This indicates the inequality in income distribution.

The above observations indicate a pattern which is in accordance with the implications of the use of the Stone system which were described in the last chapter. The caveat mentioned there is shown in Table 4.5: the income elasticity

of demand for foodgrains declines with a rise in income, as does the average propensity to expend. The η for food - a necessary subsistence good - was shown to rise from a number less than 1 towards unity.

By interpreting the MPE's to approximately correspond to the β 's in the Stone system, the demand parameters derived for DYNURB are shown in Table 4.6. Expenditures on foodgrains and milk are assumed to correspond to sector 1 in DYNURB; clothing is regarded as the main industrial good consumed in a low income country such as India; and the service parameters are essentially residuals; minimum subsistence requirements for food are taken to be about 40 percent of average monthly expenditure for the mean. The APE for foodgrains for the 6th, 7th, 8th deciles is .47 in rural areas and .4 therefore seems a reasonable assumption. Note that this β estimation is necessarily tentative and rather arbitrary though informed by actual consumption studies.

Table 4.6 Demand Parameters for DYNURB

<u>Goods</u>	Rural	Urban	
	Agricultural	Industry	Services
	β_{i1}	β_{i2}	β_{i3}
Agriculture (β_{1j})	0.40	0.25	0.25
Industry (β_{2j})	0.25	0.20	0.20
Services (β_{3j})	0.35	0.55	0.55

$$FMIN_1 = 0.1, \quad FMIN_2 = FMIN_3 = 0$$

Source. Table 4.5 and text.

A few words by way of interpretation are necessary here:

- i) The β 's for sector 3 look rather large. This is partly because government (including defence) is included in sector 3. Government is financed through taxes but DYNURB does not have any taxes in the model. Thus, what would normally go in taxes is included as demand for services here. In India, rural taxes are largely indirect taxes, while urban taxes include income taxes as well.
- ii) Recall that the service and industrial sectors are based in urban areas in DYNURB. It is also reasonable to interpret that services are space specific i.e. can only be consumed in urban areas. Government services, banks, etc. are therefore assumed to be in urban areas and rural people have to travel there to consume them. It would, however, be consistent to also interpret that services while produced in the urban areas are 'transported' to rural areas. Some government services and mobile banks, movies, etc. can easily come in this category. The a_T coefficient is therefore quite important in such an interpretation of the service sector.
- iii) One of the central points in this study relates to the importance of the service sector in the urbanization process. The large service β 's for urban areas support this point strongly.

4.24 Savings

Savings are made from all sources of income in DYNURB. The model allows different savings rates from labour income and capital income and for urban and rural areas. While there is evidence that more is saved from capital income and less from labour income - as pointed out in the last chapter - these rates are presumed to be the same in the simulation of DYNURB. This is in recognition of the large self-employed sector in India. Since income from both sources is pooled in this model, it does not really make sense to distinguish the source of income for savings purposes.

There is, however, a need to assume different rates of savings for the urban and rural sectors. Diwan (1968), for example, finds that 60 percent of all savings in India come from the urban sector (which has just over 20 percent of the population). Greater availability of financial intermediaries is probably one cause of this. Rural savers are more dependent on returns to investment in their own enterprises and their savings are therefore more constrained. Non-monetary savings, though accounted for in some studies, e.g. Panikar (1970), are clearly difficult to estimate and may well be understated. Panikar finds the rural savings rate to be 8.2 percent, the urban rate to be 17.2 percent. Bhalla (1976) in a study of rural farm households finds the average rural savings rate to be 13.8 percent in the period

1968 to 1970. The national income accounts show the national average savings rates to be gradually increasing with time. Table 4.7 shows gross capital formation as a proportion of gross domestic product over the period 1950 to 1974. While savings rates are somewhat less than this because of net foreign transfer the difference is seldom greater than 2 percentage points. Because DYNURB has no foreign sector, savings are identically equal to investment. In the interest of accurately tracing the growth experience of the economy it was decided to use the gross capital formation information to reflect savings rates. While the increase in the rate of savings is not consistent because of bad years owing to weather variation, etc., the upward trend is unmistakable. DYNURB takes account of this by postulating a growth rate in the rate of savings. Table 4.8 gives the chosen savings parameters.

One further point worth mentioning here is that, in India, household savings account for 65 to 80 percent of total savings (G.O.I. (1976), p. xxxv) - thus the depiction of savings in DYNURB is a good approximation of reality.

Depreciation

Dholakia gives the following table in his derivation of the rate of depreciation of capital stock. (Table 4.9)

Table 4.7 Gross Capital Formation in India - A Proxy
for Savings Rates

Year	GCF as percent of G.D.P.	Year	GCF as percent of G.D.P.
1950	11.23	1963	15.9;
1951	11.85	1964	17.32
1952	12.66	1965	16.67
1953	9.84	1966	19.12
1954	12.65	1967	18.95
1955	12.55	1968	16.72
1956	13.43	1969	18.03
1957	17.42	1970	16.7
1958	16.22	1971	17.3
1959	15.09	1972	17.2
1960	14.86	1973	18.4
1961	15.16	1974	17.2
1962	14.42		

Source: (1) 1950-1969 Dholakia (1974), Table V-c-5, p. 197

(2) 1970-1974 GOI (1976) Table 12, p. 32.

Note (1) that since the series is taken from two different sources it is not completely consistent. Source (1) is at const. 1960-1961 prices while source (2) is at current prices. This inconsistency is not important for the purposes of DYNURB

(2) 1950 refers to 1949-50 and so on.

Table 4.8 Savings Parameters for DYNURB

	Rural Agriculture	Urban Industry	Services
SLAB _i (1)	0.10	0.14	0.14
SCAP _i (1)	0.10	0.14	0.14
GSLAB _i	0.015	0.015	0.015
GSCAP _i	0.015	0.015	0.015

Table 4.9 Estimates of Depreciation of Capital
Stock

	Item	Estimated Ave. Life (in years)	Estimated Rate of Depreciation
1	Farm Houses	40	2.56
2	Irrigation	40	2.56
3	Construction in Agric.	40	2.56
4.	Ag. Implements and Machinery	24	7.5
5	Non Resident in Structure	30	3.2
6	Machinery in Industry	20	4.6
7	Residential Dwellings		
	- rural	40	2.56
	- urban	60	1.70

Source Dholakia (1974) p. 190.

The value of δ - the depreciation rate of capital is set at 3.3 percent/year.

4.25 Wage and Rental Structure

It was shown in the last chapter that there is overwhelming evidence that wage rates differ between urban and rural areas for even the same skills. Further evidence is provided here on average incomes. According to NCAER (1962), based on a household survey, the average annual income of an urban household was Rs.2215 as compared with Rs. 1328 for a rural household. This included imputed house rentals. Mukherjee (1969, p. 434) shows that the urban average per capita income ranged from 1.76 to 2.18 times the rural figure between 1951 to 1960. Accounting for some skill differentials between the average urban labourer and rural labourer, θ_2 and θ_3 the efficiency wage differentials are set at 1.7.

There is no overwhelming evidence that rates of return to capital differ on average between the sectors as defined in DYNURB. There is, of course, wide variation between rates of return to capital for more disaggregated sectors. Thus efficiency capital rentals are equalized across all sectors. The wage and rental structure is therefore as follows in the basic simulation of DYNURB:

Table 4.10 Wage and Capital Structure in DYNURB

Factor/Sector	1	2	3
Labour	1.0	1.7	1.7
Capital	1.0	1.0	1.0

4.26 Technical Change: The simulation of technical change is embedded in the factor augmenting rates λ_{i1} for labour and λ_{i2} for capital and the exogenous rate of neutral technical change GB_i . While estimations have been made of the labour augmenting rates in terms of education, skill, etc., there is no direct way of measuring λ_{i2} - the rates for capital. Now, the growth rate of technical change may be written:

$$GTECH_i(t) = S_{iL}(t) \cdot \lambda_{i1} + S_{iK} \cdot \lambda_{i2} \quad (4.2)$$

where $S_{iL}(t)$ and $S_{iK}(t)$ are the sectoral shares of labour and capital respectively. These change over time in C.E.S. production functions Eqn. (4.2) may be shown easily: The technical change in sector i ,

$$GTECH_i(t) = \frac{\partial Q_i(t)}{\partial t} \cdot \frac{1}{Q_i(t)}$$

where $Q_i(t) = F^i \left[X_i(t) K_i(t), Y_i L_i(t) \right]$

Now, removing time subscripts,

$$\frac{\partial Q_i}{\partial t} = \frac{\partial F^i}{\partial (X_i K_i)} \cdot \frac{\partial (X_i K_i)}{\partial t} + \frac{\partial F^i}{\partial (Y_i L_i)} \cdot \frac{\partial (Y_i L_i)}{\partial t}$$

Writing $F_k^i = \frac{\partial F^i}{\partial (X_i K_i)}$ and correspondingly F_L^i

$$\frac{\partial Q_i}{\partial t} = F_K^i \left[K_i \frac{\partial x_i}{\partial t} + x_i \frac{\partial K_i}{\partial t} \right] + F_L^i \left[L_i \frac{\partial y_i}{\partial t} + y_i \frac{\partial L_i}{\partial t} \right]$$

but in the evaluation of technical change K_i and L_i are fixed, hence

$$\begin{aligned} \frac{\partial Q_i}{\partial t} &= F_K^i \cdot K_i \cdot \frac{\partial x_i}{\partial t} + F_L^i \cdot L_i \cdot \frac{\partial y_i}{\partial t} \\ &= F_K^i x_i K_i \cdot \frac{\partial x_i}{\partial t} \cdot \frac{1}{x_i} + F_L^i \cdot y_i L_i \cdot \frac{\partial y_i}{\partial t} \cdot \frac{1}{y_i} \end{aligned}$$

With constant returns to scale, profit maximization assumptions,

$$W_i = F_L^i \quad \text{and} \quad R_i = F_K^i$$

Thus

$$\text{GTECH}_i = \frac{x_i K_i R_i}{Q_i} \cdot \frac{\partial x_i}{\partial t} \cdot \frac{1}{x_i} + \frac{y_i L_i W_i}{Q_i} \cdot \frac{\partial y_i}{\partial t} \cdot \frac{1}{y_i}$$

$$\text{but} \quad S_K = \frac{x_i K_i R_i}{Q_i} \quad \text{and} \quad S_L = \frac{y_i L_i W_i}{Q_i}$$

$$\text{and} \quad \lambda_{i1} = \frac{\partial y_i}{\partial t} \cdot \frac{1}{y_i}, \quad \lambda_{i2} = \frac{\partial x_i}{\partial t} \cdot \frac{1}{x_i}$$

Hence

$$\text{GTECH}_i(t) = S_{iK}(t) \cdot \lambda_{i2} + S_{iL}(t) \cdot \lambda_{i1} \quad (4.2)$$

Including neutral technical change GB_i ,

$$GTECH_i(t) = S_{iK}(t) \cdot \lambda_{i2} + S_{iL}(t) \cdot \lambda_{i1} + GB_i \quad (4.3)$$

In principle, therefore λ_{i2} can be calculated if all the other parameters are known in (4.3). While there are some estimates of $GTECH_i(t)$ and λ_{i1} , the other parameters have not been estimated. Dholakia (1974) in doing a Denison type source of growth exercise for India found technical change (change in output per unit of input) in agriculture to be 0.56 percent per year (p. 237) between 1949 to 1969. Tara Shukla's estimate for the years 1950 and 1960 was 1.70 percent per year. Mohan (1974) reports statewide estimates whose average is about 1.5 to 1.6 percent per year. Dholakia reports growth in net product in agriculture to be about 1.88 percent per year which differs from almost all other estimates which are usually in the range of 3.0 percent per year. His underestimate (caused by his own manipulation of series) of net product growth would appear to explain all his error in the calculation of total productivity growth. Thus it is reasonable to assume that total productivity growth in Indian agriculture has been in the region of 1.5 to 1.7 percent a year.

Dholakia's estimates for the non-agricultural sector appear to be more reasonable: his net product growth rates

are in line with other estimates. Productivity growth in the non-agricultural sector is estimated to be about 1.5 percent per year by Dholakia (p. 239) for the period 1949 to 1969.

He also estimates the change in quality of labour as measured by education changes and changes in age - sex composition. His estimate is about 0.45 percent per year (p. 127) augmentation of the labour force. Kelley-Williamson (1974) assume λ_{i2} i.e. the rate of capital augmentation to be 1.14 percent per year and that of labour to be 1.94 percent per year for Meiji Japan. For want of better information it is assumed here that the rate of capital augmentation in India should be of the same order. However, recognizing that the service sector includes residential dwellings, banking, insurance, etc. i.e., sectors in which capital has a long life, it is assumed that

$$\lambda_{32} < \lambda_{22}$$

i.e. that service sector capital undergoes slower technical changes. This is in accordance with the vintage view of capital as outlined in Chapter 2.

If it is now assumed that

$$\lambda_{22} = 0.01 \quad \text{i.e. 1 percent a year}$$

$$S_{2K} = 0.4, \quad S_{2L} = 0.6$$

$$GB(2) = 0$$

and $GTECH_2 = 0.015$.

Then the solution of equation (4.3) gives $\lambda_{21} = 0.018$ (approx).

This is much nearer to K-W's figure for Meiji Japan. The education changes in Meiji Japan were, however, much greater than in contemporary India, hence λ_{21} must be less than this calculated value. It is probably in the range $0.01 < \lambda_{21} < 0.018$.

When a calculation is made with similar magnitudes of λ_{11} and λ_{12} $GTECH_1$ is found to be in the range of only about 0.5 to 0.6 percent, rather than the 1.5 percent concluded earlier. There is therefore reason to believe that GB_1 is probably significant for agriculture. Changes such as the hybrid seed revolution perhaps cause such effects. GB_1 is therefore set at 1 percent per year.

The increase in skills in the industrial sector has probably been greater in the industrial labour force as compared with both the agricultural and service labour force. An interpretation of such a difference within the assumption of a homogeneous labour force was provided in the last chapter. Thus it is assumed that

$$\begin{aligned} \lambda_{11} &= \lambda_{31} < \lambda_{21} && \text{Labour} \\ \text{and } \lambda_{12} &= \lambda_{22} > \lambda_{32} && \text{Capital} \\ \text{and } GB_1 &> 0, \quad GB_2 = GB_3 = 0. \end{aligned}$$

Having established these ranges the final values were selected by trial and error in the dynamic simulation of DYNURB. The purpose was to approximate the sectoral growth of the Indian economy as closely as possible. The use of trial and error is justified on 2 counts:

- i) Lack of better information
- ii) DYNURB is a theoretical model designed for experimentation.

Table 4.11 gives the technical change parameters chosen for DYNURB.

Table 4.11 Technical Change Parameters in DYNURB

Sector	Labour (λ_{i1})	Capital (λ_{i2})	GB_i
1. Agriculture	0.0125	0.010	0.01
2. Industry	0.015	0.010	0.0
3. Services	0.0125	0.008	0.0

As a result,

$$GTECH_1 > GTECH_2 > GTECH_3 .$$

That $GTECH_1 > GTECH_2$ is somewhat surprising but is in accordance with data and also with KWC (1972) and K-W (1974). That $GTECH_3$ is the least is in accordance with experience as outlined in Section 2.2.

Bias

Recalling eqn. (2.8) the bias of technical change is given by

$$\begin{aligned} \text{BIAS}_i &= \left(\frac{dy_i}{y_i} - \frac{dx_i}{x_i} \right) \left(\frac{1 - \sigma_i}{\sigma_i} \right) \\ &= \frac{(\lambda_{i1} - \lambda_{i2}) (1 - \sigma_i)}{\sigma_i} \end{aligned} \quad (4.4)$$

With $\sigma_1 = 1.2$, $\sigma_2 = 0.6$, $\sigma_3 = 0.8$ and the λ 's in Table 4.11

BIAS_1	< 0	labour using, capital saving
BIAS_2	> 0	labour saving, capital using
BIAS_3	> 0	labour saving, capital using.

Thus, in DYNURB, each sector undergoes non-neutral technical change with agriculture being the only labour using sector.

4.27 Growth Rates of Population:

GURB and GRUR are the natural growth rates of population in the urban and rural sectors, respectively. These are set to approximately project India's population as it has grown since 1951. As shown in the last chapter $\text{GURB} < \text{GRUR}$.

Accordingly, for the basic simulation:

$$\begin{aligned} \text{GURB} &= 0.017 \quad \text{i.e. 1.7 percent a year} \\ \text{and GRUR} &= 0.020 \quad \text{i.e. 2.0 percent a year} \end{aligned}$$

which gives a total population growth rate of somewhat less than 2 percent a year. This declines with an increase in urbanization.

4.28 Choice of Initial Conditions

A simulation of DYNURB requires an initial guess of the following:

- i) $L_i(1)$, $K_i(1)$, $LAND(1)$ and $LVSTK(1)$, i.e. the initial factor allocations by sector.
- ii) $y_i(1)$ and $x_i(1)$ the initial factor augmentation rates. Recall from the last chapter that these are necessary to capture the skill differences between sectors while maintaining the factor homogeneity assumption for efficiency units.
- iii) $P_{ii}(1)$, the initial prices of goods. These are set at unity initially.
- iv) $Q_i(1)$, the initial gross outputs. Note that these include the production of intermediate goods.

The selection of these values is now outlined.

i) Factor Allocation

a. Labour: Labour is allocated to sectors according to actual employment in 1951 as given by the census of that year and modified by Dholakia (1974). Table 4.12 below gives the percent distribution of employment by detailed sector according to Indian census definitions.

Table 4.12 Distribution of Employment by Sector - 1951

	Percent
1. Cultivator	50.0
2. Ag. Labourer	19.72
3. Other primary	<u>2.38</u>
Sector 1. Agriculture	72.10
4. Household Industry	9.00
5. Manufacturing	0.57
6. Construction	1.05
7. Transport and Communication	<u>1.00</u> (approx)
Sector 2, Industry	11.62
8. Trade and Commerce	5.24
9. Other Services	10.49
10. Storage	<u>0.50</u> (approx)
Sector 3. Services	16.23

Source: IAMR (1968) p. 116

Dholakia adjusts the raw labour force data to account for inter-censal differences in the definition of labour.

His data for 1951 are:

<u>Sector</u>	<u>No. of Workers</u>	<u>Percent</u>
Agriculture	118,854,985	73.6
Non-Agriculture	<u>42,531,020</u>	<u>26.4</u>
Total	161,386,005	100.0

These are allocated roughly according to the proportions in Table 4.12 to give:

Table 4.13 Initial Allocation of Labour - 1951

Sector		No. of Workers ($\times 10^5$)	Percent
1.	Agriculture $L_1(1)$	1180	74
2.	Industry $L_2(1)$	180	11
3.	Services $L_3(1)$	240	15
Total $LTOT(1)$		1600	100.0

Note the unit reported for number of workers: 10^5 . This is the unit used throughout this study. $LTOT(1)$, the total labour force in the first period is fixed. Initial allocations of labour are then altered according to the equilibrium solution for the first period.

b. Capital: The allocation of capital by sector is somewhat more difficult because of paucity of data and of inconsistency between different sources. Table 4.14 reports data from 2 sources:

Table 4.14 Distribution of Capital By Sector

(current prices) 1951

Sector	Makherjee (Rs.x10 ⁸) 1	Dholakia (Rs.x10 ⁸) 2
1. Agriculture	280	540
2. Industry	460	470
3. Services	512	670
Total	1252	1680

Source: Column 1. Mukherjee (1969) p. 392

Column 2. Dholakia (1974) p. 201

Note: (1) Both sets of figures do not include value of Livestock in Sector 1.

(2) Both sets are aggregates derived from the 2 sources according to sector definitions in DYNURB.

(3) The figures for sector 1 include value of farm structures and construction.

(4) In column 2, the value for sector 3 is exclusively residential property.

(5) In column 1, the value for sector 3 excludes approx. value of rural residential property.

Note from this table that the sector 2 values corroborate well but not those for the other 2 sectors, particularly

those for agriculture. It would appear that these estimates include some approximations for values of land improvement in agriculture. It is therefore obvious that estimates of capital stock are rather tentative. The values chosen for DYNURB are:

Table 4.15 Initial Allocation of Capital Stock

Sector	Value of Capital (Rs.x10 ⁸) 1951 prices
1. Agriculture K ₁ (1)	325
2. Industry K ₂ (1)	500
3. Services K ₃ (1)	<u>650</u>
Total KTOT(1)	<u>1475</u>

Note the units used here: Rs. 10⁸ at 1951 prices. This is the value unit used throughout this study.

c. Land and Livestock: These values are also taken from Mukherjee (1969, p. 392) and set at

$$\begin{aligned}\text{LAND}(1) &= \text{Rs. } 1700 \times 10^8 \\ \text{LVSTK}(1) &= \text{Rs. } 240 \times 10^8\end{aligned}$$

These values correspond well with Dholakia's estimate. In accordance with actual estimates land and livestock are set to grow at constant rates:

$$\begin{aligned}\text{GLAND} &= 0.010 \quad \text{i.e. 1 percent a year} \\ \text{GLVSTK} &= 0.008 \quad \text{i.e. 0.8 percent a year.}\end{aligned}$$

ii) Outputs: The outputs required for DYNURB are inclusive of intermediate goods. National income accounts report outputs net of intermediate goods, say $X = (X_1, X_2, X_3)$. Then gross output i.e. net output + intermediate goods output,

$$Q = (Q_1, Q_2, Q_3)$$

$$Q = (I - A)^{-1}X$$

where A is the input-output matrix.

Table 4.16 shows the value of initial net output:

Table 4.16 Initial Net Output

Sector	Rs x 10 ⁸
1. Agriculture	<u>490</u>
2. Mining and Manufacturing	153
3. Railways and Communication	22
4. Other Transport	<u>30</u>
<u>Industry</u>	205
5. Banks and Insurance	7
6. Commerce	110
7. Professions and Liberal Arts	47
8. Government	43
9. Domestic Service	13
10. House Property	<u>31</u> (Excludes rural).
<u>Services</u>	251

Source: M. Mukherjee (1969) p. 162 (approximations)

The resulting values for Q are shown below:

Sector			Rs. x 10^8
1.	Agriculture	$Q_1(1)$	613
2.	Industry	$Q_2(1)$	331
3.	Services	$Q_3(1)$	276

iii) Initial Factor Augmentation Rates: Since returns to factors are being balanced (with the given structure) for efficiency units, adjustment needs to be made for quality in the initial period.

There are 2 sources of quality differences between the urban and rural labour force:

- a) Difference in average education level,
- and b) Difference in age sex composition.

Dholakia (1974, pp. 133-137) gives approximate average wage or income levels for different education levels for urban and rural areas. In addition, he gives the number of workers by education level. Given the wage information by education level, the following weights were derived:

<u>Education Level</u>	<u>Weight</u>
Illiterate	1.00
Primary	1.45
Secondary	2.30
Graduate	4.32

i.e. a graduate is equivalent to 4.32 illiterate workers. Using these weights, the urban labour force was found to be 1.115 times as educated as the rural labour force in 1951.

The approximate age sex composition of the labour force is given below in table 4.17:

Table 4.17. Age-Sex Composition of the Labour Force 1961

	Percent	
	Urban	Rural
Children	4.7	9.33
Women	19.3	33.05
Men	76.0	57.62
	100.00	100.00

This shows significant difference in the urban/rural composition of the labour force. Taking account of different wage rates for men, women, and children, the following weights were allotted:

Man (adult)	1.00
Woman (adult)	0.75
Child	0.50

(See Hansen (1969) and Rosenzweig-Evenson (1977) for evidence). Using these weights, the age/sex quality of urban labour was found to be 1.07 times rural labour. Combining this index with the education index,

$$\frac{y_2(1)}{y_1(1)} = \frac{y_3(1)}{y_1(1)} = 1.2 \quad (\text{approx.})$$

Reasons were given earlier for the capital in services to be regarded as being 'less efficient' than in the other two sectors. Accordingly, $K_3(1)$ is arbitrarily set at 0.75. The initial factor augmenting rates are given in table 4.18 below:

Table 4.18 Initial Factor Augmentation

Sector	Labour $y_i(1)$	Capital $x_i(1)$
1. Agriculture	1.0	1.0
2. Industry	1.2	1.0
3. Services	1.2	0.75

A final note on the selection of parameters and initial conditions needs to be made here. It should be obvious that an initial selection will not be consistent with the model being in equilibrium. In particular, the initial values of outputs, capital and labour will be altered as the model finds a base period solution. Thus the base period solution will not produce the initial values derived from real data. Here capital allocations were regarded as the least reliable and were adjusted to keep output and labour values close to actual base period values. This necessarily involved some

trial and error. Indeed, the parameter choices reported here, though based on actual data were finally fixed to reproduce a plausible base period simulation for the year 1951.

4.3 List of Chosen Parameters and Initial Conditions

1. Production Parameters:

$$\begin{array}{lll} B_1 = 0.3821 & \gamma_1 = 0.1363 & \sigma_1 = 1.2 \\ B_2 = 1.0339 & \gamma_2 = 0.5385 & \sigma_2 = 0.6 \\ B_3 = 0.7568 & \gamma_3 = 0.3444 & \sigma_3 = 0.8 \end{array}$$

[for Cobb Douglas functions:

$$\begin{array}{lll} B_1 = 0.5457 & \text{EXPL}_1 = 0.55 & \text{EXPK}_1 = 0.07 \\ B_2 = 1.0960 & \text{EXPL}_2 = 0.60 & \text{EXPK}_2 = 0.40 \\ B_3 = 0.7520 & \text{EXPL}_3 = 0.70 & \text{EXPK}_3 = 0.30] \end{array}$$

$$\text{ALPH} = 0.33 \quad \text{BET} = 0.62 \quad \text{GAM} = 0.05.$$

2. Input Output Table

a_{ij}	1 Ag.	2 Industry	3 Services
1. Agriculture	0.080	0.190	0.040
2. Industry	0.030	0.300	0.030
3. Services	0.003	0.070	0.004

$$a_T = 0.005$$

3. Demand Parameters

$$\beta_{11} = 0.40$$

$$\beta_{12} = 0.25$$

$$\beta_{13} = 0.25$$

$$\beta_{21} = 0.25$$

$$\beta_{22} = 0.20$$

$$\beta_{23} = 0.20$$

$$\beta_{31} = 0.35$$

$$\beta_{32} = 0.55$$

$$\beta_{33} = 0.55$$

$$FMIN_1 = 0.1$$

$$FMIN_2 = 0.0$$

$$FMIN_3 = 0.0$$

$$\text{All } GFMIN_i = 0.0$$

4. Savings:

$$SLAB_1(1) = 0.10$$

$$SLAB_2(1) = 0.14$$

$$SLAB_3(1) = 0.14$$

$$SCAP_1(1) = 0.10$$

$$SCAP_2(1) = 0.14$$

$$SCAP_3(1) = 0.14$$

$$GSLAB_i = 0.015$$

$$i = 1, 2, 3$$

$$GSCAP_i = 0.015$$

$$i = 1, 2, 3$$

$$\delta = 0.033$$

5. Wage and Rental Structure

$$\theta_1 = 1.0$$

$$\theta_2 = 1.7$$

$$\theta_3 = 1.7$$

$$\phi = 1.0$$

$$\phi_2 = 1.0$$

$$\phi_3 = 1.0$$

6. Technical Change

$$\lambda_{11} = 0.0125$$

$$\lambda_{21} = 0.015$$

$$\lambda_{31} = 0.0125$$

$$\lambda_{12} = 0.01$$

$$\lambda_{22} = 0.01$$

$$\lambda_{32} = 0.008$$

$$GB_1 = 0.01$$

$$GB_2 = 0.0$$

$$GB_3 = 0.0$$

7. Population

$$\text{GURB} = 0.017$$

$$\text{GRUR} = 0.020$$

8. Initial Conditions

$$L_1 = 1180$$

$$L_2 = 180$$

$$L_3 = 240$$

$$\text{LTOT} = 1600.$$

$$\text{Units: } 10^5 \text{ people}$$

$$K_1 = 325$$

$$K_2 = 500$$

$$K_3 = 650$$

$$\text{KTOT} = 1475$$

$$\text{Units: Rs.} \times 10^8 \text{ (1951 prices)}$$

$$\text{LAND} = 1700$$

$$\text{LVSTK} = 240$$

$$\text{Units: Rs.} \times 10^8 \text{ (1951 prices)}$$

$$\text{GLAND} = 0.010$$

$$\text{GLVSTK} = 0.008$$

$$y_1(1) = 1.0$$

$$y_2(1) = 1.2$$

$$y_3(1) = 1.2$$

$$x_1(1) = 1.0$$

$$x_2(1) = 1.0$$

$$x_3(1) = 0.75.$$

5. India In the Year 1984: A Simulation of DYNURB

This chapter presents the numerical results of a simulation of DYNURB conducted with the parameters and initial conditions chosen in the last chapter. This simulation will hence forth be called the BASRUN. The full output of the BASRUN simulation is provided in the Appendix to provide an idea of all the results that DYNURB can provide.

In reporting the main results from DYNURB, comparisons are provided with actual data from the post independence Indian economy wherever possible. This is often difficult because model categories are designed to keep DYNURB theoretically pure (in the neoclassical tradition) and therefore do not always correspond well with actual categories as measured in Indian accounts. Moreover, some Indian series, e.g. that of the labour force, have gone through definitional changes, thus making comparability difficult over time. The comparisons with actual data are therefore only approximate and are intended to validate the usefulness of DYNURB as a plausible vehicle for investigating structural changes in a low-income economy undergoing development.

A brief overview of the performance of the Indian economy over the century preceding 1951 is provided to put in perspective the post-independence period simulated by DYNURB.

5.1 A Stagnant Economy: India 1860 to 1950¹

Information on the national income of India, in the past is not very reliable. It is not even clear if per capita income in 1950 was greater than that in 1900 or that in 1850. Information on this century, though, is much better than that for the period 1850-1900. Table 5.1 gives one estimate of the growth of per capita income over the period 1860 to 1950. This was obtained by Mukherjee after a review of almost all existing estimates and by consideration of whatever information that was available on wage rates, prices, agricultural production, etc. The picture that emerges is one of overall growth over the period but one characterized by spurts and stagnation. Table 5.2 shows growth rates of national income, population and of per capita income for different sub-periods. These tables show that the growth of per capita income was rather slow, 0.5 per cent per year, over the whole period, though there were 2 sub-periods when it was over 1 per cent a year. These sub-periods are comparable to the contemporary period. The growth of national income, however, has been much greater since 1950 than the whole period preceding -- as has the growth in population. It must be emphasized here that the estimates given have not received widespread agreement. Others, e.g. Patel (1958) and Daniel Thorner (1955), have surmised that there was a decline in per capita income over the period in question.

¹The information in this section is largely from M. Mukherjee (1969), Ch. 2.

Table 5.1 Average Per Capita Income of India: 1860 - 1950

Year	Per capita Income in 1948-49 Rs
1	2
1860	169
1865	196
1870	172
1875	177
1880	197
1885	216
1890	204
1895	201
1900	199
1905	203
1910	220
1915	241
1920	253
1925	261
1930	260
1935	260
1940	265
1945	255
1950	253

SOURCE: M. Mukherjee (1969), p. 61.

NOTE: The estimates are 7-year averages centered on the years mentioned.

Table 5.2 Rates of Growth in Different Sub Periods
(const. 1949 prices)

Period	No. of Years	Annual Rate of Growth of		
		National Income	Popu- lation	Per capita Income
1		3	4	5
1860 - 1900	40	0.90	0.50	0.40
1900 - 1950	50	1.32	0.84	0.48
1860 - 1950	90	1.15	0.70	0.45
<u>Sub-Periods</u>				
1865 - 1885	20	1.76	0.53	1.23
1905 - 1925	20	1.73	0.44	1.29
1948 - 1962	14	3.07	1.95	1.12

SOURCE: M. Mukherjee (1969), p. 65.

The Mukherjee study used here is the most recent and probably the most careful.

Table 5.3 shows that along with the slow growth, the economy did not go through significant structural change. It is remarkable that the percent of labour force engaged in agriculture remained largely constant while that in industry first declined and then increased. The rate of urbanization was greatest in the period 1941 to 1951, but this was a special period because of the dislocations caused by World War II, and Indian independence (1947) which was accompanied by the massive influx of refugees from Pakistan.

Table 5.3 Structure of the Indian Economy: 1911 - 1951

Year	Percent of Lab. Force in			Percent Urban Population
	Agric.	Industry	Services	
1	2	3	4	5
1911	75.60	11.35	13.04	10.29
1921	76.90	10.60	12.50	11.18
1931	76.50	10.36	13.15	11.97
1941				13.85*
1951	76.10	11.06	12.84	17.29

SOURCE: Ambannavar (1970), p. 130.

* From Bose (1973), p. 64.

It is because of this stationary nature of the Indian economy before 1951 and relatively faster change since then that the post 1951 period has been chosen for simulation. It would be instructive to probe the causes of accelerated urbanization since 1931, but the special nature of the 1940s decade precludes a systematic analysis of that period.

5.2 Growth of Output

Table 5.4 shows results of the BASRUN along with actual values for India. The two sets of series are in remarkably close agreement considering the many unrealistic assumptions incorporated in DYNURB. The actual per capita

Table 5.4 National Product in Constant Prices

(Index, 1951 = 100)

Year	BASRUN		ACTUAL	
	GNP	Per Capita	GNP	Per Capita
	1	2	3	5
1951	100	100	100	100
1954	110.7	104.5	114	107
1957	122.7	109.4	124	110
1960	136.4	114.8	134	112
1963	151.7	120.7	151	118
1966	169.1	127.1	166	121
1969	188.5	133.9	184	129
1972	210.5	141.2	210	137
1975	235.5	149.2	217	136
1978	263.5	157.6		
1981	295.0	166.7		
1984	330.5	176.5		

SOURCES: Cols. (1), (2) Simulation, Table A.1
 Cols. (3), (4) from Table B.1.

- NOTES: (1) The simulation results are in constant 1951 prices.
- (2) The "Actual" data are in 1948-49 prices for the years 1951 to 1966, while later years are in 1961 prices.

income lags somewhat towards the end of the period. This is probably because

- (i) population growth tends to slow down in DYNURB with increasing urbanization
- (ii) the last year for which actual data is available, 1974-75, was the third of a succession of bad years in India.

Table 5.5 shows the BASRUN growth rates of gross national product along with those for per capita national product.¹ The feature to note is the acceleration of growth rates. The DYNURB economy grows faster and faster with the passage of time. Estimates for growth in GNP in different periods for India are given below:

1949 to 1955	2.92 %
1954 to 1961	3.63 %
1961 to 1967	3.61 %
1949 to 1969	3.41 %
1954 to 1969	3.62 %

(Dholakia, p. 20)

Correspondence between these estimates and the BASRUN is good. The average for the later years, 1969-75, however, is not as high as suggested by DYNURB. This is partly because of unusually adverse weather conditions in the last 3 years in India.

¹In the Appendix Tables, gross product refers to total product inclusive of intermediate outputs, while Net income is Gross National Product.

Table 5.5 Growth Rates of National Product
(percent per year)

Year From 1951 to:	Growth Rates	
	GNP	Per capita
1954	3.45	1.49
1957	3.48	1.52
1960	3.51	1.55
1963	3.54	1.58
1966	3.56	1.61
1969	3.59	1.63
1972	3.61	1.66
1975	3.63	1.68
1978	3.65	1.70
1981	3.67	1.72
1984	3.69	1.74

SOURCE: BASRUN, Table A.12.

That DYNURB shows an accelerating trend of growth is no accident, since the savings rate is exogenously made to increase over time in the model.¹ Correspondingly, the Indian economy had a rising savings rate until about 1969-70, but has since remained stationary or declined -- as noted in the last chapter in Table 4.7. The model would be improved if the rising savings rate were made endogenous. It would

¹See Section 6.4 for discussion of the effects of changes in the savings rate.

then, perhaps, become stationary as a response to changes in other parts of the economy.

DYNURB's success in tracking the Indian development record over 25 years gives reason to believe that the structure of the model is plausible and that the parameters used are well founded even though they were not systematically estimated.

5.3 Population and Urbanization

One of the main objectives of DYNURB is to predict and explain the phenomenon of urbanization. The prediction is done by the results of the simulation while the explanation is embedded in the structure of the model. Further explanation is obtained in the next chapter when sensitivity tests are performed to evaluate the effects of parameter changes on the rate of urbanization. Being a general equilibrium model, chains of causality are not entirely obvious and therefore, sensitivity tests have to be used to obtain information on what causes what.

DYNURB regards all labour employed in the industry and service sectors, and their dependents, as being based in the urban region. Thus, as defined by equation (3.33), (Section 3.7) urban population is

$$\begin{aligned}
 \text{URBPOP}(t) &= \text{POP}_2(t) + \text{POP}_3(t) \\
 &= \frac{L_2(t)}{\text{WPR}_2} + \frac{L_3(t)}{\text{WPR}_3}
 \end{aligned}$$

and the index of urbanization is

$$\frac{\text{URBPOP}(t)}{\text{TOTPOP}(t)} \times 100 \quad ,$$

i.e. percent of population living in urban areas.

This definition of urbanization places in the urban region all labour that works in industry and services even if some of these activities are located in the rural region. This is clearly a shortcoming of the model but one which is difficult to avoid until more refined theories of industrial location are developed. Table 3.1 showed the distribution of workers by sector and region in India for 1961 and that table indicated the unimportance of industry and services to rural areas and of agriculture to urban areas. This misspecification is therefore not expected to affect substantially the workings of DYNURB except that the index of urbanization is and will always be over-stated.

Population: Although the population sub-model used is extremely simple, it tracks well the growth of population

in India. This is not altogether surprising since the growth rate parameters GURB and GRUR -- the natural growth rates of urban and rural population -- are exogenously specified. The total growth rate is, however, endogenous since the movement of labour from rural to urban areas is endogenous. Table 5.6 compares the BASRUN with actual values.

Table 5.6 Population (in millions)

<u>Year</u>	<u>BASRUN</u>	<u>Actual^a</u>
	<u>1</u>	<u>2</u>
1951	362	361
1961	430	439
1966	482	485
1971	540	548
1974	571	577
1981	640	695 ^b
1984	678	

SOURCE: (1) BASRUN, Table A.8

(2) a. Up to 1974, G.O.I. (1974), p. 2,
(taken from Indian Census).

b. 1981, Bose (1973), p. 423, estimate.

The main point to note is that the growth of population slows down in DYNURB in later years as compared with actual data from India. This would indicate somewhat faster

urbanization and industrialization in DYNURB. (Bose's estimate for 1981 seems far too high: his estimate for 1971 of 560 million was also high.) In summary, the population sub-model in DYNURB performs well but would be improved if it was made more elaborate to take account of changing age structure, etc.

Urbanization: The problems in the definition of urban population alluded to above can cause difficulties in comparisons with actual values. Table 5.7 shows the trend of urbanization in the BASRUN.

Table 5.7 BASRUN Trend of Urbanization: 1951-1984

<u>Year</u>	<u>Urban Population (in millions)</u>	<u>% Urban</u>
1951	96.7	26.73
1957	115.3	28.41
1963	136.6	30.04
1969	100.9	31.57
1975	188.5	33.00
1981	219.7	34.31
1984	237.2	35.01

SOURCE: BASRUN, Table, A. 8.

The growth rate of urban population from 1951 to 1960 is 2.96 percent per year and from 1951 to 1972 it is 2.84

per cent per year in the BASRUN. Table 5.8 gives the actual data on urbanization in India since the beginning of this century.

Table 5.8 Trend of Urbanization in India: 1901 - 1971

<u>Year</u> <u>Year</u>	<u>Urban Population</u> <u>(in millions)</u>	<u>% Urban</u>
1901	25.85	10.85
1911	25.94	10.29
1921	28.08	11.18
1931	32.45	12.00
1941	44.15	13.86
1951 .	62.45	17.30
1961 .	78.93	17.98
1971	108.89	19.87

SOURCE: Bose (1973), p. 63.

With the differences in the definition of urban population, the only reasonable statistic that may be comparable is the growth rate of urban population. From 1951 to 1961 the growth rate was 2.64 per cent per year, and that from 1951 to 1971 was 2.96 per cent per year. These rates compare well with the BASRUN growth rates but with one major difference. The rate of urbanization appears to be slowing down in DYNURB while it is increasing in India. One explanation of this

could be that the actual number for 1951 is higher than 'normal' because of the dislocations resulting from independence. The absorption of millions of refugees into productive work in the cities could have had the effect of dampening 'demand for rural urban migration' during the 1950s. This, however, is speculation: the differences in growth rates could merely be because of the definitional differences.

It is worth recalling at this point that all labour in DYNURB is always fully employed which is clearly not true in reality. If it is true, as some contend, that urban unemployment has risen over the past 10-15 years, then the trends that DYNURB shows are, in some sense, the trends that 'ought' to be for the country not to be "over-urbanized". According to this interpretation, urban unemployment rates are a better index of over-urbanization than a comparison with some norm derived from international country data. An improvement of DYNURB which could allocate some industry and service employment to rural areas would give better answers to the appropriate level of urbanization as a country develops over time.

5.4 Structural Change in the Developing Economy

Table 5.3 showed the stationary nature of the Indian economy in the first fifty years of this century. Compared

with some other faster growing economies, structural change in India has been minor in even the post-independence period. There has, however, been a perceptible change in structure with agriculture contributing a smaller share of output over time and resulting in a shift of labour to urban pursuits. This section shows the change in sectoral shares of output along with the redistribution of labour accompanying these changes.

Table 5.9 shows the percentage shares of output in the three sectors as computed in the BASRUN and the actual numbers for the Indian economy. This table involves comparability problems as well:

- i) All computations in the BASRUN are in 1951 prices while the Indian national accounts system has changed from 1948-49 prices to 1960-61 prices for the computation of constant price series. As evident in Table 5.9, this change makes such a significant difference that the series prior to 1961 is really not comparable with the later series.
- ii) There is a further problem internal to DYNURB. Table A.10 which shows the terms of trade in the economy, shows that the relative price of service goods was about 0.8 in the first period. [As indicated in section 3.9, prices are normalized in every period on the initial period weights such that $\sum_i S_i P_i = 1.0$ where S_i are the initial period sectoral production weights].

Table 5.9 Structural Change in the Developing Economy:
Sectoral Output Shares

(in percent)

Year	<u>Agriculture</u>		<u>Industry</u>		<u>Services</u>	
	BASRUN	Actual	BASRUN	Actual	BASRUN	Actual
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
1951	57.4	48.8	22.1	21.3	20.5	29.9
1954	55.8	48.9	23.1	20.8	21.2	30.3
1957	54.3	47.7	23.9	21.4	21.8	30.9
1960	52.7	46.5	24.9	21.5	22.4	32.0
1963	51.1	48.7	26.0	25.5	22.9	25.8
1966	49.5	43.8	27.1	28.4	23.5	27.8
1969	47.9	44.8	28.0	27.7	24.1	27.5
1972	46.3	44.0	29.1	28.0	24.6	28.0
1975	44.7	42.6 ¹	30.2	28.3 ¹	25.1	29.1 ¹
1978	43.0		31.5		25.5	
1981	41.6		32.5		25.9	
1984	40.0		33.8		26.3	

SOURCE: Cols. 1, 3, 5. BASRUN, Table A.2.
 Cols. 2, 4, 6. 1951-1960, Mukherjee (1969), p. 176,
 1949 prices.
 1961-1974, G.O.I. (1976), p. 14,
 1961 prices.

Note 1: These figures are for 1974.

Correspondingly, the price of agricultural goods was somewhat greater than 1.0. If both the demand and supply sides were modelled correctly, all initial period prices would be unity. As indicated in section 4.21, the production function scaling parameters (B_i) were calculated to tune initial period production in DYNURB as closely as possible to Indian data -- with prices being assumed to be unity -- for each good. Prices had to be altered in finding a general equilibrium solution such that all markets were cleared. That the price of services changed as much as 20 per cent is an indication that the demand system could be modelled better. This is clearly a shortcoming of DYNURB which should be kept in mind when evaluating its results. The result of this price distortion is that the share of agricultural production is overstated while that of services is understated in the initial period and all following periods. The trends, however, may not be as seriously affected.

Table 5.9 shows that the share of agriculture declines from 57.4 percent to 41.6 percent, industry increases from 22.1 percent to 33.8 percent and services from 20.5 percent to 26.3 percent as the DYNURB economy develops at a modest rate of growth. In light of the remarks above, it is worth noting that the share of agriculture is consistently overstated in DYNURB and that of services, understated.

Correspondence with the post 1960 series is good. The industrial sector has the highest relative growth although the service sector is not far behind. This validates one of the main contentions of this work: that the shift in structure from agriculture dominated activities can be properly understood when it is seen to be a parallel shift to industry and services.

Having seen the relative changes in the structure of the economy, it is also important to consider the absolute changes in each sector. Table 5.10 shows the growth of product in each sector. Comparison with actual data is once again difficult. The trend of agricultural production is easiest to follow since there are few definitional problems. It is seen that agricultural production in DYNURB lags actual Indian data. This is partly because of the overvaluation of initial period production but partly a shortcoming of the dynamic model. The actual data for industry are for only the organized part of industry and therefore, for only a sub-sector of industry as defined in DYNURB. The comparison with DYNURB is consequently only for illustrative purposes. The main point to note from Table 5.10 is that in a growing economy like DYNURB, industry grows at the highest rate, services somewhat less faster, and agriculture the lowest. In 30 years, from 1951 to 1981, the gross national product grew at 3.67 per cent

Table 5.10 Growth of Sectoral Output
(Index 1951 = 100)

Year	<u>Agriculture</u>		<u>Industry</u>		<u>Services</u>	
	<u>BASRUN</u>	<u>Actual</u>	<u>BASRUN</u>	<u>Actual</u>	<u>BASRUN</u>	<u>Actual</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
1951	100	100	100	100	100	N.A.
1957	116	122 ¹	132	143 ¹	130	--
1963	135	146	178	219	170	--
1969	157	167	239	294	221	--
1975	183	191 ²	322	330 ²	288	--
1981	213		433		373	--
1984	230		504		424	--

SOURCE: Cols. 1, 3, 5. BASRUN, Table A.2.
 Cols. 2,4. Indian Planning Commission:
 Statistics and Survey Division
Basic Statistics Relating to Indian
 Economy, 1950-51 - 1970-71.

Notes 1. These figures are for 1956.
 2. These figures are for 1971.

per year, agriculture at 2.56%, industry at 5.01% and services at 4.49%. (See Table A.13) In comparison, the actual growth rates of agriculture and non-agricultural product were as follows:

	<u>Agriculture</u>	<u>Non-Agriculture</u>
1952-1961	3.1%	4.9%
1962-1971	2.7%	5.1%

(Ahluwalia (1976) p.9)

Thus, although it is not entirely clear how closely DYNURB replicates the structural changes in the Indian economy according to the three sectors defined, its performance is close enough to the agriculture/non-agriculture dichotomy to give confidence in its basic structure.

Redistribution of Labour Force: The rural/urban movement of labour has already been covered. Now the changing composition of labour force structure by sector of employment is given attention. Once again, comparability with actual data is difficult. The change in the definition of workers in the 1971 census makes comparability with earlier years almost impossible. The main change took place in the definition of female workers. The only consistent series that could be found was in Dholakia (1974), but that only goes up to 1969 and distinguishes workers as agricultural and non-agricultural. Table 5.11 therefore, presents comparisons with total labour force in DYNURB and with those employed in agriculture. Only spot comparisons are possible for the other two sectors. These are presented below in Table 5.12.

DYNURB is seen to track the redistribution of the labour force well, though the change is somewhat faster than the actual data would seem to indicate. This may be attributed to the assumption of full employment in DYNURB. If, indeed, there is substantial surplus or underemployed labour in the

Table 5.11 Structural Change in the Developing Economy:
Sectoral Labour Shares

Year	Labour Force (in millions)				Employment Shares (%)			
	Total		Agriculture		Agriculture		Ind. Serv.	
	BASRUN	Actual	BASRUN	Actual	BASRUN	Actual	BASRUN	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
1951	160.0	161.4	119.3	118.8	74.6	73.6	10.5	14.9
1954	169.3	167.5	124.7	123.0	73.7	73.4	10.9	15.4
1957	179.1	175.5	130.7	128.5	73.0	72.2	11.2	15.9
1960	189.7	185.2	136.8	135.2	72.2	73.0	11.5	16.3
1963	200.7	195.4	143.2	141.4	71.4	72.4	11.9	16.7
1966	212.3	206.4	149.9	147.8	70.6	71.6	12.2	17.1
1969	224.5	218.6	156.9	156.8	69.9	71.7	12.5	17.6
1972	237.6		164.5		69.2		12.9	17.9
1975	251.4		172.2		68.5		13.2	18.3
1978	266.1		180.4		67.8		13.6	18.6
1981	281.6		189.3		67.2		13.9	18.9
1984	297.9		198.2		66.5		14.3	19.2

SOURCE: Cols. 1,3,5,7,8. BASRUN, Table A.4
Cols. 2,4,6. Dholakia (1974), pp. 97, 102.

Table 5.12 Structure of Labour Force: Spot Comparisons

No. of Workers (millions)

Sector	1951		1961	
	Actual	BASRUN	Actual	BASRUN ¹
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Agriculture	118.0	119.3	137.6	136.8
Industry	18.0	16.9	23.0	21.9
Services	24.0	23.8	20.2	30.9

SOURCE: Cols. 2, 4: BASRUN, Table A.4. Col. 4 is for 1960.

Col. 1 Table 4.13.

Col. 3 Bose (1973), p. 304.

agricultural sector, the actual working force data would show a larger proportion of labour in that sector. The changes in these proportions are however, too small to make definitive statements.

In comparing Table 5.11 with 5.9, one trend stands out. The changes in the sectoral shares of output are far greater than the accompanying changes in labour force distribution. Share of agricultural output declines far more than the share of agricultural labour force. This indicates relatively faster growth in labour productivity in the urban region.

5.5 Capital Accumulation

Among series of economic magnitudes, that of capital stock is probably the most hazardous to estimate. There is no official series of total capital stock in India. The normal procedure is to make an estimate for some base year, and then to carry it forward by using capital formation information which is available in national income accounts. In India, the problem is further complicated by the existence of a large agricultural sector where capital stocks are even more difficult to evaluate and estimate. This is borne out by the discrepancy between two estimates presented in Table 4.14 in the last chapter. The discrepancy was greatest for the agriculture sector and least for the industrial sector -- which is not cause for surprise.

Table 5.13 shows investment as a proportion of national product. This rises continuously in the BASRUN partly because of the assumption of an increasing savings rate. The actual series also has an increasing trend until the late sixties but is then stagnant.

Table 5.13 Investment as a Proportion of G.N.P.
(in percent)

Year	BASRUN		Actual	
	Gross	Net	Gross	Net
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1951	11.5	5.9	11.8	6.6
1954	12.1	6.5	9.8	7.6
1957	12.7	7.0	17.4	12.6
1960	13.3	7.6	14.9	9.6
1963	13.9	8.1	15.9	10.2
1966	14.6	8.6	19.1	13.4
1969	15.2	9.2	18.0	12.1
1972	15.9	9.7	17.2	13.1
1975	16.7	10.2	17.2 ¹	14.5 ¹
1978	17.4	10.7		
1981	18.1	11.3		
1984	18.9	11.8		

SOURCE: Cols. 1,2 BASRUN, Table A.7.

Cols. 3,4 Up to 1969, Dholakia (1974), p. 197.
After 1969, G.O.I. (1970) p. 32.

Note (1): These figures are for 1974.

On the whole, though, the actual investment series is quite volatile: indeed some of its variations are masked because data is presented for only three year intervals. It would be preferable if the investment function were more behaviorally based rather than being identically equal to savings. This is difficult since there is even little theoretical agreement on the behavioral determinants of investment rates. It is seen that the simulated investment rates do not correspond very well to actual rates when compared annually. The trends of capital stock are, however, not too different since many discrepancies between actual and simulated magnitudes get averaged out in the long run.

Table 5.14 shows the trends in the accumulation of capital stock in the BASRUN as compared with actual estimates. Once again, the only consistent series found were from Dholakia (1974) but even these had only an agriculture/non-agriculture sectoral breakdown. The actual magnitudes are not comparable since the BASRUN used Mukherjee's estimates as initial period values. The trends, however, of the BASRUN and of actual values are in surprisingly close agreement which again lends support to the plausibility of the model. Agreement between the two sets of series is somewhat less close for the sectoral capital stock series, though even these are not too far apart. DYNURB invests more in agriculture and less in industry and services as

Table 5.14 Trends in the Accumulation of Capital Stock in India

(Index 1951 = 100)

(at constant prices)

Year	Total		Agriculture		Industry	Services	Non. Ag.
	BASRUN	Actual	BASRUN	Actual	BASRUN	BASRUN	Actual
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
1951	100	100	100	100	100	100	100
1954	111	109	107	110	112	113	108
1957	125	128	117	125	126	127	129
1960	141	141	130	138	143	145	142
1963	161	160	146	149	163	167	165
1966	184	187	165	162	187	192	197
1969	213	215	190	177	214	223	231
1972	246		219		247	259	
1975	286		254		286	303	
1978	334		297		333	353	
1981	390		350		386	414	
1984	457		413		450	485	

SOURCE: Cols. 1,3,5,6 BASRUN, Table A.4.
 Cols. 2,4,7 Appendix, Table B.2.

compared with the Indian record. This could be interpreted to mean that the Indian industry and/or service sectors are either over capitalized, or that capital in them is under-utilized. Note from Table 5.14 that as the economy develops,

the service sector capital stock increases faster than that in the industrial sector. The importance of the service sector in a developing and urbanizing economy is therefore underscored once again.

Capital-Labour Ratios: Table 5.15 shows the trends in economy wide as well as sectoral capital labour ratios. These are for "unaugmented" capital and labour. Note the vast difference in initial period ratios between agriculture and the other two sectors. This difference, perhaps, is the most dramatic illustration of dualism in this 2-region economy. As one would expect in a dynamic general equilibrium system, albeit a lurching one, there is a slow trend towards equalization of the capital/labour ratios over time. With the imposed inter-region wage structure, this equalizing trend cannot, of course, ever be accomplished. Further distortions in this equalizing trend are caused by the differential rates of factor augmentation between the three sectors. Note that the agriculture capital/labour ratio accelerates its rate of increase in later years: this conforms with the experience of almost all developing systems.

Table 5.15 Capital Labour Ratios in the BASRUN

(Index: 1951 = 100)

Year	Economy	Agriculture	Industry	Services
	<u>1</u>	<u>2</u>	<u>3</u>	
1951	100 (0.9219)	100 (0.2802)	100 (2.9012)	100 (2.7408)
1954	105	103	102	103
1957	111	107	106	107
1960	119	114	110	112
1963	128	122	115	118
1966	139	132	121	125
1969	151	144	128	134
1972	166	159	136	145
1975	182	177	145	156
1978	200	197	155	170
1981	221	221	166	185
1984	246	249	178	202

SOURCE: BASRUN, Table A.11

Note: Figures in parenthesis are the initial period K/L ratios.

5.6 Behaviour of Prices

DYNURB is a wage and price endogenous model so the movements of these magnitudes are of interest. Indeed, the model is brought into equilibrium in each period by altering

commodity prices on the demand side and factor prices on the supply side.

Commodity Prices: One of the more interesting results of DYNURB is the change in relative prices that it indicates over the thirty-year period. It has already been remarked upon that the initial period service sector price is far too low in equilibrium. Table 5.16 shows the terms of trade in terms of agricultural prices. What is unmistakable is that agricultural goods become relatively more expensive over the whole period and would continue to do so were the simulation run for a longer period. The actual record -- as far as can be ascertained -- shows a similar trend though it really only started around 1960. Between 1950 and 1960, relative prices had really remained essentially unchanged. DYNURB, of course, shows a regular trend in the decline of both industry and service relative prices. One estimate of relative price changes in India is shown in Table 5.17 below.

The trend of a faster rate of change in agricultural prices is clear from the above mentioned table. The changes in the first decade were minimal, but changes since then have been significant. Thus, DYNURB is substantially correct in the terms of trade variations that it shows.

Table 5.16 Terms of Trade

(Relative to Agriculture)

Year	BASRUN		Actual	
	Industry	Services	Industry	Manuf.
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1951	100	77	99	104
1954	99	76	96	102
1957	98	76	98	101
1960	97	75	98	101
1963	96	74	101	98
1966	95	73	88	85
1969	93	71	86	
1972	92	70	84	
1975	90	69		
1978	89	67		
1981	87	66		
1984	86	65		

SOURCE: Cols. 1,2. BASRUN, Table A.10
Col. 3. S. Chakravarty (1973) p. 12.
Col. 4 Ford Foundation (1976) p. 5.05.

Table 5.17 Actual Annual Per Cent Change in Implicit Price Deflator for G.D.P.

(all in percent/yr)

<u>Years</u>	<u>Total</u>	<u>Agriculture</u>	<u>Non-Agric.</u>
	<u>1</u>	<u>2</u>	<u>3</u>
1952-61	0.42	0.75	0.27
1962-71	6.14	7.36	5.27
1972	4.32	4.89	4.32
1973	8.78	14.94	5.32

SOURCE: Isher J. Ahluwalia (1976), p. 8.

Several caveats are in order here:

- (i) Service Sector: It is not made clear here what the unit of services is. Section 2.2 alluded to some of the difficulties involved in the definition of quantities in the service sector. That the initial period service price is 0.77 relative to agricultural goods indicates that either something is wrong with the service production function, or with the modelling of the demand side. This is a shortcoming of DYNURB but is also an index of the underdeveloped state of knowledge on the service sector.

- (ii) Price Indices: The actual price series are obviously indices of whole sets of prices. They are amalgams of prices of different products and of prices in different areas. Thus, they do not have as clear meanings as the prices in DYNURB's 3 - good economy. They are subject to the normal index number problems. Furthermore, the extent of coverage of the prices shown in Table 5.16 is not clear.
- (iii) Food Imports: It must be recalled here that DYNURB is a closed economy while food prices, in reality, in India, are significantly affected by the volume of food imports. On the whole, therefore, agricultural prices calculated in DYNURB should be over-estimates. Government influence on food prices is always to keep them down for obvious political reasons.

What Table 5.16 shows is the likely movement in relative prices, were India a closed economy. The extent of this movement is surprisingly large and points to the long term problem of containing food prices without the use of large scale food imports. It is important to realize that the trend shown in the BASRUN is a secular trend caused by the behavioral and technological assumptions underlying the structure of DYNURB. Since these are regarded as realistic, the results are of importance. In reality, such a trend cannot continue

indefinitely: it indicates conditions which are likely to induce technical change so that agricultural goods can be produced more efficiently and therefore reverse or halt the rising trend. Modelling such a structural change is, however, beyond the scope of DYNURB.

Factor Prices: It may be recalled that although factor prices are determined as marginal value product in DYNURB, they are not equalized across sectors because:

- 1) there is an imposed inter-region wage structure such that urban wages are greater than rural wages.
- 2) the rates of factor augmentation differ between sectors.

Thus, the absolute levels of urban and rural wages (for efficiency units) differ by a constant proportion, but their trends over time are identical. Table 5.18 reports the changes in wages and capital rentals -- both for efficiency units as well as for augmented units. In the case of labour, augmented units are interpreted to be actual people in man-equivalent units. For capital, however, there is the classic problem of defining what a unit is and further, what an augmented unit is. Table 5.18 reports these magnitudes for the agriculture sector only while details for other sectors are given in the Appendix, Table A.5

It is seen that real wages per man rise continuously over the period, while capital rentals, decline. Evidence on the actual trends of these magnitudes is scanty. It can, however, be said with certainty that even if wages have risen in India in all the three sectors, they have not risen by as much as 40 per cent as shown in Table 5.18. What evidence there is shows that real wages have either remained roughly constant since 1951, or have shown a slight rising trend. Actual numbers are difficult to compare with here because:

- 1) There is full employment and the simulation wages equal labour's marginal product in each sector.
- ii) They also include the self-employed sector where wages are only imputed.
- iii) They are indexes for the whole country, and across sub-sectors, while in reality, wages differ across regions and across industries. In particular, in agriculture, wages have risen significantly in the green revolution, i.e., high productivity areas, and even declined in the low productivity areas, e.g. in the whole Eastern region.

Evenson and Oomen (in their unpublished tentative paper) found that industrial wages were substantially below labour's marginal product in India. The results of DYNURB tend to support that finding, since real increases in wages do not match those shown by DYNURB.

It is even more difficult to find real magnitudes that correspond to the notional capital rentals. That these have declined, i.e., that the marginal product of a unit of

Table 5.18 Wages and Capital Rentals Per Efficiency Unit
and Per Actual Unit in Agriculture

(Index: 1951 = 100)

Year	WAGES		RENTAL	
	per Efficiency Unit	per Man	per Efficiency Unit	per Augmented Unit
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1951	100.0	100.0	100.0	100.0
1954	100.2	104.0	98.6	101.6
1957	100.6	108.4	95.9	101.8
1960	101.2	113.1	92.7	101.4
1963	101.9	118.3	88.7	100.0
1966	102.8	123.9	84.3	97.8
1969	103.9	130.0	79.4	95.0
1972	105.1	130.4	74.4	91.7
1975	106.3	143.2	69.5	88.3
1978	107.6	150.5	64.6	84.5
1981	108.9	158.1	59.7	80.5
1984	110.3	166.2	55.1	76.5

SOURCE: BASRUN, Table A.5

capital has declined, would be consistent with observed rising capital output ratios. Kelley and Williamson (1974) also found a declining trend in capital rentals for Japan in the Meiji period and explained it by saying that real interest

rates had declined over the period. If the latter is true for India is not clear, since it is difficult to derive a real interest rate series. With rising capital/labour ratios, as was seen in the last section, it is not surprising that wage/rental ratios are increasing. If the investment rate was more behaviorally based, the causation would be the opposite: a rising wage-rental ratio would be seen to lead to substitution of capital for labour. Here the investment rate is not sensitive to rental rates. But it is behaviourally based to the extent that savings rates in DYNURB model reality well and are then made identically equal to investment. One can then argue that capital is being substituted for labour in response to rising wage-rental ratios, leading to rising capital/labour and capital/output ratios. Larger productivity increases could arrest the rise in capital/output ratios and the decline in capital rentals.

Factor Shares: Table 5.19 reports the factor shares for each sector and for the economy as a whole. Recall that in agriculture, capital and labour together have a fixed share of income (67 percent) but are combined in a C.E.S. production function. The other two sectors have only capital and labour as inputs and have C.E.S. production functions. Table 5.19 shows the share of labour to be decreasing in agriculture, while increasing in the two urban sectors and

Table 5.19 Factor Shares
(percent)

Year	BASRUN				Actual (Economy)		
	Share of Labour				Labour Capital Mixed		
	Agric. 1	Ind. 2	Services 3	Economy 4	5	6	7
1951	54.96	60.66	68.53	58.79			
1954	54.96	60.84	68.58	58.95			
1957	65.91	61.14	68.71	59.08			
1960	54.86	61.52	68.88	59.23	34.5	15.0	50.5
1963	54.76	61.98	69.09	59.34	36.5	16.6	46.9
1966	54.68	62.55	69.33	59.46	36.2	16.3	47.5
1969	54.61	63.21	69.64	59.59	36.5	14.3	50.2
1972	54.54	63.92	70.02	59.71	36.6	14.9	48.5
1975	54.41	64.63	70.30	59.74			
1978	54.33	65.44	70.71	59.81			
1981	54.18	66.24	71.06	59.78			
1984	54.07	67.07	71.46	59.77			

SOURCE: Cols. 1,2,3,4. BASRUN, Table A.9.
Cols. 5,6,7. G.O.I. (1976), p. xxxi.

in the economy as a whole. The distribution of income is also difficult to compare with actual values because of the presence of a high proportion of self employed in a largely agricultural economy like that of India. The share of

employees, shown in column 5 is seen to be clearly rising, a trend which supports the results of DYNURB. In agriculture, Evenson and Jha (1974) reported a decreasing labour share along with rising shares of capital and land, though this varied across states. The results of DYNURB are therefore corroborated.

5.7 Consumption Behaviour

The demand system in DYNURB is designed to model plausibly the behaviour of consumers in the economy. As mentioned in previous sections and in the last chapter, the Stone Linear Expenditure System used in DYNURB is less than perfect but is probably the best demand system that can be used for the purposes at hand.

Table 5.20 reports the trends of the shares in consumption expenditure of each of the three commodity groups for the agriculture and industry based populations. The behaviour of the service population is not reported, since it is essentially similar to that of the industrial population.¹ The following points are worth noting:

¹Full details are found in Appendix, Table A.6. The small difference between the industry and service populations are because of the different augmentation rates of industrial and service labour.

Table 5.20 Shares of Agricultural, Industrial and Service Goods and of Subsistence in Consumption Expenditures
(percent) in BASRUN

Year	Agriculture Sector				Industry Sector			
	Agric. Goods	Industry Goods	Service Goods	Subsistence	Agric. Goods	Industry Goods	Service Goods	Subsistence
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>
1951	72.2	11.6	16.2	53.7	49.6	13.4	37.0	32.8
1954	71.2	12.0	16.8	52.0	48.7	13.7	37.6	31.7
1957	70.2	12.4	17.4	50.4	48.0	13.9	38.1	30.7
1960	69.2	12.8	17.9	48.7	47.3	14.1	38.6	29.7
1963	68.2	13.2	18.5	47.1	46.7	14.2	39.1	28.9
1966	67.3	13.6	19.1	45.5	46.0	14.4	39.6	28.1
1969	66.3	14.0	19.6	43.9	45.5	14.5	40.0	27.3
1972	65.4	14.4	20.2	42.4	44.9	14.7	40.4	26.6
1975	64.5	14.8	20.7	40.9	44.4	14.8	40.8	25.9
1978	63.7	15.1	21.2	39.4	43.9	15.0	41.1	25.2
1981	62.8	15.5	21.7	38.1	43.5	15.1	41.4	24.6
1984	62.0	15.8	22.1	36.1	43.0	15.2	41.8	24.0

SOURCE: BASRUN, Table A.6

- i) Share of Food: Over 30 years, the share of food in the consumption expenditure of the rural population declines from about 72 to 62 percent. The surprising thing is not that it declines, but that the decline is slow. The corresponding decline in the industrial population is from 50 to 43 percent. That this decline is slow, is an indication of low level of the economy at the beginning of the period and of the modest nature of its growth, though significant. Such consumption data are available on a continuing basis from the National Sample Surveys (N.S.S.) in India. The decline in the share of food is not yet perceptible. This is not surprising, since in DYNURB the decline is of about 6 percent until 1969 at constant prices. The figures reported in the N.S.S. are at current prices and the relative rise in food prices therefore, partly accounts for the constancy of expenditure shares. The average food share reported in these surveys is in the region of about 70 percent for rural areas and about 58 percent for urban areas. (D.B. Gupta (1973), p.143), thus, lending support to the plausibility of DYNURB.
- ii) Urban/Rural Differences: Note that the large difference in consumption behaviour between urban and rural consumers is in the proportion of income spent on services.

- iii) Subsistence: Columns (4) and (8) of Table 5.20 show the proportion of consumption expenditure spent on subsistence requirements. The decline in these proportions is more dramatic than the decline in food shares. Almost half of rural expenditures are on food.

Income Elasticity of Demand

The ranges of the income or expenditure elasticity of demand for each good are as follows:

	<u>Agriculture</u>	<u>Industry and Services</u>
Rural	0.55 to 0.65	2.16 to 1.58
Urban	0.47 to 0.58	1.59 to 1.31

(See Table A.6 for details)

As shown in Section 3.5, in equations (3.27) and (3.28) $\eta_{1j} < 1$ and $\eta_{2,3j} > 1$ and each tends towards 1 as the subsistence component of expenditure decreases. Among the various estimates of expenditure elasticities, are those of D.B. Gupta (1973) and L. Jureen (1956).

These correspond well with the results of DYNURB although Jureen's estimates appear to be on the high side. Gupta's food figures are for foodgrains only, and therefore lower than the elasticities reported for DYNURB. It is

	<u>Food</u>		<u>Clothing</u>
	Jureen	Gupta (foodgrains)	Gupta
Rural	0.8	0.46 to 0.57	1.4 to 1.5
Urban	0.7	0.23 to 0.29	1.6 to 1.9

interesting to note that the income or expenditure elasticity for the demand for clothing is higher for rural areas than for urban areas. In a country as poor as India, industrial goods consumed consist mainly of clothing, particularly for rural people.

One of the shortcomings of the Stone demand system used which was pointed out in Section 3.5, was that the expenditure elasticities are the same for industrial and service goods, as long as neither is regarded as a subsistence good (i.e. $FMIN_{2,3} = 0$). This shortcoming is borne out by the results.

5.8 Technical Change and Sources of Growth

As discussed in Section 4.26, technical change is rather carefully specified in DYNURB. It is exogenous to the extent that labour and capital augmenting rates are exogenously specified as is the rate of neutral (unexplained) technical change GB_i . It is endogenous to the extent that the shares of each sector change endogenously as do the shares

of labour and capital in each sector. Table 5.21(a) shows the rate of growth of net output and the contribution to it

Table 5.21(a) Growth Accounting for Economy

(BASRUN)

(percent per year)

Year From 1951 to	Net Output 1	Contribution to Growth by:		
		Labour 2	Capital 3	Tech. Change 4
1957	3.48	1.13	0.67	1.51
1963	3.54	1.13	0.73	1.49
1969	3.59	1.13	0.78	1.48
1975	3.63	1.14	0.81	1.46
1981	3.67	1.14	0.83	1.45

SOURCE: BASRUN, Table A.16.

by labour, capital and technical change.¹ Technical change in DYNURB is not regarded as the residual, but is largely accounted for by the augmentation of labour and capital -- except for the exogenous change GB_1 in agriculture.

Table 5.21(b) presents Dholakia's estimates of the sources of growth in the Indian economy, but these are derived from the use of a Cobb-Douglas production function and therefore mask the biases in technical change. Growth in DYNURB is slightly over-stated because the DYNURB economy has no

¹Cols. 2,3 and 4 do not add up to Column 1 in Table 5.21(a) because the rates of growth of land and livestock are not reported here.

Table 5.21(b) Growth Accounting for Economy
 (Actual) (percent per year)

Years	Net Output	Contribution to Growth by		
		Labour	Capital	Tech. Change
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1949-69	3.24	1.29	0.92	0.93
1949-55	2.59	0.95	0.59	0.85
1955-61	3.97	1.33	1.02	1.56
1961-69	3.18	1.51	1.12	0.49

SOURCE: Dholakia (1974), p. 209.

'bad years' as does India in reality. The contributions to growth correspond well with reality (as reported by Dholakia). Some of the discrepancies may be explained by his inappropriate use of Cobb-Douglas functions -- as is discussed by Kelley and Williamson (1974, p. 113). The contribution by technical change is the most important while that by capital is the least. These results are a reminder that the importance of capital in growth is usually overstated, though clearly important. The increase in population (and labour force) also contributes to the growth of the economy.

Table A.16 in the Appendix shows the contribution of technical change in each sector to total technical change.

It may be surprising to some that the rate of technical change in agriculture is the biggest contributor.

Table 5.22(a) reports the sources of growth in each sector. Industry is the fastest growing sector in which the contribution to growth by capital is the greatest; labour contributes relatively more to services and to agriculture as a proportion of total sectoral growth. The rate of technical change

$$R_1 > R_2 > R_3$$

as was intended. Recall that there is a large component of exogenous (of the 'manna from heaven' type) neutral technical change in agriculture since reasonable capital and labour augmenting rates could not account for all the technical change in Indian agriculture as estimated by Evenson and Jha (1973). The contributions of capital and labour augmentation in each sector are reported in Appendix Table A.17. It is also seen that the bias of technical change is negative, (i.e. labour using and capital saving) in agriculture; and positive, (i.e. capital using and labour saving) in industry and services.

Table 5.22(b) reports Dholakia's sectoral estimates. His low estimates for agriculture have been discussed earlier and the discrepancy attributed to an erroneous estimation of total output growth rate in agriculture. Note that his

Table 5.22 (a) Growth Accounting by Sectors
(BASRUN) (percent per year)

Sector	Year From 1951 to	Net Output	<u>Contribution to Growth by</u>		
			Labour	Capital	Tech. Change
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1. Agriculture	1966	2.54	0.84	0.27	1.76
	1981	2.56	0.84	0.33	1.76
2. Industry	1966	4.96	1.82	1.59	1.31
	1981	5.01	1.88	1.56	1.33
3. Services	1966	4.50	2.00	1.36	1.11
	1981	4.49	1.93	1.40	1.12

SOURCE: BASRUN, Table A.17.

Table 5.22 (b) Growth Accounting by Sectors
(Actual) (percent per year)

Sector	Years	Net Output	<u>Contribution to Growth by</u>		
			Labour	Capital	Tech. Change
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
1. Agriculture	1948-69	1.88	0.84	0.32	0.56
2. Non- Agriculture	1948-69	4.79	1.46	1.79	1.49

SOURCE: Dholakia (1974), pp. 234, 239.

estimates of labour and capital contributions to growth in agriculture are rather close to those in DYNURB. Thus his rate of technical change calculated as the residual is very low. His estimates for the non-agriculture sector correspond well with DYNURB, though.

5.9 Summary

This chapter has reported the numerical results of the BASRUN simulation of DYNURB. While strict comparability with the actual record of Indian post-independence development has been difficult because of definitional and other problems, the plausibility of DYNURB as a model representing the development of a low income country is largely confirmed.

The simulation shows that the transfer of labour from rural to urban areas is as much to service sector occupations as to industrial occupations. Thus it is essential to study structural change in at least a 3-sector context as distinguished from the usual 2-sectors. As evidenced from the demand coefficients used in the simulation, the demand for services is particularly significant in urban areas and its neglect, therefore, would miss one of the most important components of structural change in a growing economy.

.

The representation of technical change as modelled is shown to be plausible. Its essential ingredients are:

- (i) A labour-saving bias in urban areas along with a capital saving one in rural areas.
- (ii) A higher rate of technical change in agriculture compared with the other two sectors. This is essential to provide enough food for the increasing population and for the increasing urban, i.e., non-rural based demand.
- (iii) Capital and labour augmentation account completely for technical change in the urban based sectors but 'unexplained' change is necessary in the agriculture sector.

The BASRUN also shows that even with a 'respectable' savings and investment rate a very low income economy like the one simulated has difficulty achieving very high rates of growth: particularly per capita growth when population growth rates are high. This is partly caused by the large proportion of consumption expenditures being required for food subsistence purposes. Thus, as population grows, much of the investment has to be directed towards agriculture to keep food production in line with population growth. Correspondingly, the pace of structural change, i.e., urbanization and industrialization, is slow.

Cause and effect are characteristically difficult to separate in a general equilibrium model. The next chapter provides a better idea of the underlying causes of structural change through the use of sensitivity tests of the model, now that its plausibility has been demonstrated.

6. India in the Year 1984: What Could Be Sensitivity Tests With DYNURB

6.1 Introduction

The last chapter provided justification for the use of DYNURB to study the structural changes in a low income country undergoing development. Cause and effect are characteristically difficult to disentangle in a general equilibrium model -- even when it is a relatively small one such as DYNURB. Moreover, as pointed out in Chapter 2, though small in size, DYNURB has a high degree of closure and hence the relationships among its parts are complex. Analytical results are virtually impossible so sensitivity tests have to be used to obtain a better understanding of the workings of the model and, by inference, of the economy it represents. Drawing strong conclusions from the results of sensitivity tests on a simulation model is, however, hazardous. It is not easy to distinguish results caused by technical quirks in a model from those that are consequences of the structure of the economy. Technically, sensitivity tests are used as a device to explore the behaviour of the system over an n -variable space. It would thus take an infinite number of tests to explore the whole space. The problem is then to conduct those tests that illuminate the space of most interest and relevance within feasible bounds of realism.

About 50 experiments were conducted, each of which involved a change in one of the parameters. Only 16 are reported here, being those of most interest. The issues investigated are:

1. The effects of different rates of population growth.
2. The importance of the pattern of demand in the growth process.
3. The degree of importance of capital formation.
4. The relevance of different degrees of friction in the system caused by transport costs.
5. The consequences of wage equalization between the two regions in the economy.
6. The role of different kinds of technology in the growth process.

Primary attention is given to the effects on urbanization in order to approach a dynamic theory of urbanization. Other structural effects are also investigated to shed light on the development process as a whole. In the way that it is difficult to choose the experiments that are of interest, it is also difficult to select the indicators of importance out of the mass of economic statistics that the model generates as output. Difficulties are also encountered in choosing the indices of change that can be easily comprehended and which provide for comparability between experiments. Kelley et.al. (1972) choose 'structural elasticities' to report their results. These are

$$\epsilon_{v_t} = \frac{\% \text{ change in variable at time } t}{\% \text{ change in parameter at time } t} .$$

To separate the dynamic changes from the static change, they define an 'adjusted structural elasticity' as:

$$\epsilon_{v_t}^* = \epsilon_{v_t} - \epsilon_{v_0} ,$$

i.e., the difference in each elasticity at time t compared with time 0. The change in parameter was standardized as a 1 percent change.

While this method provides a systematic way of comparing effects of different experiments, the elasticity statistic has little theoretical basis or intuitive appeal. Moreover, standardizing the change at 1 per cent only explores the effects within a very restricted parameter space from which few conclusions can be drawn for larger changes in as non-linear a model as this. The statistics reported here are not standardized but are different for different sets of variables according to what is appropriate for each. The criterion for choice is that of intuitive intelligibility. The changes in parameters are also not standardized, but are issue oriented.

However, the results of sensitivity tests are reported in a set format: each test yields 2 tables, one pertaining to urbanization and the other to other structural changes. They are explained on page 209.

The changes reported for the initial period are the comparative static results while changes in other years are dynamic results. These are often in opposite directions.

In experiments such as those on population growth, there are no changes in the initial period since a change in population growth does not affect the initial period.

One overall conclusion from the sensitivity tests performed, worth reporting at the outset, is that the dynamic general equilibrium system incorporated in DYNURB behaves much like a buffalo -- as does the Indian economy! Exogenous shocks, i.e. changes in parameter values, do not make radical differences in the growth path of the economy -- even when these changes are of a substantial magnitude. A shock in one component produces ripples across the economy and equilibrating forces are set in motion dampening the long run impact. This is what should be expected from a general equilibrium system with an unchanging structure. What is difficult to simulate and is not attempted here at all, is the response of the structure itself to these changes. If that were done, an even longer run model would be developed.

6.2 Population Growth

The experience of extremely high rates of urbanization in LDCs in recent decades has partly been attributed to high population growth rates. Thus, tests are conducted here to judge the quantitative effects of different rates of population growth. A range of tests was performed with small changes in the growth rates (GURB and GRUR) and with large changes. Tables 6.1 to 6.4 report the extreme results: those with

zero population growth and with a growth rate of 2.5 percent per year. The latter is high by Indian standards though Latin American population growth rates are characteristically in the region of 3 per cent.

The most interesting result is that with zero population growth, (ZPG), urbanization proceeds at a more rapid rate as shown in Table 6.1. In 33 years, the level of urbanization is about 42 percent as opposed to 35 percent in the BASRUN. The reasons are not difficult to find. With ZPG, the growth of per capita income is greater and with the income elasticity of demand for food being less than unity, the shift in consumption patterns toward urban goods is correspondingly faster. This shift would be even more significant if another demand system was used in which all income elasticities did not approach unity in the long run.¹ The absence of the additional demand for food from increased population and a faster shift to urban goods produces an increased demand for urban labour and consequently increasingly higher levels of urbanization. This result depends on the assumed rates of technical change which permit labour to be released from agricultural production. To the extent that agricultural terms of trade tend to deteriorate,

¹This distortion is not critical, as has been argued earlier, at low levels of income where subsistence requirements are still substantial.

(Table 6.2, line 9), it would be reasonable to expect an induced effect on the rate of innovation in agriculture. Indeed, the rate of technical change could slow down, thus requiring more labour in agriculture and consequently resulting in a slower urbanization rate. To predict such changes, a more sophisticated theory of technical change is required which, alas, DYNURB does not incorporate. Here only different possibilities can be investigated.

Although the rate of urbanization is increased significantly, the rate of growth of urban population obviously declines. The important point, however, is that these growth rates are significant (line 3, Table 6.1), even with the extreme assumption of ZPG. With more reasonable assumptions, i.e., natural population growth rates of between 1 to 2 percent per year, the rate of growth of urban population is in the range of 2.0 to 2.5 percent per year as compared with about 2.8 percent in the BASRUN. The lesson then is that a decrease in the natural growth of population will not remove urbanization problems of L.D.C.S. The six to seven percent urban population growth rates characteristic of some Latin American countries would only decline to 4 to 5 per cent if the natural population growth decreased to about 1.5 percent from the current 3.0 percent a year.

Lest these conclusions be taken too far, it is worth recalling that the definition of urban population in

(contd. on p. 210
after Table 6.1)

NOTES ON TABLES ON SENSITIVITY TESTS

Results of experiments are reported in two tables in each case. Odd numbered tables report the effect on urbanization and even numbered tables report those on other key economic indicators. Explanation of Tables:

A. Effect on Urbanization

1. NEWRN - the results of simulation with the change in parameter as noted above the table.
2. Percentage Difference - percentage change in variable at time t as compared with value in the BASRUN.
3. Growth Rate of Urbanization: This is the growth rate of the urbanization level, i.e. the growth rate of the share of urbanization.
4. Growth Rate of Urban Population: This is the growth rate of total population in urban areas.

B. Effect on Other Key Economic Indicators

1. BASRUN 1951 Value: This is the value or level of the variable in 1951 in the BASRUN. Eg. 915 is the value of GNP in 1951.
2. Growth Rates: All growth rates are based on the initial period, i.e., 1951. Thus the growth rate reported under 1972 is that from 1951 to 1972.
3. Actual Difference in Percentage Share: The changes in output and labour share are reported as the actual differences in percentage share as compared with the BASRUN in the same year. Thus, if share of agriculture is 50% in 1963 in the BASRUN and actual difference reported is -1.61, then the share of agriculture is 48.39% in 1963 in the NEWRN.
4. Percentage Changes - are reported for all the other variables: K/L ratio, W/R ratio (wages/rental), wages, K rentals, Urban Terms of Trade and Net Investment/GNP. Thus if K/L ratio is 1.00 in 1963 in the BASRUN and percentage change reported is 20.6%, the NEWRN value is 1.206 in 1963.
5. Wages, K Rentals: Only agriculture wages and K Rentals are reported, since the others are directly proportional. These are returns to efficiency units.

Table 6.1 Experiment No. 1Zero Population Growth GURB = GRUR = 0.0

<u>EFFECT ON URBANIZATION</u>			<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN		26.73	30.04	32.25	35.01
	NEWRN		26.73	33.01	37.01	41.74
(% Difference)				9.87	14.74	19.23
2. Growth Rate of Urbanization	BASRUN			0.98	0.90	0.82
	NEWRN			1.77	1.56	1.36
(% Difference)				81.25	73.73	65.61
3. Growth Rate of Urban Population	BASRUN			2.92	2.84	2.76
	NEWRN			1.80	1.59	1.39

(contd. from p. 208)

DYNURB is less than perfect in that it is assumed that all industry and service employment is in urban areas. Pros and cons of this assumption have been discussed earlier so they will not be repeated. It is only noted here to indicate that conclusions on urbanization are being offered with full cognizance of this limitation but are still considered to be valid.

It is worth delving further into the simulation results to understand the mechanism in DYNURB which produces these results. The most dramatic result in the ZPG simulation is the reversal in the terms of trade making

TABLE 6.2 Experiment No. 1Zero Population Growth: GURB=GRUR=0.0

Variable		BASRUN 1951 Value	Year			
			1951	1963	1972	1984
1. GNP Growth Rate	BASRUN	915	-	3.54	3.61	3.69
(% per year)	NEWRN	915	-	2.42	2.43	2.44
2. GNP Per Capita Growth Rate	BASRUN	0.25	-	1.58	1.66	1.74
(% per year)	NEWRN	0.25	-	2.39	2.40	2.41
3. Output Share	Agriculture	57.4	0	-1.61	-1.83	-1.18
(Actual Difference	Industry	22.1	0	0.50	0.62	0.23
in % Share)	Services	20.5	0	1.11	1.21	0.94
4. Labor Share	Economy	58.8	0	0.84	1.63	3.18
(Actual Difference	Agriculture	55.0	0	-0.16	-0.31	-0.43
in % Share)	Industry	60.7	0	1.38	2.01	2.54
	Services	68.5	0	0.64	0.87	1.17
<u>Percent Changes</u>						
5. K/L Ratio	Economy	0.92	0	20.61	32.19	44.16
6. W/R Ratio	Agriculture	2.19	0	15.76	24.66	34.41
7. Wages	Agriculture	0.2661	0	9.21	15.77	24.75
8. K Rental	Agriculture	0.1213	0	-5.67	-7.13	-7.19
9. Terms of Trade	Urban	89.6	0	4.97	9.78	17.42
10. Net Investment/GNP (Percent)		5.9	0	-6.00	-7.21	-6.91

Table 6.3 Experiment No. 2High Population Growth: GURB = GRUR = 0.025(BASRUN GURB = 0.017
GRUR = 0.020)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWNR	26.73	29.14	30.88	32.74
	(% Difference)	-	-3.00	-4.25	-6.50
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWNR	-	0.72	0.69	0.62
	(% Difference)		-26.18	-23.20	-24.98
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWNR	-	3.23	3.20	3.12

urban goods more expensive. This has a dampening effect on the demand for urban goods including capital goods. The proportion of net investment to GNP declines: the economy endogenously adjusts for a slower population growth rate. The converse happens with an increase in population growth (Table 6.4): the proportion of investment increases, thereby mitigating somewhat the negative effect on per capita incomes. Note, however, that the change in investment decreases in later years and would probably equal the BASRUN in a long enough simulation in both cases. The economy therefore has built in stabilizing influences over the long run which can

TABLE 6.4 Experiment No. 2

High Population Growth : GURB=GRUR=0.025

(BASRUN : GURB = 0.017)

GRUR = 0.020)

Variable		BASRUN 1951 Value	Year			
			1951	1963	1972	1984
1. GNP Growth Rate	BASRUN	915	-	3.54	3.61	3.69
(% per year)	NEWRN	915	-	3.86	3.96	4.05
2. GNP Per Capita Growth Rate (% per year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRN	0.25	-	1.34	1.43	1.52
3. Output Share	Agriculture	57.4	0	0.59	0.57	0.81
(Actual Difference in % Share)	Industry	22.1	0	-0.30	-0.17	-0.33
	Services	20.5	0	-0.29	-0.41	-0.48
4. Labor Share	Economy	58.8	0	-0.18	-0.41	-0.83
(Actual Difference in % Share)	Agriculture	55.0	0	0.07	0.07	0.09
	Industry	60.7	0	-0.35	-0.58	-0.65
	Services	68.5	0	-0.14	-0.28	-0.32
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	-5.31	-7.91	-10.27
6. W/R Ratio	Agriculture	2.19	0	-3.87	-6.08	-7.14
7. Wages	Agriculture	.266	0	-2.50	-4.27	-6.47
8. K Rental	Agriculture	0.121	0	1.42	1.93	0.73
9. Terms of Trade	Urban	89.6	0	-1.44	-2.68	-4.80
10. Net Investment/GNP (Percent)		5.9	0	1.62	1.85	1.32

only be captured by a general equilibrium model. To the extent that these influences tend toward a dynamic equilibrium, the implication is that policy choices may not make a substantial difference over a long period, but do over a period like 5 - 15 years. Put another way, policy choices can determine the path taken by an economy to reach an objective but perhaps not the objective itself.

As should be expected with ZPG, wages increase substantially, K rentals decline and therefore the wage rental ratio increases with a corresponding increase in the overall capital labour ratio. Since the elasticity of substitution between capital and labour is 1.2 in agriculture, capital is substituted for labour to a larger extent in that sector and the labour share consequently declines despite a substantial rise in wages. The implication is that if the elasticity of substitution in the two urban sectors was higher than the assumed 0.6 and 0.8, more capital would be employed, demand for labour would decline and wages would tend to decrease. [Some of these effects are investigated later in experiments with the elasticities of substitution]. When population growth rates are low, low elasticities of substitution are better for labour!

The opposite result holds for high population growth. Higher elasticities of substitution in the urban sectors would increase the demand for labour, cause higher wages and a higher urbanization rate. Those who call for 'appropriate

technologies' and a better allocation of factors in the interest of employment generation in the context of high population growth, should be aware that higher urbanization rates will be one of the results of such policies. This result is not dependent on the assumption of full employment. It would be the same even if unemployment is allowed and migration behaviour conforms with the Harris-Todaro (1970) hypothesis or one of its variants.

The share of the service sector in total output increases more than that of industry. Thus labour absorption in urban areas is more due to service sector expansion. A model not including the service sector would not have this detail and would therefore show a slower rate of labour absorption. It is the neglect of the service sector or its perception as a sponge that leads to fears of widespread urban unemployment along with high urbanization growth rates. The explicit inclusion of the service sector in DYNURB is therefore once again shown to be illuminating a crucial aspect of development and urbanization. Recall that the relatively faster growth in the demand for service goods is determined in DYNURB by specification of the demand parameters. The conclusions drawn above therefore depend on the validity of the numerical magnitudes used. These have already been justified in Chapter 4, hence these conclusions must be deemed to be valid.

The last result of ZPG worth noting is that the increase in the growth of per capita income is not striking and that the difference relative to the BASRUN declines over time. The implication is that, ceteris paribus, over a long enough period, a high population growth rate does not necessarily mean a smaller growth in per capita income. This is partly because endogenous adjustments induce a higher investment rate. What is true, though, is that per capita income is increased with lower population growth in the short run and it is likely that such increases cause other structural changes which make the growth self sustaining. This cannot be modelled by DYNURB.

The experiments on population growth do not allow for differential growth rates between population and labour. The participation rate is assumed to be constant though different for urban and rural areas. A richer demographic sub-model would allow the modelling of changes in age structure over time -- in particular, the lag between population growth and labour force growth.

6.3 Changes in Demand Patterns

Discussions of development and urbanization are typically supply oriented. Thus, a large amount of attention is paid to the possibilities of increasing efficiency in production, to inappropriate choice of techniques, to the rate of population growth and so on. It is usually assumed

that Say's Law holds in low income countries, i.e., that whatever is supplied will be consumed and that the important constraints are to do with supply. Phenomena such as the "embarrassment of riches" associated with the recent bumper harvest in India indicate that demand constraints may be as important. Thus the effects of changes in demand patterns are investigated with some care in this work.

Two sets of experiments are reported. One set reports the effects associated with changes in marginal budget shares (β_{ij} 's) (Tables 6.5 to 6.8) and the other, those associated with changes in perceptions of subsistence requirements (Tables 6.9 to 6.12).

Recalling the derivation of the Stone demand system from its associated utility functions, it is fair to say that the set of experiments with changing marginal budget shares is really investigating the effects of changing consumer tastes. It is somewhat surprising when viewed in this manner, that growth rates of real income can be affected by a mere change in preferences!

Tables 6.5 and 6.6 report the effects of an increased preference for food in urban areas and Tables 6.7 and 6.8 report those of an increased preference for urban goods in rural areas. The results of one experiment are the converse of the other. Thus, only the results of Experiment No. 3 are discussed and those of Experiment 4 simply presented.

As a result of the shift in urban demand in favour of food and away from urban goods [the experiment performed makes the urban demand pattern identical to the rural pattern], the level of urbanization decreases in the initial year and continues to decrease relative to the BASRUN in later years. The growth rate of urbanization decreases as well. Thus a change in preferences produces a comparative static result which tends to persist over time.

The shift in demand towards agriculture increases the share of agriculture in total product and resources shift to that sector accordingly. Given that agriculture is a less productive sector (in the sense that an equivalent amount of resources produces less value added) the level of GNP decreases in the initial year and continues to decrease relative to the BASRUN levels in later years. The economy wide growth rate is lower. Since urban based income decreases, and because urban savings rates are higher than rural rates, the level of total investment in the economy declines. Thus the overall K/L ratio declines relative to the BASRUN over time. Associated with this result is a counter-intuitive one: the K/L ratio increases in each of the sectors! This seeming paradox is explained as follows in a comparative static framework: A greater demand for agricultural goods induces a relatively greater demand for agricultural labour and capital; but since

$$\frac{K_1}{L_1} << \frac{K_2}{L_3}, \frac{K_3}{L_3} \quad (6.1)$$

Table 6.5 Experiment No. 3
Increase in Urban Demand for Food¹

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	23.63	26.40	28.42	30.70
(% Difference)		-11.60	-12.12	-11.92	-12.30
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	0.93	0.88	0.80
(% Difference)			-5.10	-1.68	-2.97
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	2.87	2.83	2.74

Note 1: Demand coefficients in the urban sector are made equal to those in rural sector, i.e.,

Ag. Goods: $\beta_{11} = \beta_{12} = \beta_{13} = 0.4$ (0.25)

Ind. Goods: $\beta_{21} = \beta_{22} = \beta_{23} = 0.25$ (0.20)

Serv. Goods: $\beta_{31} = \beta_{32} = \beta_{33} = 0.35$ (0.55)

Figures in parentheses are the BASRUN Urban Sector demand coefficients.

TABLE 6.6 Experiment No. 3
Increase in Urban Demand for Food¹

Variable			BASRUN 1951 Value	1951	1963	1972	1984
				Year			
1.	GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
		NEWRN	906	-	3.48	3.56	3.63
2.	GNP Per Capita Growth Rate (% per year)	BASRUN	0.25	-	1.58	1.66	1.74
		NEWRUN	0.25	-	1.53	1.60	1.68
3.	Output Share (Actual Difference in % Share)	Agriculture	57.4	3.76	4.23	4.25	4.63
		Industry	22.1	0.68	0.70	1.03	0.97
		Services	20.5	-4.44	-4.93	-5.28	-5.60
4.	Labor Share (Actual Difference % Share)	Economy	58.8	-0.39	-0.36	-0.36	-0.29
		Agriculture	55.0	-0.13	-0.12	-0.14	-0.16
		Industry	60.7	0.94	0.98	0.86	0.80
		Services	68.5	0.43	0.46	0.38	0.35
<u>Percentage Changes</u>							
5.	K/L Ratio	Economy	0.92	0	-0.55	-1.14	-1.89
6.	W/R Ratio	Agriculture	2.19	10.49	10.88	9.99	9.60
7.	Wages	Agriculture	0.266	0.81	0.59	0.19	-0.28
8.	K Rental	Agriculture	0.121	-8.77	-9.28	-8.91	-9.01
9.	Terms of Trade	Urban	89.6	-3.36	-3.56	-3.42	-3.40
10.	Net Investment/GNP (Percent)		5.9	-1.01	-1.65	-1.98	-2.73

Note (1) See Note 1 in Table 6.5

Table 6.7 Experiment No. 4Decrease in Rural Demand for Food¹

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	29.20	32.61	35.08	37.71
(% Difference)		9.26	8.53	8.75	7.70
2. Growth Rate of	BASRUN	-	0.98	0.90	0.82
Urbanization	NEWRN	-	0.92	0.88	0.78
(% Difference)			-5.77	-2.49	-5.34
3. Growth Rate of	BASRUN	-	2.92	2.84	2.76
Urban Population	NEWRN	-	2.86	2.79	2.69

Note 1: $\beta_{11} = 0.30$ $\beta_{21} = 0.30$ $\beta_{31} = 0.40$

BASRUN (0.40) (0.25) (0.35)

there is relatively greater pressure on the labour market.

Hence wages tend to increase, K rentals decrease, resulting in an increase in the wage-rental ratio. Thus the K/L ratio increases in each sector but relatively more in agriculture, since

$$\sigma_1 > \sigma_2, \sigma_3 \quad (\text{elasticity of substitution}) \quad (6.2)$$

Thus, while the stocks of capital and labour increase in

TABLE 6.8 Experiment No. 4Decrease in Rural Demand for Food¹

		BASRUN 1951 Value	<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. GNP Growth Rate	BASRUN	915	-	3.54	3.61	3.69
(% per year)	NEWRN	924	-	3.57	3.64	3.72
2. GNP Per Capita Growth	BASRUN	0.25	-	1.58	1.66	1.74
Rate (% per year)	NEWRN	0.25	-	1.62	1.71	1.79
3. Output Share	Agriculture	57.4	-3.50	-3.48	-3.73	-3.49
(Actual Difference	Industry	22.1	1.61	1.44	1.68	1.59
in % Share)	Services	20.5	1.90	2.04	2.05	1.90
4. Labor Share	Economy	58.8	0.24	0.18	0.11	0.01
(Actual Difference	Agriculture	55.0	0.15	0.11	0.06	0.04
in % Share)	Industry	60.7	-0.69	-0.60	-0.56	-0.41
	Services	68.5	-0.29	-0.28	-0.31	-0.22

Percentage Changes

5. K/L Ratio	Economy	0.92	0	0.63	1.24	1.71
6. W/R Ratio	Agriculture	2.19	-7.41	-6.41	-5.93	-4.45
7. Wages	Agriculture	.266	-0.60	-0.27	0.06	0.44
8. K Rental	Agriculture	0.121	7.35	6.56	6.35	5.12
9. Terms of Trade	Urban	89.6	2.85	2.61	2.58	2.14
10. Net Investment/GNP		5.9	1.85	1.38	1.14	0.60
(Percent)						

Note (1) See Note (1) in Table 6.7

agriculture, they decrease in the urban region. Consequently, in view of relationship (6.1), the overall capital labour ratio declines, while each of the sectoral ratios increases.

Dynamically, relative to the BASRUN, wages decline in later years but since K rentals decline as well, the factor price ratio continues to be greater. With the shift in demand towards food, the terms of trade move even more against urban goods and the proportion of net investment to GNP continues to decline. Thus the growth rate of national income is relatively lower.

It is found, therefore, that a shift urban consumer tastes toward food has an important effect on levels of income as well as over the long run. Tables 6.7 and 6.8 report the effects of the converse case: when rural preferences shift toward urban goods and larger marginal budget shares are spent on these goods. Such a change induces a faster growth rate of income and higher urbanization levels. 29.2% of the population in the initial period is urbanized as compared with 26.7 percent in the BASRUN. Such a difference persists over 20 years and is therefore a non-trivial effect.

The effects discussed above are to be distinguished from Engel effects which are only due to different income elasticities of demand for urban goods (> 1) and for agricultural goods (< 1). Experiment 4 simulates a further structural change which could appear with rising income causing a shift away from rural goods. A better experiment

would be to make the β_s variable over time so that the shift away from agricultural goods takes place along with rising income. The results of Experiment 4 indicate that the effects of such a structural change would be to reinforce Engel effects and to induce a progressively higher rate of growth of income and of urbanization.

Subsistence Requirements

It is assumed in the simulation of DYNURB that consumers regard only food as a subsistence good and that this is some absolute nutritional minimum which remains the same over time. Experiments 5 and 6 investigate the effects of changes in the perception of consumers as to what constitutes subsistence goods. It is sometimes argued that subsistence requirements rise over time along increases in income. Experiment 5 investigates the consequences of such a shift in requirements, so that $FMIN(1)$, the amount of food required to subsist, increases at a rate of 1.5 per cent per year. Other experiments were conducted with a once and for all increment or decrease in $FMIN(1)$. Their results were consistent with those reported from Experiment 5.

The effects on the level and rate of urbanization are dramatic. The economy begins to ruralize! In 1984 the level of urbanization declines to 24.2 per cent of population from 26.7 per cent in 1951. The BASRUN level in

1984 is 35.0 percent. The growth rate of urban population is still positive though only 1.60 percent per year.

The increased demand for food tends to shift resources to the agriculture sector. The wage-rental ratio increases with overall results similar to Experiment 3, though much more pronounced. With a shift of resources out of the urban region and consequently lower savings rates, the proportion of investment declines producing a slower overall capital accumulation rate and a lower capital labour ratio. Once again, the capital-labour ratio is relatively higher in each of the sectors. The terms of trade of urban goods decline markedly relative to the BASRUN -- 8% lower in 1984. All these results are as should be expected, but what is surprising is the magnitude of the effect. The per capita income growth rate declines from about 1.75% to 1.5%. The share of agriculture is 12.3% higher in 1984 than was the case in the BASRUN. The magnitude of these effects is important if this experiment is considered in the context of a nutrition or food subsidy programme. Where such a programme is being financed from tax revenues, it can approximately be interpreted as increasing the food subsistence requirement since taxes may be regarded as allocated price-insensitive expenditures. Note that the increase in food requirements is set at only 1.5% per year.

Experiment 6 investigates the consequences of including urban goods in the subsistence bundle. It is

Table 6.9 Experiment No. 5Growth in Subsistence Food Requirements

$$GFMIN_1 = 0.015$$

(BASRUN) (0.0)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWNRN	26.73	25.65	13.99	24.24
(% Difference)		0	-14.63	-22.52	-30.77
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWNRN	-	-0.34	-0.32	-0.30
(% Difference)		-	-135	-136	-136
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWNRN	-	1.56	1.60	1.62

often argued that urban dwellers have minimum needs in terms of urban infrastructure and housing such that they have a higher proportion of allocated price-insensitive expenditures. In Experiment 6, industrial and service subsistence requirements are set at 20 percent of the food requirements. The 'forced' consumption of urban goods produces the predictable shift of resources to the urban sectors and consequently a substantial increase in GNP and per capita income in the static case, i.e., in the initial period. GNP increases by as much as 2 per cent. In this case, the results are in the

Table 6.10 Experiment No. 5Growth in Subsistence Food Requirements

GFMIN = 0.015
(BASRUN) (0.0)

Variable			BASRUN 1951 Value	Year			
				1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN		915	-	3.54	3.61	3.69
	NEWRN		915	-	3.35	3.41	3.46
2. GNP Per Capita Growth Rate (% per year)	BASRUN		0.25	-	1.58	1.66	1.74
	NEWRN		0.25	-	1.41	1.46	1.51
3. Output Share (Actual Difference in % Share)	Agriculture		57.4	0	4.94	8.22	12.33
	Industry		22.1	0	-1.55	-2.47	-3.69
	Services		20.5	0	-3.39	-5.75	-8.64
4. Labor Share (Actual Difference in % Share)	Economy		58.8	0	-0.27	-0.48	-0.60
	Agriculture		55.0	0	-0.12	-0.21	-0.30
	Industry		60.7	0	1.20	1.75	2.07
<u>Percentage Changes</u>							
5. K/L Ratio	Economy		0.92	0	-0.58	-1.88	-4.15
6. W/R Ratio	Agriculture		2.19	0	13.55	20.68	26.85
7. Wages	Agriculture		0.266	0	0.73	0.48	-0.47
8. K Rental	Agriculture		0.121	0	-11.30	-16.74	-22.54
9. Terms of Trade	Urban		89.6	0	-4.32	-6.36	-8.03
10. Net Investment/GNP (Percent)			5.9	0	-2.38	-3.31	-3.80

opposite direction from Experiments 3 and 5 and can be analyzed in a similar manner. The main difference is that the effects tend to be attenuated over the long run.

The level of urbanization increases to 31.3 percent in the initial period as compared with 26.7 percent in the BASRUN. In 1984, however, the levels are 37.1 per cent and 35.0 per cent respectively: a smaller difference. The growth rate of urban population declines since it now starts from a higher base.

Table 6.11 Experiment No. 6

Include Urban Goods in Subsistence Bundle

$$FMIN(1) = 0.1 \quad (0.1)$$

$$FMIN(2) = 0.02 \quad (0.0)$$

$$FMIN(3) = 0.02 \quad (0.0) \\ (BASRUN)$$

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWNRN	31.26	33.66	35.21	37.08
	(% Difference)	16.95	12.03	9.18	5.90
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWNRN	-	0.62	0.57	0.52
	(% Difference)		-36.92	-36.71	-36.87
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWNRN	-	2.55	2.49	2.44

TABLE 6.12 Experiment No. 6Include Urban Goods in Subsistence Bundle

FMIN(1) = 0.1 FMIN(2) = FMIN(3) = 0.02
 (BASRUN) (0.1) (0.0)

			Year				
Variable			BASRUN 1951 Value	1951	1963	1972	1984
1.	GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
		NEWRN	934	-	3.56	3.64	3.71
2.	GNP Per Capita Growth Rate (% per year)	BASRUN	0.25	-	1.58	1.66	1.74
		NEWRN	0.26	-	1.61	1.69	1.76
3.	Output Share	Agriculture	57.4	-7.04	-5.87	-5.07	-3.91
	(Actual Difference	Industry	22.1	5.46	4.57	4.00	3.14
	in % Share)	Services	20.5	1.58	1.30	1.07	0.77
4.	Labor Share	Economy	58.8	0.21	0.10	-0.12	-0.40
	(Actual Difference	Industry	60.7	-1.35	-0.82	-0.58	-0.27
	in % Share)	Services	68.5	-0.62	-0.36	-0.26	-0.17
<u>Percentage Changes</u>							
5.	K/L Ratio	Economy	0.92	0	1.04	1.42	1.79
6.	W/R Ratio	Agriculture	2.19	-13.35	-8.79	-6.08	-2.80
7.	Wages	Agriculture	0.266	-1.18	-0.38	-0.01	0.33
8.	K Rental	Agriculture	0.121	14.05	9.23	6.46	3.22
9.	Terms of Trade	Urban	89.6	5.39	3.69	2.56	1.39
10.	Net Investment/GNP (Percent)		5.9	3.56	1.97	0.91	-0.31

The conclusion is a somewhat surprising one: the provision of some minimum level of urban goods and services produces an increase in income levels as well as growth rates along with a higher level of urbanization. Such provisions should therefore not be assumed to be a drain on the economy. It would be instructive to test this conclusion with respect to the provision of specific services such as water supply, sewerage, urban transport, etc. in an expanded model.

The overall conclusion from the demand experiments is that demand patterns matter and that changes which occur along with increases in income and development can have reinforcing effects that accelerate the development process. These results are consistent with the findings of Kelley, et. al. (1972). Nutrition and food subsidy programmes can have some surprisingly strong deleterious effects on growth while the provision of urban goods and services as subsistence goods may have beneficial effects.

6.4 Changes in Savings Behaviour

The level of savings and the rate of capital accumulation are often regarded as the most important determinants of the rate of economic growth. Indeed, one sector models depend on capital accumulation as the sole source of economic growth. Thus, it is instructive to investigate the effects

of different rates of saving and capital accumulation in a general equilibrium context.

The BASRUN assumed an exogenous constant rate of increase in the rate of savings over time. Such an assumption can clearly not be sustained indefinitely and the model would be improved, as mentioned earlier, if this increase were behaviourally related so that it could then also be attenuated over time. A family of experiments were conducted by varying the initial rate of savings (i.e. $SLAB_i$ and $SCAP_i$) and by varying the growth rate in savings ($GSLAB_i$ and $GSCAP_i$). Only two experiments are reported here as representative of the sample. Experiment No. 7 reports the effect of an increase in both savings rates to 18 percent, i.e., 18 percent of all labour and capital income is saved in all sectors. Experiment No. 8 reports the effect of no growth in the savings rates. The resulting rates of investment are shown below:

INVESTMENT AS PER CENT OF GNP

	Gross		Net	
	1951	1984	1951	1984
1. BASRUN	11.51	18.91	5.91	11.78
2. Experiment No. 7 ($SLAB_i = SCAP_i = 0.18$)	18.03	27.96	12.44	17.81
3. Experiment No. 8 ($GSLAB_i = GSCAP_i = 0.0$)	11.50	11.72	5.91	6.12

It is clear therefore that the rate of accumulation is quite different in each of the 3 scenarios.

The most striking result is that a high or low savings rate does not affect the rate of income growth radically (See Tables 6.13 to 6.16). With the high savings rates, the rate of growth of GNP increases to only 4.05 percent per year as compared with 3.69 per cent in the BASRUN. With the low savings rate, the decrease is only to 3.43 per cent. The reasons for these surprisingly small effects on economic growth will be investigated below in a growth accounting framework. To put this in perspective, it should be recalled that the levels of savings and investment in experiment No. 7 correspond well to the levels observed in rapid growth economies like Japan and Korea.

Corresponding to the small changes in income growth are similarly small effects on urbanization. As shown in Table 6.13, the increased savings rates have a static effect as well as a dynamic one. In the initial period, the level of urbanization increases to almost 28% as compared with 26.7% in the BASRUN. The rate of growth of urbanization also increases but this is attenuated in later years.

An increase in savings rates causes an increase in the demand for capital, i.e., of the sector 2 good; resources move to industry from the other 2 sectors. If there were

only 2 sectors in the economy, all the shift would have been from agriculture to industry or from the rural to urban regions and the urbanization effect would be misleadingly strong. Industry being the higher productivity sector, the effect on the growth in income would also be stronger. These effects are damped in DYNURB because of intra-urban adjustments between services and industry, as should be expected.

The most dramatic effect in experiment No. 7 is on the return to capital. K rental in 1984 is 40% less than that in the BASRUN. It is this result which really explains the small effect on income growth and suggests that such an increase in savings rates simply would not occur with the return to capital declining as drastically. The results would be different in an open economy where capital accumulation occurred as a result of foreign transfers which did not dampen domestic demand, i.e., where domestic savings were not financing investment, as did happen in the early stages of the Korean growth miracle. The effects of such growth on technical change can arrest the decline in capital rentals and ultimately make the growth self-sustaining.

Experiment No. 7 may be regarded as simulating a forced saving autarky policy. It shows that the effectiveness of such a policy can be quite limited in scope. The decline in K rentals is a clear indication of excessive investment and consequently a serious misallocation of resources. Lest this conclusion be taken too far, the possibility of

Table 6.13 Experiment No. 7Increase in Savings Rate¹

$$SLAB_i = 0.18 \quad SCAP_i = 0.18$$

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	27.94	31.76	34.22	36.98
	(% Difference)	4.53	5.73	6.10	5.63
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	1.07	0.97	0.85
	(% Difference)		9.77	7.96	3.88
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	3.03	2.91	2.79

Note 1: BASRUN SLAB(1) = SCAP(1) = 0.10 (Rural)
 SLAB(2) = SCAP(2) = 0.14 (Urban)
 SLAB(3) = SCAP(3) = 0.14 (Urban)

manufacturing capital goods themselves or other industrial goods for export should be admitted. A country could be investing in the areas of dynamic comparative advantage. In the latter case, the fruits of forced saving and autarky would appear in the long run. The results of experiment No. 7 do, however, highlight the difficulties of forcing a high growth rate through high rates of capital accumulation in a largely closed economy.

TABLE 6.14 Experiment No. 7Increase in Savings Rate¹

$$SLAB_i = SCAP_i = 0.18$$

Variable			BASRUN 1951 Value	<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
				Year			
1.	GNP Growth Rate	BASRUN	915	-	3.54	3.61	3.69
	(% per year)	NEWRN	922	-	4.12	4.09	4.05
2.	GNP Per Capita Growth	BASRUN	0.25	-	1.58	1.66	1.74
	Rate (% per year)	NEWRUN	0.25	-	2.14	2.12	2.09
3.	Output Share	Agriculture	57.4	-2.94	-5.50	-6.38	-6.51
	(Actual Difference	Industry	22.1	4.12	7.19	8.35	9.41
	in % Share)	Services	20.5	-2.18	-1.69	-1.97	-2.90
4.	Labor Share	Economy	58.8	-0.09	0.27	-0.14	-0.61
	(Actual Difference	Agriculture	55.0	0.08	-0.37	-0.72	-0.90
	in % Share)	Industry	60.7	-0.37	3.31	4.49	5.06
		Services	68.5	-0.17	1.58	2.04	2.32

Percentage Changes

5. K/L Ratio	Economy	0.92	0	38.51	56.54	68.61
6. W/R Ratio	Agriculture	2.19	-4.13	42.25	65.12	82.35
7. Wages	Agriculture	0.266	-0.37	6.59	8.79	9.83
8. K Rental	Agriculture	0.121	3.92	-25.07	-34.12	-39.77
9. Terms of Trade	Urban	89.6	1.49	-6.30	-8.22	-8.41
10. Net Investment/GNP (Percent)		5.9	110.63	74.80	61.03	51.12

Note: (1) See Note (1) in Table 6.13

Table 6.15 Experiment No. 8
 No Growth in Savings Rate

$$\text{GSLAB}_i = \text{GSCAP}_i = 0.0$$

(BASRUN) (0.015)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWNR	26.73	29.61	31.51	33.67
	(% Difference)	0	-1.43	-2.32	-3.86
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWNR	-	0.86	0.79	0.70
	(% Difference)		-12.39	-12.55	-14.56
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWNR	-	2.81	2.73	2.64

Experiment No. 8 shows the other side of the coin. With no growth in the savings rate, urbanization does slow down and reaches a level of 33.7 per cent in 1984 but this is not very different from 35 per cent in the BASRUN. Unlike the high saving rate situation where the urbanization level slowly converged to the BASRUN, here the difference appears to widen over time. The results of this experiment are exactly converse of the high savings case and therefore need not be discussed any further. One result, however, deserves comment. As pointed out in the last chapter,

TABLE 6.16 Experiment No. 8

No Growth in Savings Rate

$$\text{GSLAB}_i = \text{GSCAP}_i = 0.0$$

(BASRUN) (0.015)

		BASRUN 1951 Value	1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	915	-	3.42	3.42	3.43
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRN	0.25	-	1.46	1.47	1.48
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0	1.29	2.67	4.90
	Industry	22.1	0	-2.04	-4.05	-7.14
	Services	20.5	0	0.75	1.38	2.24
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0	0.00	-0.09	0.08
	Agriculture	55.0	0	0.13	0.23	0.56
	Industry	60.7	0	-0.52	-1.75	-3.75
	Services	68.5	0	-0.20	-0.81	-1.73
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	-5.79	-15.70	-31.62
6. W/R Ratio	Agriculture	2.19	0	-5.73	-17.13	-33.91
7. Wages	Agriculture	0.266	0	-1.13	-3.36	-6.81
8. K Rental	Agriculture	0.121	0	4.88	16.61	41.00
9. Terms of Trade	Urban	89.6	0	1.16	3.62	7.67
10. Net Investment/GNP (Percent)		5.9	0	-25.40	-37.05	-48.08

it is somewhat puzzling to observe a continued decline over time of K rentals in the BASRUN. The level of rentals per augmented unit of capital in 1984 in this (no savings growth) simulation is 7% above that in 1951. It may therefore imply that increases in savings rates as observed in the Indian economy and simulated in the BASRUN include some elements of forced savings. If this is the case and if the government is responsible for it, e.g., by mobilizing resources through taxes, etc, then the difference in the two growth rates (between Experiment No. 8 and the BASRUN) is one measure of the contribution of organized governmental efforts toward development.

Sources of Growth in the Economy

Kelley, et.al. (1972) have discussed the problems associated with the standard growth accounting methodology which assumes the existence of a Cobb-Douglas production function and therefore assumes constant factor shares. In DYNURB, as shown in the last chapter, growth accounting is "true" in the sense that there is no unexplained residual and that all the sources are accounted for. It is therefore instructive to compare the sources of growth in each of the three cases: BASRUN, higher savings rate (Experiment 7) and no savings growth rate (Experiment 8), to understand better the observed small effects on growth.

SOURCES OF GROWTH: 1951 to 1984

	Growth Rate of GNP 1	Contribution to Growth From				
		Technical Change in			Labour Capital	
		Agric.	Indus.	Serv.		
		2	3	4	5	6
1. BASRUN	3.69	0.70	0.45	0.29	1.14	0.84
2. Experiment 7 (High Savings)	4.05	0.59	0.59	0.26	1.12	1.04
3. Experiment 8 (Low Savings)	3.43	0.79	0.35	0.32	1.14	0.67

Note: Column 1 is not the sum of Columns 2,3,4,5,6 because the contribution to growth by land augmentation is not included.

The table above shows that the growth in capital contributes only 0.84% of 3.69% per year growth in GNP in the BASRUN. Thus changes in rates of capital accumulation can only affect that component of total growth and even drastic changes in investment will be limited in effectiveness. Note that the overall contribution of technical change remains roughly the same although its sectoral combination changes owing to changes in overall sector share in output. This, again, is a shortcoming of DYNURB in that the rates of factor augmentation are exogenously specified. Their contribution to growth does change as factor shares change (see Section 4.26) but they are not sensitive to changes in investment rates. If the K rentals did not decline, increased capital accumulation would also mean increased contribution to growth from capital

augmentation. This effect is largely neutralized because of the decline in K rentals. A better model of technical change would have a production function of technical change (Ch. 2, Section 2.34). A higher rate of capital accumulation could then be expected to produce higher rates of technical change or factor augmentation. Research activities, education, etc. require investment so declines in overall investment rates should produce effects in these activities as well. Note that the problem here is not one of embodiment. It has often been argued that growth accounting exercises neglect embodiment of technical change in capital and thereby understate the importance of capital accumulation in the growth process. Here technical change is embodied in new capital through the concept of factor augmentation but its effects are damped because of the decline in K rentals and therefore of the total capital share. The argument here is that this embodiment would itself be related to the rate of capital accumulation so that lower investment rates would be accompanied by lower rates of factor augmentation and vice versa. Thus, DYNURB does understate the effects of changes in savings rates. It should, however, be emphasized that these effects would also be limited in scope and it is reasonable to estimate that the error in change of growth rates is not much more than 100%. Even then, the GNP growth rate would be about 4.5% with the high savings rates and about 3.0% with the low savings rate. The range is still not large.

This set of experiments confirms a finding of Kelley et. al. (1972): that a dramatic growth in rates of savings is not necessary for sustained economic growth. Experiment 8 demonstrates this. Once again, a word of caution is necessary. This does not negate the importance of a jump from 5 per cent to 10-15 per cent gross saving rate which is the kind of jump that has traditionally been discussed (e.g., Lewis (1954)). The sources of growth exercise shows the importance of technical change in determining the efficacy of changes in savings. Indeed, if technical change is completely exogenous $[GB_1]$, e.g., freely imported, increase in capital would not necessarily lead to a decline in K rentals and thus lead to increases in capital share. The process would then be an accelerating one of growth and urbanization. Higher urbanization would also lead to smaller population growth rates and higher rates of labour augmentation resulting in very high growth rates of per capita income. The Korean and Japanese phenomena would probably be explained in this way. The above analysis tends to argue against proponents of unbalanced growth. High rates of capital accumulation unaccompanied by other changes do not have major effects in a generalequilibrium setting.

6.5 Wage Equalization

DYNURB has assumed inequality of wages between the urban and rural sectors to simulate reality. The wage differential assumed is 1.7, i.e., $\theta_2 = \theta_3 = 1.7$, with $\theta_1 = 1.0$; the urban efficiency wage is 1.7 times the rural efficiency wage. This difference is not due to skill differences since the latter are simulated by differences in augmentation rates. This difference can be seen as a market imperfection or as a reflection of different costs of living between urban and rural areas -- pecuniary or psychic. A set of experiments was conducted to investigate the effects of different degrees of urban/rural friction. Experiment No. 9 reports the consequences of efficiency wage equalization. The results of an increase in friction were in a direction opposite to those reported here. Experiments were also done with intermediate degrees of friction, i.e., $1.0 < \theta_2 = \theta_3 < 1.7$ and the results were generally in the same direction.

Equalizing wages appears to increase GNP, and therefore per capita income in the static case, but the growth rate declines. Thus, in 1984, GNP is less than that in the BASRUN. (See Tables 6.17 and 6.18). This is a curious result and the reasons are not intuitively clear.

The first result of wage equalization is that the level of urbanization in the initial period increases

Table 6.17 Experiment No. 9

Wage Equalization: $\theta_1 = \theta_2 = \theta_3 = 1.0$
 (BASRUN: $\theta_2 = \theta_3 = 1.7$)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEW RN	31.23	34.98	37.51	40.39
	(% Difference)	16.84	16.42	16.31	15.35
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEW RN	-	0.95	0.88	0.78
	(% Difference)		-3.12	-2.47	-4.78
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEW RN	-	2.89	2.81	2.71

significantly from 26.7% in the BASRUN to 31.7%. Thus wages decrease in urban areas and increase in rural areas. The K/L ratio therefore decreases in urban areas as labour is substituted for capital and the converse happens in rural areas. The overall K/L ratio is, of course, the same in the initial period, but increases in later periods. The reason is that the higher elasticity of substitution in agriculture overcompensates for the declining K/L ratio in urban areas. Although the wage increases in agriculture,

TABLE 6.18 Experiment No. 9

Wage Equalization

$\theta_1 = \theta_2 = \theta_3 = 1.0$

(BASRUN : $\theta_2 = \theta_3 = 1.7$)

			BASRUN 1951 Value	<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69	
	NEWRN	930	-	3.51	3.57	3.62	
2. GNP Per Capita Growth Rate (% per year)	BASRUN	0.25	-	1.58	1.66	1.74	
	NEWRN	0.26	-	1.55	1.61	1.67	
3. Output Share	Agriculture	57.4	4.23	3.74	3.32	3.18	
(Actual Difference	Industry	22.1	-0.89	-0.74	-0.51	-0.60	
in % Share)	Services	20.5	-3.33	-3.00	-2.82	-2.58	
4. Labor Share	Economy	58.8	-1.50	-1.60	-1.94	-2.28	
(Actual Difference in	Agriculture	55.0	-0.26	-0.36	-0.50	-0.50	
% Share)	Industry	60.7	-3.03	-2.02	-1.68	-1.42	
	Services	68.5	-1.40	-0.85	-0.81	-0.64	
<u>Percentage Changes</u>							
5. K/L Ratio	Economy	0.92	0	7.71	10.43	11.34	
6. W/R Ratio	Agriculture	2.19	23.96	37.38	42.02	44.62	
7. Wages	Agriculture	0.266	18.17	20.04	20.31	20.10	
8. K Rental	Agriculture	0.121	-4.67	-12.62	-15.29	-16.95	
9. Terms of Trade	Urban	89.6	-24.84	-26.18	-26.38	-26.07	
10. Net Investment/GNP (Percent)		5.9	8.18	0.93	-1.67	-3.53	

the labour share declines marginally as it does in the other two sectors and overall. The removal of one aspect of urban/rural duality has rather interesting implications.

There is a higher measure of equality in the economy between urban and rural incomes. Although each labourer in agriculture gains, the losses of urban labourers more than offset their gains, resulting in a net loss to labour and gain to capital owners. In an economy with a high proportion of self-employed as this one, the net effect on income distribution remains unclear. The removal of urban/rural wage disparities, except those related to skill, slows down the rate of urbanization and increases the share of agriculture in output. Capital is also distributed towards agriculture and to the extent that capital owners are based in their own sectors, distribution is improved. With a shift in output from the urban to rural region -- even though now more labour is based in the urban sector -- eventually the investment rate falls (since urban savers save more than rural ones). Note that the service sector loses more than the industry sector in the shift to agriculture.

The policy that can be identified with this experiment is the removal of urban minimum wage laws. The decline in the share of the service sector can be seen as a decline in the share of government and, perhaps, in the provision of urban public services. Stretching this illustration further,

this experiment sheds light on the popular tendency of governments and urban people to discourage the influx of rural migrants into urban areas. The following scenario can be likened to this experiment: All minimum wage laws are removed. Urban wages decline in response to the arriving stream of rural migrants. The city becomes a collection of shanty towns. The lowering of average urban income reduces the demand for expensive consumer goods and urban type services. The departure of a significant proportion of rural people pushes up wages in rural areas until equilibrium is reached between urban and rural areas and incentives develop to substitute capital for labour. The reduced demand for urban goods also increases capital, which can go to the rural area. In such a scenario, the rural labourers are clearly better off as well as the migrants. Correspondingly, urban labour is worse off and the change in net welfare is ambiguous. Rural people gain even more if they own all the capital that moves to their area. It is then not surprising that people, governments, planners, see massive rural-urban migration as a threat -- though the problem is seldom stated in this manner.

Once this kind of equilibrium is achieved -- this would take a long time, unlike the instantaneous adjustment in the initial period in DYNURB -- the pace of urbanization would slow down as in Experiment 9. This also gives a clue as to why urbanization increases at exponential rates in the

middle stages of development and then slows down later achieving an overall logistic pattern. As the duality in wages declines with increasing urbanization and rural-urban migration, the incentives to migrate slow down and factor proportions start reversing.

This experiment is another example of the general equilibrium system working in intuitively unexpected ways but then giving results which can ultimately be rationalized. The kind of analysis offered above would also not be possible in a much larger model where chains of events become difficult to trace.

6.6 Increase in Transport Costs

One of the innovations attempted in DYNURB was the introduction of spatial friction between urban and rural areas through the introduction of transport costs. The method used was somewhat curious though simple. The attempt is essentially to simulate costs incurred in transportation between urban and rural areas. In a general equilibrium system, if costs are incurred, they have to accrue to someone as income. Hence costs are incurred on something which is produced and which uses resources in being produced. There have to be demand as well as supply effects.

The simple method used is to regard transport as an intermediate good produced by the industrial sector. It is demanded wherever goods move between urban and rural areas. Factors do not use transport in movement in DYNURB. Thus it is demanded in the inter-region movement of intermediate goods as well as consumer goods. Consumer goods cost more in the region other than the region of production. The coefficient of transportation AT used is the proportional increase in price between regions and quantity of transportation used is the product of the amount of good being transported and AT.

The value of AT used in the BASRUN is 0.005, i.e., half a per cent. This number was derived from Indian input-output tables and corresponds roughly with the coefficient for transportation. Various experiments were conducted and Experiment No. 10 reported here is the most extreme. AT is increased ten-fold to equal 0.05, i.e., 5 per cent. The surprising result is that nothing much happens! The inclusion of $AT = 0.005$ in the BASRUN makes almost no difference: the results would be almost identical if AT was completely excluded. The results of increasing AT to 0.05 are perceptible and are shown in Tables 6.19 and 6.20. Two conclusions can be reached from this 'non-result'.

Either

- i) costs of transportation are unimportant in the growth of an economy and its spatial configuration,

or

- ii) The modelling of transportation used in DYNURB is inadequate and too simplistic.

The difficulty with (i) is that it seems implausible and that with (ii) is that alternatives are difficult to design. Increasing AT ten-fold encompasses any feasible transport costs that are incurred in goods movement. Thus an effect greater than the one observed would have been expected. The marginal effects shown in Table 6.19, 6.20 are easily explained: The added cost of goods outside their own region reduces their demand. Thus industry and service goods suffer net losses because of the much larger size of the rural region. Balancing this loss is the increased demand for transport, i.e., industrial goods, so there is almost no change in the share of the industry sector. The net result observed is a decline in the service sector share and increase in agriculture. These changes are, however, negligible as is the change in urbanization.

The shortcomings in the modelling of transport in DYNURB are essentially

- (i) Movement of factors, especially people, should also use transport. Increased costs would then have a greater effect.
- (ii) There should be provision for variation over time, i.e., AT should be time dependent. The effect of increasing or decreasing transport costs on urbanization could then be investigated.

Table 6.19 Experiment No. 10
Increase in Transport Costs

AT = 0.05
 (BASRUN) (0.005)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	26.96	30.18	32.44	35.03
	(% Difference)	0.86	0.46	0.56	0.05
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	0.94	0.88	0.80
	(% Difference)		-3.48	-1.59	-3.00
3. Growth Rate of	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	2.88	2.82	2.73

The correct conclusion from the transport experiments is probably somewhere between conclusions (i) and (ii). It can certainly be better modelled -- particularly in the context of a better specified demographic-migration model. But the results are not likely to show transportation costs as a significant factor in urbanization and growth experiences.

TABLE 6.20 Experiment No. 10
Increase in Transport Costs

AT = 0.05
 (BASRUN) (0.005)

Variable		BASRUN 1951 Value	Year			
			1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	897	-	3.52	3.60	3.68
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRUN	0.25	-	1.57	1.65	1.73
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0.31	0.41	0.26	0.35
	Industry	22.1	0.03	-0.14	0.01	-0.04
	Services	20.5	-0.34	-0.27	-0.27	-0.31
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0.91	0.91	0.90	0.89
	Agriculture	55.0	0.06	0.03	0.01	-0.01
	Industry	60.7	-0.04	-0.12	-0.17	-0.16
	Services	68.5	-0.01	-0.06	-0.12	-0.11
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	-0.77	-1.14	-1.28
6. W/R Ratio	Agriculture	2.19	-0.79	-1.38	-1.91	-1.56
7. Wages	Agriculture	0.266	-0.60	-0.62	-0.79	-0.73
8. K Rental	Agriculture	0.121	0.19	0.66	1.14	0.85
9. Terms of Trade	Urban	89.6	1.03	1.11	1.19	1.05
10. Net Investment/GNP (Percent)		5.9	0.63	1.24	1.52	1.49

6.7 Appropriate Technology: The Relevance of the Elasticity of Substitution

There is a widespread belief that the technology used in urban areas in LDCs is, in some sense, inappropriate. It is argued that the factor proportions used do not reflect prevailing factor prices well: in particular, industry is 'too capital intensive.' A large amount of literature has developed on the question of 'employment generation.' It is argued that the use of appropriate technology would make processes more labour intensive and therefore help in solving the problem of urban unemployment. As argued in Chapter 4 (Section 4.21), the question of appropriate technology is really a debate on the existing value of the elasticity of substitution. If the value is unity, there is then little justification in the argument that factor proportions do not respond to changes in factor prices. Thus a set of experiments was done with different elasticities of substitution to

- (a) shed light on this issue
- (b) to test the sensitivity of DYNURB to different parameter assumptions.

The latter is important to do because the magnitudes of the elasticities of substitution used in the BASRUN were all guesstimates.

A number of experiments were conducted with different elasticities of substitution for each sector. Only three

are reported here:

- (i) Experiment 11 with the elasticity reduced in industry
- (ii) Experiment 12 with the elasticity set at unity in agriculture
- (iii) Experiment 13 with the elasticity set at unity in all sectors, i.e., all production functions are Cobb-Douglas.

The results are reported in Tables 6.21 to 6.26. In conducting each of these experiments, the scaling parameter in the production functions, B_i , is adjusted to equate initial period production levels to the initial conditions. Static effects are therefore reduced.

One general result from these experiments is that the economy gains in efficiency the nearer each elasticity is to unity. The GNP growth rate increases as each elasticity moves toward unity. This is not surprising since factors are then being substituted faster in response to changes in factor prices. Employment generation effects are, however, somewhat surprising. Urbanization increases with reductions in the elasticity of substitution in the two urban sectors. Table 6.21 (Experiment 11) shows this for $\sigma_2 = 0.5$ for illustration. The causation for this is somewhat difficult to trace in the general equilibrium system. The K/L ratio decreases in the industry sector while it increases (in comparison with the BASRUN) in services and agriculture. Industry releases some capital, but

Table 6.21 Experiment No. 11Reduced Elasticity of Substitution in Industry

$$\sigma_2 = 0.5$$

(BASRUN) (0.6)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	27.16	30.60	32.90	35.86
	(% Difference)	1.63	1.87	2.01	2.41
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	1.00	0.92	0.84
	(% Difference)		2.06	2.04	2.88
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	2.94	2.86	2.78

employs more labour. One intuitive way of explaining this result is that with a low elasticity of substitution, more labour is needed to be combined with the capital to produce the same output. The rural/urban effect is mitigated by compensating changes in the service sector. Otherwise, the urbanization effect would be even stronger. This result once again demonstrates the value of modelling a general equilibrium system where a change in one part of the system is balanced by compensating changes in another part. When σ_1 (agriculture) is reduced to 1.1, the labour using bias

TABLE 6.22 Experiment No. 11Reduced Elasticity of Substitution in Industry

$$\sigma^2 = 0.5$$

$$(\text{BASRUN}) \quad (0.06)$$

Variable		BASRUN 1951 Value	Year			
			1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	917	-	3.52	3.60	3.67
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRUN	0.25	-	1.58	1.64	1.72
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0.10	0.11	-0.18	0.37
	Industry	22.1	-0.02	-0.14	-0.14	-0.43
	Services	20.5	-0.08	0.03	-0.04	0.06
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0.60	0.80	0.89	1.12
	Agriculture	55.0	-0.09	-0.04	-0.07	-0.11
	Industry	60.7	3.96	4.35	4.73	5.23
	Services					
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	0.47	0.24	-0.26
6. W/R Ratio	Agriculture	2.19	4.58	5.76	6.18	6.71
7. Wages	Agriculture	0.266	0.96	1.11	0.96	0.78
8. K Rental	Agriculture	0.121	-3.46	-4.40	-4.91	-5.56
9. Terms of Trade	Urban	89.6	-1.07	-0.90	-0.57	0.14
10. Net Investment/GNP (Percent)		5.9	0.49	-0.03	-0.29	-0.46

in agriculture is reduced and labour is released to go to the urban sector resulting in higher urbanization. A higher GNP growth rate is also achieved. Thus, making agriculture more efficient and increasing GNP growth simultaneously produces pressure on the urban labour market. This effect is demonstrated better by Experiment 12 (Tables 6.23, 6.24), where $\sigma_1 = 1.0$, i.e., the agricultural production function is Cobb-Douglas. The improvement in GNP growth rate is quite significant, as is the growth in urbanization. The net investment/GNP ratio also increases without any change in savings parameters. This experiment demonstrates that too high an elasticity of substitution like the assumed $\sigma_1 = 1.2$ can have very significant deleterious effects on growth, even though it signifies labour-using technology.

Finally, Experiment 13 shows the effects of what might be characterized as appropriate technology. The assumption of all Cobb-Douglas production functions amounts to a technology which responds to changes in factor prices perfectly. The experiments cited above show that any other elasticities induce efficiency losses. The striking result in Table 6.26 is that it is not too different from Table 6.24, which had Cobb-Douglas technology in agriculture only. The main difference is that K rentals are increased, which implies that capital is being used more efficiently. Note that labour share declines significantly in the urban sector

Table 6.23 Experiment No. 12Agricultural Production Function: Cobb-Douglas

$$\sigma_1 = 1.0$$

(BASRUN) (1.2)

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	26.72	31.42	34.49	37.92
	(% Difference)	-0.05	4.59	6.93	8.32
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	1.36	1.22	1.07
	(% Difference)		39.04	36.12	29.96
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	3.32	3.17	3.01

by the end of the simulation period. This result is somewhat reminiscent of the wage equalization experiment where higher efficiency and income growth was accompanied by income losses to urban labour and a higher rate of urban labour absorption.

The conclusions from this set of experiments are therefore:

- i) The choice of technique or elasticity of substitution matters. However, the effects of choices within a reasonable range do not appear

TABLE 6.24 Experiment No. 12Agricultural Production Function : Cobb Douglas

$$\sigma_1 = 1.0$$

$$(\text{BASRUN}) \quad (1.2)$$

Variable			Year			
			BASRUN 1951 Value	1951	1963	1972 1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	915	-	3.83	3.89	3.95
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRN	0.25	-	1.85	1.93	1.99
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0.01	-0.23	-0.28	0.06
	Industry	22.1	-0.02	-0.07	-0.03	-0.15
	Services	20.5	0.01	0.30	0.31	0.08
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0.01	0.35	0.89	2.01
	Agriculture	55.0	0.01	0.20	0.42	0.91
	Industry	60.7	0.01	-0.24	-0.23	0.10
	Services	68.5	-0.01	-0.12	-0.16	-0.01
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	0.56	1.76	4.11
6. W/R Ratio	Agriculture	2.19	0.12	-2.68	-2.40	1.04
7. Wages	Agriculture	0.266	0.02	2.86	5.59	9.93
8. K Rental	Agriculture	0.121	-0.10	5.69	8.19	8.80
9. Terms of Trade	Urban	89.6	-0.03	4.89	8.03	11.48
10. Net Investment/GNP (Percent)		5.9	-0.01	1.79	2.89	4.31

Table 6.25 Experiment No. 13All Production Functions: Cobb-Douglas

$$\sigma_1 = 1.0 \quad \sigma_2 = 1.0 \quad \sigma_3 = 1.0$$

(BASRUN) (1.2) (0.6) (0.8)

EFFECT ON URBANIZATION

			<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN		26.73	30.04	32.25	35.01
	NEWRN		26.74	31.20	33.82	36.53
	(% Difference)		0.04	3.85	4.87	4.35
2. Growth Rate of Urbanization	BASRUN	-		0.98	0.90	0.82
	NEWRN	-		1.29	1.13	0.95
	(% Difference)			32.24	25.22	15.69
3. Growth Rate of Urban Population	BASRUN	-		2.92	2.84	2.76
	NEWRN	-		3.25	3.07	2.89

to be significant enough to warrant the large amount of literature devoted to the labour absorption issue.

- ii) Efficiency losses do occur the further σ is from unity. "Smooth" production functions induce efficiency.
- iii) The choice of appropriate technology is associated with significant efficiency gains but not necessarily with employment generation. Indeed, low elasticities of substitution may be generating higher employment as well as wages. Capital owners may gain relatively more as a result of better utilization of capital!

TABLE 6.26 Experiment No. 13AU Production Functions : Cobb Douglas

$$\sigma_1 = \frac{1.0}{(1.2)} \quad \sigma_2 = \frac{1.0}{(0.6)} \quad \sigma_3 = \frac{1.0}{(0.8)}$$

Variable		BASRUN 1951 Value	Year			
			1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	925	-	3.82	3.88	3.95
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRUN	0.26	-	1.86	1.92	1.99
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	-0.02	-0.17	-0.07	0.27
	Industry	22.1	0.03	-0.10	-0.13	-0.22
	Services	20.5	-0.00	0.28	0.21	-0.05
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0.19	0.27	0.21	0.13
	Agriculture	55.0	0.04	0.23	0.44	0.90
	Industry	60.7	-0.66	-2.00	-3.93	-7.09
	Services	68.5	1.49	0.91	-0.04	-1.46
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	1.11	2.33	4.66
6. W/R Ratio	Agriculture	2.19	2.17	-2.00	-5.51	-9.58
7. Wages	Agriculture	0.266	1.41	4.02	5.96	8.93
8. K Rental	Agriculture	0.121	-0.74	6.13	12.15	20.48
9. Terms of Trade	Urban	89.6	-2.61	2.38	5.93	9.74
10. Net Investment/GNP (Percent)		5.9	0.69	1.91	3.39	4.65

6.8 Factor Augmentation, Bias and Technical Change

Technical change is rather carefully specified in DYNURB. The magnitudes of factor augmentation chosen affect the bias of technical change in each sector (see Section 4.26). The question to be investigated is the importance of the bias and of the magnitudes of factor augmentation in the context of structural change in a growing economy. A number of experiments were conducted exploring a wide range of factor augmenting possibilities in each sector. Only three of the experiments are reported here:

- (1) The effect of no exogeneous, unexplained "manna from heaven" type technical change in agriculture, i.e., $GB_1 = 0$.
- (2) The effect of no factor augmentation.
- (3) The effect of reversing the bias of technical change in every sector.

Ideally, it would be preferable not to rely on "unexplained" technical change for growth in the economy. As explained in section 4.26, however, any reasonable rates of factor augmentation do not produce the observe rate of technical change in agriculture. It was also suggested that positing such neutral change (GB_1) is, perhaps, appropriate for green revolution or seed improvement type phenomena in agriculture. Experiment 14 shows the effects of the absence of such a change. As shown in Table 6.27, the rate of urbanization decreases dramatically and reduces over time.

Table 6.27 Experiment No. 14No Neutral Technical Change in Agriculture

$$\begin{array}{lcl} \text{GB(1)} & = & 0.0 \\ (\text{BASRUN}) & & (0.1) \end{array}$$

EFFECT ON URBANIZATION

			<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN		26.73	30.04	32.25	35.01
	NEWRN		26.73	27.66	28.23	28.84
	(% Difference)		0	-7.94	-12.47	-17.61
2. Growth Rate of Urbanization	BASRUN		-	0.98	0.90	0.82
	NEWRN		-	0.28	0.26	0.23
	(% Difference)			-70.89	-70.98	-71.86
3. Growth Rate of Urban Population	BASRUN		-	2.92	2.84	2.76
	NEWRN		-	2.20	2.18	2.15

This experiment captures well the effect of stagnation in agriculture. It should be recalled that savings and investment are proceeding as normal. In addition, there is technical change in the form of factor augmentation in every sector. As shown below, the growth rate suffers almost equally in each sector:

TABLE 6.28 Experiment No. 14

No Neutral Technical Change in Agriculture

$$\begin{aligned} \text{GB}(1) &= 0.0 \\ (\text{BASRUN}) &= (0.01) \end{aligned}$$

Variable		BASRUN 1951 Value		Year			
				1951	1963	1972	1984
1. GNP Growth Rate	BASRUN	915	-	3.54	3.61	3.69	
(% per year)	NEWRN	915	-	3.04	3.11	3.19	
2. GNP Per Capita Growth	BASRUN	0.25	-	1.58	1.66	1.74	
Rate (% per Year)	NEWRUN	0.25	-	1.11	1.18	1.25	
3. Output Share	Agriculture	57.4	0	0.57	0.77	1.02	
(Actual Difference	Industry	22.1	0	-0.09	0.02	-0.03	
in % Share)	Services	20.5	0	-0.48	-0.79	-0.98	
4. Labor Share	Economy	58.8	0	-0.32	-1.03	-2.38	
(Actual Difference in	Agriculture	55.0	0	-0.03	-0.09	-0.13	
% Share)	Industry	60.7	0	0.58	0.72	0.60	
	Services	68.5	0	0.32	0.31	0.21	
<u>Percentage Changes</u>							
5. K/L Ratio	Economy	0.92	0	-0.95	-3.10	-7.17	
6. W/R Ratio	Agriculture	2.19	0	6.29	7.86	7.21	
7. Wages	Agriculture	0.266	0	-4.34	-8.35	-14.24	
8. K Rental	Agriculture	0.121	0	-10.00	-15.03	-20.01	
9. Terms of Trade	Urban	89.6	0	-7.57	-12.08	-16.98	
10. Net Investment/GNP		5.9	0	-2.89	-4.83	-7.56	
(Percent)							

Growth Rates of Sectoral Output

	(percent/year)	1951/1984		
	<u>Agriculture</u>	<u>Industry</u>	<u>Services</u>	
BASRUN	2.56	5.03	4.47	
Experiment 14 ($GB_1 = 0.0$)	2.14	4.52	3.85	
Experiment 15 (All $\lambda_{ij} = 0$)	2.04	3.49	2.47	

As shown in Table 6.28, the overall growth rate also declines correspondingly. Wages decline as well as K rentals, though the latter relatively more. With lower income growth and a smaller shift to the urban region, the investment rate declines as well. Thus an adequate rate of technical change in agriculture is crucial to the growth of the economy and to the rate of urbanization.

These results may be compared with those of experiment 15 where there is no factor augmentation in any sector, but there is exogenous technical change in agriculture. The overall growth rate of income declines much more than in experiment 14, as it does in every sector as shown in the table above. However, the rate of urbanization does not decline as much even though the rate of growth of agriculture has decreased. Efficiency wages and K rentals increase in this case, although wages per man and K rentals per augmented unit, decline. This is an interesting result: the augmentation of factors causes a decline in the return to efficiency units. The augmentation

Table 6.29 Experiment No. 15
No Factor Augmentation

$$\text{All } \lambda_{ij} = 0^1$$

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	26.73	28.49	29.96	31.92
	(% Difference)		-5.16	-7.11	-8.81
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	0.53	0.55	0.54
	(% Difference)		-45.44	-39.34	-34.28
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	2.47	2.48	2.47

Note 1: BASRUN $\lambda_{11} = 0.0126$ $\lambda_{12} = 0.010$
 $\lambda_{21} = 0.015$ $\lambda_{22} = 0.010$
 $\lambda_{31} = 0.0125$ $\lambda_{32} = 0.008$

has a supply increasing effect but the augmentation itself balances the decline in returns so that the augmented unit (i.e., a man) does get higher wages in the BASRUN. Thus it is seen that different kinds of technical change do matter. In the absence of labour augmentation, for example, the urban sectors are a greater amount of labour. Demand for labour may be adversely affected by education! The absence of neutral technical change in agriculture causes a greater slowing of urbanization.

TABLE 6.30 Experiment No. 15
 No Factor Augmentation

$$AU \quad \lambda_{ij} = 0.0^1$$

Variable		BASRUN 1951 1951 Value		1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	915	-	2.46	2.49	2.51
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRN	0.25	-	0.53	0.55	0.57
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0	3.63	6.12	9.42
	Industry	22.1	0	-1.33	-2.13	-3.42
	Services	20.5	0	-2.30	-3.99	-6.00
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0	-0.09	-0.04	0.42
	Agriculture	55.0	0	-0.06	-0.04	0.07
	Industry	60.7	0	0.50	0.18	-0.64
	Services	68.5	0	0.24	0.05	-0.35
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	-4.19	-11.62	-23.23
6. W/R Ratio	Agriculture	2.19	0	5.57	2.05	3.03
7. Wages	Agriculture	0.266	0	4.01	5.91	8.00
8. K Rental	Agriculture	0.121	0	-1.47	3.79	16.08
9. Terms of Trade	Urban	89.6	0	2.63	6.45	12.58
10. Net Investment/GNP (Percent)		5.9	0	-8.05	-10.03	-10.18

Note (1) See Note (1) in Table 6.29

Finally, the last experiment (no. 16) reported here, reverses the biases in each sector. The rate of capital augmentation is made uniformly greater than that of labour. A more 'pure' experiment to test the effect of bias would have been one which changed the bias but kept the same rate of technical change. This, however, is not easy to accomplish since each sector has differing factor proportions. In addition, capital share being much less than labour share in every sector, when bias is reversed, it requires a much greater compensating rate of capital augmentation to achieve equivalent rates of technical change. In experiment 16, for example, where the overall rate of technical change is approximately equal to that in the BASRUN, capital is augmented at the rate of 2% per year and labour at 1%. In the BASRUN, the rate of labour augmentation was in the range of 1.25 to 1.5% per year, while that of capital was 0.8 to 1.0%.

The reversal of bias does produce the expected result: demand for labour increases in the two urban sectors as their technical change now has a labour using bias, while that in agriculture decreases since it has a capital using bias. K/L ratios decrease in industry and services, while the ratio increases in agriculture. The level and rate of growth of urbanization increase as a result. Note (Table 6.32) that efficiency capital rentals register a precipitous decline. This decline is so large that the return to augmented units is also less than that in the BASRUN. The share of labour

Table 6.31 Experiment No. 16Capital Augmentation > Labour Augmentation¹

$$\lambda_{i1} = 0.01 \quad \lambda_{i2} = 0.02$$

EFFECT ON URBANIZATION

		<u>1951</u>	<u>1963</u>	<u>1972</u>	<u>1984</u>
1. Level (% Urban)	BASRUN	26.73	30.04	32.25	35.01
	NEWRN	26.73	30.22	32.77	35.81
	(% Difference)	0	0.59	1.61	2.27
2. Growth Rate of Urbanization	BASRUN	-	0.98	0.90	0.82
	NEWRN	-	1.03	0.98	0.89
	(% Difference)		5.05	8.55	8.35
3. Growth Rate of Urban Population	BASRUN	-	2.92	2.84	2.76
	NEWRN	-	2.97	2.91	2.83

Note 1: See Note 1 in Table 6.29.

increases in the two urban sectors as a result as does the overall share.

In conclusion, it is clear that the rate of urbanization does depend on the nature of technical change. Neutral technical change in agriculture produces a greater shift to urban areas than technical change which has a labour using bias. The reversal of bias in the technology, where the urban sectors become labour using, also increases the rate of urbanization as expected. The effect is small in magnitude relative to the rather significant change in the nature of technology that uses it.

TABLE 6.32 Experiment No. 16

Capital Augmentation > Labour Augmentation¹.

$$\lambda_{11} = 0.01 \quad \lambda_{12} = 0.02$$

Variable		BASRUN 1951 Value	1951	1963	1972	1984
1. GNP Growth Rate (% per year)	BASRUN	915	-	3.54	3.61	3.69
	NEWRN	915	-	3.57	3.65	3.72
2. GNP Per Capita Growth Rate (% per Year)	BASRUN	0.25	-	1.58	1.66	1.74
	NEWRN		-	1.62	1.70	1.77
3. Output Share (Actual Difference in % Share)	Agriculture	57.4	0	-0.44	-0.87	-0.72
	Industry	22.1	0	0.27	0.65	0.50
	Services	20.5	0	0.17	0.22	0.22
4. Labor Share (Actual Difference in % Share)	Economy	58.8	0	0.28	0.22	0.14
	Agriculture	55.0	0	-0.23	-0.53	-0.82
	Industry	60.7	0	1.97	3.28	4.86
	Services					
<u>Percentage Changes</u>						
5. K/L Ratio	Economy	0.92	0	0.74	1.61	2.55
6. W/R Ratio	Agriculture	2.19	0	23.28	44.03	77.26
7. Wages	Agriculture	0.266	0	4.39	7.43	11.27
8. K Rental	Agriculture	0.121	0	-15.33	-25.41	-37.23
9. Terms of Trade	Urban	89.6	0	-3.38	-5.14	-6.31
10. Net Investment/GNP (Percent)		5.9	0	0.61	-0.04	-1.38

Note(1) See Note (1) in Table 6.29

7. Toward a Dynamic Theory of Urbanization:

Directions for Further Research

"Errors should be judged in relation
to the uses to which estimates are put."

Simon Kuznets

DYNURB was developed in an attempt to advance understanding of the dynamic processes which lead to continuing urbanization as an economy develops from very low levels of income. Simulation of the model and the sensitivity tests performed on it indicate that, at best, it is an imperfect way of studying urbanization. The results obtained, however, do induce enough confidence in the model to suggest that an attempt has been made in the right direction. In drawing together the implications of the model, it is instructive to compare its results with the general observations made by Kuznets (1971) in summarizing the long term growth experience of the presently developed countries.

It has been remarked that DYNURB behaves much like a buffalo: not much happens when parameters are changed within reasonable ranges. This is not surprising when the economy simulated starts from such low levels of income. Kuznets points out that the presently developed (henceforth called "rich") countries started their era of "modern economic growth" (MEG) at levels of per capita income comparable to

about \$250 (1965) dollars) or above, except for Japan. If, as claimed by Jorgenson (1961), "the critical condition which marks the dividing line between economies caught in the low level equilibrium trap and economies capable of sustained growth is simply that for sustained growth an agricultural surplus must come into existence and must persist," then the sluggish behaviour of DYNURB may be regarded as typical for economies starting from per capita income levels of \$100 (1965 dollars). Moreover, the share of labour force in agriculture was only 50 to 60 percent at the dawn of MEG in rich countries as compared with 70 to 80 percent in many LDCs now.

Notwithstanding these problems, the growth of national product in DYNURB is in the range of 3-4 percent per year as in MEG. In the now rich countries, however, population grew at only 1% per year in the period of MEG thereby yielding a per capita income growth rate of about 2% which has persisted for a century to a century and a half. In India and in DYNURB, population is growing at about 2% and per capital income at 1% per year. Kuznets emphasizes the importance of productivity growth or technical change in this growth process, as is also shown in DYNURB. While the capital-labour ratio has consistently increased in rich countries, the share of capital income has declined from about 40% to 20%, according to Kuznets. The return to capital must have threfore registered a secular decline as is also shown by DYNURB. This must, therefore,

be regarded as a general result. One consequence of this result is that more and more capital must be invested to produce similar rates of growth: technical change consequently assumes increasing importance. The use of only 3 sectors obfuscates the technical change issue to some extent. In any given time period, only a subset of industries experience rapid technological change and increase their share while others decline. The total sectoral rate of change can in this way remain constant while the structure could be changing rapidly within the sector.

One of the important differences in DYNURB which reflects a novel feature of the present development process in LDCs is that the service sector expands faster than is reported for the rich countries in their early stages. As mentioned in Chapter 2, the general sequence of structural change has traditionally been seen to be from agriculture to industry to services. As shown by DYNURB, the current experience is one of a concurrent shift from agriculture to industry and services. This is a somewhat neglected characteristic of the development process of latecomers that DYNURB is specifically designed to capture. It is partly a result of the dualistic structure of the economy. As Kuznets points out, the capital-labour ratios in rural and urban areas were not too different at the beginning of MEG. Now, of course, urban capital-labour ratios are much greater than rural ones. It is partly because of this that the service sector has become important

in LDCs. The labour released from agriculture cannot all be employed in industry (as it often was at the beginning of MEG) and therefore goes simultaneously to the service sector. Given that demands for services also exist to enable this service employment, the causation chain is not entirely clear. Kuznet's speculation is, however, appealing: technical innovations cause growth in productivity which then leads to changes in the structure of production. Changes in "other aspects" such as conditions of housing and work result and these finally produce changes in demand. Such complex interrelations are difficult to model even in general equilibrium models but must be allowed for when interpreting results.

The foregoing illustrates the usefulness and validity of DYNURB as a vehicle for interpreting long term growth and changes in the structure of an economy starting from very low levels of income. Its shortcomings are now noted to provide directions for further research -- in particular to make it a better model for analyzing urbanization:

- i) Theory of Location: Clearly, the most important shortcoming of DYNURB needing correction is its assumption that all industry and service employment is based in urban areas. Given the lack of spatial location theory, this is not an easy task. One way to approach the problem could be to estimate separately the production functions for urban industry and rural industry. If they are found to be significantly different, modelling

them as such would automatically solve the location problem in terms of simulation. Finding out why they are different would provide the theory of location. Doing this would increase the number of sectors to be modelled to four but that is the price that would have to be paid.

- ii) The Service Sector: As pointed out earlier, most difficulty is encountered in simulating the service sector production function since no estimates exist for its parameters. It is for this reason that distinguishing urban and rural services is not suggested above at this stage. Various divisions of the sector could be made (e.g., those suggested by Katouzian (1970) -- see section 2.2) to reduce the heterogeneity encompassed by it at present. This would involve a further expansion of the number of sectors while the benefits of so doing are dubious. In this area, the immediate priority is empirical estimation of the parameters of the production function.
- iii) Demographic Sub-Model: The main shortcoming that DYNURB suffers from in this respect is that it does not distinguish the labour force from population adequately. In a static sense, it does make this distinction through the use of worker participation rates. Dynamically,

however, these rates remain constant so labour grows at the same rate as population. The next improvement should therefore make this distinction to simulate the changing age structure of the population. While detailed population models which do this are easily available, they are all far too detailed for the purposes of DYNURB. What is needed is a simple model which only makes a distinction between workers and non-workers.

The second improvement necessary in this general area is the introduction of some friction in rural-urban population movements. The development of the demographic sub-model should therefore incorporate this consideration. It must be kept in mind though that DYNURB is a long term model and Harris-Todaro type migration functions may not be adequate.

- iv) Trade: DYNURB is now restricted to simulating closed economies and is therefore only useful for relatively large countries. There should therefore be an external trade component in it. As a start, it could be regarded as essentially exogenous and could be used as a control lever on the economy. Alternatively, an external price responsive demand function(s) could be specified but world prices would still have to be specified.

This extension is a very important one to make DYNURB more generally useful for simulating open economies.

- v) Savings and Demand: The problems in using the Stone demand system have already been discussed in some detail. More research needs to be done to specify behavioural reasons for changing demand parameters as an economy develops. This would probably involve including some feedback effects as alluded to above. Similarly, savings in DYNURB are currently "blind". The savings function should be made more responsive to returns to investment as should the level of investment. There is, however, no wide agreement on the behavioral specification of savings functions: clearly a case for further research.
- vi) Input-Output Structure: Currently, the input-output structure is constant throughout the period of simulation. This is clearly not true for developing economies. The problem in changing it is that changed estimates are available for only some dates. Thus new coefficients could be specified, say, every ten years. Such discrete changes affect the smooth operation of the model and the effects of such shocks would then have to be assessed.
- vii) Technical Change: This is mentioned last since it is the most difficult extension being suggested and the one requiring intensive research. The results of DYNURB leave no doubt that a) the rate of technical change is crucial to overall growth and b) its nature affects the

kind of structural change that comes about. The theoretical suggestions for endogenizing technical change (as in section 2.3) should now be estimated so that models such as DYNURB can incorporate production functions of technical change. Then resources could be denoted to producing technical change as well.

If all the above changes are incorporated in DYNURB, it might well advance understanding of the development process and, in particular, as it relates to urbanization. It is difficult to speculate if these would be second order improvements or relatively major ones. As it is, DYNURB provides a host of insights into the development-urbanization process and these are now brought together as concluding remarks of this study.

As has been assumed, explained or asserted by many authors, the process of urbanization is inextricably linked with that of economic development. The rate of urbanization depends on the kind of structural change an economy undergoes. The "normal" or "common" case can be described thus:

As an economy grows from low incomes, the proportion of income necessary to buy food declines and thus demand is created for non-food goods. Technical change in agriculture permits labour to be released to work in urban pursuits. The lack of technical change or productivity growth in agriculture would slow down the rate of urbanization. It is a moot question

to say which comes first: income growth, technical change or urbanization. What is important to understand is that they happen simultaneously, one reinforcing the other.

Rapid population growth is not necessary for rapid urbanization. It is a popular misconception that high population growth rates induce urbanization, though high urban population growth rates are obviously affected by high population growth. Indeed, the rate of growth of urbanization can increase with zero population growth if there is accompanying technical change in agriculture and incomes are rising. The provision of some urban services which may be perceived as required for urban living may themselves induce a higher rate of urbanization and a higher rate of income growth. It is a characteristic of recent development experience that urban capital-labour ratios are considerably higher than those in rural areas: thus high rates of investment are necessary for rapid urbanization. The increase in urban labour demand at later stages is more because of service demand than industrial demand as the rate of productivity growth is characteristically low in the service sector. Thus, industrialization and urbanization are not synonymous for development latecomers though they could have been for rich countries in their early stages. The functioning of the service sector is therefore essential to understand the current urbanization. The labour-using technology in agriculture and capital-using technology in urban areas has had the effect of slowing down

urbanization in LDCS. If technology policy in these countries succeeded in introducing the adoption of "appropriate" technology, the rate of urbanization may well increase. These technological bias effects are, however, usually exaggerated and their impact on the rate of urbanization is at best secondary. Similarly, contrary to popular belief, transport costs may have no effect on urbanization either way.

In summary, rapid agricultural productivity growth, relatively slow service productivity growth, high rates of investment and Engel demand effects combine to produce a continuing increase of urbanization levels albeit in a logistic manner.

APPENDIX

The following tables constitute the full output as produced by the simulation program of DYNURB. Note the following points:

A. Units

- (1) All values, i.e., output values and capital values are in base period (1951) prices and in units of Rs. $\times 10^8$, i.e., in hundreds of millions or tens of crores.
- (2) Labour units are in 10^5 people.
- (3) Wage rates are therefore in Rs. 10^8 per 10^5 people, i.e., thousands of Rupees. .25 is therefore equivalent to Rs 250 per person. Income per capita is also in the same units.

B. Output

- (4) National income accounts report "gross" national product net of the production of intermediate goods. Here, "gross" output refers to output including intermediate goods, while "net" output is exclusive of these goods. The latter includes depreciation and therefore corresponds to GNP according to national accounts statistics.

C. Growth Rates

- (5) Growth rates are calculated using the initial period values as base. Thus, for example, the growth rate of any variable reported for 1978 is its growth from 1951 to 1978 -- not the growth from 1975 to 1978.

Table headings should otherwise be self explanatory.

TABLE A.1

COLUMN ROW	NATIONAL PRODUCT				PER CAPITA			
	NET 1	INDEX 2	GROSS 3	INDEX 4	NET 5	INDEX 6	GROSS 7	INDEX 8
1 1951	915.29	100.00	1191.07	100.00	0.25	100.00	0.33	100.00
2 1954	1013.40	110.72	1325.14	111.26	0.26	104.55	0.35	105.06
3 1957	1123.54	122.75	1475.60	123.89	0.28	109.45	0.36	110.47
4 1960	1248.54	136.41	1648.50	138.41	0.29	114.83	0.38	116.51
5 1963	1388.97	151.75	1843.95	154.81	0.31	120.72	0.41	123.15
6 1966	1547.52	169.07	2065.41	173.41	0.32	127.07	0.43	130.32
7 1969	1725.53	188.53	2314.47	194.32	0.34	133.89	0.45	138.00
8 1972	1926.72	210.50	2598.37	218.15	0.36	141.19	0.48	146.32
9 1975	2155.45	235.49	2922.95	245.41	0.38	149.17	0.51	155.45
10 1978	2411.77	263.50	3291.07	276.31	0.40	157.65	0.54	165.31
11 1981	2699.83	294.97	3702.36	310.84	0.42	166.71	0.58	175.68
12 1984	3024.84	330.48	4173.93	350.44	0.45	176.51	0.62	187.17

Notes: (1) Net is excluding intermediate output.

(2) Gross is including intermediate output.

TABLE A.2

SECTORAL GROSS OUTPUTS AND SHARES									
AGRICULTURE			INDUSTRY			SERVICES			
OUTPUT	INDEX	PERCENT	OUTPUT	INDEX	PERCENT	OUTPUT	INDEX	PERCENT	
1	2	3	4	5	6	7	8	9	
COLUMN									
ROW									
1 1951	651.16	100.00	54.67	331.67	100.00	27.85	208.23	100.00	17.48
2 1954	706.47	108.49	53.31	380.61	114.76	28.72	238.06	114.32	17.96
3 1957	768.80	118.07	52.10	435.44	131.29	29.51	271.36	130.31	18.39
4 1960	836.49	128.46	50.74	502.10	151.39	30.46	309.92	148.83	18.80
5 1963	911.05	139.91	49.41	579.44	174.70	31.42	353.46	169.74	19.17
6 1966	993.03	152.50	48.08	668.48	201.55	32.37	403.90	193.96	19.56
7 1969	1083.35	166.37	46.81	769.14	231.90	33.23	461.99	221.86	19.96
8 1972	1183.19	181.75	45.55	888.30	267.82	34.19	526.58	252.98	20.27
9 1975	1293.17	198.59	44.24	1027.36	309.75	35.15	602.43	289.30	20.61
10 1978	1413.21	217.03	42.94	1192.12	359.43	36.22	685.74	329.31	20.84
11 1981	1548.17	237.75	41.82	1372.44	413.79	37.07	781.75	375.42	21.11
12 1984	1693.33	260.05	40.57	1591.35	479.79	38.13	889.26	427.05	21.31

SECTORAL OUTPUTS AND SHARES									
AGRICULTURE			INDUSTRY			SERVICES			
OUTPUT	INDEX	PERCENT	OUTPUT	INDEX	PERCENT	OUTPUT	INDEX	PERCENT	
1	2	3	4	5	6	7	8	9	
COLUMN									
ROW									
1 1951	525.05	100.00	57.36	202.48	100.00	22.12	187.75	100.00	20.51
2 1954	565.06	107.62	55.76	233.67	115.40	23.06	214.67	114.34	21.18
3 1957	610.23	116.22	54.31	268.60	132.65	23.91	244.71	130.34	21.78
4 1960	657.80	125.28	52.69	311.41	153.80	24.94	279.33	148.78	22.37
5 1963	709.40	135.11	51.07	361.25	178.41	26.01	318.33	169.55	22.92
6 1966	765.23	145.74	49.45	418.74	206.81	27.06	363.54	193.63	23.49
7 1969	826.13	157.34	47.87	483.78	238.92	28.03	415.73	221.42	24.09
8 1972	892.20	169.92	46.31	561.15	277.14	29.12	473.37	252.12	24.57
9 1975	962.67	183.35	44.66	651.67	321.84	30.23	541.11	288.20	25.10
10 1978	1037.39	197.58	43.01	759.49	375.09	31.49	614.88	327.50	25.50
11 1981	1122.22	213.73	41.57	877.20	433.22	32.49	700.42	373.05	25.94
12 1984	1208.47	230.16	39.95	1021.06	504.28	33.76	795.31	423.59	26.29

Note: The lower table is for net output, i.e., exclusive of intermediate good output.

TABLE A.3

INCOME PER CAPITA BY SECTOR AND REGION									
COLUMN ROW	INCOME PER CAPITA				INDEX				
	AGRIC 1	INDUS 2	SERV 3	URBAN 4	AGRIC 5	INDUS 6	SERV 7	URBAN 8	URB/RUR 9
1 1951	0.1990	0.5044	0.3317	0.4034	100.0000	100.0000	100.0000	100.0000	2.0374
2 1954	0.2038	0.5323	0.3456	0.4229	102.9249	105.5284	104.1922	104.8465	2.0755
3 1957	0.2100	0.5636	0.3618	0.4452	106.0605	111.7391	109.0475	110.3620	2.1201
4 1960	0.2152	0.5981	0.3790	0.4697	109.2201	118.5677	114.2577	116.4433	2.1722
5 1963	0.2229	0.6362	0.3984	0.4972	112.5715	126.1366	120.0807	123.2484	2.2307
6 1966	0.2297	0.6777	0.4194	0.5269	116.0252	134.3506	126.4374	130.6232	2.2938
7 1969	0.2359	0.7225	0.4426	0.5591	119.6462	143.2317	133.4212	138.5980	2.3602
8 1972	0.2441	0.7712	0.4673	0.5944	123.2659	152.8919	140.8750	147.3434	2.4354
9 1975	0.2515	0.8242	0.4941	0.6325	127.0175	163.3944	148.9454	156.7966	2.5151
10 1978	0.2587	0.8805	0.5221	0.6736	130.6874	174.5603	157.3846	166.9911	2.6034
11 1981	0.2667	0.9418	0.5535	0.7181	134.7283	186.7059	166.8331	178.0117	2.6920
12 1984	0.2744	1.0066	0.5856	0.7656	138.5992	199.5703	176.5205	189.7942	2.7900

TABLE A.4

COLUMN ROW	SECTORAL CAPITAL STOCKS AND SHARES OVER TIME							
	TOTAL 1	INDEX 2	AGRIC 3	PERCENT 4	INDUS 5	PERCENT 6	SERV 7	PERCENT 8
1 1951	1475.00	100.00	334.35	22.67	489.14	33.16	651.51	44.17
2 1954	1640.01	111.19	358.75	21.87	547.92	33.41	733.34	44.72
3 1957	1840.14	124.76	393.72	21.40	615.70	33.46	830.72	45.14
4 1960	2081.75	141.14	435.55	20.92	699.25	33.59	946.94	45.49
5 1963	2372.20	160.83	488.77	20.60	798.17	33.65	1085.25	45.75
6 1966	2720.15	184.42	554.05	20.37	914.08	33.60	1252.02	46.03
7 1969	3136.03	212.61	634.91	20.25	1047.92	33.41	1453.30	46.34
8 1972	3632.01	246.24	734.47	20.22	1209.26	33.29	1688.28	46.48
9 1975	4222.89	286.30	852.13	20.18	1400.02	33.15	1970.75	46.67
10 1978	4925.19	333.91	996.19	20.23	1629.81	33.09	2299.19	46.68
11 1981	5759.14	390.45	1174.66	20.40	1888.76	32.80	2695.72	46.81
12 1984	6746.85	457.41	1385.16	20.53	2205.32	32.69	3156.37	46.78

COLUMN ROW	SECTORAL LABOUR STOCKS AND SHARES							
	TOTAL 1	INDEX 2	AGRIC 3	PERCENT 4	INDUS 5	PERCENT 6	SERV 7	PERCENT 8
1 1951	1600.00	100.00	1193.37	74.59	168.60	10.54	237.70	14.86
2 1954	1693.02	105.81	1247.80	73.70	184.37	10.89	260.85	15.41
3 1957	1791.98	112.00	1307.71	72.98	200.15	11.17	284.11	15.85
4 1960	1897.07	118.57	1368.86	72.16	218.69	11.53	309.52	16.32
5 1963	2007.40	125.46	1432.30	71.35	238.47	11.88	335.62	16.72
6 1966	2123.77	132.74	1499.04	70.58	259.52	12.22	364.03	17.14
7 1969	2245.94	140.37	1563.36	69.88	281.24	12.52	394.49	17.56
8 1972	2376.12	148.51	1645.09	69.23	305.61	12.86	425.42	17.90
9 1975	2514.65	157.17	1722.61	68.50	332.09	13.21	459.95	18.29
10 1978	2661.10	166.32	1804.18	67.80	362.28	13.61	494.63	18.59
11 1981	2815.91	175.99	1893.17	67.23	391.21	13.89	531.53	18.88
12 1984	2978.16	186.14	1981.74	66.54	426.01	14.30	570.41	19.15

TABLE A.5

		WAGES AND CAPITAL RENTALS PER EFFICIENCY UNIT AND PER ACTUAL UNIT				AGRICULTURE		
		LABOR		CAPITAL				
		EFF WAGE	INDEX	PER MAN	INDEX	EFF RENT	INDEX	PER UNIT
COLUMN	ROW	1	2	3	4	5	6	7
	1 1951	0.2661	100.0000	0.2661	100.0000	0.1213	100.0000	0.1213
	2 1954	0.2655	100.1901	0.2767	103.9942	0.1196	98.6100	0.1232
	3 1957	0.2677	100.6027	0.2884	108.3872	0.1163	95.8972	0.1235
	4 1960	0.2632	101.1766	0.3011	113.1443	0.1124	92.6716	0.1229
	5 1963	0.2712	101.9302	0.3148	118.3151	0.1076	88.7089	0.1212
	6 1966	0.2737	102.8460	0.3297	123.9107	0.1022	84.2720	0.1187
	7 1969	0.2755	103.9189	0.3458	129.9571	0.0963	79.4252	0.1152
	8 1972	0.2796	105.0833	0.3629	136.4030	0.0902	74.3996	0.1112
	9 1975	0.2828	106.2722	0.3810	143.1840	0.0843	69.5146	0.1071
	10 1978	0.2853	107.5849	0.4003	150.4562	0.0784	64.6071	0.1025
	11 1981	0.2898	108.9044	0.4206	158.0844	0.0724	59.6956	0.0976
	12 1984	0.2935	110.3155	0.4423	166.2127	0.0669	55.1245	0.0928

		WAGES AND CAPITAL RENTALS PER EFFICIENCY UNIT AND PER ACTUAL UNIT				INDUSTRY		
		LABOR		CAPITAL				
		EFF WAGE	INDEX	PER MAN	INDEX	EFF RENT	INDEX	PER UNIT
COLUMN	ROW	1	2	3	4	5	6	7
	1 1951	0.4523	100.0000	0.5428	100.0000	0.1213	100.0000	0.1213
	2 1954	0.4532	100.1901	0.5687	104.7664	0.1196	98.6100	0.1232
	3 1957	0.4551	100.6027	0.5971	110.0028	0.1163	95.8972	0.1235
	4 1960	0.4577	101.1766	0.6279	115.6834	0.1124	92.6716	0.1229
	5 1963	0.4611	101.9302	0.6615	121.8682	0.1076	88.7089	0.1212
	6 1966	0.4652	102.8460	0.6979	128.5796	0.1022	84.2720	0.1187
	7 1969	0.4701	103.9189	0.7374	135.8551	0.0963	79.4252	0.1152
	8 1972	0.4753	105.0833	0.7797	143.6521	0.0902	74.3996	0.1112
	9 1975	0.4807	106.2722	0.8246	151.9130	0.0843	69.5146	0.1071
	10 1978	0.4866	107.5849	0.8729	160.8137	0.0784	64.6071	0.1025
	11 1981	0.4926	108.9044	0.9240	170.2215	0.0724	59.6956	0.0976
	12 1984	0.4990	110.3155	0.9787	180.3029	0.0669	55.1245	0.0928

		WAGES AND CAPITAL RENTALS PER EFFICIENCY UNIT AND PER ACTUAL UNIT				SERVICES		
		LABOR		CAPITAL				
		EFF WAGE	INDEX	PER MAN	INDEX	EFF RENT	INDEX	PER UNIT
COLUMN	ROW	1	2	3	4	5	6	7
	1 1951	0.4523	100.0000	0.5428	100.0000	0.1213	100.0000	0.0910
	2 1954	0.4532	100.1901	0.5645	103.9943	0.1196	98.6100	0.0919
	3 1957	0.4551	100.6027	0.5883	108.3874	0.1163	95.8972	0.0915
	4 1960	0.4577	101.1766	0.6142	113.1445	0.1124	92.6716	0.0906
	5 1963	0.4611	101.9302	0.6422	118.3152	0.1076	88.7089	0.0888
	6 1966	0.4652	102.8460	0.6726	123.9108	0.1022	84.2720	0.0864
	7 1969	0.4701	103.9189	0.7054	129.9572	0.0963	79.4252	0.0834
	8 1972	0.4753	105.0833	0.7404	136.4031	0.0902	74.3996	0.0800
	9 1975	0.4807	106.2722	0.7772	143.1841	0.0843	69.5146	0.0766
	10 1978	0.4866	107.5849	0.8167	150.4563	0.0784	64.6071	0.0729
	11 1981	0.4926	108.9044	0.8591	158.0846	0.0724	59.6956	0.0690
	12 1984	0.4990	110.3155	0.9022	166.2131	0.0669	55.1245	0.0652

TABLE A.6

DEMAND PROPORTIONS AND ELASTICITIES AGRICULTURE

COLUMN ROW	YCONS 1	AVERAGE PROPENSITY TO CONSUME/INCOME			ELASTICITY OF DEMAND/			SUBSIST DEM/INC 8
		AGRIC 2	INDUS 3	SERV 4	AGRIC 5	INDUS 6	SERV 7	
1 1951	519.853	0.722	0.116	0.162	0.554	2.162	2.162	0.537
2 1954	562.530	0.712	0.120	0.168	0.562	2.085	2.085	0.520
3 1957	611.652	0.702	0.124	0.174	0.570	2.015	2.015	0.504
4 1960	665.218	0.692	0.128	0.179	0.578	1.950	1.950	0.487
5 1963	724.635	0.682	0.132	0.185	0.586	1.890	1.890	0.471
6 1966	790.484	0.673	0.136	0.191	0.595	1.834	1.834	0.455
7 1969	863.575	0.663	0.140	0.196	0.603	1.782	1.782	0.439
8 1972	945.074	0.654	0.144	0.202	0.611	1.735	1.735	0.424
9 1975	1033.522	0.645	0.148	0.207	0.620	1.692	1.692	0.409
10 1978	1130.759	0.637	0.151	0.212	0.628	1.651	1.651	0.394
11 1981	1239.784	0.628	0.155	0.217	0.636	1.615	1.615	0.381
12 1984	1355.961	0.620	0.158	0.221	0.645	1.580	1.580	0.367

DEMAND PROPORTIONS AND ELASTICITIES INDUSTRY

COLUMN ROW	YCONS 1	AVERAGE PROPENSITY TO CONSUME/INCOME			ELASTICITY OF DEMAND/			SUBSIST DEM/INC 8
		AGRIC 2	INDUS 3	SERV 4	AGRIC 5	INDUS 6	SERV 7	
1 1951	129.712	0.496	0.134	0.370	0.504	1.487	1.487	0.328
2 1954	147.116	0.487	0.137	0.376	0.513	1.463	1.463	0.317
3 1957	165.544	0.480	0.139	0.381	0.521	1.443	1.443	0.307
4 1960	187.487	0.473	0.141	0.386	0.528	1.423	1.423	0.297
5 1963	211.865	0.467	0.142	0.391	0.536	1.406	1.406	0.289
6 1966	238.853	0.460	0.144	0.396	0.543	1.390	1.390	0.281
7 1969	268.037	0.455	0.145	0.400	0.550	1.375	1.375	0.273
8 1972	301.454	0.449	0.147	0.404	0.556	1.362	1.362	0.266
9 1975	338.806	0.444	0.148	0.408	0.563	1.349	1.349	0.259
10 1978	382.159	0.439	0.150	0.411	0.569	1.338	1.338	0.252
11 1981	426.201	0.435	0.151	0.414	0.575	1.327	1.327	0.246
12 1984	479.357	0.430	0.152	0.418	0.581	1.317	1.317	0.240

DEMAND PROPORTIONS AND ELASTICITIES SERVICES

COLUMN ROW	YCONS 1	AVERAGE PROPENSITY TO CONSUME/INCOME			ELASTICITY OF DEMAND/			SUBSIST DEM/INC 8
		AGRIC 2	INDUS 3	SERV 4	AGRIC 5	INDUS 6	SERV 7	
1 1951	161.921	0.528	0.126	0.346	0.474	1.588	1.588	0.370
2 1954	183.239	0.520	0.128	0.352	0.481	1.562	1.562	0.360
3 1957	205.978	0.512	0.130	0.358	0.488	1.538	1.538	0.350
4 1960	231.736	0.505	0.132	0.363	0.495	1.516	1.516	0.341
5 1963	259.657	0.499	0.134	0.368	0.501	1.496	1.496	0.332
6 1966	291.176	0.492	0.135	0.372	0.508	1.477	1.477	0.323
7 1969	326.331	0.486	0.137	0.377	0.515	1.458	1.458	0.314
8 1972	363.818	0.480	0.139	0.381	0.521	1.442	1.442	0.306
9 1975	406.615	0.474	0.140	0.386	0.527	1.426	1.426	0.299
10 1978	451.827	0.469	0.142	0.390	0.534	1.411	1.411	0.291
11 1981	501.349	0.463	0.143	0.393	0.539	1.398	1.398	0.285
12 1984	555.449	0.458	0.144	0.397	0.545	1.385	1.385	0.278

Note: Column 8 is the proportion of income devoted to subsistence food requirements.

TABLE A.7

COLUMN ROW	INVESTMENT		DINV/CAP PER CENT	DEP	PERCENT OF GNP		GROWTH RATES	NET
	GROSS	NET			GROSS	NET		
	1	2		4	5	6	7	8
1 1951	100.10	51.42	6.79	5.59	11.50	5.91	0.0	0.0
2 1954	116.67	62.55	7.11	5.60	12.07	6.47	5.24	6.75
3 1957	136.30	75.57	7.41	5.64	12.66	7.02	5.28	6.63
4 1960	159.70	91.01	7.67	5.71	13.28	7.57	5.33	6.55
5 1963	187.37	109.09	7.90	5.81	13.91	8.10	5.36	6.47
6 1966	220.28	130.51	8.10	5.94	14.57	8.63	5.40	6.41
7 1969	259.22	155.73	8.27	6.09	15.24	9.16	5.43	6.35
8 1972	305.35	185.50	8.41	6.26	15.94	9.68	5.45	6.30
9 1975	360.22	220.87	8.53	6.44	16.65	10.21	5.48	6.26
10 1978	424.88	262.35	8.63	6.65	17.39	10.74	5.50	6.22
11 1981	500.97	310.92	8.70	6.88	18.13	11.25	5.51	6.18
12 1984	590.83	368.19	8.76	7.13	18.91	11.78	5.53	6.15

- Notes:
- (1) DINV/CAP (Column 3) is investment as a proportion of total capital.
 - (2) Column 4 is depreciation as a proportion of GNP (net of intermediate output).

TABLE A.8

COLUMN ROW	URBANIZATION AND URBAN AND RURAL POPULATIONS					RURPOP 6	INDEX 7	PERCENT 8
	TOTPOP 1	INDEX 2	URBPOP 3	INDEX 4	PERCENT 5			
1 1951	3619.33	100.00	967.39	100.00	26.73	2651.94	100.00	73.27
2 1954	3832.94	105.90	1060.04	109.58	27.66	2772.90	104.56	72.34
3 1957	4059.04	112.15	1153.01	119.19	28.41	2906.03	109.58	71.59
4 1960	4299.56	118.79	1257.65	130.00	29.25	3041.92	114.71	70.75
5 1963	4549.77	125.71	1366.99	141.30	30.04	3182.88	120.02	69.96
6 1966	4815.34	133.06	1484.64	153.47	30.83	3331.20	125.61	69.17
7 1969	5096.32	140.81	1608.87	166.31	31.57	3487.46	131.51	68.43
8 1972	5396.30	149.10	1740.54	179.92	32.25	3655.76	137.85	67.75
9 1975	5713.82	157.87	1885.81	194.94	33.00	3828.02	144.35	67.00
10 1978	6049.57	167.15	2040.27	210.91	33.73	4009.30	151.18	65.27
11 1981	6404.03	176.94	2196.99	227.11	34.31	4207.05	158.64	65.69
12 1984	6776.30	187.23	2372.45	245.24	35.01	4403.86	166.06	64.99

TABLE A.9

COLUMN ROW	FACTOR SHARES IN EACH SECTOR AND TOTAL				INDUSTRY		SERVICES		ECONOMY	
	AGRICULTURE				LABOUR	CAPITAL	LABOUR	CAPITAL	LABOUR	CAPITAL
	LABOUR 1	CAPITAL 2	LAND 3	LVSTK 4						
1 1951	54.96	7.02	33.00	5.00	60.66	39.33	68.53	31.48	58.79	17.38
2 1954	54.96	7.04	33.00	5.00	60.84	39.18	68.58	31.38	58.95	17.68
3 1957	54.91	7.08	33.00	5.00	61.14	38.89	68.71	31.25	59.08	17.86
4 1960	54.86	7.13	33.00	5.00	61.52	38.51	68.88	31.08	59.23	18.04
5 1963	54.76	7.20	33.00	5.00	61.98	38.02	69.09	30.89	59.34	18.16
6 1966	54.68	7.27	33.00	5.00	62.55	37.46	69.33	30.63	59.46	18.24
7 1969	54.61	7.36	33.00	5.00	63.21	36.80	69.64	30.33	59.59	18.25
8 1972	54.54	7.46	33.00	5.00	63.92	36.07	70.02	30.02	59.71	18.22
9 1975	54.41	7.56	33.00	5.00	64.63	35.38	70.30	29.67	59.74	18.18
10 1978	54.33	7.68	33.00	5.00	65.44	34.57	70.71	29.33	59.81	18.10
11 1981	54.18	7.80	33.00	5.00	66.24	33.78	71.06	28.97	59.78	17.94
12 1984	54.07	7.93	33.00	5.00	67.07	32.94	71.46	28.59	59.77	17.81

TABLE A.10

COLUMN ROW	TERMS OF TRADE		SERV 3	URBAN 4	PRICES		
	AGRIC 1	INDUS 2			AGRIC 5	INDUS 6	SERV 7
1 1951	100.0000	99.7877	76.6685	89.6331	1.0536	1.0513	0.8078
2 1954	100.0000	99.3215	76.3221	89.2195	1.0558	1.0487	0.8058
3 1957	100.0000	98.4210	75.5889	88.3925	1.0604	1.0436	0.8015
4 1960	100.0000	97.4225	74.7700	87.4728	1.0655	1.0380	0.7967
5 1963	100.0000	96.1970	73.7430	86.3345	1.0719	1.0311	0.7904
6 1966	100.0000	94.8406	72.6361	85.0878	1.0789	1.0233	0.7837
7 1969	100.0000	93.3690	71.4211	83.7288	1.0867	1.0147	0.7762
8 1972	100.0000	91.8332	70.0855	82.2810	1.0952	1.0058	0.7676
9 1975	100.0000	90.2598	68.7973	80.8328	1.1038	0.9963	0.7594
10 1978	100.0000	88.7412	67.4624	79.3949	1.1125	0.9872	0.7505
11 1981	100.0000	87.0885	66.0217	77.8354	1.1220	0.9771	0.7408
12 1984	100.0000	85.6172	64.7197	76.4384	1.1307	0.9681	0.7318

Note: Columns 5,6,6 are actual solved prices.

TABLE A.11

CAPITAL LABOUR RATIOS

COLUMN ROW	ECONOMY		INDEX		AGRIC		UNAUGMENTED INDUS SERV		AGRIC		AUGMENTED INDUS SERV		W/R	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 1951	0.9219	100.0000	0.2802	2.9012	2.7408	0.2802	2.4177	1.7130	2.1937					
2 1954	0.9687	105.0778	0.2875	2.9718	2.8114	0.2854	2.4401	1.7338	2.2289					
3 1957	1.0269	111.3902	0.3011	3.0761	2.9240	0.2966	2.4886	1.7793	2.3014					
4 1960	1.0973	119.0339	0.3182	3.1975	3.0594	0.3112	2.5487	1.8370	2.3951					
5 1963	1.1817	128.1874	0.3412	3.3471	3.2336	0.3313	2.6287	1.9158	2.5207					
6 1966	1.2808	138.9351	0.3696	3.5221	3.4394	0.3561	2.7255	2.0107	2.6772					
7 1969	1.3953	151.4640	0.4046	3.7258	3.6840	0.3870	2.8407	2.1251	2.8702					
8 1972	1.5285	165.8085	0.4465	3.9569	3.9685	0.4239	2.9726	2.2588	3.0985					
9 1975	1.6793	182.1631	0.4947	4.2158	4.2847	0.4662	3.1205	2.4064	3.3537					
10 1978	1.8508	200.7659	0.5522	4.4987	4.6493	0.5165	3.2810	2.5760	3.6530					
11 1981	2.0452	221.8541	0.6205	4.8280	5.0717	0.5761	3.4693	2.7733	4.0021					
12 1984	2.2654	245.7425	0.6990	5.1766	5.5335	0.6442	3.6651	2.9857	4.3901					

- Notes: (1) Column 1 is $KTOT(t)/LTOT(t)$.
(2) Columns 3,4,5 are $K_i(t)/L_i(t)$.
(3) Columns 6,7,8 are $n_i(t)/y_i(t) L_i(t)$.
(4) Column 9 is $W_1(t)/R_1(t)$, i.e., wage-rental ratio.

TABLE A.12

LABOUR PRODUCTIVITY GROSS OUTPUT PER UNIT LABOUR

COLUMN ROW	ECONOMY		INDEX		AGRIC		UNAUGMENTED INDUS SERV		AGRIC		AUGMENTED INDUS SERV			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 1951	0.7444	100.0000	0.5179	1.8712	1.0845	0.5179	1.5593	0.9037						
2 1954	0.7827	105.1432	0.5374	1.9636	1.1298	0.5177	1.5648	0.9071						
3 1957	0.8234	110.6160	0.5580	2.0693	1.1924	0.5179	1.5770	0.9146						
4 1960	0.8690	116.7315	0.5800	2.1838	1.2396	0.5187	1.5916	0.9237						
5 1963	0.9186	123.3950	0.6037	2.3111	1.3038	0.5201	1.6109	0.9360						
6 1966	0.9725	130.6412	0.6288	2.4500	1.3736	0.5219	1.6330	0.9501						
7 1969	1.0305	138.4314	0.6552	2.6013	1.4498	0.5239	1.6581	0.9661						
8 1972	1.0935	146.8977	0.6828	2.7647	1.5324	0.5260	1.6853	0.9838						
9 1975	1.1624	156.1447	0.7125	2.9425	1.6215	0.5288	1.7154	1.0029						
10 1978	1.2367	166.1341	0.7435	3.1299	1.7163	0.5316	1.7449	1.0227						
11 1981	1.3148	176.6211	0.7762	3.3369	1.8208	0.5347	1.7791	1.0453						
12 1984	1.4015	188.2690	0.8110	3.5530	1.9300	0.5383	1.8115	1.0674						

- Notes: (1) Gross output includes intermediate goods output.
(2) Columns 3,4,5 are output/man.
(3) Columns 6,7,8 are output/man.

TABLE A.13

GROWTH RATES OF OUTPUT TOTAL AND PER CAPITA										
COLUMN ROW	OUTPUT					OUTPUT PER CAPITA				
	ECONOMY NET	GROSS	AGRIC	INDUS	SERV	NET	GROSS	AGRIC	INDUS	SERV
	1	2	3	4	5	6	7	8	9	10
1 1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 1954	3.45	3.62	2.48	4.89	4.57	1.49	1.66	0.97	1.81	1.38
3 1957	3.48	3.63	2.54	4.82	4.51	1.52	1.67	0.99	1.87	1.45
4 1960	3.51	3.68	2.54	4.90	4.51	1.55	1.71	0.98	1.91	1.49
5 1963	3.54	3.71	2.54	4.94	4.50	1.58	1.75	0.99	1.95	1.54
6 1966	3.56	3.74	2.54	4.96	4.50	1.61	1.78	1.00	1.99	1.58
7 1969	3.59	3.76	2.55	4.96	4.52	1.63	1.81	1.00	2.02	1.61
8 1972	3.61	3.78	2.56	4.97	4.50	1.66	1.83	1.00	2.04	1.65
9 1975	3.63	3.81	2.56	4.99	4.51	1.68	1.86	1.00	2.07	1.67
10 1978	3.65	3.84	2.55	5.02	4.49	1.70	1.88	1.00	2.08	1.69
11 1981	3.67	3.85	2.56	5.01	4.49	1.72	1.90	1.00	2.10	1.72
12 1984	3.69	3.87	2.56	5.03	4.47	1.74	1.92	0.99	2.12	1.74

Note: All growth rates are in percent per year from 1951.

TABLE A.14

GROWTH RATES OF FACTORS TOTAL AND SECTORAL								
COLUMN ROW	CAPITAL				LABOUR			
	TOTAL	AGRIC	INDUS	SERV	TOTAL	AGRIC	INDUS	SERV
	1	2	3	4	5	6	7	8
1 1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 1954	3.50	2.38	3.86	4.02	1.90	1.50	3.03	3.15
3 1957	3.76	2.76	3.91	4.13	1.91	1.54	2.90	3.02
4 1960	3.90	2.98	4.05	4.24	1.91	1.54	2.93	2.98
5 1963	4.04	3.21	4.17	4.34	1.91	1.53	2.93	2.92
6 1966	4.16	3.42	4.26	4.45	1.91	1.53	2.92	2.88
7 1969	4.28	3.63	4.32	4.56	1.90	1.53	2.88	2.85
8 1972	4.38	3.82	4.40	4.64	1.90	1.54	2.87	2.81
9 1975	4.48	3.98	4.48	4.72	1.90	1.54	2.86	2.79
10 1978	4.57	4.13	4.56	4.78	1.90	1.54	2.87	2.75
11 1981	4.65	4.28	4.61	4.85	1.90	1.55	2.85	2.72
12 1984	4.72	4.40	4.67	4.90	1.90	1.55	2.85	2.69

Note: All growth rates are in per cent per year from 1951.

TABLE A.15

GROWTH RATES OF POPULATION, INDUSTRIALISATION AND URBANISATION						
COLUMN ROW	TOTAL	POPULATION URBAN	RURAL	URBAN OUTPUT	INDUSTRI ALISATION	URBAN ISATION
	1	2	3	4	5	6
1 1951	0.0	0.0	0.0	0.0	0.0	0.0
2 1954	1.93	3.10	1.50	4.74	1.24	1.14
3 1957	1.93	2.97	1.54	4.67	1.16	1.02
4 1960	1.93	2.96	1.54	4.71	1.16	1.01
5 1963	1.92	2.92	1.53	4.73	1.15	0.98
6 1966	1.92	2.90	1.53	4.75	1.14	0.96
7 1969	1.92	2.87	1.53	4.75	1.12	0.93
8 1972	1.92	2.84	1.54	4.75	1.10	0.90
9 1975	1.92	2.82	1.54	4.77	1.09	0.88
10 1978	1.92	2.80	1.54	4.77	1.08	0.86
11 1981	1.92	2.77	1.55	4.77	1.06	0.84
12 1984	1.92	2.76	1.55	4.77	1.04	0.82

- Notes:
- (1) All growth rates are in per cent per year from 1951.
 - (2) Column 5 is the growth rate of the percentage share of urban based output in total.
 - (3) Column 6 is the growth rate of the percentage share of urban population.

TABLE A.16

GROWTH ACCOUNTING FOR ECONOMY								
COLUMN ROW	NET OUTPUT	CONTRIBUTION TO GROWTH BY						
	1	AGTECH 2	INDTECH 3	SERTECH 4	LABOUR 5	CAPITAL 6	TECH234 7	SUM567 8
1 1951	0.0	1.01	0.29	0.23	0.0	0.0	1.52	1.52
2 1954	3.45	0.98	0.30	0.23	1.12	0.64	1.52	3.27
3 1957	3.48	0.95	0.31	0.24	1.13	0.67	1.51	3.31
4 1960	3.51	0.93	0.33	0.25	1.13	0.70	1.50	3.34
5 1963	3.54	0.90	0.34	0.25	1.13	0.73	1.49	3.36
6 1966	3.56	0.87	0.36	0.26	1.13	0.76	1.48	3.38
7 1969	3.59	0.84	0.37	0.27	1.13	0.78	1.48	3.39
8 1972	3.51	0.81	0.38	0.27	1.14	0.80	1.47	3.41
9 1975	3.63	0.78	0.40	0.28	1.14	0.81	1.46	3.41
10 1978	3.65	0.76	0.42	0.29	1.14	0.83	1.46	3.42
11 1981	3.67	0.73	0.43	0.29	1.14	0.83	1.45	3.42
12 1984	3.69	0.70	0.45	0.29	1.14	0.84	1.45	3.42

- Notes:
- (1) All growth rates are in per cent per year from 1951.
 - (2) Columns 2,3,4 are the contribution of technical progress in each sector to total output growth.
 - (3) Column 7 is the sum of columns 2,3,4, i.e., the total contribution of technical progress.
 - (4) Column 8 is the sum of columns 5,6,7.
 - (5) Ignore first row.

TABLE A.17

GROWTH ACCOUNTING BY SECTORS . AGRICULTURE									
COLUMN ROW	NET OUTPUT	CONTRIBUTION TO GROWTH BY							BIAS
	1	LABAUG 2	CAPAUG 3	PRICES 4	LABOUR 5	CAPITAL 6	TECH2+3 7	SUM 567 8	
1 1951	0.0	0.59	0.07	0.0	0.0	0.0	1.76	1.76	-0.00
2 1954	2.48	0.69	0.07	0.07	0.82	0.17	1.76	2.75	-0.00
3 1957	2.54	0.69	0.07	0.11	0.84	0.20	1.76	2.80	-0.00
4 1960	2.54	0.69	0.07	0.12	0.84	0.21	1.76	2.81	-0.00
5 1963	2.54	0.68	0.07	0.14	0.84	0.23	1.76	2.83	-0.00
6 1966	2.54	0.68	0.07	0.16	0.84	0.25	1.76	2.84	-0.00
7 1969	2.55	0.68	0.07	0.17	0.84	0.27	1.76	2.86	-0.00
8 1972	2.56	0.68	0.07	0.18	0.84	0.28	1.76	2.88	-0.00
9 1975	2.56	0.68	0.08	0.19	0.84	0.30	1.76	2.89	-0.00
10 1978	2.55	0.68	0.08	0.20	0.84	0.32	1.76	2.91	-0.00
11 1981	2.56	0.68	0.08	0.21	0.84	0.33	1.76	2.93	-0.00
12 1984	2.56	0.68	0.08	0.21	0.84	0.35	1.76	2.94	-0.00

GROWTH ACCOUNTING BY SECTORS . INDUSTRY									
COLUMN ROW	NET OUTPUT	CONTRIBUTION TO GROWTH BY							BIAS
	1	LABAUG 2	CAPAUG 3	PRICES 4	LABOUR 5	CAPITAL 6	TECH2+3 7	SUM 567 8	
1 1951	0.0	0.91	0.39	0.0	0.0	0.0	1.30	1.30	0.00
2 1954	4.89	0.91	0.39	-0.08	1.84	1.51	1.30	4.66	0.00
3 1957	4.82	0.92	0.39	-0.12	1.77	1.52	1.31	4.60	0.00
4 1960	4.90	0.92	0.39	-0.14	1.80	1.56	1.31	4.67	0.00
5 1963	4.94	0.93	0.38	-0.16	1.82	1.58	1.31	4.71	0.00
6 1966	4.96	0.94	0.37	-0.18	1.82	1.59	1.31	4.73	0.00
7 1969	4.96	0.95	0.37	-0.20	1.82	1.59	1.32	4.73	0.00
8 1972	4.97	0.96	0.36	-0.21	1.84	1.59	1.32	4.74	0.00
9 1975	4.99	0.97	0.35	-0.22	1.85	1.58	1.32	4.76	0.00
10 1978	5.02	0.98	0.35	-0.23	1.88	1.58	1.33	4.78	0.00
11 1981	5.01	0.99	0.34	-0.24	1.88	1.56	1.33	4.77	0.00
12 1984	5.03	1.01	0.33	-0.25	1.91	1.54	1.34	4.78	0.00

(continued)

TABLE A.17 (cont)

		GROWTH ACCOUNTING BY SECTORS				SERVICES				
		NET	CONTRIBUTION TO GROWTH BY							
		OUTPUT	LABAUG	CAPAUG	PRICES	LABOUR	CAPITAL	TECH2+3	SUM 567	BIAS
COLUMN	ROW	1	2	3	4	5	6	7	8	9
	1 1951	0.0	0.86	0.25	0.0	0.0	0.0	1.11	1.11	0.00
	2 1954	4.57	0.86	0.25	-0.08	2.16	1.26	1.11	4.53	0.00
	3 1957	4.51	0.86	0.25	-0.13	2.07	1.29	1.11	4.47	0.00
	4 1960	4.51	0.86	0.25	-0.15	2.05	1.32	1.11	4.48	0.00
	5 1963	4.50	0.86	0.25	-0.18	2.01	1.34	1.11	4.47	0.00
	6 1966	4.50	0.87	0.25	-0.20	2.00	1.36	1.11	4.47	0.00
	7 1969	4.52	0.87	0.24	-0.22	1.99	1.38	1.11	4.48	0.00
	8 1972	4.50	0.88	0.24	-0.24	1.97	1.39	1.12	4.48	0.00
	9 1975	4.51	0.88	0.24	-0.26	1.96	1.40	1.12	4.48	0.00
	10 1978	4.49	0.88	0.23	-0.27	1.95	1.40	1.12	4.47	0.00
	11 1981	4.49	0.89	0.23	-0.29	1.93	1.40	1.12	4.46	0.00
	12 1984	4.47	0.89	0.23	-0.30	1.92	1.40	1.12	4.44	0.00

- Notes:
- (1) LABAUG and CAPAUG are the augmentation of capital and labour. Thus columns 2 and 3 are the contribution of technical change in factors.
 - (2) Column 7 is sum of columns 2 and 3.
 - (3) Column 8 is sum of columns 5,6,7.
 - (4) There is a discrepancy between columns 1 and 8 because of price changes. Value of net output is based on initial period prices.
 - (5) Note that $BIAS_1 < 0$ while $BIAS_2$, $BIAS_3 > 0$. These are shown as 0 because of truncation.
 - (6) Ignore first row,

Table B.1 India: Actual National Product

Year	Index: 1951=100		Rs x 10 ⁸		Rs	
	GNP	per capita	GNP		per capita	
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
1951	100	100	887		247	
1952	103	100	912		250	
1953	107	102	947		256	
1954	114	107	1003		266	
1955	116	107	1028		268	
1956	119	107	1048		268	
1957	124	110	1099		276	
1958	123	107	1090		267	
1959	132	112	1167		280	
1960	134	112	1189		279	
1961	144	118	1278	1326	293	306
1962	148	118	1313	1373	294	309
1963	151	118	1339	1399	293	308
1964	158	121	1404	1477	300	318
1965	169	127	1509	1588		335
1966	166	121	1482	1508		311
1967	169	121	1517	1524		308
1968	179	128	1667	1649		326
1969	184	129	1712	1699		328
1970	196	134		1809		342
1971	207	138		1903		352
1972	210	137		1937		350
1973	207	133		1908		337
1974	217	136		2003		347

SOURCE: Column (1): Column (3) up to 1967, Column (4) 1967-74.
 Column (2): Column (5) up to 1964, Column (6) 1964-74.
 Column (3): Dholakia (1974), p. 67, 1948-49 prices.
 Column (4),(6): G.O.I. (1976), p. xix, 1961 prices.
 Column (5): M. Mukherjee (1969), p. 138, 1948-49 prices.

Table B.2 Estimates of Net Capital Stock in India
(1961 prices)

Year	Agriculture		Non-Agric.		Total	
	Rs × 10 ⁸	Index	Rs × 10 ⁸	Index	Rs × 10 ⁸	Index
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
1951	610	100	1450	100	2060	100
1952	627	103	1499	103	2126	103
1953	647	106	1520	105	2147	104
1954	674	110	1569	108	2243	109
1955	698	114	1619	112	2317	113
1956	729	120	1676	116	2405	117
1957	763	125	1870	129	2633	128
1958	786	129	1880	130	2666	130
1959	816	134	1968	136	2784	135
1960	839	138	2059	142	2898	141
1961	866	142	2159	149	3025	147
1962	888	146	2262	156	3150	153
1963	908	149	2385	165	3293	160
1964	937	154	2532	175	3469	168
1965	971	159	2676	185	3647	177
1966	991	162	2856	197	3847	187
1967	1017	167	3027	209	4044	196
1968	1051	172	3172	219	4223	205
1969	1080	177	3350	231	4430	215

SOURCE: Dholakia (1974), pp. 198,199.

- Notes: (1) The figures for agriculture exclude value of livestock.
- (2) The figures for non-agriculture are the sum of stock of capital in sector Non-Ag. and the value of residential dwellings.

- Abu-Lughod, J. "Urbanization in Egypt: Present State and Future Prospects, Economic Development and Cultural Change, Vol. 13, April 1965), pp. 313-343.
- Adelman, Irma. Practical Approaches to Development Planning: Korea's Second Five Year Plan, Baltimore, (1969).
- Adelman, Irma and Robinson, Sherman. "A Wage and Price Endogenous General Equilibrium Model of a Developing Country: Factors Affecting the Distribution of Income in the Short Run" (forthcoming) (1976).
- Agrawal, S.B. Price Trends in India, Delhi (1972).
- Ahluwalia, Isher J. A Macro-Econometric Model of the Indian Economy, Analyzing Inflation During 1951-73. M.I.T. Ph.D. Dissertation, 1976.
- Ahmad, Jaleel. "Import Substitution and Structural Change in Indian Manufacturing Industry, 1950-66," Journal of Development Studies, Vol. 4 (July 1968).
- Ahmad, Qazi. Indian Cities: Characteristics and Correlates. University of Chicago, Dept. of Geography Research Paper #102, Chicago (1965).
- Ahmad, Syed. "On the Theory of Induced Invention," Economic Journal, Vol. 76 (June 1966), pp. 344-357.
- Ahmed, Fakhruddin. Migration and Employment in a Multi-Sector Model -- An Application to Bangladesh, Princeton University, Ph. D. Dissertation (1974).
- Alonso, William. "Urban and Regional Imbalances in Economic Development," Economic Development and Cultural Change, Vol. 17, (October 1968), Vol. 17, 1-14.
- Amano, Akihiro. "Neoclassical Biased Technological Progress and a Neoclassical Theory of Economic Growth," Quarterly Journal of Economics, Vol. 70, (February 1964) pp. 129-38.
- Ambannavar, J.P. "Changes in the Employment Pattern of the Indian Working Force: 1911-1961," Developing Economies, Vol. 8, (March 1970), pp. 128-146.
- Arrow, K.J. Chenery, H., Minhas, B.S., and Solow, R. Capital Labour Substitution and Economic Efficiency, Review of Economics and Statistics Vol. 43 (August 1961), pp. 225-250.
- Arrow, K.J., Karlin, S. and Suppes, P. Mathematical Methods in the Social Sciences, 1959, Stanford, California: (1960).
- Banerji, A., Capital Intensity and Productivity in Indian Industry, New Delhi, 1975.

- Berry, Brian, J.L., The Human Consequences of Urbanization. New York (1973).
- Beckmann, M.J. and Sato, R. "Aggregate Production Functions and Types of Technical Progress: A Statistical Analysis," American Economic Review Vol. 59 (March 1969), pp. 88-101.
- Berndt, Ernst, R. "Reconciling Alternative Estimates of the Elasticity of Substitution," Review of Economics and Statistics, Vol. 59 (February 1976), pp. 59-68.
- Bhalla, Surjit, S. Aspects of Savings Behaviour in Rural India, Princeton, New Jersey (mimeo) (1976).
- Bhatia, R.J. "The Production Function for Indian Manufacturers: 1948," Journal of the Bombay University (January 1954).
- Blitzer, Charles. Development and Income Distribution in a Dual Economy: A Dynamic Simulation Model for Zambia, Dept. of Economics, University of California - Berkeley. (Mimeo) (March 1975).
- Bose, Ashish. Studies in India's Urbanization - 1901-1971. New Delhi, (1973).
- Brown, Murray. On the Theory and Measurement of Technological Change, Cambridge (1966).
- Brown, Murray, (Ed). The Theory and Empirical Analysis of Production, National Bureau of Economic Research, New York (1967).
- Brown, M. and Popkin, J. "A Measure of Technological Change and Returns to Scale," Review of Economics and Statistics, Vol. 44 (November 1962) pp. 402-411.
- Bruton, Henry J. The Elasticity of Substitution in Developing Countries, Centre for Development Economics, Research Memorandum No. 45, Williams College (April 1972).
- Chatterji, M.K. "A Study of Consumption Expenditure on Food in India, Artha Vijnana, Vol. 4 (December 1962), pp. 353-368.
- Chaudhuri, Pramit. Readings in Indian Agricultural Development, London (1972).
- Chaudhry, Mahinder. "National Income Statistics of India," Economic Development and Cultural Change, Vol. 13 (October 1964) pp. 107-114.
- Clague, Christopher C. "Capital Laour Substitution in Manufacturing in Underdeveloped Countires," Econometrica, Vol. 37 (July 1969), pp. 528-537.

- Clark, Colin. The Conditions of Economic Progress, London (1951).
- Conlisk, John. "A Neoclassical Growth Model with Endogenously Positioned Technical Change Frontier," Economic Journal, Vol. 79 (June 1969), pp. 348-362.
- Dar, Ashok. Domestic Terms of Trade and Economic Development of India: 1952-53 to 1964-65. Cornell International Development Bulletin, 12, Ithaca, N.Y. (1968).
- Davis, Kingsley. "Urbanization and the Development of Pre-Industrial Areas," Economic Development and Cultural Change (October 1954), pp. 6-24.
- Deakin, B.M. and George, K.D. "Productivity Trends in the Service Industries, 1948-1963," London and Cambridge Economic Bulletin, No. 53 (March 1965).
- Denison, E.G. "The Unimportance of the Embodiment Question," American Economic Review, Vol. 54 (March 1964).
- Dervis, Kemal. Substitution, Employment and Intertemporal Equilibrium in a Non-Linear Multi-Sector Planning Model for Turkey, Princeton Ph.D. Dissertation (1973).
- Desai, B.M. Analysis of Consumption Expenditure Patterns in India, Cornell University, Department of Agricultural Economics, Occ. Paper #54 (1972).
- Dholakia, Bakul H. The Sources of Economic Growth in India, Baroda (1974).
- Dhrymes, P.J. "A Comparison of Productivity Behaviour in Manufacturing and Service Industries," Review of Economics and Statistics, Vol. 45 (February 1963), pp. 64-69.
- Diwan, Romesh K. "The Effect of Prices on Savings," Economic Development and Cultural Change, Vol. 16 (April 1968) pp. 430-435.
- Dixit, A.K. "Growth Patterns in a Dual Economy," Oxford Economic Papers, Vol. 22 (July 1970) pp. 229-234.
- Dowie, J.A. "Productivity Growth in Goods and Services: Australia, U.S.A., U.K." Economic Record, Vol. 42 (December 1966) pp. 536-554.
- Dutt, M.M. "The Production Function for Indian Manufactures," Sankhya, Vol. 15, Part IV (1955).

- Easterlin, Richard. "Long Swings in U.S. Demographic and Economic Growth: Some Findings on the Historical Pattern," Demography, Vol. 2, (1965) pp. 490-507.
- Eckaus, Richard S. and Parikh, Kirit. Planning for Growth, Cambridge (1968).
- Evenson, Robert and Jha, Dayanath. "The Contribution of Agricultural Research System to Agricultural Production in India," Indian Journal of Agricultural Economics, (December 1973) pp. 212-230.
- Evenson, Robert and M.A. Oomen. "Scale Economies, Elasticities of Substitution and Productivity Change in the Indian Manufacturing Sector." Mimeo (1975).
- Fei, J.C.H. and Ranis, G. Development of the Labour Surplus Economy: Theory and Policy, Homewood, Illinois (1964).
- Fisher, Allan G.B. "The Economic Implications of Material Progress," International Labour Review (1935).
- Freedman, Deborah. "Role of the Consumption of Modern Durables in Economic Development," Economic Development and Cultural Change, Vol. 19 (October 1970) pp. 25-48.
- Fuchs, Victor R. The Service Economy, New York (1968).
- _____. "The Contribution of Health Services to the American Economy," Milbank Memorial Fund Quarterly (October 1966).
- Fuchs, Victor R. (Ed.). Production and Productivity in the Service Industries, New York (1969).
- Goldberger, Arthur. Functional Form and Utility: A Review of Consumer Demand Theory, Madison, Wisconsin (1967) Mimeo.
- Gorman, John A. "Alternative Measures of Real Output and Productivity of Banks," in V.R. Fuchs (1968).
- Govt. of India (G.O.I.). Central Statistical Organization. National Accounts Statistics: 1960-61 - 1973-74, New Delhi (1976).
- Gupta, D.B. Consumption Patterns in India, Bombay (1973).
- Habakkuk, H.J. "Historical Experience of Economic Development," in E.A.G. Robinson (1965).
- Hahn, F.H. and Matthews, R.C.O. "The Theory of Economic Growth: A Survey," Economic Journal, Vol. 74 (December 1964) pp. 781-902.

- Hansen, Bent. "Wages and Employment in Rural Egypt," American Economic Review, Vol. 59 (June 1969) pp. 298-313.
- Harris, J.E. and Todaro, M.P. "Migration, Unemployment and Development: A Two Sector Analysis," American Economic Review, Vol. 60 (March 1970), pp. 126-142.
- Hazari, Bharat R. and Krishnamurthy, J. "Employment Implications of India's Industrialization: Analysis in an Input-Output Framework," Review of Economics and Statistics, Vol. 52 (May 1970) pp. 59-68.
- Hoselitz, Bert F. "Urbanization and Economic Growth in Asia," Economic Development and Cultural Change, Vol. 5 (October 1957), pp. 42-54.
- Houthakker, H.S. "On Some Determinants of Saving in Developed and Underdeveloped Countries," in E.A.G. Robinson (1965).
- I.A.M.R. (Institute of Applied Manpower Research). Fact Book on Manpower, Part I, 2nd Edition, New Delhi, India (1968).
- International Association for Research in Income and Wealth. Asian Studies in Income and Wealth, London (1965).
- Johansen, Leif. Production Functions: An Integration of Micro and Macro Short-Run and Long-Run Aspects, Amsterdam (1972).
- . A Multi-Sectoral Study of Economic Growth, Amsterdam (1974).
- Jorgenson, D.W. "The Development of a Dual Economy," Economic Journal, Vol. 71 (June 1961), pp. 309-334.
- Jorgenson, D.W. and Griliches, Zvi. "The Explanation of Productivity Change," Review of Economic Studies, Vol. 34 (July 1967), pp. 249-284.
- Jureen, L. "Long Term Trends in Food Consumption -- A Multi-Country Study," Econometrica, January 1956.
- Kamerschen, David R. "Further Analysis of Over-urbanization," Economic Development and Cultural Change, Vol. 17 (January 1969), pp. 235-253.
- Katouzian, M.A. "The Development of the Service Sector: A New Approach," Oxford Economic Papers, Vol. 22 (November 1970) pp. 362-383.
- Kelley, Allen C. "Demand Patterns, Demographic Change and Economic Growth," Quarterly Journal of Economics, Vol. 83 (February 1969), pp. 110-126.

- Kelley, Allen C. and Williamson, J.G. "Household Saving Behaviour in the Developing Economies: The Indonesian Case," Economic Development and Cultural Change, Vol. 16 (April 1968) pp. 385-403.
- Kelley, Allen C. and Williamson, Jeffrey, G. Lessons from Japanese Development: An Analytical Economic History, Chicago (1974).
- Kelley, A.C., Williamson, J.G. and Cheetham, R.J. Dualistic Economic Development Theory and History, Chicago (1972).
- Kendrick, David A. and Taylor, Lance J. "A Dynamic Non-Linear Planning Model for Korea," in Irma Adelman (ed.) (1969).
- Kennedy, Charles. Induced Bias in Innovation and the Theory of Distribution, Economic Journal, Vol. 74 (September 1964), pp. 541-547.
- _____. "Technical Progress and Investment," Economic Journal, Vol. 71 (June 1961) pp. 294.
- Kennedy, Charles and Thirlwall, A.P. "Technical Progress," Economic Journal, Vol. 82 (March 1972).
- Krishnamurthy, K. "Economic Development and Population Growth in Low Income Countries: An Empirical Study for India," Economic Development and Cultural Change, Vol. 15 (October 1966), pp. 70-76.
- Kulkarni, V.G. Statistical Outline of the Indian Economy, Bombay, India, 1968.
- Kuznets, Simon. Modern Economic Growth, New Haven (1966).
- _____. Economic Growth of Nations: Total Output and Production Structure, Cambridge, Massachusetts (1971).
- Lal, Amrit. Some Characteristics of Indian Cities of Over 100,000 Inhabitants in 1951 with Special Reference to their Occupational Structure and Functional Specialization, Ph.D. Dissertation, Indiana University (1958).
- Leibenstein, Harvey. Economic Backwardness and Economic Growth. London, (1957).
- Lengellé, Maurice. The Growing Importance of the Service Sector in Member Countries, O.E.C.D., Paris (1966).
- Lewis, Arthur, W. "Economic Development with Unlimited Supplies of Labour," Manchester school, Vol. 22 (May 1954) pp. 139-91.

- Lluch, C. "Development in Segmented Economics," World Bank Research Centre, (Mimeo) (1974).
- Lysy, Frank J. Application of the Linear Expenditure System to South Korea, Princeton University, B.A. Thesis (1973).
- Mabogunje, Akin L. "Urbanization in Nigeria: A Constraint on Economic Development," Economic Development and Cultural Change, Vol. 13 (July 1965) pp. 413-438.
- Macintosh, J. "Growth and Dualism in Less Developed Countries," Review of Economic Studies, Vol. 42 (July 1975) pp. 421-435.
- Marimont, Martin. "Measuring Real Output for Industries Providing Services: OBE Concepts and Methods," in V.R. Fuchs (1969).
- Massel, Benton F. "A Disaggregated View of Technical Change," Journal of Political Economy, Vol. 69 (December 1961) pp. 547-557.
- Mazumdar, H. "The Financing of Indian Capital Formation," in International Association for Research and Wealth, (1965).
- Minami, Ryoshin. "Population Migration Away from Agriculture in Japan," Economic Development and Cultural Change, Vol. 15 (January 1967) pp. 183-201.
- Mitra, S. The Future of Population, Urbanization and Working Force in India, Ph.D. Dissertation, University of Chicago (1961).
- Mohan, Rakesh. "Contribution of Research and Extension to Productivity Change in Indian Agriculture," Economic and Political Weekly, Vol. 9 (September 28, 1974) A-97-104.
- Morawetz, David. "Employment Implications of Industrialization in Developing Countries: A Survey," Economic Journal, Vol. 84 (September 1974) pp. 491-542.
- Mukherjee, M. "A Preliminary Study of the Growth of National Income in India - 1957-1957," in Int. Assoc. for Res. in Income and Wealth (1965).
- _____. National Income of India: Trends and Structure, Calcutta (1969).
- Murti, V.H. and Sastry, V.K. "Production Functions for Indian Industry," Econometrica, Vol. 25 (April 1957), pp. 205-21.
- Nadiri, Ishaq. M. "Some Approaches to the Theory and Measurement of Total Factor Productivity: A Survey," Journal of Economic Literature (December 1970).

- N.C.A.E.R. (National Council for Applied Economic Research). Long Term Projections of Demand and Supply of Selected Agricultural Commodities, New Delhi, India (1962).
- National Council for Applied Economic Research. India Rural Household Survey, Occasional Paper #13, New Delhi, India (1962).
- National Council for Applied Economic Research. Savings in India, New Delhi, India (1965).
- National Council for Applied Economic Research. All India Consumer Expenditure Survey, Vol. II, New Delhi, India (1967).
- Nelson, Richard R. "Aggregate Production Functions and Medium Range Growth Projections," American Economic Review, Vol. 54 (September 64) pp. 575-605.
- Nerlove, M. "Recent Empirical Studies of the C.E.S. and Related Production Functions," in M. Brown (1967).
- Nicholls, William H. "Industrialization, Factor Markets and Agricultural Development," Journal of Political Economy Vol. 69 (August 1961) pp. 319-340.
- Ofer, Gur. "Industrial Structure, Urbanization and the Growth Strategy of Socialist Countries," Quarterly Journal of Socialist Countries, Quarterly Journal of Economics, Vol. 90 (May 1976) pp. 219-244.
- Ofer, Gur. The Service Industries in a Developing Economy, New York (1967).
- Ofer, Gur. The Service Sector in Soviet Economic Growth: A Comparative Study, Cambridge, Massachusetts (1973).
- Oshima, Harry T. "Labour Force Explosion and Labour Intensive Sector in Asian Growth," Economic Development and Cultural Change, Vol. 19 (January 1971) pp. 161-183.
- Pandey, S.M. "Nature and Determinants of Urbanization in a Developing Economy: The Case of India." Economic Development and Cultural Change, Vol. 25 (Jan. 1977), pp. 265-278.
- Panikar, P.G.K. Rural Savings in India, Bombay 1970.
- Patel, S.J. "Long Term Changes in Output and Income in India: 1896-1905," Indian Economic Journal, Vol. 5 (January 1958) pp. 233-247.
- Phelps, E.S. "Models of Technical Progress and the Golden Rule of Research," Review of Economic Studies, Vol. 33 (April 1966) pp. 133-145.

- Philips, Doris G. "Rural to Urban Migration in Iraq," Economic Development and Cultural Change, Vol. 7 (July 1959) pp. 405-421.
- Pitchford, J.D. Population in Economic Growth, Amsterdam (1974).
- Price, Derek de Solla. Science Since Babylon, New Haven, 1975.
- Raj, K.N. The Marginal Rate of Saving in the Indian Economy, Oxford Economic Papers, Vol. 14 (February 1962) pp. 36-51.
- Resek, Robert W. "Neutrality of Technical Progress," Review of Economic Statistics, Vol. 45 (February 1963), pp. 55-63.
- Robinson, E.A.G. Problems in Economic Development, New York, New York (1965).
- Rosenzweig, Mark and Evenson, Robert. "Fertility, Schooling and the Economic Contribution of Children in Rural India: an Econometric Analysis," Econometrica (forthcoming) (September 1977).
- Rudra, Ashok. Relative Rates of Growth: Agriculture and Industry, Bombay, India (1966).
- Salter, W.E.G. Productivity and Technical Change, Cambridge, Massachusetts (1960).
- Sandesara, J.C. "Scale and Technology in Indian Industry," Oxford University Institute of Economics and Statistics Bulletin, Vol. 28 (August 1966) pp. 181-199.
- Sankar, U. "Elasticities of Substitution and Returns to Scale in Indian Manufacturing Industries," International Economic Review, Vol. 11 (1970) pp. 399-411.
- Schwartzman, David. "The Growth of Sales per Man-Hour in Retail Trade: 1929-1963, in V.R. Fuchs (1969).
- Shukla, Tara. Capital Formation in Indian Agriculture, Bombay, India (1965).
- Sinha, R.P. "An Analysis of Food Expenditure in India," Journal of Farm Economics, Vol. 48 (1966), pp. 113-123.
- Solow, Robert M. "Technical Change and the Aggregate Production Function," Review of Economics and Statistics, Vol. 39 (August 1957), pp. 312-20.
- _____. "Investment and Technical Progress," in K.J. Arrow, et. al. (1962).

- Sovani, N.V. "The Analysis of Overurbanization," Economic Development and Cultural Change, Vol. 12 (January 1962) pp. 216-222.
- _____. Urbanization and Urban India, New York, Asian Publications House (1966).
- Stigler, George. Trends in Employment in the Service Industries, (N.B.E.R.) National Bureau of Economic Research, Princeton, N.J. (1956).
- Stone, R. and Brown, A. "Behavioral and Technical Change in Economic Models," in E.A.G. Robinson (1965).
- Tewari, J. "Productivity of Capital Investment in U.P.," Bulletin of the International Statistical Institute, Vol. XXXIII, Part III (1951).
- Thamarajakshi, R. "Trade and Marketed Surplus of Agricultural Produce 1951-52 to 1965-66," in P. Chaudhuri (1972).
- Tiwari, S.G. "Indian Gross Capital Formation Including Non-Monetary Parts," in International Association for Research in Income and Wealth (1965).
- Tolley, G.S. and Smidt, S. "Agriculture and the Secular Position of the U.S. Economy," Econometrica, Vol. 32 (October 1964) pp. 554-575.
- Treadway, Arthur. "What is Output: Problems of Concept and Measurement," in V.R. Fuchs (1969).
- Triantis, S.G. "Economic Progress and Occupational Redistribution," Economic Journal, Vol. 64 (1954).
- Tsuru, Shigetou. "Effect of Technology on Productivity," in E.A.G. Robinson (1965).
- Tyler, W.G. "Labour Absorption with Import Substitution and Industrialization: An Examination of Elasticities of Substitution in the Brazilian Manufacturing Sector," Oxford Economic Papers, Vol. 26 (March 1974) pp. 93-104.
- Varma, Ravi. "Income Elasticity of Demand for Food Grains: A Regional Approach," Artha Vijnana, Vol. 1 (1959), pp. 271-280.
- Williamson, Jeffrey G. "Production Functions, Technological Change and the Developing Economics: A Review Article," Malayan Economic Review, Vol. 13 (October 1968), p. 8-21.

- Winston, Gordon C. "Factor Substitution, Ex Ante and Ex Post," Journal of Development Economics, Vol. 1 (1974) pp. 145-163.
- Worton, David. "The Service Industry in Canada," in V.R. Fuchs (1969).
- Yamaguchi, Mitoshi. Technical Change and Population Growth in the Economic Development of Japan, University of Minnesota, Ph.D. Dissertation (1973).
- _____. "Population Effects on the Economic Development of Japan," University of Minnesota, Dept. of Agricultural and Applied Economics, Staff Paper, St. Paul, Minnesota (1974) No. 74-11.
- Yamaguchi, Mitoshi and Binswanger, Hans P. "Some Structural Changes in the United States and Japanese Economics," University of Minnesota, Dept. of Agricultural and Applied Economics, Staff Paper, St. Paul, Minnesota (1974) No. 74-6.
- _____. "The Role of Sectoral Technical Change in Development: Japan, 1880-1965," American Journal of Agricultural Economics (May 1975) pp. 269-278.
- Yotopoulos, Pan A. and Lau, Lawrence J. "On Modeling the Agricultural Sector in Developing Economics," Journal of Development Economics, Vol. 1 (1974), pp. 105-127.
- Zarembka, P. "On the Empirical Relevance of the C.E.S. Production Function," Review of Economics and Statistics, Vol. 52 (February 1970) pp. 47-53.