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JOHN W. MELLOR & MOHINDER S. MUDAHAR

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This paper estimates the simulation model presented in the earlier paper entitled, "Modernizing Agriculture, Employment and Economic Growth - A Simulation Model," by Mellor and Mudahar. The simulation model emphasizes the effect on economic growth and on employment of varying assumptions with respect to foodgrains production, the distribution of resultant income and the consequent structure of demand. The model is estimated by using Indian data. The results indicate that the foodgrains (wages goods) supply serves as an effective constraint for increasing employment in the economy. The devised demand effects of different income distribution patterns provides important growth linkages between sectoral outputs and employment patterns.

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# SIMULATING A DEVELOPING ECONOMY WITH MODERNIZING AGRICULTURAL SECTOR

## - IMPLICATIONS FOR EMPLOYMENT AND ECONOMIC GROWTH -

By

John W. Mellor

and

Mohinder S. Mudahar

Occasional Paper No. 76
Employment and Income Distribution Project
Department of Agricultural Economics
Cornell University

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Figure 1. Simulation Model: Conceptual Framework Illustrating Interdependence between Foodgrains Production, Demand Creation and Employment. . . . . 6

# SIMULATING A DEVELOPING ECONOMY WITH MODERNIZING AGRICULTURAL SECTOR - IMPLICATIONS FOR EMPLOYMENT AND ECONOMIC GROWTH*-

by

John W. Mellor and Mohinder S. Mudahar

## 1. INTRODUCTION

This paper estimates the simulation model presented in Occasional Paper No. 75 by Mellor and Mudahar [1974]. Indian data are used to analyze the direct and indirect implications of technological change in the foodgrain sector on various elements of the economy. More specifically, the paper analyzes (i) the effects of farm technologies of various characteristics on production and marketable surplus of foodgrains; (ii) the growth rates of total employment and sectoral employment patterns consistent with given rates of growth in foodgrains production; (iii) the magnitude of income and demand related linkages among various sectors of the economy; and (iv) the effect on the system of different growth rates of population.

Introduction of new agricultural technology in the form of high yielding crop varieties with related changes has the potential for significant direct and indirect effects on various sectors of the economy. Most models of growth give little effect to these changes because of neglect of the roles of varying returns to land and labor, to income distribution and to consumption.[1/] The model used in this paper emphasizes the effect on economic

*The research reported in this paper is financed by contract No. AID/csd-2805 entitled, "The Impact of New Technology on Rural Employment and Income Distribution." The initial effort in generating data used was made by Dr. Roger Selley as part of this project. We are grateful to him for his contribution.

1/ For a discussion of the implications of alternative formulations of growth, see John W. Mellor, "Models of Economic Growth and Land-Augmenting Technological Change in Foodgrain Production," in Nurul Islam (ed.) Agricultural Policy in Developing Countries, London: The Macmillan Press, Ltd., 1974. Pp. 3-31.

growth, and on employment of varying assumptions with respect to foodgrain production, the distribution of resultant income and the consequent structure of demand.

The conceptual framework of the simulation model is described briefly in Section 2; the data used to test the model, the underlying assumptions and the estimation procedure are outlined in Section 3; the empirical results obtained from the 'reference' run along with the economic analysis are reported in Section 4; the results of various simulation experiments and the sensativity analysis are outlined in Section 5.

## 2. SIMULATION MODEL STRUCTURE: THE CONCEPTUAL FRAMEWORK

The simulation model used here,as reported in Mellor and Mudahar [1974], incorporates several interrelationships among different sectors of the economy through various mathematical functions. It is not an optimization model in the sense of maximization (or minimization) of a single or multiple objective function subject to various technological and behavioral constraints. Rather, it is an econometric model consisting of a simple simultaneous equation system.

The model is developed to describe and measure the interdependence among sectors and to trace out the effects of technological change on foodgrains production, employment growth and sectoral employment patterns, income level and income distribution patterns, consumption behavior of different expenditure classes and the subsequent implications for demand and employment. The model is highly aggregative in nature and is developed for the economy as a whole. However, the economy is divided into several sectors and sub-sectors.

### The Agricultural Sector and Technological Change

The agricultural sector is subdivided into the foodgrains and nonfoodgrains sectors. The foodgrains sector includes the production of cereals and pulses. The foodgrains are produced concurrently using both traditional

and modern farm techniques. This implies that technological dualism exists in the foodgrains sector. The total production of foodgrains is determined endogenously by the technological conditions assumed to prevail in the foodgrains sector: (i) cultivated land allocated for foodgrains production, (ii) cultivated area under irrigation, (iii) possibilities of multiple cropping, and (iv) yield per unit of land.

The nonfoodgrains sector includes the production of livestock products, fruits, vegetables, cotton, oil seeds and various other commodities not classified as foodgrains. The total production of nonfoodgrains is equated to and hence determined by the derived demand and includes use of an input-output framework.

## The Nonagricultural Sector

The nonagricultural sector is subdivided into the agro-industrial sector (i.e. processed agricultural sector) and nonagro-industrial sector. The agro-industrial sector produces commodities, including vegetable oil, other edible oils, sugar, gur (raw-brown sugar), khandsari, cotton and woolen textiles. Again, the total production of agro-industrial sector is determined by the derived demand. Analysis of the nonagricultural sector is limited to determining the potential level of employment in the nonagricultural sector which can be supported by the residual supply of foodgrains (wage goods) without any change in relative prices.

## Consumption Demand and Income Distribution

The total consumption demand of various consumption commodities depends on the level and distribution of the existing and incremental income among various expenditure classes. The consumption behavior for different expenditure classes can be represented by their marginal propensity to consume and income elasticities for various consumer commodity groups. The marginal propensity to consume differs substantially among different expenditure classes. As reported by Mellor and Mudahar [1974], the landless laborers spend 55 percent of their incremental income to purchase foodgrains

whereas farmers in the highest expenditure class spend only two percent. This has important implications for marketable surplus of foodgrain from the large farmers, and demand for foodgrains by the laboring class. The proportion of incremental income spent on nonfoodgrains increases gradually, and stays more or less constant for agro-industrial products, for different expenditure classes.

In this model, consumers are divided into two expenditure classes: (i) laborers (in essence including small and marginal farmers), and (ii) entrepreneurs. Consumer goods are divided into four groups: (i) foodgrains, (ii) nonfoodgrains, (iii) agro-industrial goods (processed agriculture), and (iv) nonagro-industrial goods and services. The demand for the first three commodity groups is determined endogenously through log-log-inverse consumption functions and the demand for the fourth commodity group is determined as a residual. The per capita consumption is a function of per capita income. The total consumption demand is determined by multiplying per capita consumption by the total number of consumers, for each expenditure class.

Interdependence between the Agricultural and Nonagricultural Sectors

The agricultural and nonagricultural sectors are highly interdependent. In this model, four different types of linkages are explicitly incorporated. These are (i) intermediate demand among sectors, (ii) household demand for nonfarm consumer goods, (iii) food supply and demand, and (iv) labor supply and employment.

The intermediate demand for outputs of different sectors depends on the magnitude of the input-output coefficients, and size of total output of different sectors. Consequently, the total output of one particular sector depends on the output of other sectors which is made available as an input to that sector. The intermediate demand is determined endogenously by the input-output framework. Secondly, the agricultural sector provides a market for the consumer goods produced in the nonagricultural sector.

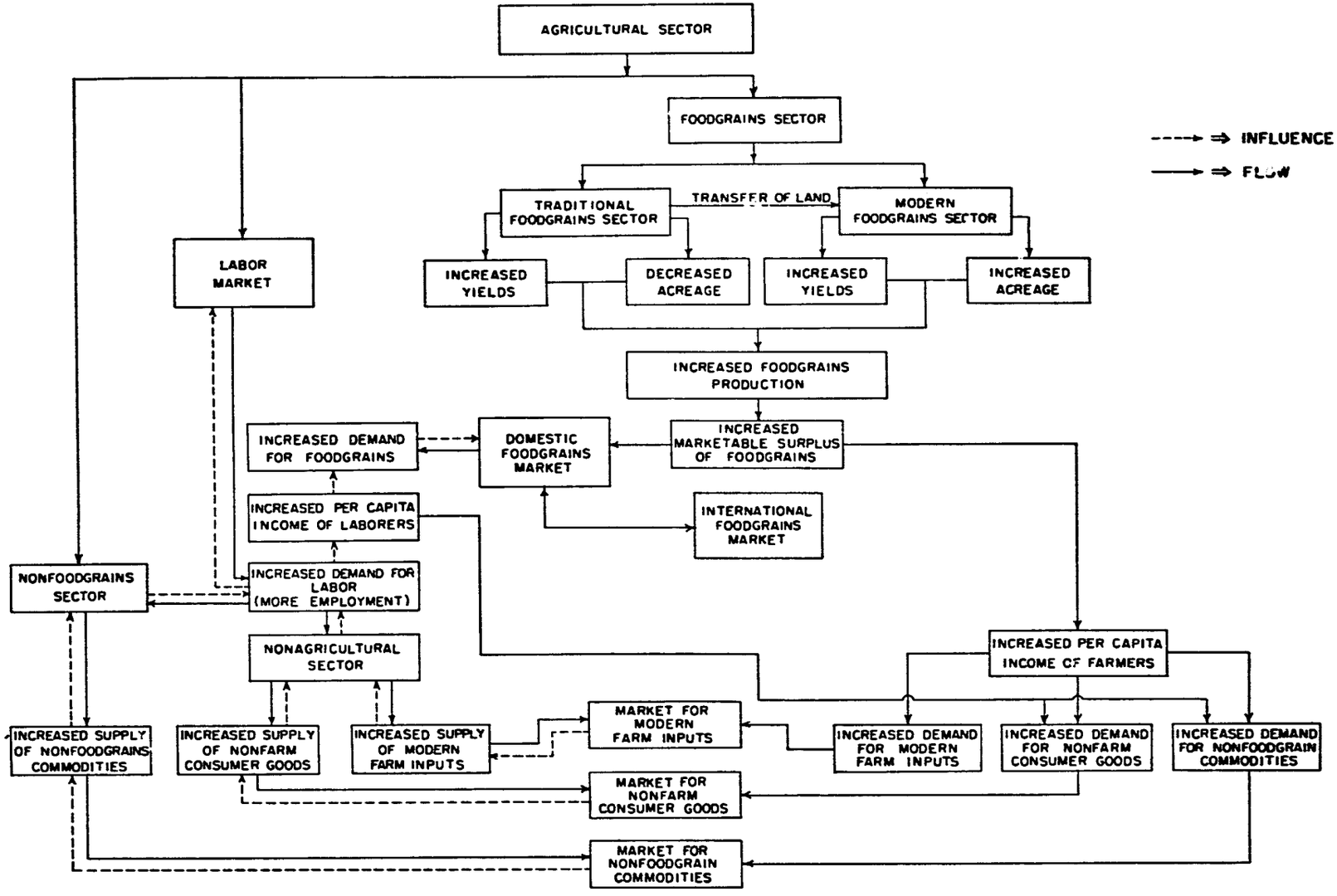
Consequently, the total output of the nonfarm consumer goods is also determined by the potential demand by the consumers in the agricultural sector. Thirdly, consumers in the nonagricultural sector provide a market for the foodgrains produced in the agricultural sector. Foodgrains production increases in response to various factors, including technological change. Finally, the agricultural sector includes a pool of unemployed or partly unemployed laborers who are willing to migrate to the nonagricultural sector if they are assured full time employment in that sector. Consequently, the nonagricultural sector creates demand for labor which is supplied by the agricultural sector.

Determination of Employment

In this model employment is determined separately in three different sectors. These are (i) foodgrain sector, (ii) nonfoodgrains agricultural sector, and (iii) nonagricultural sector. The employment in the foodgrains sector is determined by the technological conditions prevailing in that sector. The employment in the nonfoodgrains agricultural sector is determined by the output-labor ratio and the total output. Finally, the employment in the nonagricultural sector is determined by the ratio of residual supply of foodgrains to that sector and per capita consumption of the laboring class. This is potential rather than actual employment. The residual supply of foodgrains is obtained by subtracting all other demands except the household consumption demand by the laborers in the nonagricultural sector from the total supply of foodgrains. Consequently, we can determine the potential level of employment generated in the non-agricultural sector in response to an expansion in the foodgrains sector and changes in consumption patterns.

The conceptual framework of the simulation model incorporating all the key relationships and with an emphasis on the interdependence between foodgrain production, demand creation and employment is illustrated graphically in Figure 1.

FIGURE 1. SIMULATION MODEL: CONCEPTUAL FRAMEWORK ILLUSTRATING INTERDEPENDENCE BETWEEN FOODGRAINS PRODUCTION, DEMAND CREATION AND EMPLOYMENT



## 3. DATA, ASSUMPTIONS AND ESTIMATION

The macro-type simulation model has been tested by using data from the Indian Economy. India's case seems to be ideal for this purpose since (i) it has growing population, and the supply of labor is relatively elastic to economic opportunities, (ii) the size of the agricultural sector is large with a low industrial base, (iii) there is an acute food problem and relatively inelastic food supply, and (iv) the agricultural research system offers potential for a series of technological breakthroughs in agricultural production.

This section deals with generating the data used to estimate the model. A particular emphasis is given to the methodology used to derive various parameters, exogenous variables and the initial conditions of various endogenous variables. The sources of data are documented either within the text of this section or under the table. The assumptions are explicitly stated and are justified as to their relevance. The data generated are used to estimate the 'reference' simulation run. However, various parameters and variables have been changed to test the sensitivity of the system and perform various simulation experiments.

### Incremental Irrigated Area Under Foodgrains

The cultivated irrigated area under foodgrains is assumed to increase at an exogenously given constant rate. This could be accomplished by any of the sources of irrigation used in India such as canals, private or public tubewells, tanks, etc. Mathematically, the cultivated irrigated area under foodgrains during 't' can now be expressed as:

(1) $H_F^m(t) = H_F^m(t-1) + M_F(t)$,

where $H_F^m(t)$ and $H_F^m(t-1)$ refer to cultivated irrigated area under foodgrains during 't' and 't-1' respectively, and $M_F(t)$ is the annual addition (increment)

to the cultivated irrigated area which is allocated to foodgrains. The incremental irrigated area is determined by:

(2) $M_F(t) = \mu\,[H_F(t-1) - H_F^m(t-1)]$,

where $H_F(t-1)$ is the total cultivated area under foodgrains during t-1, and $\mu$ is the coefficient representing incremental irrigation capacity. The total cultivated area under foodgrains remains constant implying

(3) $H_F(t) = H_F(t-1) = H_F$

Since the total cultivated area under foodgrains is assumed to stay constant over time, the above functional form indicates that the incremental irrigated area under foodgrains declines over time. However, the total cultivated irrigated area under foodgrains increases over time but at a diminishing rate.

Initial Conditions for Cultivated and Cropped Area Under Foodgrains

The total cultivated area under foodgrains, $H_F(t)$, is the sum of

(4) $H_F(t) = H_F^m(t) + H_F^d(t)$,

where $H_F^m(t)$ and $H_F^d(t)$ are cultivated irrigated and cultivated unirrigated areas under foodgrains, respectively. Similarly, the total cropped area under foodgrains, $H_{CF}(t)$, is the sum of

(5) $H_{CF}(t) = H_{CF}^m(t) + H_{CF}^d(t)$,

where $H_{CF}^m(t)$ and $H_{CF}^d(t)$ refer to cropped irrigated and cropped unirrigated areas under foodgrains, respectively. $H_{CF}^m(t)$ and $H_{CF}^d(t)$ are determined as

(6) $H_{CF}^m(t) = [1+\alpha^m]\,H_F^m(t)$, and

(7) $H_{CF}^d(t) = [1+\alpha^d]\,H_F^d(t)$,

where $\alpha^m$ and $\alpha^d$ refer to the number of crops grown over and above the regular

single crop on irrigated and unirrigated land, respectively. Assuming double cropping on irrigated land and single cropping on unirrigated land i.e., $\alpha^m = 1$ and $\alpha^d = 0$, the equations (6) and (7) can be rewritten as:

(8) $H^m_{CF}(t) = \alpha\,[H^m_F(t)]$, and

(9) $H^d_{CF}(t) = H^d_F(t)$,

which implies that

(10) $H_{CF}(t) = \alpha\,[H^m_F(t)] + H^d_F(t)$

The total cropped area under foodgrains during 1964-65 was 75 percent of the total cropped area under foodgrains and nonfoodgrains. Approximately, 20 percent of the cropped area under foodgrains was irrigated. However, we assume that only ten percent of the cropped area under foodgrains was under well controlled and assured irrigation.

Assuming that the total cropped area is equal to 1.0, the implied cropped area under foodgrains is 0.75. Given our assumption about irrigation, the cropped irrigated area under foodgrains is equal to 0.075. This implies that $H_{CF}(t) = 0.75$, $H^m_{CF}(t) = 0.075$, $H^d_{CF}(t) = 0.675$,

$H^m_F(t) = 0.0375$, $H^d_F(t) = 0.675$, and $H_F(t) = 0.7125$.

We have specified $H^m_F(t)$ and $M_F(t)$ above as

(11) $H^m_F(t) = H^m_F(t-1) + M_F(t)$, and

(12) $M_F(t) = \mu\,[H_F(t-1) - H^m_F(t-1)]$.

Substituting for $M_F(t)$ in equation (11), we obtain

(13) $H^m_F(t) = [1-\mu]\,H^m_F(t-1) + \mu H_F(t-1)$.

We know that $H_F(t-1) = 0.7125$ and $H^m_F(t) = 0.0375$. Assuming $\mu = 0.01$ and hence $(1-\mu) = 0.99$, we can solve for $H^m_F(t-1)$ by using equation (13). It turns out that $H^m_F(t-1) = 0.0307$.

Sectoral Population Distribution

The initial distribution of the population between the agricultural and the non-agricultural sectors and between laborers and entrepreneurs is based on 1961 Census of India and is reported in Table 1. The male population is taken as representative of the distribution of total population. The adult male population in the agricultural sector is arbitrarily divided between laborers and entrepreneurs on the basis of land ownership and farm size.

The landless laborers and farmers (pure tenant, tenant-cum-owner and pure owner operated) operating farms below five acres are classified as laborers. On the other hand, farmers operating five acres and above are classified as entrepreneurs. This is a simplifying assumption which recognizes that many families with farms of over five acres provide family labor on their farms and those with less than five acres receive land income from land, but assumes that errors in the simplifying assumption roughly cancel. This assumption is intended to provide a crude estimate of the labor force participation of the agricultural population, and the proportion of population that is most likely to gain from increased employment in the agricultural sector and/or is most likely to migrate to urban areas if new jobs become available there.

The agricultural sector includes crop farming, livestock raising and related activities. The nonagricultural sector, on the other hand, includes household industry, forestry, fishing, hunting, mining and quarrying, manufacturing, trade, electricity, gas, storage, transport, communication, sanitary services, etc. The laborers in the nonagricultural sector are defined as those who work under an employer for wages in cash. The landless laborers in the agricultural sector are those who work on another person's land for cash or kind wages. Some of them, however, may have a contract for work for a specific amount of time and may be called permanently hired laborers. In this model, however, we do not make any such distinction between casual and permanently hired laborers.

Table 1: POPULATION DISTRIBUTION BASED ON ADULT MALE WORKERS AND FARM SIZE IN INDIA, 1961

In Millions

| Working status | Agricultural sector | | Nonagricultural sector |
|---|---|---|---|
| Laborers[1/] | | 49.9 | 43.4 |
| Landless laborers[2/] | 17.3 | | |
| Farms <1 acre[2/] | 5.1 | | |
| Farms 1 to 4.9 acres[2/] | 27.5 | | |
| Entrepreneurs[1/] | | 33.8 | 2.0 |
| Farms 5 to 10 acres[2/] | 15.5 | | |
| Farms 10 to 15 acres[2/] | 7.1 | | |
| Farms 15 to 30 acres[2/] | 7.4 | | |
| Farms 30 to 50 acres[2/] | 2.5 | | |
| Farms over 50 acres[2/] | 1.3 | | |
| Total | | 83.7 | 45.4 |

Sources:

1/ Census of India, 1961, Vol. I, Part II B (i), General Economic Tables, Table B-I, pp. 86-87.

2/ Census of India, 1961, Vol. I, Part III (ii), Household Economic Tables, Table B-XII, pp. 20. This source gives the data of family workers in different holding sizes for 20 percent of the sample in India. Thus, in order to obtain the number of family workers for all-India the reported figures were multiplied by five.

As shown in Table 2, 72.3 percent of the total adult male workers are considered laborers and 27.7 percent entrepreneurs. Among the laborers, 53.5 percent reside in the agricultural sector and 46.5 reside in non-agricultural sector. Among the entrepreneur, 94.4 percent are in the agricultural sector and only 5.6 percent are in the nonagricultural sector.

In this model we assume that all the labor force in the nonagricultural sector is fully employed, but that only 70 percent of the labor force in the agricultural sector is fully employed. The 70 percent figure is arbitrarily specified. It is a simplifying assumption that 30 percent of the labor force in the agricultural sector is highly elastic to the economic opportunities made available to them in the agricultural or in the non-agricultural sectors, and relates to the widespread seasonal unemployment in the agricultural sector and the opportunities for low cost mechanization.

Table 2: POPULATION DISTRIBUTION BASED ON ADULT MALE WORKERS IN INDIA, 1961

In Millions

| Sector | Laborers | | Entrepreneurs | | Total |
|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | |
| Agriculture | 49.9 | 53.5 | 33.3 | 94.4 | 83.7 |
| Nonagriculture | 43.4 | 46.5 | 2.0 | 5.6 | 45.4 |
| Total | 93.3 | 100.0 | 35.8 | 100.0 | 129.1 |
| Percent | 72.3 | | 27.7 | | 100.0 |

Source: Adapted from Table 1.

Initial Conditions for the Labor Population

The growth of labor population (both in the agricultural and the non-agricultural sectors) can be expressed as:

$$(14) \quad P_L(t) = [1+\theta_L] \; P_L(t-1),$$

where $P_L(t)$ is the total labor population and $\theta_L$ is the annual growth rate of labor population. Assuming that the index of initial total labor population is equal to 1.0 and that labor population grows at 2.5 percent per annum ie. $\theta_L = 0.0025$, the value of $P_L(t-1)$ turns out to be equal to 0.9756. The labor population growth rate is given exogenously and is assumed to stay constant for each simulation run. However, simulation experiments are conducted by assigning different values to $\theta_L$.

It is assumed that the nonlabor population (i.e. entrepreneurial class) increases at the same rate as the labor population, therefore keeping the ratio of laborers to entrepreneurs constant over time. It is also assumed that the proportion of the nonlaboring class in agriculture (and therefore in nonagriculture) remains constant. This latter simplifying assumption is needed to determine the marketable surplus of foodgrains.

Household Consumption Expenditure Patterns

All the consumption commodities considered in this model are classified into three groups: (i) foodgrains agriculture, (ii) nonfoodgrains agriculture, and (iii) processed agricultural commodities or agro-industrial products. The details of commodity grouping under each category is reported in Table 3. The consumption functions were estimated from the expenditure data collected during 1964-65.

The log-log-inverse function of the following form was used to estimate the consumption demand for three different commodity categories.

$$(15) \quad \log_e c_{ij}(t) = \alpha_j + \frac{\beta_j}{Y_i(t)} + \gamma_j \log_e Y_i(t),$$

Table 3. COMMODITY GROUPING FOR HOUSEHOLD CONSUMPTION FUNCTIONS

| Group number | Commodity Group | Commodities |
|---|---|---|
| I | Foodgrains agriculture | Cereals<br>Pulses |
| II | Nonfoodgrains agriculture | Meat, eggs & fish<br>Milk & milk products<br>Tobacco<br>Other foods* |
| III | Processed agriculture | Vegetable oil<br>Other edible oils<br>Sugar<br>Gur and khandsari<br>Cotton textiles<br>Woolen textiles |

* Other foods include vegetables, fruits, nuts, spices, salt, beverages, refreshments, jams and jellies.

Source: All India Consumer Expenditure Survey, Vol. II, National Council of Applied Economic Research, New Delhi, 1967.

where $c_{ij}(t)$ is per capita consumption of $i^{th}$ expenditure class and for $j^{th}$ commodity group, $Y_i(t)$ is per capita income of $i^{th}$ expenditure class, $\alpha_j$, $\beta_j$ $\gamma_j$ are the consumption function coefficients for $j^{th}$ commodity group. The regression results are reported below in Table 4.

Table 4: HOUSEHOLD CONSUMPTION FUNCTIONS: REGRESSION RESULTS

| Commodity group | Regression Coefficients[1] | | | |
|---|---|---|---|---|
| | $\alpha j$ | $\beta j$ | $\gamma j$ | $R^2$ |
| Foodgrains agriculture | 2.579** (0.604) | -9.15* (4.242) | 0.019 (0.131) | 0.964 |
| Nonfoodgrains agriculture | -1.225** (0.428) | -5.291 (3.008) | 0.954** (0.093) | 0.993 |
| Processed agriculture | 0.599 (0.563) | -16.508** (3.952) | 0.433** (0.122) | 0.982 |

[1]Figures in parentheses represent the standard errors of the respective coefficients.

* Significant at 95 percent level.

** Significant at 99 percent level.

Using data from NSS consumer expenditure survey,[2/] rural and urban combined, it was found that the consumption expenditure of the lower 72.3 percent of the sample (same as the proportion of laborers) amounted to approximately 50 percent of the total consumption expenditure by that sample while the upper 27.7 percent (same as the proportion of entrepreneurs) accounted for the remaining 50 percent of the total consumption expenditure. Furthermore, according to the NSS sample the monthly per capita expenditure for laborers and entrepreneurs was Rs. 16.9 and Rs. 44.1, respectively.

Using indices to represent the per capita annual expenditure and population, let the index of per capita annual experditure of the labor be equal to 1.0, and the index of the size of labor population be equal to 1.0. It follows that the index of the total expenditure by the labor population is equal to 1.0. Since both groups divide the total consumption expenditure equally, it follows that the index of the total expenditure by the entrepreneurial population is equal to 1.0. It also follows that the index of the entrepreneurial population is equal to 0.277/0.723 = 0.383 and the index of their per capita annual consumption expenditure is equal to 44.1/16.9 = 2.61. The multiple of 0.383 and 2.61 is approximately equal to 1.0. The distribution of expenditure between laborers and entrepreneurs, and the consumption patterns based on the consumption functions (described above) is reported in Table 5.

## Input-Output Coefficients and Structure of Sectoral Output

The total demand for output from different sectors is composed of (i) consumption demand, and (ii) intermediate demand. The total initial demand here represents the total initial output of a particular sector. Using Leontief input-output framework, the total demand can be expressed as:

$$(16) \quad Q(t) = [I-B]^{-1} \; C(t),$$

where I is the identity matrix, $[I-B]^{-1}$ is the inverse of [I-B], C(t) is sectoral consumption levels vector, and Q(t) is the sectoral output levels vector. This implies that the total output of each sector is exhausted by

---

2/ National Sample Survey, No. 142, Tables on Consumer Expenditure (preliminary), The Cabinet Secretariat, Government of India, New Delhi, 1965.

Table 5. CONSUMPTION PATTERNS FOR TWO DIFFERENT EXPENDITURE CLASSES

| Expenditure class | Percent population | Percent total expenditure | Index of total expenditure | Foodgrains agriculture | | Nonfoodgrains agriculture | | Processed agriculture | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Budget share | Consumption index | Budget share | Consumption index | Budget share | Consumption index |
| Laborers | 72.3 | 50.0 | 1.0 | 0.4790 | 0.4790 | 0.1886 | 0.1886 | 0.1379 | 0.1379 |
| Entrepreneurs | 27.7 | 50.0 | 1.0 | 0.2611 | 0.2611 | 0.2189 | 0.2189 | 0.1463 | 0.1463 |
| Total (mean) | 100.0 | 100.0 | 2.0 | (0.3700) | 0.7401 | (0.2038) | 0.4075 | (0.1421) | 0.2842 |

Sources: 1. Distribution of consumer expenditure - National Sample Survey No. 142, Tables with Notes on Consumer Expenditure (Preliminary), the Cabinet Secretariat, Government of India, 1965.

2. Estimated demand equation from NCAER data, All India Consumer Expenditure Survey, Vol. II, National Council of Applied Economic Research, New Delhi, 1967.

NOTES:

(i) Budget shares ($\pi_{ij}$) refer to the proportion of total per capita expenditure for $i^{th}$ expenditure class and for $j^{th}$ commodity group:

$$\pi_{ij}(t) = \frac{c_{ij}(t)}{Y_i(t)} ,$$

where $Y_i$ is the total per capita expenditure for $i^{th}$ expenditure class, and $c_{ij}(t)$ is the per capita expenditure by $i^{th}$ expenditure class on $j^{th}$ commodity group and is determined by using the appropriate demand equations reported above.

(ii) The consumption patterns are reported in monetary rather than in physical units.

the intermediate demand and household consumption demand. This model deals with three sectors: (i) foodgrains agriculture, (ii) nonfoodgrains agriculture, and (iii) processed agriculture or agro-industrial sector.

The input-output table, developed by the Perspective Planning Division of the Government of India, has been used to estimates $[I-B]^{-1}$, and is reported below:

$$[I-B]^{-1} = \begin{bmatrix} 1.0975 & 0.1097 & 0.1572 \\ 0.0139 & 1.0950 & 0.5114 \\ 0.0004 & 0.0318 & 1.2155 \end{bmatrix}$$

The total household consumption expenditure demand vector of indices has been estimated in the previous section and is reported below:

$$C(t) = \begin{bmatrix} 0.7401 \\ 0.4075 \\ 0.2842 \end{bmatrix}$$

By substituting for $[I-B]^{-1}$ and $C(t)$ in equation (16), it follows that

$$Q(t) = \begin{bmatrix} 0.9016 \\ 0.6018 \\ 0.3587 \end{bmatrix}$$

where $Q_1(t)$, $Q_2(t)$ and $Q_3(t)$ are the indices of initial output levels of foodgrains agriculture, nonfoodgrains agriculture and processed agriculture, respectively. All the coefficients and the demand components are expressed in monetary rather than physical terms. The sectors grouped together in the input-output table which are used to determine matrix B are reported in Table 6. These three sectors account for 100 percent of the intermediate demand for foodgrains agriculture, 97 percent of the intermediate demand for nonfoodgrains agriculture, and 82 percent of the intermediate demand for processed agriculture.

The input-output coefficients, i.e. the elements of matrix B, are reported in Table 7. The structure of output as determined above depends only on intermediate demand and household consumption demand. However, it could be expanded to include government demand, net exports and change

Table 6. CATEGORIZATION OF SECTORS INTO THREE MAIN COMMODITY GROUPS

| Sector grouping | Sector Number * | Sector |
|---|---|---|
| I. Foodgrains agriculture | 32 | Foodgrains |
| II. Nonfoodgrains agriculture | 12 | Leather |
| | 15 | Animal husbandry |
| | 18 | Plantations |
| | 33 | Cotton |
| | 36 | Jute |
| | 45 | Oil seeds |
| | 46 | Sugarcane |
| | 47 | Tobacco |
| | 48 | Fruits and vegetables |
| | 49 | Other crops |
| III. Processed agriculture (agro-industrial commodities) | 11 | Rubber |
| | 13 | Other leather products |
| | 14 | Leather footwear |
| | 16 | Floor milling |
| | 17 | Sugar |
| | 19 | Gur and khandsari |
| | 20 | Vegetable oils |
| | 21 | Vanaspati ghee |
| | 23 | Starch |
| | 24 | Milk products |
| | 25 | Breweries and soft drinks |
| | 26 | Biscuits and confections |
| | 27 | Cigarettes and cigars |
| | 28 | Bidi |
| | 29 | Other tobacco products |
| | 30 | Fruit and vegetable preservatives |
| | 31 | Cashewnut processing |
| | 34 | Cotton yarn |
| | 35 | Cotton textiles |
| | 37 | Jute textiles |
| | 38 | Woolen yarn |
| | 39 | Woolen textiles |

* These numbers correspond to the sector numbers in the Input-Output table for India prepared by the Perspective Planning Division, Government of India, 1965

Source: Structure of Indian Economy, Industrial Flows and Patterns of Final Demand, Studies in the Perspective Planning Division, Government of India, 1966.

Table 7. INPUT-OUTPUT COEFFICIENTS*

| Sector | FA | NA | PA |
|---|---|---|---|
| FA | $b_{FF}$= 0.087681 | $b_{FN}$=0.089076 | $b_{FP}$=0.080562 |
| NA | $b_{NF}$=0.011561 | $b_{NN}$=0.074322 | $b_{NP}$=0.387907 |
| PA | $b_{PF}$=0.0 | $b_{PN}$=0.024176 | $b_{PP}$=0.167141 |

FA => Foodgrains agriculture

NA => Nonfoodgrains agriculture

PA => Processed agriculture

* The coefficients are expressed in rupees based on 1960-61 producer's prices.

Source: Structure of Indian Economy, Industrial Flows and Patterns of Final Demand, Studies in the Perspective Planning Division, Government of India, New Delhi, 1966.

in the stock of inventories. Finally, the output of foodgrains from the second period onward is determined by the supply conditions in the foodgrains sector which in turn are determined by the farm technology and other technological conditions. The output of nonfoodgrains agriculture and processed agriculture, however, continues to be determined by the derived demand conditions described above.

Labor's Relative and Total Shares in Sectoral Output

The relative share of labor in the foodgrains output from a single hectare can, in general, be specified as

$$(17) \quad s_{1F}(t) = \frac{E^{h}_{LF}(t) \cdot w}{h_F(t)},$$

where $s_{1F}(t)$ is the relative share of labor in foodgrains output from a single hectare, $E^{h}_{LF}(t)$ is amount of labor used to cultivate a single hectare under foodgrains, w is the wage rate and $h_F(t)$ is the foodgrains output per hectare. Since the labor use and output per hectare differs between the modern and traditional foodgrains sector, we can specify the relative labor shares for each of these sectors:

$$(18) \quad s^{m}_{1F}(t) = \frac{E^{hm}_{LF}(t) \cdot w}{h^{m}_{F}(t)}, \text{ and}$$

$$(19) \quad s^{d}_{1F}(t) = \frac{E^{hd}_{LF}(t) \cdot w}{h^{d}_{F}(t)},$$

where $s^{m}_{1F}(t)$ and $s^{d}_{1F}(t)$ refer to the relative share of labor in foodgrains output from modern and traditional foodgrains output, respectively.

The total share of employed labor in total foodgrains production from modern and traditional sectors can be determined as:

$$(20) \quad S^{m}_{1F}(t) = s^{m}_{1F}(t) \cdot Q^{m}_{F}(0) + s^{m\Delta}_{1F}(t) \left[ Q^{m}_{F}(t) - Q^{m}_{F}(0) \right], \text{ and}$$

$$(21)\quad S^{d}_{1F}(t) = s^{d}_{1F}(t) \cdot Q^{d}_{F}(0) + s^{d\Delta}_{1F}(t)\,[Q^{d}_{F}(t)-Q^{d}_{F}(0)]\,,$$

where $S_{1F}(t)$ is the total labor share from foodgrains production, $Q_F(0)$ is the initial foodgrains output, $Q_F(t)$ is the foodgrains output during 't' (i.e. after the initial period), and $s^{\Delta}_{1F}$ is the relative labor share from the incremental output of foodgrains. The superscripts 'm' and 'd' refer to modern and traditional sectors, respectively. The values of $s_{1F}(t)$ and $s^{\Delta}_{1F}(t)$ are given exogenously.

The total labor share in the nonfoodgrains agriculture can be determined similarly as follows:

$$(22)\quad S_{1N}(t) = s_{1N} \cdot Q_N(0) + s^{\Delta}_{1N}(t)\,[Q_N(t)-Q_N(0)]\,,$$

where $S_{1N}$, $s_{1N}$ and $Q_N$ are the total labor share, relative labor share and the total output of nonfoodgrains agriculture. For the simulation runs the exogenously given values of relative labor shares for different sectors are:

$$s^{m}_{1F}(t) = 0.200,\quad s^{m\Delta}_{1F}(t) = 0.200$$

$$s^{d}_{1F}(t) = 0.425,\quad s^{d\Delta}_{1F}(t) = 0.800$$

$$s_{1N}(t) = 0.300,\quad s^{\Delta}_{1N}(t) = 0.300$$

Agricultural Productivity, Wage Rate and Labor Share

During 1964-65, approximately 20 percent of the cropped area under foodgrains was irrigated.[3/] However, all of this land was not under assured and well controlled irrigation. To be more realistic, we assume that only half of this area was under effective and well controlled irrigation. The

3/ The proportion of foodgrains area under irrigation during 1964-65 was 0.2009 as reported in the Statistical Abstract of India, Central Statistical Organization, New Delhi, 1968.

availability of irrigation water seems to be a prerequisite for the adoption of modern farm technology available in the low income countries along with high yielding seed varieties, chemical fertilizer, etc. It is assumed that farmers use modern technology on all areas under effective irrigation. It follows that in the initial period only ten percent of the foodgrains area is under modern production techniques.

The total cropped area is divided between foodgrains and nonfoodgrains, with approximately 75 percent of the total cropped area initially under foodgrains during 1964-65.[4/] The average output-hectare ratios for modern foodgrains, traditional foodgrains, and nonfoodgrains are computed as a ratio of the total output and total cropped area under each sector, respectively. Given that ten percent of the foodgrains cropped area is under modern production techniques, and assuming that the yield per hectare in the modern foodgrains sector is 30 percent higher over the yield in the traditional foodgrains sector, the proportion of foodgrains production that is from the modern foodgrains sector can be determined as follows. Let

(23) $\delta_m(t) = 1 - \delta_d(t)$,

where $\delta_m(t)$ and $\delta_d(t)$ are the proportions of foodgrains production from modern and traditional foodgrains sectors, respectively. The value of $\delta_d(t)$ can be determined as

(24) $$\delta_d(t) = \frac{\psi_d(t) \cdot H_{CF}(t)}{r \cdot \psi_m(t) \cdot H_{CF}(t) + \psi_d(t) \cdot H_{CF}(t)},$$

where $H_{CF}(t)$ is the total cropped area under foodgrains, $\psi_d(t)$ is the proportion of total cropped area under traditional foodgrains sector, $\psi_m(t)$ is the proportion of total cropped area under modern foodgrains sector, and r is the ratio of yield per cropped hectare under modern

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4/ As reported in Estimates of Area and Production of Principal Crops in India, Directorate of Economics and Statistics, 1968-69, the total cropped area in 1964-65 was 158878 thousand hectares and cropped area under foodgrains was 118112 thousand hectares.

production techniques to the yield per cropped hectare under traditional production techniques. The above equation can further be simplied to:

$$(25) \quad \delta_d(t) = \frac{\psi_d(t)}{r.\psi_m(t) + \psi_d(t)}$$

From the above we know that during 1964-65,

$$\psi_d(t) = 0.9,$$
$$\psi_m(t) = 0.1, \text{ and}$$
$$r = (1.30/1.0) = 1.3.$$

By substituting these values in the above equation, we can solve for $\delta_d(t)$ as

$$\delta_d(t) = \frac{0.9}{(1.3)(0.1)+0.9} = \frac{0.9}{1.03} = 0.8738.$$

From equation (23), it follows that

$$\delta_m(t) = 1.0 - 0.8738 = 0.1262$$

The output - hectare ratio for foodgrains in the traditional foodgrains sector $h_F^d(t)$, can now be determined as:

$$(26) \quad h_F^d(t) = \frac{Q_F(t) \cdot \delta_d(t)}{\psi_d(t) \cdot \pi_F(t)}$$

where $Q_F(t)$ is the total production of foodgrains, and $\pi_F(t)$ is the proportion of total cropped area which is under foodgrains. We know that:

$$Q_F(t) = 0.9016,$$
$$\delta_d(t) = 0.8738,$$
$$\psi_d(t) = 0.9, \text{ and}$$
$$\pi_F(t) = 0.75$$

By substituting these values in equation (26) we can solve for $h_F^d(t)$ which turns out to be 1.1671. Finally, the output - hectare ratio for foodgrains in the modern foodgrains sector can be determined as:

(27) $h_F^m(t) = r.\ H_F^d(t)$

We know that $r = 1.3$ and $h_F^d(t) = 1.1671$, the value of $h_F^m(t)$ turns out to be equal to 1.5173.

The implicit wage rate in the agricultural sector in the initial period can be determined as:

(28) $w = \dfrac{W}{P_{LA}^E}$,

where w is the implicit wage rate, W is the total wage bill in monetary units in the agricultural sector and $P_{LA}^E$ is the fully employed labor force in the agricultural sector. Earlier we have assumed that only 70 percent of the agricultural labor force is fully employed. This implies that $P_{LA}^E = 0.7\ P_{LA}$, where $P_{LA}$ is the total labor force in the agricultural sector. The size of $P_{LA}$ is determined as a ratio between the wage bill and per capita income of laborers in the agricultural sector. Assuming that laborers don't save, it implies that per capita income is equal to per capita expenditure of the laboring class which is assumed to be equal to unity. It follows that $P_{LA}$=W. The wage bill can be determined as a sum of the total labor shares in different sectors within the agricultural sector. It can be specified as:

(29) $W = s_{1F}^d.Q_F^d + s_{1F}^m.\ Q_F^m + s_{1N}.\ Q_N.$

we know that

$$Q_F^d = \delta_d.Q_F = 0.8738\ (0.9016) = 0.7878,$$

$$Q_F^m = \delta_m.Q_F = 0.1262\ (0.9016) = 0.1138, \text{ and}$$

$$Q_N = 0.6018$$

Furthermore, we know that $s_{1F}^d$, $s_{1F}^m$ and $s_{1N}$ refer to labor's relative shares

in the traditional foodgrains sector, modern foodgrains sector and non-foodgrains sector, respectively. The values of initial relative labor shares are specified exogenously, which are:

$s^d_{1F} = 0.425$

$s^m_{1F} = 0.200$, and

$s_{1N} = 0.300.$

Substituting these values in equation (29), we can solve for W as follows:

$$W = (0.425)\ (0.7878) + (0.200)\ (0.1138) + (0.300)\ (0.6018)$$
$$= 0.3348 + 0.0228 + 0.1805$$
$$= 0.5381$$

Substituting for $P^E_{LA}$ and W in equation (28), it follows that the implicit wage rate of laborers in the agricultural sector is:

$$W = \frac{0.5381}{0.7\ (0.5381)} = 1.4286$$

The output - labor ratio in a particular sector within the agricultural sector can be determined by dividing the total output and the labor force employed in that particular sector. It can be expressed as:

$$(30)\quad q^k_j = \frac{Q^k_j}{P^{Ek}_{Lj}}, \text{ and}$$

$$(31)\quad P^{Ek}_{Lj} = \frac{S^k_{1j}}{w},$$

where $q^k_j$ is the output - labor ratio in the $j^{th}$ agricultural sector using $k^{th}$ technology, $Q^k_j$ is the total output of $j^{th}$ agricultural sector using $k^{th}$ technology, $P^{Ek}_{Lj}$ is the total labor force employed in the $j^{th}$ agricultural sector using $k^{th}$ technology and finally $S^k_{1j}$ is the total labor share in the $j^{th}$ agricultural sector using $k^{th}$ technology. By combining equations (30) and (31), we obtain

$$(32)\quad q^k_j = \frac{Q^k_j \cdot w}{S^k_{1j}}$$

Since in the initial period $S^k_{1j} = s^k_{1j} \cdot Q^k_j$, equation (32) can be rewritten as:

$$(33) \quad q^k_j = \frac{Q^k_j . w}{s^k_{1j} . Q^k_j} = \frac{w}{s^k_{1j}} .$$

From above we know the values of w and $s^k_{1j}$. By substituting these values in equation (33) we obtain:

$$q^d_F = 1.4286/0.425 = 3.3614,$$

$$q^m_F = 1.4286/0.200 = 7.1430, \text{ and}$$

$$q_N = 1.4286/0.300 = 4.7620,$$

where $q^d_F$, $q^m_F$ and $q_N$ refer to output-labor ratios in traditional foodgrains sector, modern foodgrains sector, and nonfoodgrains sector, respectively.

Initial Conditions for Output-Hectare Ratios for Foodgrains

The output per hectare (i.e. yield per hectare) of foodgrains both in the modern and traditional foodgrains sectors, is increasing over time at an exogenously given growth rate. The yield equations can be expressed as:

$$(34) \quad h^m_F(t) = [1+\gamma^m]\, h^m_F(t-1), \text{ and}$$

$$(35) \quad h^d_F(t) = [1+\gamma^d]\, h^d_F(t-1),$$

where $h^m_F(t)$ and $h^d_F(t)$ refer to output per hectare of foodgrains from irrigated and unirrigated land, respectively. $\gamma^m$ and $\gamma^d$ are the per hectare yield growth rates from modern and traditional foodgrains sectors, respectively.

The values of $h^m_F(t)$ and $h^d_F(t)$ are determined in Section 3.8 which are $h^m_F(t) = 1.5173$ and $h^d_F(t) = 1.1671$. The yield growth rates for the reference run are assumed to be $\gamma^m = 0.03$ and $\gamma^d = 0.02$. Given these values, we can solve for the initial output-hectare ratios which turn out to be $h^m_F(t-1) = 1.4731$ and $h^d_F(t-1) = 1.1442$.

The model has been tested by using a special computer algoritham, MACRO-SIM, on IBM 360-65 computer system. By specifying the values of various parameters, exogenous variables, initial conditions for various endogenous variables, and various feedback functions, the system is solved for t=1. The solution vector of endogenous variables during t=1 along with exogenous information (exogenous variables and parameter values) serves as a benchmark to set up the problem for t=2. The cycle is repeated thereon until the economy achieves full employment.

## 4. EMPIRICAL RESULTS AND ECONOMIC ANALYSIS

The empirical results are obtained from the 'reference run' based on the assumptions described above. This section deals with interpreting these results and analyzing their economic content.

The total cropped area under foodgrains increases over time. This is accomplished by bringing more and more unirrigated area under irrigation which subsequently leads to double cropping. The proportion of the total cropped area under irrigation grows from ten percent in the initial period to approximately 30 percent at the end of the twelfth period, when the economy achieves full employment. However, the growth rate of cultivated irrigated area decreases steadily from 22.5 percent in the initial period to 6.3 percent in the twelfth period. The area under irrigation increases over time but at a diminishing rate. This is due to the fact that the magnitude of the initial level of irrigated area is very low, and the gap between total cultivated and total irrigated area under foodgrains is declining over time.

Given the assumptions about technology, foodgrains production grows at approximately 3.9 percent and stays more or less constant over time. The marketable surplus out of the foodgrains sector, however, grows faster at a more or less constant 4.3 percent over time. This occurs because the budget share of foodgrains in the consumption set for the

agricultural enterpreneurial class declines over time. Not only the growth rate but the proportion of the foodgrains marketed out of the foodgrains sector also increases from 60 percent in the initial period to slightly over 62 percent in the twelfth period.

An increase in employment and wages leads to an increase in per capita income for the laboring class. The per capita income for the laboring class increases at an increasing rate from 2.8 percent initially to 3.3 percent at the end of the twelfth period when full employment is achieved. Given the consumption behavior of the laboring class, demand grows for more foodgrains. As a result, the increased supply of foodgrains is absorbed by the corresponding increase in demand by the laboring class. However, the market is cleared in a way so that foodgrains prices do not rise and consistency of the system is maintained since all these variables are determined simultaneously and endogenously in the system.

The growth rates for the production of foodgrains, nonfoodgrains, agricultural production and agro-industrial products are reported in Table 8. As stated earlier, the annual growth rate for the production of foodgrains is 3.9 percent and stays rather constant. The growth rate for the demand for nonfoodgrains is not only substantially higher but also increases over time from 5.7 percent initially to 6.1 percent in the twelfth period. The growth rate for the agro-industrial commodities is 5.6 percent initially and increases slowly to 5.7 percent in the twelfth period. Finally the growth rate of the agricultural production (which is a weighted average of foodgrains and nonfoodgrains agricultural production) increases from 4.7 percent in the initial period to 4.9 percent in the terminal period.

The increase in the production of foodgrains has very important economic implications for the growth rates and distribution of employment among different sectors of the economy. Employment in the foodgrains sector is determined by the technological relationships and the labor shares. Employment in the nonfoodgrains sector, on the other hand, is determined by

Table 8. PRODUCTION OF FOODGRAINS, NONFOODGRAINS AND AGRO-INDUSTRIAL COMMODITIES IN INDIA: SIMULATION RESULTS FOR THE REFERENCE RUN*

| Time Period | ØFA | ØNA | ØAG | ØPA |
|---|---|---|---|---|
| | | | | Growth Rate |
| 1 | | | | |
| 2 | 3.936 | 5.735 | 4.656 | 5.627 |
| 3 | 3.935 | 5.786 | 4.684 | 5.652 |
| 4 | 3.933 | 5.806 | 4.698 | 5.647 |
| 5 | 3.931 | 5.862 | 4.728 | 5.674 |
| 6 | 3.928 | 5.877 | 4.742 | 5.665 |
| 7 | 3.925 | 5.934 | 4.772 | 5.691 |
| 8 | 3.922 | 5.962 | 4.792 | 5.691 |
| 9 | 3.918 | 6.000 | 4.816 | 5.700 |
| 10 | 3.913 | 6.030 | 4.837 | 5.699 |
| 11 | 3.909 | 6.053 | 4.855 | 5.692 |
| 12 | 3.904 | 6.103 | 4.885 | 5.708 |
| 13 | ** | ** | ** | ** |

* where

ØFA => Production of Foodgrains Sector

ØNA => Production of Nonfoodgrains Sector

ØAG => ØFA + ØNA

ØPA => Production of Agro-industrial Sector

** => Approximate full employment in the Economy

the production of nonfoodgrains and the labor shares. The production of nonfoodgrains, in turn, is determined by the total demand which is comprised of intermediate demand and consumption demand. Finally, the potential employment in the nonagricultural (agro-industrial plus nonagro-industrial) sector is determined by the residual supply of foodgrains and per capita consumption of foodgrains by the laboring class. The residual supply of foodgrains is determined by substracting from the total production (i) the intermediate demand, (ii) the consumption demand of foodgrains by laborers and entrepreneurs in the agricultural sector, and (iii) the consumption demand of entrepreneurs in the nonagricultural sector.

The sectoral employment growth rates obtained from the simulation model are reported in Table 9. The economy achieves close to full employment by the end of twelfth period. This, however, is subject to a critical assumption made with respect to initial unemployment in the agricultural sector, that 30 percent of the agricultural labor force is initially partly unemployed or unproductively employed. This implies that 30 percent of the total supply of agricultural labor is highly elastic to economic opportunities. Employment in the foodgrains sector grows at 2.9 percent and stays more or less constant over time. On the other hand, the growth rate for employment in the nonfoodgrains sector is quite high and increases over time from 5.7 percent initially to 6.1 percent in the twelfth period. For the agricultural sector employment as a whole, the employment growth rate is 3.9 percent initially and gradually increasing to 4.2 percent in the twelfth period.

The growth rate for employment in the nonagricultural sector gradually declines from 4.2 percent initially to 3.9 percent at the end of the twelfth period. This decline is partly caused by a substantial increase in employment in the nonfoodgrains agricultural sector. Finally, the overall employment growth rate is slightly over four percent and stays constant over time. However, it is consistently higher than the growth

Table 9. SECTORAL EMPLOYMENT GROWTH RATES FOR THE INDIAN ECONOMY: SIMULATION RESULTS FOR THE REFERENCE RUN

| Time Period | EFA | ENA | ELA | ELN | ELE |
|---|---|---|---|---|---|
| | | | | | Growth Rate |
| 1 | | | | | |
| 2 | 2.945 | 5.748 | 3.885 | 4.164 | 4.041 |
| 3 | 2.943 | 5.774 | 3.910 | 4.148 | 4.040 |
| 4 | 2.941 | 5.815 | 3.940 | 4.125 | 4.042 |
| 5 | 2.940 | 5.843 | 3.967 | 4.103 | 4.040 |
| 6 | 2.938 | 5.888 | 4.001 | 4.076 | 4.045 |
| 7 | 2.938 | 5.924 | 4.033 | 4.047 | 4.039 |
| 8 | 2.937 | 5.953 | 4.064 | 4.026 | 4.041 |
| 9 | 2.937 | 5.986 | 4.097 | 4.003 | 4.042 |
| 10 | 2.937 | 6.002 | 4.132 | 3.975 | 4.043 |
| 11 | 2.937 | 6.073 | 4.174 | 3.938 | 4.047 |
| 12 | 2.938 | 6.116 | 4.214 | 3.902 | 4.045 |

EFA => Employment in Foodgrains Sector

ENA => Employment in Nonfoodgrains Sector

ELA => Employment in Agricultural Sector

ELN => Employment in Nonagricultural Sector

ELE => Employment in the Economy as a Whole

rate for foodgrains production. The results clearly reflect the importance of foodgrains supply and shift in consumption patterns as important determinants of employment in different sectors of the economy.

The sectoral distribution of employment for the whole economy is reported in Table 10. Initially, 38 percent are employed in the agricultural sector and 46 percent are employed in the nonagricultural sector. This leaves approximately 16 percent unemployed for the economy as a whole. At the end of the twelfth period the economy is close to full employment with 44.5 percent of the laborers in the agricultural sector and 54.5 percent in the nonagricultural sector. The substantial part of the potential increase in employment in the agricultural sector comes from the non-foodgrain sector. Initially the foodgrains sector employs 25 percent of the total labor force which gradually increases to approximately 26 percent at the end of the twelfth period. However, the nonfoodgrains sector initially employs 12.6 percent of the total labor force and gradually increases to 18 percent at the end indicating a large potential for employment.

The incremental employment patterns by sectors are reported in Table 11. These indicate that annual increments in nonagricultural employment are decreasing gradually. However, in the case of the agricultural sector, the results show just the opposite. This increase in incremental employment in the agricultural sector is mainly due to the large potential for employment in the nonfoodgrains sector. In the foodgrains sector also the annual increments in employment are declining over time. This is partly caused by the gradual transformation of the agricultural sector from the traditional to the modern sector.

The distribution of employment by sectors in agriculture is shown in Table 12. In the initial period 30 percent of the agricultural labor is unemployed. During the same period the foodgrains and nonfoodgrains sectors employ 46.5 percent and 23.5 percent, respectively. At the end of the

Table 10. SECTORAL EMPLOYMENT PATTERNS FOR THE INDIAN ECONOMY: SIMULATION RESULTS FOR THE REFERENCE RUN

Percent

| Time Period | PL/T | EFA | ENA | ELA | ELN | ULE |
|---|---|---|---|---|---|---|
| 1 | 100 | 25.024 | 12.635 | 37.659 | 46.192 | 16.149 |
| 2 | 100 | 25.133 | 13.035 | 38.168 | 46.944 | 14.888 |
| 3 | 100 | 25.242 | 13.452 | 38.694 | 47.698 | 13.610 |
| 4 | 100 | 25.350 | 13.887 | 39.237 | 48.453 | 12.310 |
| 5 | 100 | 25.458 | 14.342 | 39.800 | 49.207 | 10.993 |
| 6 | 100 | 25.567 | 14.815 | 40.382 | 49.967 | 9.651 |
| 7 | 100 | 25.677 | 15.310 | 40.987 | 50.718 | 8.295 |
| 8 | 100 | 25.786 | 15.828 | 41.614 | 51.471 | 6.915 |
| 9 | 100 | 25.847 | 16.368 | 42.265 | 52.221 | 5.514 |
| 10 | 100 | 26.006 | 16.932 | 42.938 | 52.969 | 4.093 |
| 11 | 100 | 26.117 | 17.520 | 43.637 | 53.718 | 2.645 |
| 12 | 100 | 26.230 | 18.135 | 44.365 | 54.458 | 1.177 |

PL/T = Total Labor Force
ULE = Total Unemployment for the Economy
EFA, ENA, ELA, ELN — For definitions see Table 9.

Table 11. INCREMENTAL EMPLOYMENT PATTERNS BY SECTORS IN THE INDIAN ECONOMY: SIMULATION RESULTS FOR THE REFERENCE RUN

Percent

| Time Period | EFA | ENA | ELA | ELN | Total |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | 21.74 | 21.42 | 43.16 | 56.84 | 100 |
| 3 | 21.52 | 21.92 | 43.44 | 56.56 | 100 |
| 4 | 21.25 | 22.40 | 43.65 | 56.35 | 100 |
| 5 | 21.03 | 22.94 | 43.97 | 56.03 | 100 |
| 6 | 20.79 | 23.43 | 44.22 | 55.78 | 100 |
| 7 | 20.59 | 24.07 | 44.66 | 55.34 | 100 |
| 8 | 20.34 | 24.64 | 44.98 | 55.02 | 100 |
| 9 | 20.14 | 25.23 | 45.37 | 54.63 | 100 |
| 10 | 19.90 | 25.85 | 45.75 | 54.25 | 100 |
| 11 | 19.68 | 26.43 | 46.11 | 53.29 | 100 |
| 12 | 19.50 | 27.14 | 46.64 | 53.36 | 100 |

EFA
ENA
ELA
ELN
For definitions see Table 9.

Table 12. LABOR SUPPLY AND EMPLOYMENT PATTERNS IN INDIAN AGRICULTURE: SIMULATION RESULTS FOR THE REFERENCE RUN

| Time Period | PLA | EFA | ENA | ULA (Percent) |
|---|---|---|---|---|
| 1 | 100 | 46.506 | 23.482 | 30.012 |
| 2 | 100 | 47.370 | 24.569 | 28.061 |
| 3 | 100 | 48.259 | 25.719 | 26.022 |
| 4 | 100 | 49.179 | 26.942 | 23.879 |
| 5 | 100 | 50.122 | 28.235 | 21.643 |
| 6 | 100 | 51.101 | 29.609 | 19.290 |
| 7 | 100 | 52.102 | 31.067 | 16.831 |
| 8 | 100 | 53.135 | 38.615 | 14.250 |
| 9 | 100 | 57.201 | 34.257 | 11.562 |
| 10 | 100 | 55.297 | 36.001 | 8.702 |
| 11 | 100 | 56.431 | 37.854 | 5.715 |
| 12 | 100 | 57.594 | 39.820 | 2.506 |

PLA => Total Labor Force in the Agricultural Sector

ULA => Unemployed Labor Force in the Agricultural Sector

EFA, ENA } For definitions see Table 9.

twelfth period the unemployment is reduced to 2.5 percent. The sectoral distribution pattern also changes over time. At the end of the twelfth period the nonfoodgrains sector employs almost 40 percent of the total labor in the agricultural sector, implying increasing importance of the nonfoodgrains sector as industrialization takes place. Finally the shifts in the consumption patterns of the laboring class as indicated by per capita relative budget shares are reported in Table 13. The budget share for foodgrains consumption goes down while it rises for nonfoodgrains, processed agriculture and non-agro-industrial commodities. The rate of growth, however, differs among different consumption commodity groups. This result clearly portrays the Engel effects.

From the above discussion it is possible to tentatively conclude that (i) the production of foodgrains serves as an effective constraint for increasing employment in different sectors of the economy, (ii) increased supply of foodgrains facilitates (given that the institutional structure does not serve as a barrier) more and more employment as indicated by the higher employment growth rates as compared to the growth rate of foodgrains production, (iii) the potential for employment in the nonfoodgrains sector is quite substantial, and finally (iv) the implications of new technologies in the agricultural sector are quite substantial both for the agricultural sector and for the rest of the economy.

## 5. SIMULATION EXPERIMENTS AND SENSITIVITY ANALYSIS

The sensitivity of the dynamic system is analyzed by performing different simulation experiments on the basic model and comparing the subsequent empirical results with the 'reference' run. Since the main objective of the paper is to analyze the implications of technological change in the foodgrains sector with respect to economic growth and sectoral employment, we are limiting the scope of this section to four

Table 13. SHIFTS IN THE CONSUMPTION PATTERNS OF THE LABORING CLASS IN INDIA AS EXPRESSED BY PER CAPITA CONSUMPTION BUDGET SHARES: SIMULATION RESULTS FOR THE REFERENCE RUN

Percent

| Time | BSF | BSN | BSP | BSR | Total |
|---|---|---|---|---|---|
| 1 | 47.706 | 18.859 | 13.794 | 19.441 | 100 |
| 2 | 47.321 | 18.996 | 13.945 | 19.889 | 100 |
| 3 | 46.412 | 19.132 | 14.090 | 20.066 | 100 |
| 4 | 46.084 | 19.266 | 14.229 | 20.421 | 100 |
| 5 | 45.421 | 19.400 | 14.301 | 20.808 | 100 |
| 6 | 44.762 | 19.531 | 14.486 | 21.221 | 100 |
| 7 | 44.068 | 19.662 | 14.603 | 21.667 | 100 |
| 8 | 43.357 | 19.791 | 14.763 | 22.140 | 100 |
| 9 | 42.627 | 19.918 | 14.812 | 22.643 | 100 |
| 10 | 41.800 | 20.043 | 14.903 | 23.174 | 100 |
| 11 | 41.012 | 20.165 | 14.984 | 23.239 | 100 |
| 12 | 40.302 | 20.286 | 15.056 | 24.316 | 100 |
| 13 | ** | ** | ** | ** | ** |

BSF => Budget Share for Foodgrains Consumption

BSN => Budget Share for Nonfoodgrains Consumption

BSP => Budget Share for Agro-industrial Products Consumption

BSR => Budget Share for Residual Consumption Commodities

** => Approximate Full Employment in the Economy

different simulation experiments. These are (i) rapid growth in the modern foodgrains sector, (ii) foodgrains sector dominated by traditional technology implying very little modern components, (iii) slow growth in foodgrains production, and (iv) alternative rates of growth in population. The magnitude of values assigned to different model parameters under these simulation experiments are given in Table 14. The economic implications are then analyzed with respect to (i) time taken to reach approximate full employment in the economy, (ii) rate of growth of foodgrains production, (iii) sectoral employment growth rates, (iv) sectoral employment patterns, (v) rates of growth in demand for nonfoodgrains and agro-industrial products, and (vi) per capita income.

Rapid Growth in the Modern Foodgrains Sector

This case is represented by Run A in the following tables. The rapid growth in the modern foodgrains sector is obtained by the rapid transfer of land from unirrigated to irrigated acreage, hence increasing the potential for double cropping, while the traditional foodgrains sector shows a slow rate of growth of yield per hectare. In this case the economy moves close to full employment in ten periods as against twelve periods in the reference run. The foodgrains production grows at a faster rate beginning with 3.965 percent and gradually increasing to 4.227 percent annual growth rate in the terminal period. The growth rates for foodgrains production for initial, intermediate and terminal periods are reported in Table 15.

The rapidly modernizing foodgrains sector has important implications for employment growth rates and sectoral employment patterns. As demonstrated in Table 16, the temporal growth rates for employment in the foodgrains sector are very low, starting with 0.317 percent and gradually increasing to 1.337 percent annually. This is because the modern technology which is being used to transform the traditional foodgrains sector has very little incremental employment content. Furthermore, the low employment potential of the rapidly modernizing foodgrains sector is illustrated by the

Table 14. MAGNITUDE OF VALUES ASSIGNED TO DIFFERENT PARAMETERS UNDER ALTERNATIVE SIMULATION EXPERIMENTS

| Run | PARAMETERS | | | |
|---|---|---|---|---|
| | $\gamma^m$ | $\gamma^d$ | $\mu$ | g |
| Reference | 0.0300 | 0.0200 | 0.0125 | 0.0250 |
| A | 0.0300 | 0.0075 | 0.0200 | 0.0250 |
| B | 0.0300 | 0.0280 | 0.0070 | 0.0250 |
| C | 0.0300 | 0.0200 | 0.0060 | 0.0250 |
| D | 0.0275 | 0.0175 | 0.0060 | 0.0250 |
| E | 0.0300 | 0.0200 | 0.0125 | 0.0300 |
| F | 0.0300 | 0.0200 | 0.0125 | 0.0200 |

$\gamma^m$ => Yield growth in the modern foodgrains sector

$\gamma^d$ => Yield growth in the traditional foodgrains sector

$\mu$ => Land transfer (from traditional to modern) coefficients

g => Growth in population

TABLE 15: SIMULATION OF THE PRODUCTION OF FOODGRAINS, NONFOODGRAINS AND AGRO-INDUSTRIAL COMMODITIES*

Growth Rate

| Time Period | A | | | | B | | | | C | | | | D | | | | E | | | | F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ϕFA | ϕNA | ϕAG | ϕPA | ϕFA | ϕNA | ϕAG | ϕPA | ϕFA | ϕNA | ϕAG | ϕPA | ϕFA | ϕNA | ϕAG | ϕPA | ϕFA | ϕNA | ϕAG | ϕPA | ϕFA | ϕNA | ϕAG | ϕPA |
| 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 3.965 | 5.742 | 4.696 | 5.683 | 3.837 | 5.511 | 4.507 | 5.411 | 3.001 | 3.619 | 3.248 | 3.584 | 2.749 | 3.058 | 2.872 | 3.042 | 3.936 | 5.107 | 4.405 | 5.039 | 3.936 | 6.387 | 4.917 | 6.232 |
| 3 | 4.016 | 5.971 | 4.807 | 5.826 | 3.826 | 5.524 | 4.513 | 5.400 | 3.015 | 3.661 | 3.274 | 3.621 | 2.762 | 3.080 | 2.890 | 3.060 | 3.935 | 5.109 | 4.409 | 5.030 | 3.935 | 6.458 | 4.960 | 6.257 |
| 4 | 4.061 | 6.127 | 4.906 | 5.949 | 3.815 | 5.532 | 4.516 | 5.390 | 3.028 | 3.685 | 3.293 | 3.643 | 2.776 | 3.116 | 2.913 | 3.096 | 3.933 | 5.124 | 4.413 | 5.035 | 3.933 | 6.549 | 5.010 | 6.299 |
| 5 | 4.101 | 6.269 | 4.998 | 6.052 | 3.805 | 5.544 | 4.521 | 5.381 | 3.041 | 3.725 | 3.318 | 3.673 | 2.789 | 3.150 | 2.934 | 3.127 | 3.931 | 5.150 | 4.429 | 5.051 | 3.931 | 6.611 | 5.050 | 6.309 |
| 6 | 4.135 | 6.387 | 5.078 | 6.133 | 3.795 | 5.559 | 4.529 | 5.377 | 3.054 | 3.764 | 3.342 | 3.712 | 2.802 | 3.180 | 2.955 | 3.156 | 3.928 | 5.146 | 4.429 | 5.037 | 3.928 | 6.670 | 5.091 | 6.317 |
| 7 | 4.164 | 6.545 | 5.174 | 6.243 | 3.785 | 5.559 | 4.530 | 5.354 | 3.066 | 3.789 | 3.361 | 3.730 | 2.814 | 3.213 | 2.975 | 3.184 | 3.925 | 5.167 | 4.438 | 5.044 | 3.925 | 6.766 | 5.147 | 6.357 |
| 8 | 4.189 | 6.658 | 5.249 | 6.309 | 3.774 | 5.584 | 4.542 | 5.357 | 3.078 | 3.836 | 3.389 | 3.774 | 2.826 | 3.235 | 2.992 | 3.209 | 3.922 | 5.163 | 4.439 | 5.032 | 3.922 | 6.840 | 5.197 | 6.373 |
| 9 | 4.210 | 6.757 | 5.319 | 6.334 | 3.765 | 5.580 | 4.543 | 5.332 | 3.090 | 3.863 | 3.408 | 3.792 | 2.838 | 3.267 | 2.012 | 3.235 | 3.918 | 5.175 | 4.446 | 5.032 | 3.918 | 6.935 | 5.257 | 6.404 |
| 10 | 4.227 | 6.932 | 5.420 | 6.476 | 3.755 | 5.613 | 4.559 | 5.341 | 3.102 | 3.894 | 3.429 | 3.821 | 2.850 | 3.296 | 2.032 | 3.262 | 3.913 | 5.189 | 4.453 | 5.036 | ** | ** | ** | ** |
| 11 | ** | ** | ** | ** | 3.746 | 5.613 | 4.562 | 5.319 | 3.113 | 3.939 | 3.456 | 3.857 | 2.861 | 3.331 | 3.053 | 3.294 | 3.909 | 5.189 | 4.454 | 5.026 | | | | |
| 12 | | | | | 3.737 | 5.620 | 4.568 | 5.305 | 3.124 | 3.964 | 3.475 | 3.876 | 2.872 | 3.354 | 3.069 | 3.313 | 3.904 | 5.205 | 4.460 | 5.026 | | | | |
| 13 | | | | | 3.728 | 5.639 | 4.580 | 5.300 | 3.135 | 3.994 | 3.495 | 3.899 | 2.883 | 3.374 | 3.085 | 3.334 | 3.898 | 5.221 | 4.469 | 5.032 | | | | |
| 14 | | | | | 3.719 | 5.663 | 4.594 | 5.299 | 3.145 | 4.039 | 3.521 | 3.938 | 2.893 | 3.407 | 3.105 | 3.362 | 3.893 | 5.193 | 4.458 | 4.997 | | | | |
| 15 | | | | | ** | ** | ** | ** | 3.155 | 4.056 | 3.536 | 3.949 | 2.903 | 3.434 | 3.123 | 3.384 | 3.887 | 5.228 | 4.474 | 5.018 | | | | |
| 16 | | | | | | | | | 3.165 | 4.107 | 3.566 | 3.983 | 2.913 | 3.465 | 3.142 | 3.414 | 3.881 | 5.202 | 4.464 | 4.985 | | | | |
| 17 | | | | | | | | | 3.175 | 4.127 | 3.582 | 4.001 | 2.923 | 3.487 | 3.157 | 3.431 | 3.875 | 5.219 | 4.472 | 4.988 | | | | |
| 18 | | | | | | | | | 3.184 | 4.172 | 3.609 | 4.038 | 2.932 | 3.513 | 3.174 | 3.453 | 3.869 | 5.220 | 4.473 | 4.978 | | | | |
| 19 | | | | | | | | | 3.193 | 4.192 | 3.625 | 4.049 | 2.941 | 3.531 | 3.187 | 3.467 | 3.862 | 5.221 | 4.473 | 4.967 | | | | |
| 20 | | | | | | | | | 3.202 | 4.229 | 3.648 | 4.077 | 2.950 | 3.561 | 3.206 | 3.495 | ** | ** | ** | ** | | | | |
| 21 | | | | | | | | | 3.210 | 4.266 | 3.671 | 4.103 | 2.959 | 3.586 | 3.225 | 3.516 | | | | | | | | |
| 22 | | | | | | | | | 3.218 | 4.306 | 3.697 | 4.133 | 2.967 | 3.619 | 3.242 | 3.542 | | | | | | | | |
| 23 | | | | | | | | | 3.226 | 4.316 | 3.708 | 4.134 | 2.975 | 3.628 | 3.252 | 3.549 | | | | | | | | |
| 24 | | | | | | | | | 3.234 | 4.360 | 3.735 | 4.168 | 2.983 | 3.658 | 3.270 | 3.573 | | | | | | | | |
| 25 | | | | | | | | | 3.241 | 4.404 | 3.761 | 4.197 | 2.990 | 3.680 | 3.285 | 3.591 | | | | | | | | |
| 26 | | | | | | | | | 3.249 | 4.422 | 3.777 | 4.207 | 2.997 | 3.715 | 3.305 | 3.621 | | | | | | | | |
| 27 | | | | | | | | | 3.256 | 4.445 | 3.794 | 4.218 | 3.004 | 3.718 | 3.311 | 3.618 | | | | | | | | |
| 28 | | | | | | | | | ** | ** | ** | ** | 3.011 | 3.748 | 3.329 | 3.644 | | | | | | | | |
| 29 | | | | | | | | | | | | | 3.017 | 3.779 | 3.348 | 3.670 | | | | | | | | |
| 30 | | | | | | | | | | | | | 3.024 | 3.795 | 3.360 | 3.679 | | | | | | | | |
| 31 | | | | | | | | | | | | | 3.030 | 3.813 | 3.372 | 3.692 | | | | | | | | |
| 32 | | | | | | | | | | | | | 3.035 | 3.838 | 3.388 | 3.710 | | | | | | | | |
| 33 | | | | | | | | | | | | | 3.041 | 3.846 | 3.396 | 3.713 | | | | | | | | |
| 34 | | | | | | | | | | | | | 3.046 | 3.886 | 3.418 | 3.747 | | | | | | | | |
| 35 | | | | | | | | | | | | | 3.051 | 3.886 | 3.423 | 3.741 | | | | | | | | |
| 36 | | | | | | | | | | | | | 3.057 | 3.918 | 3.442 | 3.766 | | | | | | | | |
| 37 | | | | | | | | | | | | | 3.061 | 3.937 | 3.455 | 3.778 | | | | | | | | |
| 38 | | | | | | | | | | | | | 3.066 | 3.970 | 3.474 | 3.803 | | | | | | | | |
| 39 | | | | | | | | | | | | | 3.070 | 3.962 | 3.478 | 3.791 | | | | | | | | |
| 40 | | | | | | | | | | | | | ** | ** | ** | ** | | | | | | | | |

*See Table 8 for definitions of ϕFA, ϕNA, ϕAG and ϕPA.

Table 16: SIMULATION OF SECTORAL EMPLOYMENT GROWTH RATES IN AGRICULTURE*

| Time Period | A | | | B | | | C | | | D | | | E | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EFA | ENA | ELA | EFA | ENA | ELA | EFA | ENA | ELA | EFA | ENA | ELA | EFA | ENA | ELA | EFA | ENA | ELA |
| 1 | | | | | | | | | | | | | | | | | | |
| 2 | 0.317 | 5.813 | 2.161 | 4.683 | 5.521 | 4.964 | 3.343 | 3.626 | 3.438 | 2.887 | 3.054 | 2.943 | 2.945 | 5.096 | 3.666 | 2.945 | 6.396 | 4.103 |
| 3 | 0.443 | 5.975 | 2.365 | 4.593 | 5.525 | 4.908 | 3.311 | 3.653 | 3.426 | 2.867 | 3.088 | 2.941 | 2.943 | 5.111 | 3.680 | 2.943 | 6.470 | 4.152 |
| 4 | 0.571 | 6.117 | 2.566 | 4.510 | 5.540 | 4.859 | 3.279 | 3.692 | 3.418 | 2.847 | 3.125 | 2.941 | 2.941 | 5.135 | 3.697 | 2.941 | 6.535 | 4.200 |
| 5 | 0.699 | 6.254 | 2.766 | 4.431 | 5.546 | 4.812 | 3.250 | 3.726 | 3.411 | 2.829 | 3.154 | 2.938 | 2.939 | 5.136 | 3.708 | 2.939 | 6.599 | 4.251 |
| 6 | 0.827 | 6.400 | 2.972 | 4.357 | 5.554 | 4.769 | 3.222 | 3.759 | 3.404 | 2.811 | 3.183 | 2.937 | 2.938 | 5.143 | 3.720 | 2.938 | 6.592 | 4.314 |
| 7 | 0.956 | 6.533 | 3.173 | 4.288 | 5.568 | 4.731 | 3.195 | 3.797 | 3.400 | 2.794 | 3.207 | 2.934 | 2.938 | 5.152 | 3.733 | 2.938 | 6.776 | 4.376 |
| 8 | 1.089 | 6.644 | 3.367 | 4.222 | 5.576 | 4.695 | 3.170 | 3.830 | 3.395 | 2.779 | 3.238 | 2.935 | 2.937 | 5.168 | 3.750 | 2.937 | 6.851 | 4.438 |
| 9 | 1.211 | 6.782 | 3.571 | 4.100 | 5.593 | 4.665 | 3.146 | 3.863 | 3.392 | 2.763 | 3.272 | 2.936 | 2.937 | 5.189 | 3.769 | 2.937 | 6.917 | 4.498 |
| 10 | 1.337 | 6.869 | 3.753 | 4.102 | 5.600 | 4.634 | 3.124 | 3.899 | 3.390 | 2.749 | 3.301 | 2.938 | 2.937 | 5.195 | 3.782 | ** | ** | ** |
| 11 | ** | ** | ** | 4.047 | 5.606 | 4.606 | 3.102 | 3.930 | 3.388 | 2.735 | 3.323 | 2.937 | 2.937 | 5.206 | 3.798 | | | |
| 12 | | | | 3.995 | 5.627 | 4.585 | 3.082 | 3.957 | 3.386 | 2.723 | 3.344 | 2.936 | 2.938 | 5.214 | 3.813 | | | |
| 13 | | | | 3.945 | 5.649 | 4.568 | 3.063 | 4.002 | 3.391 | 2.710 | 3.380 | 2.941 | 2.939 | 5.203 | 3.821 | | | |
| 14 | | | | 3.898 | 5.654 | 4.547 | 3.044 | 4.031 | 3.391 | 2.699 | 3.408 | 2.945 | 2.940 | 5.211 | 3.837 | | | |
| 15 | | | | ** | ** | ** | 3.027 | 4.069 | 3.396 | 2.688 | 3.439 | 2.949 | 2.941 | 5.215 | 3.851 | | | |
| 16 | | | | | | | 3.011 | 4.102 | 3.399 | 2.678 | 3.460 | 2.951 | 2.942 | 5.219 | 3.865 | | | |
| 17 | | | | | | | 2.995 | 4.134 | 3.403 | 2.668 | 3.479 | 2.953 | 2.944 | 5.232 | 3.884 | | | |
| 18 | | | | | | | 2.980 | 4.167 | 3.409 | 2.659 | 3.503 | 2.957 | 2.946 | 5.233 | 3.897 | | | |
| 19 | | | | | | | 2.967 | 4.199 | 3.415 | 2.650 | 3.536 | 2.965 | 2.948 | 5.236 | 3.911 | | | |
| 20 | | | | | | | 2.953 | 4.241 | 3.425 | 2.642 | 3.567 | 2.973 | ** | ** | ** | | | |
| 21 | | | | | | | 2.941 | 4.270 | 3.432 | 2.634 | 3.593 | 2.979 | | | | | | |
| 22 | | | | | | | 2.929 | 4.294 | 3.437 | 2.627 | 3.609 | 2.982 | | | | | | |
| 23 | | | | | | | 2.918 | 4.327 | 3.447 | 2.620 | 3.632 | 2.988 | | | | | | |
| 24 | | | | | | | 2.908 | 4.367 | 3.460 | 2.614 | 3.663 | 2.998 | | | | | | |
| 25 | | | | | | | 2.898 | 4.390 | 3.468 | 2.608 | 3.688 | 3.006 | | | | | | |
| 26 | | | | | | | 2.889 | 4.417 | 3.473 | 2.602 | 3.701 | 3.010 | | | | | | |
| 27 | | | | | | | 2.880 | 4.459 | 3.494 | 2.596 | 3.726 | 3.019 | | | | | | |
| 28 | | | | | | | ** | ** | ** | 2.593 | 3.758 | 3.031 | | | | | | |
| 29 | | | | | | | | | | 2.589 | 3.773 | 3.037 | | | | | | |
| 30 | | | | | | | | | | 2.584 | 3.784 | 3.042 | | | | | | |
| 31 | | | | | | | | | | 2.581 | 3.809 | 3.052 | | | | | | |
| 32 | | | | | | | | | | 2.577 | 3.826 | 3.060 | | | | | | |
| 33 | | | | | | | | | | 2.574 | 3.855 | 3.074 | | | | | | |
| 34 | | | | | | | | | | 2.572 | 3.878 | 3.084 | | | | | | |
| 35 | | | | | | | | | | 2.569 | 3.900 | 3.096 | | | | | | |
| 36 | | | | | | | | | | 2.567 | 3.927 | 3.109 | | | | | | |
| 37 | | | | | | | | | | 2.565 | 3.947 | 3.120 | | | | | | |
| 38 | | | | | | | | | | 2.563 | 3.954 | 3.127 | | | | | | |
| 39 | | | | | | | | | | 2.562 | 3.974 | 3.139 | | | | | | |
| 40 | | | | | | | | | | ** | ** | ** | | | | | | |

*See Table 9 for the definitions of EFA, ENA, and ELA

declining proportion of labor employed in the foodgrains sector. As shown in Table 17, while the foodgrains sector employed 24.024 percent of laborers in the initial period, it employed only 21.579 percent during the tenth period when the economy achieves close to full employment.

On the other hand, the nonfoodgrains and agro-industrial sectors show a great potential for incremental employment. This is caused by both the changed demand structure in favor of nonfoodgrains and agro-industrial products and increased supply of foodgrains. The employment in the nonfoodgrains sector grows initially at 5.813 percent and increases to 6.869 percent annually during the tenth period. Initially, it employs 12.636 percent of the laborers rising to 17.652 percent during the tenth period. However, this substantial increase is partially offset by the gradual decline in foodgrains agriculture, leaving the overall employment situation in the agricultural sector somewhat improved as shown in Table 16.

Nonagricultural sector employment grows rapidly, increasing its employment share in the total economy (Table 17 and 18). However, the employment growth slows gradually partly because the foodgrains and nonfoodgrains sectors gain added significance to employ more labor over time as the demand for nonfoodgrains goes up. This significant sectoral (or structural) shift in employment over time is mainly due to (i) foodgrains production growing faster than population, (ii) increase in per capita income, hence increase in nonfoodgrains and agro-industrial products (as shown in Table 15) leading to a structural shift in demand patterns.

The incremental employment patterns by sectors are reported in Table 19. Initially, the agricultural sector absorbs only 22 percent of the incremental employment. The rest is in the nonagricultural sector. However, over time increments in employment are increasing in the agricultural sector and decreasing in the nonagricultural sector. The major share in the incremental employment in agriculture comes from the nonfoodgrains sector. The per capita income for the laboring class grows quite rapidly as shown in Table 20. It is this increase in income for both laborers and entrepreneurs which leads to a substantial shift in demand patterns.

**Table 17: SIMULATION OF SECTORAL EMPLOYMENT PATTERNS IN THE TOTAL ECONOMY***

Percent

| Time Period | A | | | | B | | | | C | | | | D | | | | E | | | | F | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EFA | ENA | ELN | ULE | EFA | ENA | ELN | ULE | EFA | ENA | ELN | ULE | EFA | ENA | ELN | ULE | EFA | ENA | ELN | ULE | EFA | ENA | ELN | ULE | PLT |
| 1 | 25.024 | 12.636 | 46.187 | 16.153 | 25.026 | 12.632 | 46.180 | 16.162 | 25.025 | 12.633 | 46.185 | 16.157 | 25.028 | 12.635 | 46.184 | 16.153 | 25.024 | 12.635 | 46.192 | 16.149 | 25.024 | 12.635 | 46.191 | 16.150 | 100 |
| 2 | 24.492 | 13.042 | 47.853 | 14.613 | 25.559 | 13.003 | 46.280 | 15.158 | 25.231 | 12.771 | 46.211 | 15.787 | 25.123 | 12.705 | 46.206 | 15.966 | 25.010 | 12.893 | 46.795 | 15.302 | 25.256 | 13.179 | 47.191 | 14.474 | 100 |
| 3 | 24.400 | 13.483 | 49.441 | 13.076 | 26.081 | 13.387 | 46.422 | 14.110 | 25.431 | 12.915 | 46.258 | 15.396 | 25.213 | 12.776 | 46.248 | 15.767 | 24.996 | 13.156 | 47.402 | 14.446 | 25.489 | 13.755 | 48.004 | 12.752 | 100 |
| 4 | 23.549 | 13.960 | 50.955 | 11.536 | 26.593 | 13.783 | 46.599 | 13.025 | 25.624 | 13.065 | 46.329 | 14.982 | 25.298 | 12.853 | 46.303 | 15.546 | 24.982 | 13.428 | 48.003 | 13.587 | 25.724 | 14.368 | 48.921 | 10.987 | 100 |
| 5 | 23.135 | 14.473 | 52.399 | 9.993 | 27.093 | 14.193 | 46.816 | 11.898 | 25.811 | 13.222 | 46.421 | 14.546 | 25.380 | 12.934 | 46.374 | 15.312 | 24.967 | 13.709 | 48.594 | 12.730 | 25.961 | 15.017 | 50.848 | 9.174 | 100 |
| 6 | 22.757 | 15.022 | 53.784 | 8.437 | 27.583 | 14.616 | 47.063 | 10.738 | 25.993 | 13.384 | 46.532 | 14.091 | 25.457 | 13.020 | 46.460 | 15.063 | 24.952 | 13.995 | 49.187 | 11.566 | 26.200 | 15.705 | 50.789 | 7.306 | 100 |
| 7 | 22.414 | 15.616 | 55.093 | 6.877 | 28.066 | 15.052 | 47.347 | 9.535 | 26.169 | 13.553 | 46.667 | 13.611 | 25.529 | 13.110 | 46.559 | 14.802 | 24.937 | 14.288 | 49.773 | 11.002 | 26.441 | 16.440 | 51.727 | 5.392 | 100 |
| 8 | 22.105 | 16.248 | 56.346 | 5.301 | 28.537 | 15.505 | 47.656 | 8.302 | 26.340 | 13.729 | 46.817 | 13.114 | 25.599 | 13.205 | 46.677 | 14.519 | 24.922 | 14.588 | 50.358 | 10.132 | 26.683 | 17.220 | 52.672 | 3.425 | 100 |
| 9 | 21.827 | 16.924 | 57.547 | 3.702 | 28.999 | 15.971 | 47.998 | 7.032 | 26.507 | 13.912 | 46.986 | 12.595 | 25.665 | 13.304 | 46.805 | 14.226 | 24.907 | 14.897 | 50.933 | 9.263 | 26.929 | 18.052 | 53.615 | 1.404 | 100 |
| 10 | 21.579 | 17.652 | 58.675 | 2.094 | 29.452 | 16.455 | 48.360 | 5.733 | 26.668 | 14.101 | 47.176 | 12.055 | 25.728 | 13.407 | 46.945 | 13.920 | 24.891 | 15.213 | 51.502 | 8.394 | ** | ** | ** | ** | 100 |
| 11 | ** | ** | ** | ** | 29.897 | 16.955 | 48.751 | 4.397 | 26.825 | 14.298 | 47.378 | 11.499 | 25.787 | 13.516 | 47.096 | 13.601 | 24.876 | 15.537 | 52.067 | 7.520 | | | | | 100 |
| 12 | | | | | 30.333 | 17.471 | 49.165 | 3.031 | 26.977 | 14.503 | 47.601 | 10.919 | 25.891 | 13.628 | 47.261 | 13.220 | 24.862 | 15.869 | 52.621 | 6.648 | | | | | 100 |
| 13 | | | | | 30.760 | 18.006 | 49.599 | 1.635 | 27.125 | 14.715 | 47.840 | 10.320 | 25.896 | 13.745 | 47.440 | 12.919 | 24.847 | 16.351 | 53.166 | 5.636 | | | | | 100 |
| 14 | | | | | 31.180 | 18.562 | 50.048 | 0.210 | 27.269 | 14.935 | 48.091 | 9.705 | 25.945 | 13.866 | 47.629 | 12.559 | 24.832 | 16.556 | 53.715 | 4.897 | | | | | 100 |
| 15 | | | | | ** | ** | ** | ** | 27.410 | 15.163 | 48.362 | 9.065 | 25.994 | 13.993 | 47.828 | 12.185 | 24.818 | 16.914 | 54.245 | 4.023 | | | | | 100 |
| 16 | | | | | | | | | 27.546 | 15.400 | 48.640 | 8.414 | 26.039 | 14.124 | 48.034 | 11.803 | 24.804 | 17.276 | 54.778 | 3.142 | | | | | 100 |
| 17 | | | | | | | | | 27.679 | 15.645 | 48.939 | 7.737 | 26.081 | 14.260 | 48.252 | 11.407 | 24.790 | 17.648 | 55.298 | 2.264 | | | | | 100 |
| 18 | | | | | | | | | 27.809 | 15.900 | 49.244 | 7.047 | 26.122 | 14.401 | 48.480 | 10.997 | 24.777 | 18.027 | 55.813 | 1.383 | | | | | 100 |
| 19 | | | | | | | | | 27.935 | 16.162 | 49.567 | 6.336 | 26.160 | 14.546 | 48.718 | 10.576 | 24.765 | 18.417 | 56.318 | 0.500 | | | | | 100 |
| 20 | | | | | | | | | 28.059 | 16.435 | 49.898 | 5.108 | 26.197 | 14.696 | 48.964 | 10.143 | ** | ** | ** | ** | | | | | 100 |
| 21 | | | | | | | | | 28.179 | 16.718 | 50.242 | 4.861 | 26.231 | 14.852 | 49.217 | 9.700 | | | | | | | | | 100 |
| 22 | | | | | | | | | 28.298 | 17.012 | 50.592 | 4.098 | 26.263 | 15.014 | 49.474 | 9.249 | | | | | | | | | 100 |
| 23 | | | | | | | | | 28.413 | 17.314 | 50.959 | 3.314 | 26.294 | 15.180 | 49.744 | 8.782 | | | | | | | | | 100 |
| 24 | | | | | | | | | 28.526 | 17.628 | 51.332 | 2.514 | 26.323 | 15.351 | 50.019 | 8.307 | | | | | | | | | 100 |
| 25 | | | | | | | | | 28.637 | 17.955 | 51.711 | 1.697 | 26.351 | 15.529 | 50.299 | 7.821 | | | | | | | | | 100 |
| 26 | | | | | | | | | 28.745 | 18.292 | 52.102 | 0.861 | 26.377 | 15.712 | 50.583 | 7.328 | | | | | | | | | 100 |
| 27 | | | | | | | | | 28.852 | 18.640 | 52.502 | 0.006 | 26.402 | 15.899 | 50.879 | 6.820 | | | | | | | | | 100 |
| 28 | | | | | | | | | ** | ** | ** | ** | 26.427 | 16.092 | 51.177 | 6.304 | | | | | | | | | 100 |
| 29 | | | | | | | | | | | | | 26.450 | 16.293 | 51.476 | 5.781 | | | | | | | | | 100 |
| 30 | | | | | | | | | | | | | 26.471 | 16.499 | 51.784 | 5.246 | | | | | | | | | 100 |
| 31 | | | | | | | | | | | | | 26.492 | 16.710 | 52.095 | 4.703 | | | | | | | | | 100 |
| 32 | | | | | | | | | | | | | 26.512 | 16.928 | 52.411 | 4.149 | | | | | | | | | 100 |
| 33 | | | | | | | | | | | | | 26.531 | 17.151 | 52.739 | 3.584 | | | | | | | | | 100 |
| 34 | | | | | | | | | | | | | 26.550 | 17.382 | 53.054 | 3.014 | | | | | | | | | 100 |
| 35 | | | | | | | | | | | | | 26.568 | 17.618 | 53.383 | 2.431 | | | | | | | | | 100 |
| 36 | | | | | | | | | | | | | 26.585 | 17.862 | 53.712 | 1.841 | | | | | | | | | 100 |
| 37 | | | | | | | | | | | | | 26.602 | 18.113 | 54.043 | 1.242 | | | | | | | | | 100 |
| 38 | | | | | | | | | | | | | 26.619 | 18.371 | 54.373 | 0.637 | | | | | | | | | 100 |
| 39 | | | | | | | | | | | | | 26.634 | 18.634 | 54.713 | 0.019 | | | | | | | | | 100 |
| 40 | | | | | | | | | | | | | ** | ** | ** | ** | | | | | | | | | ** |

*See Table 10 for definitions of EFA, ENA, ELN, ULE, AND PLT.

Table 18. SIMULATION OF SECTORAL EMPLOYMENT GROWTH RATES IN THE TOTAL ECONOMY*

Growth Rate

| Time Period | A | | | B | | | C | | | D | | | E | | | F | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ELA | ELN | ELE | ELA | ELN | ELE | ELA | ELN | ELE | ELA | ELN | ELE | ELA | ELN | ELE | ELA | ELN | ELE |
| 1 | | | | | | | | | | | | | | | | | | |
| 2 | 2.161 | 6.185 | 4.383 | 4.964 | 2.716 | 3.728 | 3.438 | 2.552 | 2.952 | 2.943 | 2.551 | 2.728 | 3.666 | 5.096 | 4.043 | 4.103 | 6.396 | 4.039 |
| 3 | 2.365 | 5.894 | 4.344 | 4.908 | 2.809 | 3.765 | 3.426 | 2.608 | 2.975 | 2.941 | 2.588 | 2.748 | 3.680 | 5.111 | 4.042 | 4.152 | 6.470 | 4.054 |
| 4 | 2.566 | 5.644 | 4.316 | 4.859 | 2.889 | 3.796 | 3.418 | 2.655 | 3.003 | 2.941 | 2.617 | 2.765 | 3.697 | 5.135 | 4.033 | 4.200 | 6.535 | 4.062 |
| 5 | 2.766 | 5.417 | 4.288 | 4.812 | 2.971 | 3.827 | 3.411 | 2.702 | 3.024 | 2.938 | 2.652 | 2.783 | 3.708 | 5.136 | 4.021 | 4.251 | 6.599 | 4.079 |
| 6 | 2.973 | 5.203 | 4.273 | 4.769 | 3.045 | 3.852 | 3.404 | 2.747 | 3.046 | 2.937 | 2.687 | 2.802 | 3.720 | 5.143 | 4.019 | 4.314 | 6.692 | 4.097 |
| 7 | 3.173 | 5.003 | 4.245 | 4.731 | 3.112 | 3.880 | 3.400 | 2.791 | 3.073 | 2.934 | 2.722 | 2.817 | 3.733 | 5.152 | 4.011 | 4.376 | 6.776 | 4.106 |
| 8 | 3.367 | 4.839 | 4.236 | 4.695 | 3.174 | 3.897 | 3.395 | 2.831 | 3.089 | 2.935 | 2.753 | 2.837 | 3.750 | 5.160 | 4.006 | 4.438 | 6.851 | 4.121 |
| 9 | 3.571 | 4.670 | 4.230 | 4.665 | 3.227 | 3.920 | 3.392 | 2.873 | 3.111 | 2.936 | 2.778 | 2.851 | 3.769 | 5.189 | 3.996 | 4.498 | 6.917 | 4.135 |
| 10 | 3.753 | 4.537 | 4.212 | 4.634 | 3.280 | 3.933 | 3.390 | 2.910 | 3.134 | 2.938 | 2.805 | 2.866 | 3.782 | 5.195 | 3.987 | ** | ** | ** |
| 11 | ** | ** | ** | 4.606 | 3.332 | 3.952 | 3.388 | 2.946 | 3.149 | 2.937 | 2.835 | 2.879 | 3.798 | 5.206 | 3.982 | | | |
| 12 | | | | 4.585 | 3.367 | 3.965 | 3.386 | 2.986 | 3.171 | 2.936 | 2.887 | 2.896 | 3.813 | 5.214 | 3.972 | | | |
| 13 | | | | 4.568 | 3.397 | 3.976 | 3.391 | 3.010 | 3.189 | 2.941 | 2.885 | 2.911 | 3.821 | 5.203 | 3.961 | | | |
| 14 | | | | 4.547 | 3.433 | 3.985 | 3.391 | 3.043 | 3.203 | 2.945 | 2.906 | 2.925 | 3.837 | 5.211 | 3.962 | | | |
| 15 | | | | ** | ** | ** | 3.396 | 3.069 | 3.225 | 2.949 | 2.924 | 2.937 | 3.851 | 5.215 | 3.945 | | | |
| 16 | | | | | | | 3.399 | 3.094 | 3.235 | 2.951 | 2.947 | 2.947 | 3.865 | 5.219 | 3.946 | | | |
| 17 | | | | | | | 3.403 | 3.121 | 3.256 | 2.953 | 2.971 | 2.961 | 3.884 | 5.232 | 3.934 | | | |
| 18 | | | | | | | 3.409 | 3.143 | 3.267 | 2.957 | 2.990 | 2.973 | 3.897 | 5.253 | 3.929 | | | |
| 19 | | | | | | | 3.415 | 3.166 | 3.284 | 2.965 | 3.002 | 2.985 | 3.911 | 5.236 | 3.921 | | | |
| 20 | | | | | | | 3.425 | 3.179 | 3.297 | 2.973 | 3.012 | 2.996 | ** | ** | ** | | | |
| 21 | | | | | | | 3.432 | 3.200 | 3.311 | 2.979 | 3.025 | 3.005 | | | | | | |
| 22 | | | | | | | 3.437 | 3.222 | 3.321 | 2.982 | 3.043 | 3.013 | | | | | | |
| 23 | | | | | | | 3.447 | 3.238 | 3.338 | 2.988 | 3.057 | 3.026 | | | | | | |
| 24 | | | | | | | 3.460 | 3.245 | 3.348 | 2.998 | 3.061 | 3.034 | | | | | | |
| 25 | | | | | | | 3.468 | 3.264 | 3.360 | 3.006 | 3.070 | 3.042 | | | | | | |
| 26 | | | | | | | 3.478 | 3.279 | 3.371 | 3.010 | 3.086 | 3.049 | | | | | | |
| 27 | | | | | | | 3.494 | 3.281 | 3.384 | 3.019 | 3.094 | 3.062 | | | | | | |
| 28 | | | | | | | ** | ** | ** | 3.031 | 3.093 | 3.067 | | | | | | |
| 29 | | | | | | | | | | 3.037 | 3.105 | 3.072 | | | | | | |
| 30 | | | | | | | | | | 3.042 | 3.118 | 3.081 | | | | | | |
| 31 | | | | | | | | | | 3.052 | 3.121 | 3.089 | | | | | | |
| 32 | | | | | | | | | | 3.060 | 3.128 | 3.095 | | | | | | |
| 33 | | | | | | | | | | 3.074 | 3.125 | 3.104 | | | | | | |
| 34 | | | | | | | | | | 3.084 | 3.127 | 3.100 | | | | | | |
| 35 | | | | | | | | | | 3.096 | 3.129 | 3.116 | | | | | | |
| 36 | | | | | | | | | | 3.109 | 3.124 | 3.120 | | | | | | |
| 37 | | | | | | | | | | 3.120 | 3.125 | 3.125 | | | | | | |
| 38 | | | | | | | | | | 3.127 | 3.134 | 3.128 | | | | | | |
| 39 | | | | | | | | | | 3.139 | 3.135 | 3.138 | | | | | | |
| 40 | | | | | | | | | | ** | ** | ** | | | | | | |

* See Table 9 for definitions of ELA, ELN, and ELE.

TABLE 19. SIMULATION OF INCREMENTAL EMPLOYMENT GROWTH BY SECTORS (PERCENT)

| Year | A | | | | B | | | | C | | | | D | | | | E | | | | F | | | | ELE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | EFA | ENA | ELA | ELN | EFA | ENA | ELA | ELN | EFA | ENA | ELA | ELN | EFA | ENA | ELA | ELN | EFA | ENA | ELA | ELN | EFA | ENA | ELA | ELN | |
| 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| 2 | 2.18 | 19.92 | 22.10 | 77.90 | 37.52 | 22.28 | 59.80 | 40.20 | 33.78 | 18.46 | 52.24 | 47.76 | 31.61 | 16.92 | 48.53 | 51.47 | 21.74 | 19.03 | 40.77 | 59.23 | 21.76 | 23.86 | 45.62 | 54.38 | 100 |
| 3 | 2.92 | 20.96 | 23.88 | 76.12 | 36.74 | 22.48 | 59.22 | 40.78 | 33.37 | 18.65 | 52.02 | 47.98 | 31.18 | 16.94 | 48.12 | 51.88 | 21.50 | 19.23 | 40.73 | 59.27 | 21.43 | 24.54 | 45.97 | 54.03 | 100 |
| 4 | 3.65 | 22.02 | 25.67 | 74.33 | 74.33 | 36.08 | 22.74 | 58.82 | 32.82 | 18.77 | 51.59 | 48.41 | 30.81 | 17.08 | 47.89 | 52.11 | 21.31 | 19.56 | 40.87 | 59.13 | 21.15 | 25.39 | 46.54 | 53.46 | 100 |
| 5 | 4.33 | 23.06 | 27.39 | 12.61 | 35.39 | 22.94 | 58.33 | 41.67 | 32.36 | 18.92 | 51.28 | 48.72 | 30.46 | 17.23 | 47.69 | 42.31 | 21.12 | 19.91 | 41.03 | 58.97 | 20.81 | 26.16 | 46.97 | 53.03 | 100 |
| 6 | 4.97 | 24.05 | 29.02 | 70.98 | 34.78 | 23.25 | 58.03 | 41.97 | 31.95 | 19.11 | 51.06 | 48.94 | 30.09 | 17.34 | 47.43 | 52.57 | 20.92 | 20.11 | 41.03 | 58.97 | 20.51 | 26.93 | 47.44 | 52.56 | 100 |
| 7 | 5.59 | 25.31 | 30.90 | 69.10 | 34.17 | 23.46 | 57.63 | 42.37 | 31.47 | 19.22 | 50.69 | 49.31 | 29.70 | 17.47 | 47.17 | 52.83 | 20.74 | 20.42 | 41.16 | 58.84 | 20.23 | 27.94 | 48.17 | 51.83 | 100 |
| 8 | 6.17 | 26.34 | 32.51 | 67.49 | 33.67 | 23.82 | 57.49 | 42.51 | 31.08 | 19.45 | 50.53 | 49.47 | 29.36 | 17.55 | 46.91 | 53.09 | 20.53 | 20.70 | 41.23 | 58.77 | 19.90 | 28.83 | 48.73 | 51.27 | 100 |
| 9 | 6.68 | 27.44 | 34.12 | 65.88 | 32.96 | 24.10 | 57.06 | 42.94 | 30.66 | 19.64 | 50.30 | 49.70 | 29.03 | 17.71 | 46.74 | 53.26 | 20.40 | 21.03 | 41.43 | 58.57 | 19.64 | 29.89 | 49.53 | 50.47 | 100 |
| 10 | 7.10 | 28.81 | 36.01 | 63.99 | 32.53 | 24.49 | 57.02 | 42.98 | 30.24 | 19.78 | 50.02 | 49.98 | 28.72 | 17.83 | 46.55 | 53.45 | 20.21 | 21.36 | 41.57 | 58.43 | ** | ** | ** | ** | 100 |
| 11 | ** | ** | ** | ** | 32.01 | 24.79 | 56.80 | 43.20 | 29.86 | 80.03 | 49.89 | 50.11 | 28.40 | 18.03 | 46.43 | 53.57 | 20.04 | 21.66 | 41.70 | 58.30 | | | | | 100 |
| 12 | | | | | 31.49 | 25.14 | 56.63 | 43.37 | 29.45 | 20.21 | 49.66 | 50.34 | 28.04 | 18.11 | 46.15 | 53.85 | 19.91 | 22.00 | 41.91 | 59.09 | | | | | 100 |
| 13 | | | | | 31.04 | 25.56 | 56.60 | 43.40 | 29.08 | 20.39 | 49.47 | 50.53 | 27.74 | 18.23 | 45.97 | 54.03 | 19.75 | 22.39 | 42.14 | 57.86 | | | | | 100 |
| 14 | | | | | 30.60 | 26.00 | 56.60 | 43.40 | 28.76 | 20.68 | 49.44 | 50.56 | 27.45 | 18.37 | 45.82 | 54.18 | 19.58 | 22.56 | 42.14 | 57.86 | | | | | 100 |
| 15 | | | | | ** | ** | ** | ** | 28.35 | 20.83 | 49.18 | 50.82 | 27.18 | 18.56 | 45.74 | 54.26 | 18.46 | 23.05 | 42.51 | 57.49 | | | | | 100 |
| 16 | | | | | | | | | 28.05 | 21.17 | 49.22 | 50.78 | 26.88 | 18.73 | 45.61 | 54.39 | 19.29 | 23.25 | 42.54 | 57.46 | | | | | 100 |
| 17 | | | | | | | | | 27.64 | 21.30 | 48.94 | 51.06 | 26.60 | 18.85 | 45.45 | 54.55 | 19.15 | 23.67 | 42.82 | 57.18 | | | | | 100 |
| 18 | | | | | | | | | 27.37 | 21.65 | 49.02 | 50.98 | 26.34 | 19.00 | 45.34 | 54.66 | 19.02 | 23.99 | 43.01 | 56.99 | | | | | 100 |
| 19 | | | | | | | | | 27.02 | 21.83 | 48.85 | 51.15 | 26.05 | 19.14 | 45.19 | 54.81 | 18.89 | 24.28 | 43.17 | 56.83 | | | | | 100 |
| 20 | | | | | | | | | 26.72 | 22.13 | 98.85 | 51.15 | 25.80 | 19.34 | 45.14 | 54.86 | ** | ** | ** | ** | | | | | 100 |
| 21 | | | | | | | | | 26.40 | 22.44 | 48.84 | 51.16 | 25.55 | 19.53 | 45.08 | 54.92 | | | | | | | | | 100 |
| 22 | | | | | | | | | 26.13 | 22.77 | 48.90 | 51.10 | 25.33 | 19.74 | 45.07 | 54.93 | | | | | | | | | 100 |
| 23 | | | | | | | | | 25.80 | 22.95 | 98.75 | 51.25 | 25.06 | 19.84 | 44.90 | 55.10 | | | | | | | | | 100 |
| 24 | | | | | | | | | 25.52 | 23.31 | 48.83 | 51.17 | 24.83 | 20.06 | 44.89 | 55.11 | | | | | | | | | 100 |
| 25 | | | | | | | | | 25.25 | 23.69 | 48.94 | 51.06 | 24.62 | 20.28 | 44.90 | 55.10 | | | | | | | | | 100 |
| 26 | | | | | | | | | 24.96 | 23.96 | 48.92 | 51.08 | 24.40 | 20.50 | 44.90 | 55.10 | | | | | | | | | 100 |
| 27 | | | | | | | | | 24.68 | 24.28 | 48.96 | 51.04 | 24.14 | 20.59 | 44.73 | 55.27 | | | | | | | | | 100 |
| 28 | | | | | | | | | ** | ** | ** | ** | 23.96 | 20.87 | 44.83 | 55.17 | | | | | | | | | 100 |
| 29 | | | | | | | | | | | | | 23.77 | 21.12 | 44.89 | 55.11 | | | | | | | | | 100 |
| 30 | | | | | | | | | | | | | 23.53 | 21.29 | 44.82 | 55.18 | | | | | | | | | 100 |
| 31 | | | | | | | | | | | | | 23.34 | 21.50 | 44.84 | 55.16 | | | | | | | | | 100 |
| 32 | | | | | | | | | | | | | 23.17 | 21.74 | 44.91 | 55.09 | | | | | | | | | 100 |
| 33 | | | | | | | | | | | | | 22.93 | 21.90 | 44.83 | 55.17 | | | | | | | | | 100 |
| 34 | | | | | | | | | | | | | 22.79 | 22.23 | 45.02 | 54.90 | | | | | | | | | 100 |
| 35 | | | | | | | | | | | | | 22.56 | 22.37 | 44.93 | 55.07 | | | | | | | | | 100 |
| 36 | | | | | | | | | | | | | 22.41 | 22.68 | 45.09 | 54.91 | | | | | | | | | 100 |
| 37 | | | | | | | | | | | | | 22.23 | 22.94 | 45.17 | 54.83 | | | | | | | | | 100 |
| 38 | | | | | | | | | | | | | 22.08 | 23.25 | 45.33 | 54.67 | | | | | | | | | 100 |
| 39 | | | | | | | | | | | | | 21.87 | 23.36 | 45.23 | 54.77 | | | | | | | | | 100 |
| 40 | | | | | | | | | | | | | ** | ** | ** | ** | | | | | | | | | -- |

EFA ⇒ Employment in Foodgrains Agriculture
ENA ⇒ Employment in Nonfoodgrains Agriculture
ELA ⇒ Employment in the Agricultural Sector
ELN ⇒ Employment in the Nonagricultural Sector
ELE ⇒ Total Employment in the Economy

Table 20. SIMULATION OF ANNUAL PER CAPITA INCOME OF THE LABORING CLASS

Growth Rate

| Time Period | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | 2.834 | 2.591 | 0.960 | 0.480 | 1.803 | 3.796 |
| 3 | 3.008 | 2.617 | 1.001 | 0.449 | 1.813 | 3.843 |
| 4 | 3.166 | 2.642 | 1.023 | 0.532 | 1.835 | 4.011 |
| 5 | 3.315 | 2.668 | 1.061 | 0.561 | 1.865 | 4.103 |
| 6 | 3.446 | 2.700 | 1.098 | 0.586 | 1.870 | 4.195 |
| 7 | 3.615 | 2.717 | 1.122 | 0.617 | 1.894 | 4.321 |
| 8 | 3.746 | 2.755 | 1.165 | 0.638 | 1.901 | 4.430 |
| 9 | 3.866 | 2.769 | 1.143 | 0.666 | 1.921 | 4.558 |
| 10 | 4.057 | 2.816 | 1.224 | 0.692 | 1.941 | ** |
| 11 | ** | 2.832 | 1.267 | 0.723 | 1.950 | |
| 12 | | 2.855 | 1.292 | 0.749 | 1.969 | |
| 13 | | 2.890 | 1.324 | 0.764 | 1.994 | |
| 14 | | 2.929 | 1.367 | 0.794 | 1.979 | |
| 15 | | ** | 1.387 | 0.819 | 2.019 | |
| 16 | | | 1.438 | 0.848 | 2.003 | |
| 17 | | | 1.458 | 0.869 | 2.028 | |
| 18 | | | 1.505 | 0.893 | 2.037 | |
| 19 | | | 1.527 | 0.912 | 2.045 | |
| 20 | | | 1.566 | 0.940 | ** | |
| 21 | | | 1.605 | 0.965 | | |
| 22 | | | 1.647 | 0.996 | | |
| 23 | | | 1.662 | 1.007 | | |
| 24 | | | 1.709 | 1.035 | | |
| 25 | | | 1.754 | 1.057 | | |
| 26 | | | 1.777 | 1.092 | | |
| 27 | | | 1.805 | 1.096 | | |
| 28 | | | ** | 1.126 | | |
| 29 | | | | 1.158 | | |
| 30 | | | | 1.174 | | |
| 31 | | | | 1.195 | | |
| 32 | | | | 1.219 | | |
| 33 | | | | 1.230 | | |
| 34 | | | | 1.270 | | |
| 35 | | | | 1.274 | | |
| 36 | | | | 1.307 | | |
| 37 | | | | 1.327 | | |
| 38 | | | | 1.361 | | |
| 39 | | | | 1.358 | | |
| 40 | | | | ** | | |

Foodgrains Sector Dominated by Traditional Technology

In this simulation run (Run B), technological conditions in the foodgrains sector are the reverse of the run dominated by the rapidly modernizing foodgrains sector. There is very little transfer of land from traditional to modern technology. This is mainly due to the lack of new irrigation facilities. The yield per unit of land in the traditional foodgrains sector has a rapid annual growth rate of 2.8 percent, mainly achieved through use of improved farm technology which is highly labor intensive. However, the growth in yield in the modern foodgrains sector remains unchanged at 3.0 percent.

Under these technological conditions it takes fourteen periods for the economy to approach full employment, which is strikingly different than in the case of the modernizing foodgrains sector. As shown in Table 15, foodgrains production grows at 3.837 percent initially and gradually declines to 3.719 percent annually during the terminal period. However, this is not significantly different from the result obtained in the foodgrains sector when dominated by modern technology. The difference in an increased rate of employment is due to the different labor absorption pattern in the foodgrains sector caused by different farm technology, and slower growth in demand for nonfoodgrains agriculture.

The differences in growth rates and sectoral patterns in employment are demonstrated in Tables 16, 17, 18 and 19. The growth rate in employment in the foodgrains sector is quite high but declines over time. The proportion of labor employed in the foodgrains sector increases over time from 25.026 percent initially to 31.180 percent in the fourteenth period. The reason for this is the heavy use of traditional labor intensive farm technology. The growth rate of employment in the nonfoodgrains sector also declines since there is relatively slower growth in the demand for nonfoodgrains due to slower growth in per capita income. In this case, however, it takes fourteen periods to employ the same proportion of labor as against ten periods in the modernizing foodgrains example.

Since the employment in the nonagricultural sector is determined by the residual supply of foodgrains, it grows very slowly but increasingly over time from 2.716 percent initially to 3.433 percent in the terminal periods. The proportion of labor employed in the nonagricultural sector changes slightly from 46.180 percent initially to 50.048 percent in the last period. Consequently, there is relatively less structural change as indicated by the shift in resources from one sector to the other. However, the incremental employment patterns are strikingly different in both cases.

The demand for nonfoodgrains and agro-industrial products grows faster than foodgrains production. As illustrated in Table 15, the growth rates for demand for both commodities rise over time. This increase is caused by increase in per capita income and a slow shift in the consumption patterns of both laborers and entrepreneurs in favor of nonfoodgrains and agro-industrial products.

Slow Growth in Foodgrains Production

The slow growth in foodgrains production may be traced to the slow transfer of unirrigated to irrigated land, slow growth in per hectare yields, or a combination of both of these factors.

A. Slow Transfer of Land

This case is represented by Run C and is the same as the 'reference run' except for the rate of transfer of land. The performance differences are striking. On the reference run it takes only 12 periods to reach full-employment whereas in this case it takes 27 periods. As shown in Table 15, foodgrains production grows at three percent initially, gradually increasing to 3.26 percent in the terminal period. However, production of nonfoodgrains and agro-industrial products grows at a rate which is faster than foodgrains production, implying a slow shift in demand patterns.

The employment growth in foodgrains, nonfoodgrains, and agricultural sectors is slower as compared to Run B, but higher than the growth in foodgrains production. The structural shift in employment patterns is relatively slow. Employment in the nonagricultural sector grows at 2.55 percent initially, gradually increasing to 3.28 percent in the terminal period. However, growth in employment in the nonagricultural sector is consistently slower than in the agricultural sector. Since the transfer of land is very slow, the foodgrains sector absorbs the substantially greater share of the incremental employment. Per capita income of the laboring class grows at 0.96 percent initially, increasing to 1.81 percent during the terminal period.

B. Slow Transfer and Slow Yield Growth

This case is represented by Run D in the preceding tables. The land transfer coefficient is the same as for Run C. However, the yield growth for both traditional and modern foodgrains sectors is lower compared to Run C. In this case it takes 39 periods to reach full-employment. As shown in Table 15, foodgrains production grows at 2.75 percent initially, gradually increasing to 3.07 percent in the terminal period. The growth rate in the production of nonfoodgrains and agro-industrial products is higher and increasing more rapidly as compared to foodgrains production.

As shown in Tables 16 and 18 the sectoral employment growth is higher as compared to foodgrains production growth rate. Given a certain growth rate in population (2.5 percent), it is clear that foodgrains production is constraining employment growth in various sectors of the economy. Furthermore, as shown in Table 17, the share of total employment in the foodgrains sector does not change significantly. The incremental employment (Table 19) declines in the foodgrains sector and increases in both nonfoodgrains and nonagricultural sectors. The per capita income (Table 20) for the laboring class increases slowly from 0.45 percent initially

to 1.36 percent in the terminal period implying little structural change in the demand pattern. This run comes close to representing Indian past performance in various sectors of the economy, and demonstrates that slow growth in foodgrains production results in slow progress towards full-employment growth. Consequently, it reflects the crucial role played by foodgrains production and population growth in the overall performance of the economy.

Alternative Rates of Growth in Population

In the reference run, the population is assumed to grow at 2.5 percent annual growth rate. The simulation runs E and F are obtained by changing the population growth to three and two percent, respectively. The technological conditions are assumed to remain unchanged. Since the foodgrains technology does not change, the growth rate of foodgrains production remains unchanged and is given in Table 15. However, these runs have important implications for sectoral employment. The economy achieves full employment in nineteen and nine periods in cases E and F respectively. The slower population growth has the same implications with respect to time taken to achieve full employment as in the case of rapidly modernizing foodgrains sector.

The growth rates and sectoral patterns of employment for runs E and F are reported in Tables 16, 17, 18 and 19. In both cases, the employment in the foodgrains sector stays more or less constant over time at 2.9 percent annual growth rate. However, the proportion of labor employed in the foodgrains sector rises slightly in Case F and declines slightly in Case E. However, the absolute level of employment is the same in both cases over time. The difference in proportions is due to different population growth rates and the difference in time taken to move the economy close to full-employment. The employment growth rate in the nonfoodgrains sector is quite high but increases more slowly in Case E

as compared to Case F. However, the proportion of labor employed in the nonfoodgrains sector is more or less the same in both cases during the initial and terminal conditions.

Employment in the nonagricultural sector grows quite rapidly in Case F starting with 6.396 percent and gradually increases to 6.917 percent during the nineth period. The proportion of population employed in the nonagricultural sector in Case F increases gradually from 46.191 percent initially to 53.615 percent in the last period. On the other hand, the growth rate of employment in Case E is relatively slower starting with 5.096 initially and increasing gradually to 5.236 percent during the nineteenth period. The proportion of labor employed in the nonagricultural sector increases slowly from 46.192 percent initially to 56.318 percent in the terminal period. Furthermore, the demand for nonfoodgrains and agro-industrial products grows faster than the foodgrains production, but is slower than in Case F (Table 15).

Foodgrains Production and Employment Growth

The simulation of the relation between the rate of growth of foodgrains production and of employment potential is presented in Table 21.

Table 21. SIMULATION OF THE RELATION BETWEEN THE RATE OF GROWTH OF FOODGRAINS PRODUCTION AND OF EMPLOYMENT RATES

| Year | A | | B | | C | | D | | E | | F | | Reference | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Foodgrains | Total Employment | Foodgrains | Total Employment | Foodgrains | Total Employment | Foodgrains | Total Employment | Foodgrains | Total Employment | Foodgrains | Total Employment | Foodgrains | Total Employment |
| | All figures percent rates of growth | | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | | | |
| 2 | 3.965 | 4.383 | 3.837 | 3.728 | 3.001 | 2.952 | 2.749 | 2.728 | 3.936 | 4.043 | 3.936 | 4.039 | 3.936 | 4.041 |
| 3 | 4.016 | 4.344 | 3.826 | 3.765 | 3.015 | 2.975 | 2.762 | 2.748 | 3.935 | 4.042 | 3.935 | 4.054 | 3.935 | 4.040 |
| 4 | 4.061 | 4.316 | 3.815 | 3.796 | 3.028 | 3.003 | 2.776 | 2.765 | 3.933 | 4.033 | 3.933 | 4.062 | 3.933 | 4.042 |
| 5 | 4.101 | 4.288 | 3.805 | 3.827 | 3.041 | 3.024 | 2.789 | 2.783 | 3.931 | 4.021 | 3.931 | 4.079 | 3.931 | 4.040 |
| 6 | 4.135 | 4.273 | 3.795 | 3.852 | 3.054 | 3.046 | 2.802 | 2.802 | 3.928 | 4.019 | 3.928 | 4.097 | 3.928 | 4.045 |
| 7 | 4.164 | 4.245 | 3.785 | 3.880 | 3.066 | 3.073 | 2.814 | 2.817 | 3.925 | 4.011 | 3.925 | 4.106 | 3.925 | 4.039 |
| 8 | 4.189 | 4.236 | 3.774 | 3.897 | 3.078 | 3.089 | 2.826 | 2.837 | 3.922 | 4.006 | 3.922 | 4.121 | 3.922 | 4.041 |
| 9 | 4.210 | 4.230 | 3.765 | 3.920 | 3.090 | 3.111 | 2.838 | 2.851 | 3.918 | 3.996 | 3.918 | 4.135 | 3.918 | 4.042 |
| 10 | 4.227 | 4.212 | 3.755 | 3.933 | 3.102 | 3.134 | 2.850 | 2.866 | 3.913 | 3.987 | ** | ** | 3.913 | 4.043 |
| 11 | ** | ** | 3.746 | 3.952 | 3.113 | 3.149 | 2.861 | 2.879 | 3.909 | 3.982 | | | 3.909 | 4.047 |
| 12 | | | 3.737 | 3.965 | 3.124 | 3.171 | 2.872 | 2.896 | 3.904 | 3.972 | | | 3.904 | 4.045 |
| 13 | | | 3.728 | 3.976 | 3.135 | 3.189 | 2.883 | 2.911 | 3.898 | 3.961 | | | ** | ** |
| 14 | | | 3.719 | 3.985 | 3.145 | 3.203 | 2.893 | 2.925 | 3.893 | 3.962 | | | | |
| 15 | | | ** | ** | 3.155 | 2.225 | 2.903 | 2.937 | 3.887 | 3.945 | | | | |
| 16 | | | | | 3.165 | 3.235 | 2.913 | 2.947 | 3.881 | 3.946 | | | | |
| 17 | | | | | 3.175 | 3.256 | 2.923 | 2.961 | 3.875 | 3.934 | | | | |
| 18 | | | | | 3.184 | 3.267 | 2.932 | 2.973 | 3.869 | 3.924 | | | | |
| 19 | | | | | 3.193 | 3.284 | 2.941 | 2.985 | 3.862 | 3.921 | | | | |
| 20 | | | | | 3.202 | 3.297 | 2.950 | 2.996 | ** | ** | | | | |
| 21 | | | | | 3.210 | 3.311 | 2.959 | 3.005 | | | | | | |
| 22 | | | | | 3.218 | 3.321 | 2.967 | 3.013 | | | | | | |
| 23 | | | | | 3.226 | 3.338 | 2.975 | 3.026 | | | | | | |
| 24 | | | | | 3.234 | 3.348 | 2.983 | 3.034 | | | | | | |
| 25 | | | | | 3.241 | 3.360 | 2.990 | 3.042 | | | | | | |
| 26 | | | | | 3.249 | 3.371 | 2.997 | 3.049 | | | | | | |
| 27 | | | | | 3.256 | 3.384 | 3.004 | 3.062 | | | | | | |
| 28 | | | | | ** | ** | 3.011 | 3.067 | | | | | | |
| 29 | | | | | | | 3.017 | 3.072 | | | | | | |
| 30 | | | | | | | 3.024 | 3.081 | | | | | | |
| 31 | | | | | | | 3.030 | 3.089 | | | | | | |
| 32 | | | | | | | 3.035 | 3.095 | | | | | | |
| 33 | | | | | | | 3.041 | 3.104 | | | | | | |
| 34 | | | | | | | 3.046 | 3.106 | | | | | | |
| 35 | | | | | | | 3.051 | 3.116 | | | | | | |
| 36 | | | | | | | 3.057 | 3.120 | | | | | | |
| 37 | | | | | | | 3.061 | 3.125 | | | | | | |
| 38 | | | | | | | 3.066 | 3.128 | | | | | | |
| 39 | | | | | | | 3.070 | 3.138 | | | | | | |
| 40 | | | | | | | ** | ** | | | | | | |

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