VII. MAKING EMPLOYMENT PROJECTIONS USING EMPLOYMENT-VALUE ADDED FUNCTIONS

A. Introduction

This chapter describes a method for projecting employment by industry, which makes use of econometrically estimated functions relating employment to value added. The method is similar to the labour productivity method described in chapter VI in that it can be used to project employment at the national or urban-rural level. Furthermore, it provides the same type of results that can be obtained by the labour productivity method. Unlike the labour productivity method, however, which can be applied even when the requisite data come only from observations for two years, the employment-value added function method can be applied only if a fairly long time series on employment and value added is available. 1/

The method can be used with several different functional forms characterizing the relationship between employment and value added. As a result, the method is considerably more flexible than simpler methods for preparing employment projections. In particular, it does not use certain restrictive assumptions which are required by those methods. Thus, unlike the employment-value added ratio technique, (see chapter VI), this method does not assume a constant average ratio of employment to value added.2/ Also, unlike the labour productivity method, it does not make an implicit assumption that increases in employment are proportional to increases in value added (unitary elasticity of employment with respect to value added).

An additional advantage of the employment-value added function method over the simpler techniques, especially the employment-value added ratio method, is that it makes better use of data sets that refer to longer time periods. By using more of the historical experience of the country the projections are less likely to be affected by unusual circumstances prevailing over short time periods, such as a down turn in economic activity or a temporary wage freeze.

However, the reliance on time series data may be one of the method's drawbacks if the coverage of employment and value added data by industry varies over time. In such situations, estimates of the employment-value added functions derived from time series data would yield misleading projections of employment.

Another potential weakness of the method arises from making an implicit assumption that the future relationship between employment and value added would be similar to that observed for the period for which the time series data are available. Depending on government wage and/or employment policies and other factors, such an assumption may not be warranted. Where this is the case, the method should not provide the only input used in preparing employment projections.

The method does not make explicit provision for capital-labour substitution, which is often manifested in the increase of the amount of capital per unit of labour (capital deepening), nor does it explicitly provide for technical change. Hence, it implicitly assumes that the average ratio of capital to labour in each industry is either constant or steadily changing over time. If the assumption is likely to be violated, say, owing to an anticipated significant increase in the rate of capital formation over the plan horizon relative to that over the period used to estimate the functions, the method may provide misleading projections.

B. The technique

1. Overview

This overview lists inputs needed by the method and describes the types of results it can generate. It also outlines the computational steps used in making an employment projection with the method.

(a) Inputs

To project employment at the national level, the following inputs are required:

(i) Projected levels of value added by industry;
(ii) Estimates of the coefficients of employment-value added functions, by industry;

If, in addition to employment, shortages and/or surpluses in the labour market are to be projected, the inputs should also include:

(iii) Projected total labour force;
(iv) Projected non-civilian emloyment.

For a national projection, the inputs ought to refer to the entire country. For an urban-rural projection, the inputs should be for urban and rural areas with the exception of projected value added levels by industry. The reasons for this exception are explained below. The requisite inputs are listed in box 20, which indicates that employment-value added functions may have different forms, examples of which are linear and non-linear forms. Those functions may include time as an additional explanatory variable.

Since the employment-value added function method is described in the context of procedures for making quinquennial projections, the projected levels of value added would be for dates five years apart, starting with the initial year of the plan. Projected total labour force and projected non-civilian employment would be for the same dates. Given the appropriate annual inputs, however, the method could be used for making annual projections.

Box 20

Inputs for making employment projections
using employment-value added functions

1. Value added, by industry (national)

2. Coefficients of the employment-value added functions (national or urban and rural)

   Coefficients of linear functions without or with the time variable or

   Coefficients of non-linear or log-linear functions without or with the time variable

3. Total labour force (national or urban and rural; if projection of labour market balances is desired)

4. Non-civilian employment (national or urban and rural; if projection of labour market balances is desired)

(b) Outputs

The outputs which the method can generate would partly depend on the type of projection being prepared. In the case of a national projection, the method would yield:

(i) Levels of employment by industry;
(ii) Various employment aggregates, such as total employment and the growth in total employment;
(iii) Indicators of the structure of employment, such as proportions of employment by sector (primary, secondary and tertiary);
(iv) Rates of change in employment, including that of total employment or employment by sector.

If the inputs include projected total labour force and projected non-civilian employment, the outputs could also include:

(v) Absolute and relative levels of excess supply of labour and/or excess demand for labour.

If the method is used to prepare an urban-rural projection, the results would include all of those listed under (i) through (v), which would be for urban and rural areas as well as for the entire country. In addition, they would include indicators of the urban-rural distribution of employment. The types of outputs that the technique can generate as part of the national or urban-rural projection are shown in box 21.

Box 21

Types of outputs obtained by making employment projections using employment-value added functions

1. Employment by industry (national or urban, rural and national)

2. Employment aggregates (national or urban, rural and national)

   Total employment and employment by sector (e.g. primary, secondary and tertiary)

   Growth in total employment and employment by sector

3. Indicators of the structure of employment (national or urban, rural and national)

   Proportions of employment, by sector

4. Indicators of the urban-rural distribution of employment (national only; if urban and rural employment is being projected)

   Proportions of the total employment and of employment by sector, in different locations

5. Rates of growth of employment (national or urban, rural and national)

   The rates of growth in total employment and employment by sector

6. Labour market balances (national or urban, rural and national)

   Absolute and relative levels of excess supply of and/or excess demand for labour

The results would be for dates five years apart or the intervening projection intervals.

(c) Computational steps

To project employment for a given date using employment-value added functions, it is first necessary to evaluate the functions by using the projected levels of value added, by industry, for that date. If the functions include time as an additional explanatory variable, it is also necessary to use a value of the time variable for the date in question. This step will yield projected levels of employment, by industry, for the selected date. Like the other techniques of projecting employment described in this volume, the method can also be used to calculate other results, examples of which are total employment and employment in various sectors, such as primary, secondary and tertiary, along with other date-specific indicators. The growth in employment and growth rates of employment for the intervening projection intervals can also be calculated. If the employment projection is accompanied by a labour force projection, the projected total employment and the projected total labour force can be used to calculate the surplus or shortage of labour.

2. National level

The description of the method will initially present employment-value added functions, followed by the steps to derive the levels of employment, by industry, at the national level using those functions. It will also discuss steps to derive other results for a given projection date or interval. A summary of those steps is shown in box 22. The functions and steps used to derive urban and rural employment by industry along with the related results will be described in a later section.

(a) Employment-value added functions, by industry

This section will describe several different specifications of employment-value added functions. First, specifications which exclude time as an explanatory variable will be discussed. Then, specifications which include time as an explanatory variable will be presented.

(i) Functions without the time variable

A simple specification of employment-value added function postulates that employment is a linear function of value added. Linear employment-value added functions, by industry, are written as follows:

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t'); \qquad i = 1,\ldots,I, \tag{1}$$

where:

$i = 1,\ldots,I$	are industries of the nation's economy,
I	is the number of industries,
t'	is the calendar year,

Box 22

Computational steps to project employment at the national level with the method using employment-value added functions

The steps used to project employment at the national level over a five-year projection interval are:

(1) Derive projected levels of employment, by industry, at the end of the interval by evaluating empirically estimated industry-specific employment-value added functions using the assumed levels of value added, by industry, for that date. If necessary, also use a value of the time variable to evaluate the functions.

(2) Calculate various employment aggregates, such as total employment and the increase in total employment.

(3) Derive indicators of the employment structure, such as the proportions of total employment found in each sector.

(4) Obtain rates of growth of employment, such as the rate of growth of total employment.

(5) If the labour force projection is available, calculate the absolute and percentage levels of excess supply of or excess demand for labour.

EM(i,t')	is the employment in industry i in year t',
VA(i,t')	is the value added in industry i in year t',
a(i)	is the intercept coefficient of the linear employment-value added function for industry i, and
b(i)	is the partial coefficient of the value added variable in the linear employment-value added function for industry i. (Blitzer and others (1975)

The partial coefficients in equation (1), b(i)'s, are the marginal employment-value added ratios in various industries. These ratios differ from the average employment-value added ratios as long as the intercept coefficients, a(i)'s, differ from zero. If all intercept coefficients were equal to zero, the method using such linear functions would be identical to the employment-value added ratio method of employment projections ((chapter VI).

A multiplicative specification of employment-value added functions postulates that employment is a non-linear function of value added. Such non-linear employment value added functions, by industry, are as follows:

$$EM(i,t') = a(i) \cdot VA(i,t')^{b(i)}; \qquad (2)$$

$$i = 1,\ldots,I,$$

where:

a(i) is the intercept coefficient of the non-linear employment-value added function for industry i, and

b(i) is the partial coefficient of the value added variable in the non-linear employment-value added function for industry i.

The non-linear functions indicated in equation (2) can be transformed into log-linear employment-value added functions by taking logarithms of their left-hand and right-hand sides:

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t'); \qquad (3)$$

$$i = 1,\ldots,I,$$

where:

ln is the natural logarithm.

The exponents in equation (2), b(i)'s, become the partial coefficients of the functions indicated in equation (3). However, they have a different meaning from the partial coefficients in the functions shown in equation (1). They stand for elasticities of employment with respect to value added, by industry. That is, they express the percentage change in employment for a given percentage change in value added.

The non-linear or log-linear functions embody assumptions which differ from those of the linear functions. Thus, in the non-linear or log-linear functions, marginal employment-value added ratios vary with the levels of value added and employment, while the elasticities of employment with respect to value added remain fixed (they are equal to the partial coefficients, b(i)'s). In the linear functions, the marginal employment-value added ratios are fixed (they are equal to b(i)'s), while the elasticities of employment with respect to value added vary with the levels of employment and value added.

In spite of these differences, the non-linear or log-linear functions tend to yield employment projections over the medium term which are very similar to those that can be obtained using linear functions. In view of this, with the limited time series data available in most developing countries, there is often little reason to select one form over the other in making employment projections. Linear functions are often preferred, since their use simplifies the process of estimation as well as that of making projections.

(ii) Functions with the time variable

The functions indicated in equations (1) and (2) can be modified to implicitly allow for the effects of the capital-labour substitution and technical change by respectively adding to them linear and exponential time trends. Linear functions that include time as a variable are as follows:

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + c(i) \cdot t'; \qquad (4)$$

$$i = 1,\ldots,I,$$

where:

c(i) is the partial coefficient of the time variable in the linear employment-value added function for industry i.

Non-linear functions that include a time are as follows:

$$EM(i,t') = a(i) \cdot VA(i,t') \cdot e^{[c(i)\ .\ t']}; \qquad (5)$$

$$i = 1,\ldots,I$$

where:

c(i) is the partial coefficient of the time variable in the non-linear employment-value added function for industry i, and

e is the base of the natural logarithm.

The non-linear functions shown in equation (5) can be transformed into log-linear employment-value added functions as follows:

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + c(i) \cdot t'; \qquad (6)$$

$$i = 1,\ldots,I$$

The coefficients of the time variable c(i)'s implicitly capture the effects of both capital-labour substitution and technical change. A positive rate of technical change, for example, would tend to make the coefficients negative. As technical progress occurs, a given increase in value added will be associated with a smaller increase in employment. Capital deepening (the use of more capital per unit of labour) would tend to have a similar effect on the coefficients.

(b) Employment by industry

The previous section described various specifications of the employment value added functions. This section will describe the steps necessary to derive levels of employment.

Projecting employment by industry with this method amounts to evaluating the empirically estimated employment-value added functions by industry for various dates over the projection period. The way that the functions are evaluated will depend on their functional form as well as on whether the time variable is used.

(i) Functions without the time variable

The levels of employment by industry for the end of any projection interval (t to t+5) could be projected using the estimates of linear functions without the time variable as follows:

$$EM(i,t+5) = a^*(i) + b^*(i) \cdot VA(i,t+5); \qquad (7)$$

$$i = 1,\ldots,I,$$

where:

t	is the year of the projection period,
EM(i,t+5)	is the employment in industry i at the end of the interval,
VA(i,t+5)	is the value added in industry i at the end of the interval,

$a^*(i)$ — is the estimate of the intercept coefficient of the linear employment-value added function for industry i, and

$b^*(i)$ — is the estimate of the partial coefficient of the value added variable in the linear employment-value added function for industry i.

Estimated non-linear functions without the time variable would yield projections of employment by industry as follows:

$$EM(i,t+5) = a^*(i) \cdot VA(i,t+5)^{b^*(i)}; \qquad i = 1,\ldots,I, \tag{8}$$

where:

$a^*(i)$ — is the estimate of the intercept coefficient of the non-linear employment-value added function for industry i, and

$b^*(i)$ — is the estimate of the partial coefficient of the value added variable in the non-linear employment-value added function for industry i.

Alternatively, the logarithmic transformations of the non-linear functions without the time variable could be used to project employment. Those functions would be first used to obtain the logarithms of employment levels by industry as follows:

$$\ln EM(i,t+5) = [\ln a(i)]^* + b^*(i) \cdot \ln VA(i,t+5); \qquad i = 1,\ldots,I, \tag{9}$$

where:

$[\ln a(i)]^*$ — is the estimate of the logarithm of the intercept coefficient of the non-linear function for industry i.

Once the logarithm of employment levels are obtained, as indicated in equation (9), the employment levels themselves can be obtained by calculating antilogarithms of the results:

$$EM(i,t+5) = \mathrm{antiln}[\ \ln EM(i,t+5)\ ]; \qquad i = 1,\ldots,I, \tag{10}$$

where:

antiln is the antilogarithm of the natural logarithm.

(ii) Functions with the time variable

To prepare a projection using estimates of linear functions which include time as a variable, the levels of employment by industry for the end of the projection interval (t to t+5) would be obtained as follows:

$$EM(i,t+5) = a^*(i) + b^*(i) \cdot VA(i,t+5) + c^*(i) \cdot (\bar{t}'+t+5); \qquad (11)$$

$$i = 1,\ldots,I,$$

where:

$\bar{t}'$ is the calendar year designated as the initial year of the projection period, and

$c^*(i)$ is the estimate of the partial coefficient of the time variable in the linear employment-value added function for industry i.

If the estimates of non-linear functions with the time variable were used, the projection for the end of the interval (t to t+5) would be made as follows:

$$EM(i,t+5) = a^*(i) \cdot VA(i,t+5)^{b^*(i)} \cdot e^{[c^*(i) \cdot (\bar{t}'+t+5)]}; \qquad (12)$$

$$i = 1,\ldots,I,$$

where:

$c^*(i)$ is the estimate of the partial coefficient of the time variable in the non-linear employment-value added function for industry i.

If the logarithmically transformed non-linear employment-value added functions were to be used, the projection would be made as follows:

$$\ln EM(i,t+5) = [\ln a(i)]^* + b^*(i) \cdot \ln VA(i,t+5) + c^*(i) \cdot (\bar{t}'+t+5); \qquad (13)$$

$$i = 1,\ldots,I.$$

After the logarithms of employment levels by industry are obtained, the employment levels themselves can be obtained as indicated by equation (10).

(c) Other results 3/

Once the levels of employment by industry are projected for the end of a given projection interval, several derived indicators can be calculated. These indicators include aggregates, indicators of the structure and the rates of change of employment.

(i) Employment aggregates

A key aggregate that one can calculate from the projected levels of employment by industry is the level of total employment. In addition, using the same results, it is possible to obtain the levels of employment in sectors, such as the primary, secondary and tertiary sectors. Once the total and sectoral levels are obtained for different dates five years apart, increases in total and sectoral employment over the intervening projection intervals can be calculated.

a. Total employment

Total employment can be obtained by aggregating the levels of employment across industries. For the end of a projection interval (t to t+5) this number can be obtained as follows:

$$EM(t+5) = \sum_{i=1}^{I} EM(i,t+5), \qquad (14)$$

where:

EM(t+5) is the total employment at the end of the interval.

b. Employment by sector

A variety of criteria can be used to aggregate industries into sectors. For example, one can aggregate industries into primary, secondary and tertiary sectors, or into agricultural, industrial and service sectors. For illustrative purposes the primary-secondary-tertiary-sector classification will be used. In addition, it will be assumed that the numbering of industries for which the levels of employment are being projected lists industries of the primary, secondary and tertiary sectors one after another.

i. Employment in the primary sector

Using these aggregation and classification rules, employment in the primary sector for the end of the projection interval (t to t+5) can be obtained as:

$$EMP(t+5) = \sum_{i=1}^{Ip} EM(i,t+5), \tag{15}$$

where:

Ip is the number of industries in the primary sector, and

EMP(t+5) is the employment in the primary sector at the end of the interval.

ii. Employment in the secondary sector

Employment in the secondary sector can be obtained as follows:

$$EMS(t+5) = \sum_{i=Ip+1}^{Ip+Is} EM(i,t+5), \tag{16}$$

where:

Is is the number of industries in the secondary sector, and

EMS(t+5) is the employment in the secondary sector at the end of the interval.

iii. Employment in the tertiary sector

Employment in the tertiary sector can be calculated as:

$$EMT(t+5) = \sum_{i=Ip+Is+1}^{I} EM(i,t+5), \tag{17}$$

where:

EMT(t+5) is the employment in the tertiary sector at the end of the interval.

c. Growth in total employment

The growth in total employment over the projection interval (t to t+5) equals the difference between total employment at the end and total employment at the beginning of the interval:

$$EMGR = EM(t+5) - EM(t), \quad (18)$$

where:

EMGR is the growth of total employment during the interval.

d. Growth of employment by sector

The increase in employment in the primary, secondary and the tertiary sectors over the projection interval is respectively obtained as follows:

The growth in employment in the primary sector is calculated as:

$$EMPGR = EMP(t+5) - EMP(t), \quad (19)$$

The growth in employment in the secondary sector is calculated as:

$$EMSGR = EMS(t+5) - EMS(t), \quad (20)$$

The growth in employment in the tertiary sector is calculated as:

$$EMTGR = EMT(t+5) - EMT(t), \quad (21)$$

where:

EMPGR is the growth of employment in the primary sector during the interval,

EMSGR is the growth of employment in the secondary sector during the interval, and

EMTGR is the growth of employment in the tertiary sector during the interval.

(ii) Indicators of the structure of employment

Once the various employment aggregates are obtained, it is possible to derive the proportions of employment accounted for by each sector.

a. Proportions by sector

Proportions of total employment accounted for by each sector (primary, secondary and tertiary) can be obtained as follows:

The proportion of employment found in the primary sector is calculated as:

$$PEMP(t+5) = EMP(t+5) \ / \ EM(t+5), \tag{22}$$

The proportion of employment found in the secondary sector is calculated as:

$$PEMS(t+5) = EMS(t+5) \ / \ EM(t+5), \tag{23}$$

The proportion of employment found in the tertiary sector is calculated as:

$$PEMT(t+5) = EMT(t+5) \ / \ EM(t+5), \tag{24}$$

where:

PEMP(t+5)	is the proportion of employment accounted for by the primary sector at the end of the interval,
PEMS(t+5)	is the proportion of employment accounted for by the secondary sector at the end of the interval, and
PEMT(t+5)	is the proportion of employment accounted for by the tertiary sector at the end of the interval.

(iii) Rates of growth of employment

As part of an employment projection, it is also possible to compute average annual rates of growth of employment, for the total employment and employment by sectors.

a. Rate of growth of total employment

The average annual rate of growth of total employment for a given projection interval can be computed from the total employment at the beginning and the end of the interval. If, as part of the projection process, the planner makes assumption that growth occurs over discrete intervals, then the percentage growth rate can be obtained using the formula for calculating a geometric growth rate:

$$GGREM = [(EM(t+5) / EM(t))^{1/5} - 1] \cdot 100, \qquad (25)$$

where:

GGREM is the average annual geometric growth rate of total employment for the interval.

Alternatively, if the planner assumes that growth is continuous, then the percentage growth rate of total employment can be calculated using the formula for calculating an exponential growth rate:

$$EGREM = [\ln (EM(t+5) / EM(t)) / 5] \cdot 100, \qquad (26)$$

where:

EGREM is the average annual exponential growth rate of total employment for the interval.

b. Rates of growth of employment, by sector

Assuming discrete growth, the percentage rates of growth of employment for major sectors can be obtained as follows:

The geometric growth rate for the primary sector is calculated as:

$$GGREMP = [(EMP(t+5) / EMP(t))^{1/5} - 1] \cdot 100, \qquad (27)$$

The geometric growth rate for the secondary sector is calculated as:

$$GGREMS = [(EMS(t+5) / EMS(t))^{1/5} - 1] \cdot 100, \qquad (28)$$

The geometric growth rate for the tertiary sector is calculated as:

$$GGREMT = [(EMT(t+5) / EMT(t))^{1/5} - 1] \cdot 100, \qquad (29)$$

where:

GGREMP is the average annual geometric growth rate of employment in the primary sector for the interval, GGREMS is the average annual geometric growth rate of employment in the secondary sector for the interval, and

GGREMT is the average annual geometric growth rate of employment in the tertiary sector for the interval.

If the projections were based on the assumption of continuous growth, then the percentage rates of growth of employment by sector would be calculated using the formulae for obtaining the exponential growth rate. The calculations would be as follows:

The exponential growth rate for the primary sector is calculated as:

$$EGREMP = [\ \ln (\ EMP(t+5)\ /\ EMP(t)\ )\ /\ 5\ ] \cdot 100, \tag{30}$$

The exponential growth rate for the secondary sector is calculated as:

$$EGREMS = [\ \ln (\ EMS(t+5)\ /\ EMS(t)\ )\ /\ 5\ ] \cdot 100, \tag{31}$$

The exponential growth rate for the tertiary sector is calculated as:

$$EGREMT = [\ \ln (\ EMT(t+5)\ /\ EMT(t)\ )\ /\ 5\ ] \cdot 100, \tag{32}$$

where:

EGREMP is the average annual exponential growth rate of employment in the primary sector for the interval,

EGREMS is the average annual exponential growth rate of employment in the secondary sector for the interval, and

EGREMT is the average annual exponential growth rate of employment in the tertiary sector for the interval.

(iv) Labour market balances

Once various projection results are obtained, it is possible to calculate the excess demand for labour or excess supply of labour using projections of labour force and employment as indicators of future supply of or demand for labour. It is also possible to calculate the excess demand or excess supply as a percentage of the total labour force.

In countries where there is sizeable non-civilian employment, which may include military or internal security personnel, the projected labour force to be used in these calculations should not be the projected total labour force obtained as described in chapter V.

The projected labour force to be used is the projected civilian labour force, obtained as the difference between the projected total labour force and the projected non-civilian employment, where the latter projection is an additional input. The reason for this is related to the fact that in projections relating to the labour market, projections of the demand for labour (or employment) will normally apply to the civilian segment of the labour market. Therefore, projections of the supply of labour (or labour force) used to compute excess supply or demand must be those for the civilian segment.

To calculate excess supply or excess demand, therefore, the civilian labour force may first have to be calculated; for the end of the time interval (t to t+5), this can be obtained as:

$$CLF(t+5) = LF(t+5) - NEM(t+5), \tag{33}$$

where:

CLF(t+5)	is the civilian labour force at the end of the interval,
LF(t+5)	is the total labour force at the end of the interval, and
NEM(t+5)	is the non-civilian employment at the end of the interval.

The excess supply of (or demand for) labour for the end of the interval can be obtained as the difference between the projected civilian labour force and the projected employment for that date:

$$EXL(t+5) = CLF(t+5) - EM(t+5), \tag{34}$$

where:

EXL(t+5)	is the excess supply of labour (if positive) or excess demand for labour (if negative) for the end of the interval.

The excess demand or excess supply as a percentage of the civilian labour supply (civilian labour force), can be calculated as:

$$PEXL(t+5) = [\ EXL(t+5) \ / \ CLF(t+5)\ ] \cdot 100, \tag{35}$$

where:

PEXL(t+5) is the excess supply of labour or excess demand for labour as a percentage of the civilian labour force at the end of the interval.

3. Urban-rural level

This section will describe employment-value added functions along with a procedure that utilizes them to calculate an urban-rural projection of employment. The procedure, which is similar to that used in the national projection, consists of steps used to project the levels of employment by industry as well as those needed to derive a variety of other results.

(a) Employment-value added functions by industry

The procedure for making urban-rural projections could make use of estimates of employment-value added functions, which are the urban-rural equivalents of the functions indicated in equations (1) through (6). This would be the case where time series data on employment and value added, by industry, are available for urban and rural areas and where it is therefore possible to empirically estimate parameters of the employment-value added functions separately for urban and rural areas.

However, sufficiently long and reliable time series on value added by industry for urban and rural areas are not available in some countries. Accordingly, estimating the urban-rural counterparts of the functions shown in equations (1) through (6) would be often difficult, if not impossible in those countries.

Where the value added time series for urban and rural areas are short, unreliable or altogether lacking, employment projections can be made by means of empirically based functions which relate employment by industry in urban and rural areas to value added by industry for the entire country. Functions of this type are briefly reviewed below.

(i) Functions without the time variable

Linear employment-value added functions by industry and urban-rural location, having the national value added by industry as explanatory variable but omitting the time variable, are as follows:

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t'); \quad (36)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$k = 1,2$	are urban and rural locations,
$EM(i,k,t')$	is the employment in industry i in location k in year t',
$a(i,k)$	is the intercept coefficient of the linear employment-value added function for industry i in location k, and
$b(i,k)$	is the partial coefficient of the value added variable in the linear employment-value added function for industry i in location k.

Non-linear functions by industry and urban-rural location, without time as a variable, are as follows:

$$EM(i,k,t') = a(i,k) \,.\, VA(i,t')^{b(i,k)}; \quad (37)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$a(i,k)$	is the intercept coefficient of the non-linear employment-value added function for industry i in location k, and
$b(i,k)$	is the partial coefficient of the value added variable in the non-linear employment-value added function for industry i in location k.

Log-linear functions by industry and location, which can be obtained by a logarithmic transformation of non-linear functions shown in equation (37), are as follows:

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t'); \qquad (38)$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

(ii) Functions with the time variable

Linear employment-value added functions by industry and location, having both national value added and time as explanatory variables, are as follows:

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + c(i,k) \cdot t'; \qquad (39)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$c(i,k)$	is the partial coefficient of the time variable in the linear employment-value added function for industry i in location k.

Non-linear functions by industry and location, having national value added and time as explanatory variables, are:

$$EM(i,k,t') = a(i,k) \cdot VA(i,t')^{b(i,k)}\, e^{[c(i,k) \cdot t']}; \qquad (40)$$

$$i = 1,\ldots,I,$$

where:

$c(i,k)$	is the partial coefficient of the time variable in the non-linear employment-value added function for industry i in location k.

Log-linear functions by industry and location, having national value added and time as explanatory variables, are:

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + c(i,k) \cdot t'; \qquad (41)$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

(b) Employment by industry

Projecting employment by industry for urban and rural areas using functions of this type would amount to evaluating empirically estimated functions by industry for the two areas for various dates over the projection period. As in the case of the national projection, the exact way of evaluating the functions would depend on their functional form as well as on whether the time variable is used.

(i) Functions without the time variable

The levels of employment by industry and location for the end of the projection interval (t to t+5) would be projected using estimates of linear functions without the time variable, as follows:

$$EM(i,k,t+5) = a^*(i,k) + b^*(i,k) \cdot VA(i,t+5); \qquad (42)$$

$$i = 1,\dots,I;$$

$$k = 1,2,$$

where:

$EM(i,k,t+5)$	is the employment in industry i in location k at the end of the interval,
$a^*(i,k)$	is the estimate of the intercept coefficient of the linear employment-value added function for industry i in location k, and
$b^*(i,k)$	is the estimate of the partial coefficient of the value added variable in the linear employment-value added function for industry i in location k.

Where estimates of non-linear functions without the time variable were used, the projected levels of employment would be obtained as follows:

$$EM(i,k,t+5) = a^*(i,k) \cdot VA(i,t+5)^{b^*(i,k)}; \qquad (43)$$

$$i = 1,\dots,I;$$

$$k = 1,2,$$

where:

a*(i,k) is the estimate of the intercept coefficient of the non-linear employment-value added function for industry i in location k, and

b*(i,k) is the estimate of the partial coefficient of the value added variable in the non-linear employment-value added function for industry i in location k.

The logarithms of the projected levels of employment, by industry and location for the end of the interval can be derived from estimates of log-linear functions that did not include the time variable, as follows:

$$\ln EM(i,k,t+5) = [\ln a(i,k)]^* + b^*(i,k) \cdot \ln VA(i,t+5); \quad (44)$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

The levels of employment can be calculated as antilogarithms of the logs of employment levels by industry:

$$EM(i,k,t+5) = \text{antiln}[\ \ln EM(i,k,t+5)\ ]; \quad (45)$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

(ii) <u>Functions with the time variable</u>

To make a projection using estimates of the linear functions with the time variable, the levels of employment by industry and location for the end of the projection interval (t to t+5) would be obtained as follows:

$$EM(i,k,t+5) = a^*(i,k) + b^*(i,k) \cdot VA(i,t+5) + c^*(i,k) \cdot (\bar{t}'+t+5); \quad (46)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$c^*(i,k)$ is the estimate of the partial coefficient of the time variable in the linear employment-value added function for industry i in location k.

To make a projection using the non-linear functions with the time variable, the projected levels of employment would be obtained as:

$$EM(i,k,t+5) = a^*(i,k) \cdot VA(i,t+5)^{b^*(i,k)} \cdot e^{[c^*(i,k) \cdot (\bar{t}'+t+5)]}; \quad i = 1,\ldots,I; \quad k = 1,2, \tag{47}$$

where:

$c^*(i,k)$ is the estimate of the partial coefficient of the time variable in the non-linear employment-value added function for industry i in location k.

Where the projection is made with log-linear functions involving the time variable, it is first necessary to derive the logarithms of the projected levels of employment, by industry and location, for the end of the interval as:

$$\ln EM(i,k,t+5) = [\ln a(i,k)]^* + b^*(i,k) \cdot \ln VA(i,t+5) + c^*(i,k) \cdot (\bar{t}'+t+5); \quad i = 1,\ldots,I; \quad k = 1,2. \tag{48}$$

Once the logarithms of employment levels by industry and location are obtained, the employment levels can be calculated by taking the antilogarithms of the results, as indicated by equation (45).

(c) Other results 4/

The indicators obtained as part of the national projection can also be computed in the course of preparing an urban-rural projection. Those indicators are calculated for urban and rural areas and for the entire country, using steps analogous to those indicated by equations (14) through (32). The projection also permits the calculation of the excess supply of (or excess demand for) labour based on steps analogous to those described by equations (33) and (35). These calculations would also refer to the urban and rural areas as well as the entire country. In addition, indicators of the distribution of employment by location--proportions urban and rural--can be calculated.

(i) Proportions of employment, urban and rural

The proportions of employment occurring in urban and rural areas can be derived both for total employment and employment by sector.

a. Proportions of total employment

The proportion of total employment that is urban (k=1) is obtained as a ratio of total employment in urban areas to total employment in the entire country:

PEMURB(t+5) = EM(1,t+5)/EM(t+5); (49)

where:

PEMURB(t+5) is the proportion of total employment that is urban at the end of the interval, and

EM(k,t+5) is the total employment in location k at the end of the interval.

The proportion of total employment that is rural (k=2) can be obtained as a complement of the proportion urban:

PEMRUR(t+5) = 1 - PEMURB(t+5); (50)

where:

PEMRUR(t+5) is the proportion of total employment that is rural at the end of the interval.

b. Proportions of employment, by sector

Proportions of total employment in the primary, secondary and tertiary sectors that are urban (k=1) can be calculated as ratios of employment in those sectors in urban areas to employment in those sectors in the entire country. In particular, urban proportions can be calculated as follows:

The proportion of employment in the primary sector that is urban:

$$PEMPURB(t+5) = EMP(1,t+5)/EMP(t+5), \tag{51}$$

The proportion of employment in the secondary sector that is urban:

$$PEMSURB(t+5) = EMS(1,t+5)/EMS(t+5), \tag{52}$$

The proportion of employment in the tertiary sector that is urban:

$$PEMTURB(t+5) = EMT(1,t+5)/EMT(t+5), \tag{53}$$

where:

PEMPURB(t+5) is the proportion of employment in the primary sector that is urban at the end of the interval,

PEMSURB(t+5) is the proportion of employment in the secondary sector that is urban at the end of the interval,

PEMTURB(t+5) is the proportion of employment in the tertiary sector that is urban at the end of the interval,

EMP(k,t+5) is the employment in the primary sector in location k at the end of the interval,

EMS(k,t+5) is the employment in the secondary sector in location k at the end of the interval, and

EMT(k,t+5) is the employment in the tertiary sector in location k at the end of the interval.

For each sector, the proportions of employment that are rural (k=2) can be obtained as complements of proportions urban:

The proportion of employment in the primary sector that is rural:

$$PEMPRUR(t+5) = 1 - PEMPURB(t+5), \tag{54}$$

The proportion of employment in the secondary sector that is rural:

$$PEMSRUR(t+5) = 1 - PEMSURB(t+5), \tag{55}$$

The proportion of employment in the tertiary sector that is rural:

$$PEMTRUR(t+5) = 1 - PEMTURB(t+5), \tag{56}$$

where:

PEMPRUR(t+5) is the proportion of employment in the primary sector that is rural at the end of the interval,

PEMSRUR(t+5) is the proportion of employment in the secondary sector that is rural at the end of the interval, and

PEMTRUR(t+5) is the proportion of employment in the tertiary sector that is rural at the end of the interval.

This completes the discussion of the technique for making employment projections using employment-value added functions.

C. The inputs

This section first lists the inputs required by the method of employment projection utilizing employment-value added functions and then describes how they can be prepared.

1. Types of inputs required

The following inputs are required in order to project employment by using the employment-value added functions:

(i) Projected levels of value added by industry;
(ii) Estimates of the coefficients of the employment-value added functions, by industry.

If projections of labour surpluses and/or shortages are also to be prepared, the inputs should include:

(iii) Projected total labour force;
(iv) Projected non-civilian employment.

Depending on whether it is desired to make a national projection or a projection for urban and rural areas, most inputs will be required for the entire country or for urban and rural areas. The projected levels of value added by industry, however, can be those for the entire country even though a projection for urban and rural areas is desired.

2. Preparation of the inputs

To apply the method, projections of value added by industry are required. These projections are part of many quantitative development planning exercises. Hence, procedures for making value added projections are not discussed in the present volume except for the procedure briefly outlined in chapter VI, box 17. Projections of the total labour force can be prepared as described in chapter V, while those of non-civilian employment can be obtained by considering likely future developments in the non-civilian sector of the economy. Estimates of the coefficients of employment-value added functions can be prepared as described below.

(a) Estimates of the coefficients of employment-value added functions

Estimates of the coefficients of employment-value added functions for each industry would be typically prepared using a standard method of regression analysis, such as ordinary least squares (OLS). Depending on the type of projection intended (national or urban-rural), the estimates of the functions would be for the entire country or for urban and rural areas. The estimation would make use of time series data on employment and value added, by industry, at the national level or for urban and rural areas.

(i) Time series data

Time series data on employment by industry at the national or urban-rural level can be obtained from annual surveys of establishments or from periodic labour force surveys of households. If those data refer only to modern establishment of various industries, which is sometimes the case in developing countries, and data on traditional establishments are available for a few years, the latter data may be used as a basis for inflating the employment in modern establishments with a view to estimating total employment levels by industry over time.

Time series data on value added by industry would normally be obtained from the national accounts. Unfortunately, the national accounts or other data sources will rarely include value added information for industries classified by urban-rural location. Where projections of employment are desired by location, it may be necessary to use data on employment by industry and location along with those on value added by industry without the locational breakdown in order to estimate requisite employment-value added functions.

(ii) Estimation procedures

Estimating employment-value added functions at the national or urban-rural level would normally entail preparing estimates of functions having different forms, which exclude and include the time variable. This would be necessary in view of the fact that it would never be possible to determine *a priori* which functional form may be more suitable than the other as well as whether including the time variable improves the fit or not. As a result, the user of the method would typically be required to estimate functions of different forms, compare the results, and select for use those estimates that appear most robust in terms of goodness of fit, significance of coefficients and so on.

This section will first describe a method to estimate coefficients of employment-value added functions of different forms at the national level. It will then describe procedures to estimate those functions at the urban-rural level. Subsequently, estimation of those functions will be illustrated using the time series data on employment and value added.

a. National level

Procedures used to estimate employment-value added functions will differ depending on whether or not those functions include time as a variable.

i. Functions without the time variable

In order to obtain estimates of linear employment value-added functions that do not include the time variable, it would be necessary to add to the functions shown in equation (1) random disturbance terms to obtain:

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + u(i,t'); \qquad (57)$$

$$i = 1,...,I,$$

where:

u(i,t') is the random disturbance term for industry i in year t'.

The functions shown in equation (57) would be then estimated with a regression technique, such as OLS, using time series data on employment and value added.

The following standard approach can be used for estimating coefficients of non-linear functions having the multiplicative form, which do not include time as a variable. First, it would be necessary to take logarithms of the functions shown in equation (2) and add a disturbance term to each:

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + u(i,t'); \qquad (58)$$

$$i = 1,...,I.$$

The resultant log-linear functions could then be estimated using a regression technique, such as OLS.

The result would be estimates of the logarithms of the intercept coefficients of the non-linear functions, [lna(i)]*'s, and estimates of the partial coefficients, b*(i)'s. The estimate of the partial coefficients can be used as obtained by OLS, while those of the logarithms of the intercept coefficients need to be transformed into estimates of the intercept coefficients. This can be done by taking antilogarithms of the estimates of the logarithms of intercept coefficients:

$$a^*(i) = \text{antiln}[\ln a(i)]^*; \qquad (59)$$

$$i = 1,\ldots,I.$$

To estimate the log-linear employment-value added functions, it would be initially necessary to add random disturbance terms to those functions (equation (3)) and to obtain functions indicated in equation (58). Those functions could be estimated by a regression technique such as OLS. The estimates of the logarithms of the intercept coefficients and of partial coefficients can be used directly from this estimation.

ii. Functions with the time variable

To derive estimates of linear employment value-added functions which include the time variable, it would initially be necessary to add random disturbance terms to those functions (equation (4)) to obtain:

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + c(i) \cdot t' + u(i,t'); \qquad (60)$$

$$i = 1,\ldots,I.$$

These functions would then be estimated with a regression technique such as OLS, using appropriate time series data.

To estimate non-linear functions with the time variable, it would initially be necessary to take logarithms of those functions (equation (5)) and add a disturbance term to each:

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + c(i) \cdot t' + u(i,t'); \qquad (61)$$

$$i = 1,\ldots,I.$$

The log-linear functions can be estimated from time series data using a regression technique such as OLS. This should be followed by the derivation of estimates of the intercept coefficients, as indicated by equation (59).

To derive estimates of log-linear functions with time as a variable, it would first be necessary to add disturbance terms to those functions (equation (6)) and in the process derive a set of functions shown in equation (61). Such functions could be estimated by a regression technique, such as OLS. The estimates of the logarithms of the intercept coefficients and of partial coefficients can be used in the form obtained by this estimation.

b. Urban-rural level

The methods for estimation of employment-value added functions at the urban-rural level will also differ, depending on whether or not the functions include the time variable.

i. Functions without the time variable

To obtain estimates of linear functions without the time variable for urban and rural areas, it would be initially necessary to add random disturbance terms to the functions shown in equation (36) to obtain:

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + u(i,k,t'); \quad i = 1,\ldots,I; \quad k = 1,2, \tag{62}$$

where:

$u(i,k,t')$ is the random disturbance term for industry i in location k in year t'.

The functions shown in equation (62) would be estimated with OLS, using time series data on employment and value added.

If estimates of non-linear functions without time as a variable are desired, it would be initially necessary to take logarithms of the functions shown in equation (37) and add a disturbance term to each:

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + u(i,k,t'); \quad i = 1,\ldots,I; \quad k = 1,2. \tag{63}$$

The resultant log-linear functions can be estimated using a regression technique, such as OLS.

The result would include estimates of the logarithms of the intercept coefficients of the non-linear functions, $[\ln a(i,k)]^*$'s, and estimates of the partial coefficients, $b^*(i,k)$'s. While the estimate of the partial coefficients can be used as obtained by OLS, those of the logarithms of the intercept coefficients must be transformed into estimates of the intercept coefficients themselves. This can be accomplished by taking antilogarithms of the estimates of the logarithms of intercept coefficients:

$$a^*(i,k) = \text{antiln}[\ln a(i,k)]^*; \quad (64)$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

To estimate the log-linear employment-value added functions, it would be initially necessary to add random disturbance terms to those functions (equation (38)) and to obtain functions indicated in equation (63). Those functions can be estimated using regression techniques, such as OLS. The estimates of the logarithms of the intercept coefficients and of partial coefficients can be used in the form obtained by this estimation.

ii. Functions with the time variable

To derive estimates of linear employment value-added functions with the time at the urban-rural level, it is necessary to add disturbance terms to those functions (equation (39)) to obtain:

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + c(i,k) \cdot t' \quad (65)$$

$$+ u(i,k,t');$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

These functions would then be estimated with a regression technique, such as OLS.

Non-linear functions with time as a variable can be estimated by taking logarithms of those functions (equation (40)) and adding a disturbance term to each:

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + c(i,k) \cdot t' \quad (66)$$

$$+ u(i,k,t');$$

$$i = 1,\ldots,I;$$

$$k = 1,2.$$

These log-linear functions can be estimated from time series data using a regression technique, such as OLS. Estimates of the intercept coefficients can be derived as indicated by equation (64).

To derive estimates of log-linear functions with time as a variable, it is necessary to add disturbance terms to those functions (equation (41)) and in the process derive a set of functions shown in equation (66). Such functions would be estimated by a regression technique, such as OLS. The estimates of the logarithms of the intercept coefficients and of partial coefficients can be used in the form obtained by this estimation.

(iii) Illustrative estimation

This section will use the time series data shown in tables 86 through 88 to illustrate a technique for estimating employment-value added functions of various specifications, first at the national level and then at the urban-rural level. Reasons will be presented why estimates of functions of a given form (for example those with time as a variable) may be preferable to those of other forms (such as those without the time variable).

a. National level

The estimation of the national-level functions without time as a variable will be illustrated, and then the estimation of the functions with time as a variable will be discussed.

i. Functions without the time variable

To project employment using estimates of national-level linear employment-value added functions without time as a variable, it would be necessary to estimate the functions indicated in equation (57). If OLS regression techniques are employed along with the data presented in tables 86 and 87 to estimate those functions, the results will be those shown in table 89.

For the most part, those results will be satisfactory as a basis for making projections of employment. All of the estimated partial coefficients (column 3) are positive, as expected, and most are statistically significant at the 0.05 level. However, forecast errors could be fairly high in the case of functions with coefficients of determination, R^2's (column 4), under 0.90, as is the case with several of the estimated functions. Column 5 of table 89 also shows Durbin-Watson statistics (box 23), which indicate whether or not the disturbance terms are serially correlated (box 24).

To obtain estimates of non-linear employment-value added functions, it is necessary to estimate the log-linear functions indicated in equation (58). The estimates of the coefficients of those functions based on the time series data shown in tables 86 and 87 are those presented in table 90.

Table 86. Employment for the entire country, by industry: 1968-1978

(Thousands of employed persons)

Year	Agri-culture	Mining	Manufac-turing	Utilities	Cons-truction	Trade	Transport	Ser-vices
1968	1656.5	5.0	124.5	9.6	57.6	79.3	68.5	312.8
1969	1688.5	5.4	127.7	9.2	53.8	79.7	73.9	330.1
1970	1739.8	6.3	137.8	8.9	55.8	77.4	84.4	336.8
1971	1766.1	7.2	155.4	9.0	59.8	85.4	82.1	365.9
1972	1764.8	7.1	145.5	11.3	64.3	83.9	86.2	375.7
1973	1843.5	7.4	159.8	9.6	69.4	81.1	82.5	391.4
1974	1846.3	9.4	171.8	10.0	76.0	100.5	89.2	442.1
1975	1887.0	8.3	170.3	13.7	71.0	94.1	83.7	468.5
1976	1917.8	10.3	184.0	14.4	81.8	104.9	88.4	483.3
1977	1955.6	9.5	198.2	15.6	85.4	108.5	89.5	503.3
1978	1994.0	6.7	217.3	15.3	93.8	109.4	95.1	516.2

Table 87. Value added for the entire country, by industry: 1968-1978

(Millions of local currency units; constant 1968 prices)

Year	Agri-culture	Mining	Manufac-turing	Utilities	Cons-truction	Trade	Transport	Ser-vices
1968	155.2	2.2	44.6	8.2	18.4	41.2	38.1	119.2
1969	165.4	2.0	48.6	9.1	18.6	44.0	38.6	128.1
1970	172.4	2.6	52.5	9.8	19.0	44.6	41.2	139.0
1971	175.9	2.7	59.3	10.6	20.2	47.1	43.1	152.9
1972	189.3	2.5	63.6	11.6	23.1	42.6	42.4	172.2
1973	199.4	3.6	70.8	11.9	23.8	45.5	45.2	185.7
1974	202.6	3.9	74.9	12.7	22.2	46.4	44.7	207.1
1975	237.1	3.5	75.5	13.7	21.2	49.5	42.0	223.0
1976	235.2	3.8	89.6	15.4	20.7	51.8	46.4	237.5
1977	256.5	4.0	103.9	16.5	22.3	50.5	47.7	252.6
1978	260.3	2.6	118.9	18.0	23.5	50.9	50.3	266.9

Table 88. Employment for urban and rural areas, by industry: 1968-78

(Thousands of employed persons)

Year	Agri-culture	Mining	Manufac-turing	Utilities	Cons-truction	Trade	Transport	Ser-vices
				Urban				
1968	21.0	4.4	113.6	8.3	54.3	77.9	67.2	214.1
1969	19.3	4.8	115.9	8.6	52.5	75.1	72.9	218.1
1970	18.2	5.4	117.2	8.6	52.7	73.7	83.4	221.6
1971	18.1	5.9	132.2	8.1	52.8	81.7	79.3	240.3
1972	19.7	5.8	128.2	8.9	56.3	76.5	84.6	267.0
1973	16.8	5.9	137.9	8.9	59.4	72.9	81.2	274.9
1974	18.5	7.5	148.7	9.1	66.6	91.9	86.5	286.3
1975	20.4	6.5	146.9	12.5	64.4	85.2	80.7	299.2
1976	18.8	8.1	158.7	12.3	73.2	94.5	85.9	306.2
1977	21.2	7.8	169.4	12.5	77.0	96.9	86.6	319.4
1978	22.2	5.9	184.2	12.7	81.4	98.8	92.2	334.3
				Rural				
1968	1635.5	0.5	10.9	1.3	3.3	1.4	1.3	98.7
1969	1668.8	0.6	11.7	0.6	1.3	4.7	1.1	112.0
1970	1721.6	0.9	20.6	0.3	3.1	3.7	1.0	115.2
1971	1748.0	1.3	23.2	0.9	7.0	3.7	2.8	125.6
1972	1745.1	1.4	17.4	2.5	8.0	7.4	1.7	108.8
1973	1826.7	1.5	21.9	0.7	10.0	8.2	1.4	116.5
1974	1827.7	1.8	23.1	0.9	9.4	8.7	2.7	155.8
1975	1866.6	1.8	23.4	1.2	6.6	8.8	3.0	169.3
1976	1898.9	2.1	25.3	2.1	8.6	10.4	2.5	177.2
1977	1934.3	1.7	28.8	3.1	8.4	11.6	2.9	184.0
1978	1971.8	0.8	33.1	2.6	12.4	10.6	2.9	181.9

Table 89. Estimates of the coefficients of linear employment-value added functions without the time variable, by industry: entire country a/

Industry	Coefficients		R-square	Durbin-Watson
	Intercept	Value added b/		
(1)	(2)	(3)	(4)	(5)
Agriculture	1235.7727	2.87485 (13.810)	0.955	2.10
Mining	0.9902	2.14693 (7.059)	0.847	2.46
Manufacturing	73.1422	1.23128 (17.817)	0.972	1.94
Utilities	1.6971	0.78495 (6.805)	0.837	1.66
Construction	-27.7123	4.60744 (2.836)	0.472	0.54
Trade	-50.1969	3.02735 (5.053)	0.739	2.36
Transport	6.4904	1.77633 (5.829)	0.791	2.25
Services	141.9969	1.42219 (28.608)	0.989	1.73

a/ Estimated by ordinary least squares (OLS) .
b/ t values are shown in parentheses.

Table 90. Estimates of the coefficients of log-linear employment-value added functions without the time variable, by industry: entire country a/

Industry	Coefficients		R-square	Durbin-Watson
	Intercept	Value added b/		
(1)	(2)	(3)	(4)	(5)
Agriculture	5.7760	0.32625 (15.226)	0.963	2.35
Mining	1.0547	0.86530 (7.280)	0.855	2.40
Manufacturing	2.6863	0.56365 (18.948)	0.976	2.47
Utilities	0.4165	0.80202 (5.802)	0.789	1.49
Construction	-0.1260	1.42891 (3.134)	0.522	0.57
Trade	-1.3045	1.51233 (4.937)	0.730	2.34
Transport	0.8048	0.96016 (5.798)	0.789	2.18
Services	2.6878	0.63680 (24.260)	0.985	1.44

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Box 23

Glossary

Durbin-Watson statistic

The statistic, developed by J. Durbin and G. S. Watson as a weighted ratio of the sum of squared differences in successive residuals, which is used to test for autocorrelation of residuals.

Serially correlated

Disturbance terms of a regression equation fitted to time series data are said to be serially correlated if there is a degree of stochastic dependence between those terms. Serial correlation occurs when effects due to particular chance disturbances or omitted variables tend to persist, through several periods or years. It could also be occasioned by methods of data collecting or reporting that incorporate elements of smoothing and interpolation which average the "true" disturbances over adjacent periods.

These results are equally satisfactory and sometimes better than those shown in table 89. The only exception are the results for utilities, for which both R^2 and the Durbin-Watson statistics are lower than those obtained by estimating the linear employment-value added function for this industry.

The estimates of partial coefficients such as those presented in table 90 can be used as derived by OLS, while the estimates of the logarithms of the intercepts must be transformed into estimates of the intercept coefficients themselves. As illustrated in table 91, the latter estimates (column 3) can be obtained by taking antilogarithms of the estimates of the logarithms of the intercept coefficients (column 2). Thus, the estimate of the intercept coefficient for agriculture, 322.467, can be calculated as:

$$322.467 = \text{antiln}(5.77600), \tag{59}$$

where 5.77600 is the estimate of the logarithm of the intercept coefficient of the non-linear function for agriculture.

Estimates of the log-linear functions can be obtained directly by estimating the functions shown in equation (58). Estimates of such functions based on the time series data presented in tables 86 and 87 are those shown in table 90 and discussed above.

Table 91. Computing estimates of intercept coefficients of non-linear employment-value added functions without the time variable, by industry: entire country

Industry (1)	Intercepts of log-linear functions a/ (2)	Intercepts of non-linear functions b/ (3)
Agriculture	5.77600	322.467
Mining	1.05470	2.871
Manufacturing	2.68634	14.678
Utilities	0.41649	1.517
Construction	-0.12600	0.882
Trade	-1.30452	0.271
Transport	0.80483	2.236
Services	2.68782	14.700

a/ From table 90, col. 2.
b/ Antiln(Col. 2).

Box 24

Serial correlation

Serial correlation occurs frequently with time-series data and suggests either that important variables have been omitted from the equation estimated or that an incorrect functional form has been employed. Although levels of significance for the Durbin-Watson statistic depend on the number of independent variables and the number of observations in the estimated regression, values of less then 1 are highly suggestive of serial correlation. In table 89, for example, such a low value of the Durbin-Watson statistics is observed in the construction industry.

When serially correlated disturbances are suspected, one of several remedial steps may be tried. One such step would be to use an alternative form for the functions being estimated. This step could involve the use, for example, of a non-linear or log-linear rather than a linear form. Alternatively, other independent variables can be added to the function to see whether their inclusion reduces the extent of serial correlation. In many contexts, an additional variable that could be tried is the time variable. Other approaches to the problem of serial correlation can be also tried.a/

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a/ See, for example, Jan Kmenta, Elements of Econometrics (New York, Macmillan, 1971).

ii. Functions with the time variable

Estimates of national-level linear employment-value added functions with the time variable can be obtained by estimating the functions shown in equation (60). Estimates of such functions based on the data shown in tables 86 and 87 are given in table 92. 5/

When judged on the basis of R^2's and Durbin-Watson statistics, the results for all the industries are better than those for the linear functions without the time variable (table 89). With the exception of the construction industry, however, the results are only marginally better. Adding the time variable has greatly increased the values of the R^2 and the Durbin-Watson

Table 92. Estimates of the coefficients of linear employment-value added functions with the time variable, by industry: entire country a/

Industry	Coefficients b/			R-square	Durbin-Watson
	Intercept	Value added	Time variable		
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	-60421.5146	0.11880 (0.190)	31.53616 (4.499)	0.987	3.01
Mining	-192.5399	1.84087 (4.454)	0.09856 (1.082)	0.867	2.53
Manufacturing	-5234.8860	0.86031 (3.478)	2.70405 (1.553)	0.979	2.62
Utilities	1413.1940	1.53768 (2.080)	-0.72018 (-1.031)	0.856	1.86
Construction	-7440.9921	0.01652 (0.018)	3.80665 (6.815)	0.922	1.62
Trade	-5477.2335	0.70268 (0.685)	2.80572 (2.550)	0.856	2.46
Transport	-1384.2503	1.19043 (1.539)	0.71784 (0.827)	0.807	2.11
Services	25170.6595	2.24062 (3.236)	-12.76418 (-1.185)	0.991	1.97

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

statistics for the construction industry. On the other hand, the value added coefficients for a number of industries are no longer statistically significant (agriculture, trade and transport). Furthermore, the value added coefficient for construction continues to be non-significant.

For five of the industries, the time variable coefficients are not statistically significant. Also, for all industries except two (utilities and services), the signs of the time variable coefficients are positive. The positive signs are contrary to a priori expectations which would call for a negative value for the coefficients in an employment-value added function, since both technical progress and capital deepening tend to reduce the amount of labour required to produce a given level of value added.

On purely statistical grounds, the results for the construction industry are clearly to be preferred to those reported for that industry in table 89. (This is not the case for the results for other industries). However, the sign of the coefficient of the time variable for the construction industry is also inconsistent with prior expectations suggested by the economic theory.

Such inconsistent results, however, are fairly common occurrences, suggesting that important variables may have been omitted from a function. Such results should not automatically be discarded, however. Instead, an effort should be made to identify the factors that have accounted for the irregular past performance, such as a steadily increasing employment in the construction industry in the presence of fairly stable levels of production (i.e., declining labour productivity). If there is reason to believe that such factors are likely to continue to exert the same impact over the planning horizon, the estimated function can be used as a basis for making future projections. If not, ad hoc adjustments will have to be made to the function for projection purposes.

Alternatively, employment-value added functions that reflect more typical conditions may be produced by deleting the observations referring to the typical periods, which reflect the effects of unusual circumstances in the past. Special statistical approaches, (such as introducing dummy variables) can be used to achieve essentially the same result without sacrificing all of the information contained in the atypical observations (Kmenta, 1971).

To obtain estimates of non-linear functions that include the time variable, it would be necessary to estimate the log-linear functions indicated in equation (61). If they were estimated on the basis of the data shown in tables 86 and 87, using ordinary least squares techniques, the results would be those presented in table 93.

Most of these results are just marginally better than the comparable results obtained without using the time variable (table 90). The only exceptions are the results for the construction industry, but as in the case of the results for this industry that were obtained by estimating a linear function with the time variable, the coefficient of this variable is

Table 93. Estimates of the coefficients of log-linear employment-value added functions with the time variable, by industry: entire country a/

Industry	Coefficients b/			R-square	Durbin-Watson
	Intercept	Value added	Time variable		
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	-28.7872	-0.00693 (-0.078)	0.01841 (3.787)	0.987	3.02
Mining	-27.5627	0.72835 (4.499)	0.01458 (1.211)	0.877	2.61
Manufacturing	-10.5030	0.49130 (2.218)	0.00684 (0.330)	0.976	2.58
Utilities	75.0737	1.31027 (0.747)	-0.03848 (-0.291)	0.791	1.47
Construction	-99.4136	0.07935 (0.305)	0.05240 (7.131)	0.935	1.98
Trade	-58.2461	0.31108 (0.609)	0.03120 (2.656)	0.857	2.54
Transport	-12.6445	0.69933 (1.632)	0.00731 (0.664)	0.800	2.02
Services	-28.8026	0.44341 (1.472)	0.01647 (0.645)	0.986	1.60

a/ Estimated by ordinary least squares (OLS) .
b/ t values are shown in parentheses.

positive. This is contrary to what would be expected of the sign of this coefficient on theoretical grounds.

To estimate the intercept coefficients of the non-linear functions, it would be necessary to take antilogarithm of the estimated logarithms of the intercepts. This can be done as described in the case of non-linear functions, which did not include the time variable.

If estimates of log-linear functions with time as a variable are required, they can be obtained by estimating the functions as indicated in equation (61). Estimates of those functions based on data given in tables 86 and 87 are presented in table 93. Such estimates can be used in the form as they are obtained by OLS.

b. Urban-rural level

This section will initially consider the estimation of functions that do not include the time variable, and then it will discuss estimation of the functions that include this variable. The discussion will be confined to functions using the national level of value added for each industry as an independent variable.

i. Functions without the time variable

To project employment for urban and rural areas using linear functions that do not include the time variable, it is necessary to estimate functions such as those indicated in equation (62). Estimates of such functions for urban and rural areas, which were obtained by OLS from the data of tables 87 and 88, are shown respectively in tables 94 and 95.

These results are largely satisfactory--all of the estimated partial coefficients are positive and most are statistically significant. The exception is the coefficient for urban agriculture (t-statistics is 1.55). However, for a few industries in either location, coefficients of determination, R^2, and Durbin-Watson statistics are lower than desired. The most obvious example is the equation for the construction industry in the urban areas, which has an R^2 of 0.330 and a Durbin-Watson statistic of 0.41. In addition, judged on the basis of the latter statistic, estimates for urban agriculture, utilities and services, as well as those for rural services are borderline in nature.

Better estimates for these industries might be obtained by using a different specification of the functions. Estimates of the non-linear functions without the time variable would be obtained by estimating the log-linear functions shown in equation (63), followed by taking antilogarithms of the estimates of the logarithms of the intercept coefficient.

Table 94. Estimates of the coefficients of linear employment-value added functions without the time variable, by industry: urban areas a/

Industry	Coefficients		R-square	Durbin-Watson
	Intercept	Value added b/		
(1)	(2)	(3)	(4)	(5)
Agriculture	15.4221	0.01980 (1.555)	0.212	1.38
Mining	1.7300	1.46615 (6.160)	0.808	2.29
Manufacturing	70.1197	0.97430 (21.114)	0.980	2.10
Utilities	2.9915	0.56431 (6.163)	0.808	1.51
Construction	-2.3773	3.07618 (2.104)	0.330	0.41
Trade	-22.4318	2.27942 (4.365)	0.679	2.42
Transport	10.8482	1.62845 (5.406)	0.765	2.36
Services	116.0514	0.81798 (25.124)	0.986	1.16

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Table 95. Estimates of the coefficients of linear employment-value added functions without the time variable, by industry: rural areas a/

Industry	Coefficients: Intercept	Coefficients: Value added b/	R-square	Durbin-Watson
(1)	(2)	(3)	(4)	(5)
Agriculture	1220.1759	2.85558 (13.113)	0.950	2.06
Mining	-0.6826	0.65595 (5.928)	0.796	1.67
Manufacturing	3.0025	0.25725 (6.532)	0.826	1.59
Utilities	-1.2738	0.21972 (3.220)	0.535	1.97
Construction	-25.3350	1.53126 (6.304)	0.815	2.35
Trade	-27.5401	0.74332 (3.887)	0.627	1.68
Transport	-4.1849	0.14453 (2.653)	0.439	2.15
Services	25.9060	0.60456 (8.246)	0.883	1.34

a/ Estimated by ordinary least squares (OLS) .
b/ t values are shown in parentheses.

Estimates of such functions made by OLS and based on the data of tables 87 and 88 are given in tables 96 and 97, respectively. When compared to the results for linear functions, which do not include the time variable (tables 94 and 95), these estimates are, on average, less satisfactory. This indicates that for the data used here, the linear specification without the time variable appears to be more suitable than the non-linear specification excluding that variable.

To complete the estimation of the non-linear functions without the time variable, it would be necessary to take antilogarithms of the estimates of the logarithms of the intercepts as indicated in equation (64). In the case of the estimate of the functions shown in tables 96 and 97, the estimates of the intercepts can be obtained as indicated in table 98, where the estimate of an intercept for a given industry in a particular location (column 3) is obtained as the antilogarithm of the estimate of the logarithm of the intercept for the same industry and location (column 2). For example, the estimate of the intercept for urban agriculture, 7.447, is obtained as:

$$7.447 = \text{antiln}(2.00785), \qquad (64)$$

where 2.00785 is the estimate of the logarithm of the intercept coefficient for urban agriculture.

If log-linear functions without time as a variable for urban and rural areas are required, it is necessary to estimate the functions indicated in equation (63). Estimates of those functions using OLS and based on data given in tables 87 and 88 are presented in tables 96 and 97. Such estimates can be used as they are obtained by OLS.

ii. Functions with the time variable

If linear functions with the time variable are to be used to project urban and rural employment, it will be necessary to estimate the functions shown in equation (65).

The estimates of such functions, derived by OLS from the data of tables 87 and 88 for the urban areas, are presented in table 99, while those for the rural areas are shown in table 100. Some of these results represent a significant improvement over those obtained earlier by estimating linear functions without time as a variable (e.g. the results for agriculture in the urban areas), while others are only slightly better (for example, utilities in the urban areas). However, most of the coefficients of the time variable are not statistically significant and have an unexpected positive sign.

Time series data can be used to estimate non-linear employment-value added functions which include the time variable. This can be done by estimating the functions indicated in equation (66) and then taking the antilogarithms of the estimates of the logarithms of the intercepts.

Table 96. Estimates of the coefficients of log-linear employment-value added functions without the time variable, by industry: urban areas a/

Industry	Coefficients: Intercept	Coefficients: Value added b/	R-square	Durbin-Watson
(1)	(2)	(3)	(4)	(5)
Agriculture	2.0079	0.18058 (1.297)	0.157	1.40
Mining	1.0409	0.70495 (6.221)	0.811	2.30
Manufacturing	2.7744	0.50974 (21.261)	0.980	2.48
Utilities	0.6165	0.67028 (5.726)	0.785	1.31
Construction	0.9619	1.03814 (2.245)	0.359	0.42
Trade	-0.3037	1.23106 (4.186)	0.661	2.41
Transport	0.9953	0.90305 (5.397)	0.764	2.28
Services	2.6496	0.56462 (26.861)	0.988	1.48

a/ Estimated by ordinary least squares (OLS) .
b/ t values are shown in parentheses.

Table 97. Estimates of the coefficients of log-linear employment-value added functions without the time variable, by industry: rural areas a/

Industry	Coefficients		R-square	Durbin-Watson
	Intercept	Value added b/		
(1)	(2)	(3)	(4)	(5)
Agriculture	5.7557	0.32803 (14.471)	0.959	2.32
Mining	-1.7077	1.73724 (5.734)	0.785	1.40
Manufacturing	-1.1202	0.97796 (5.667)	0.781	1.51
Utilities	-4.6021	1.91228 (2.655)	0.439	1.83
Construction	-16.8638	6.12216 (5.001)	0.735	2.32
Trade	-22.3092	6.28241 (3.371)	0.558	1.63
Transport	-12.2902	3.43645 (2.771)	0.460	2.16
Services	0.8769	0.77605 (7.176)	0.851	1.30

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Table 98. Computing estimates of intercept coefficients of non-linear employment-value added functions without the time variable, by industry: urban and rural areas

Industry (1)	Intercepts of log-linear functions a/ (2)	Intercepts of corresponding non-linear functions b/ (3)
	Urban	
Agriculture	2.00785	7.447
Mining	1.04094	2.832
Manufacturing	2.77442	16.029
Utilities	0.61652	1.852
Construction	0.96192	2.617
Trade	-0.30370	0.738
Transport	0.99535	2.706
Services	2.64962	14.149
	Rural	
Agriculture	5.75573	315.996
Mining	-1.70771	0.181
Manufacturing	-1.12016	0.326
Utilities	-4.60211	0.010
Construction	-16.86382	0.000
Trade	-22.30920	0.000
Transport	-12.29016	0.000
Services	0.87692	2.403

a/ From tables 96 and 97, col. 2.
b/ Antiln(Col. 2).

Table 99. Estimates of the coefficients of linear employment-value added functions with the time variable, by industry: urban areas a/

Industry	Coefficients b/			R-square	Durbin-Watson
	Intercept	Value added	Time variable		
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	2643.5283	0.13728 (2.370)	-1.34421 (-2.065)	0.486	2.04
Mining	-205.2709	1.13878 (3.767)	0.10542 (1.582)	0.854	2.71
Manufacturing	-3345.9050	0.73556 (4.406)	1.74021 (1.481)	0.984	2.81
Utilities	191.3496	0.66477 (1.066)	-0.09610 (-0.163)	0.809	1.54
Construction	-6700.6656	-1.07196 (-1.291)	3.43951 (6.999)	0.906	1.24
Trade	-3170.7871	0.93082 (0.863)	1.62767 (1.408)	0.743	2.34
Transport	-845.8819	1.26753 (1.616)	0.44220 (0.502)	0.772	2.25
Services	-2506.0234	0.73224 (1.492)	1.33721 (0.175)	0.986	1.20

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Table 100. Estimates of the coefficients of linear employment-value added functions with the time variable, by industry: rural areas a/

Industry	Coefficients b/			R-square	Durbin-Watson
	Intercept	Value added	Time Variable		
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	-63135.5310	-0.02109 (-0.032)	32.91633 (4.464)	0.986	3.05
Mining	-1.0586	0.65536 (4.070)	0.00019 (0.005)	0.796	1.67
Manufacturing	-1913.9193	0.12329 (0.805)	0.97652 (0.906)	0.842	1.75
Utilities	1226.2377	0.87433 (2.174)	-0.62630 (-1.647)	0.653	2.23
Construction	-740.3265	1.08848 (3.683)	0.36714 (2.099)	0.881	3.04
Trade	-2304.8547	-0.23217 (-1.110)	1.17734 (5.251)	0.916	2.16
Transport	-524.7971	-0.07479 (-0.641)	0.26871 (2.053)	0.632	2.65
Services	27683.7275	1.50896 (1.424)	-14.10500 (-0.855)	0.893	1.51

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Such functions, which were estimated by the OLS using tables 87 and 88, are shown in table 101 for urban areas and in table 102 for the rural areas. The results are almost uniformly less satisfactory than those obtained by estimating the linear function with the time variable.

To complete the estimation of the coefficients of non-linear functions with the time variable, it is necessary to take the antilogarithms of the estimated logarithms of the intercept coefficients. This can be done using a procedure illustrated with reference to table 98.

If log-linear functions with the time variable are to be used in projections, it is necessary to estimate the functions indicated in equation (66). Estimates of those functions, derived by OLS and based on data given in tables 87 and 88, were presented in tables 101 and 102. Such estimates can be used in the same form as they are obtained.

(b) Calibration of the empirically estimated functions

After obtaining satisfactory estimates of employment-value added functions, the planner will sometimes desire to make special adjustments in the estimated coefficients. Although the adjustments may apply to the estimates of the intercepts as well as to those of the partial coefficients, they will often be restricted to the intercept estimates. These adjustments, which are typically referred to as "calibration", ensure that once adjusted, the functions are capable of precisely predicting the levels of employment by industry for a particular year or a group of years of the time period to which the data used pertain, given the level of value added by industry for that year or group of years. (If left unadjusted, the functions will be capable of predicting mean levels of employment over the entire time period to which data refer, using the average levels of value added for the period.) The calibration procedures for employment-value added functions of different forms are described in annex I.

D. Illustrative examples of projections

The examples presented below will illustrate the use of employment-value added functions to prepare a national projection and an urban-rural projection, respectively. These examples, using log-linear and linear employment-value added functions, will indicate how the relevant calculations are made for the projection interval 0-5. In addition, they will provide complete projection results for a 20-year period.

This section will not, however, illustrate how to make projections of employment using estimates of the coefficients of the non-linear functions. This alternative approach would give the same results as that using the estimates of the coefficients of the log-linear functions.

Table 101. Estimates of the coefficients of log-linear employment-value added function with the time variable, by industry: urban areas a/

Industry	Coefficients b/ Intercept	Value added	Time variable	R-square	Durbin-Watson
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	108.0827	1.20312 (1.345)	-0.05651 (-1.156)	0.278	1.55
Mining	-35.5475	0.52984 (3.715)	0.01864 (1.758)	0.864	2.68
Manufacturing	-4.2995	0.47094 (2.629)	0.00367 (0.219)	0.981	2.55
Utilities	-106.5143	-0.05904 (-0.040)	0.05522 (0.498)	0.791	1.31
Construction	-100.0441	-0.33477 (-1.296)	0.05332 (7.305)	0.916	1.37
Trade	-35.8235	0.48173 (0.800)	0.01946 (1.405)	0.728	2.35
Transport	-6.7802	0.75226 (1.707)	0.00423 (0.373)	0.768	2.17
Services	33.9520	0.75686 (3.183)	-0.01637 (-0.812)	0.989	1.49

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

Table 102. Estimates of the coefficients of log-linear employment-value added functions with the time variable, by industry: rural areas a/

Industry	Coefficients b/			R-square	Durbin-Watson
	Intercept	Value added	Time variable		
(1)	(2)	(3)	(4)	(5)	(6)
Agriculture	-30.3726	-0.02023 (-0.210)	0.01925 (3.665)	0.985	2.97
Mining	-3.1059	1.73055 (3.855)	0.00071 (0.021)	0.785	1.39
Manufacturing	-94.2981	0.46685 (0.365)	0.04833 (0.403)	0.785	1.54
Utilities	991.4696	8.69332 (0.981)	-0.51343 (-0.768)	0.478	1.75
Construction	-138.9310	4.46296 (2.605)	0.06443 (1.331)	0.783	2.54
Trade	-380.3987	-1.27194 (-0.422)	0.19621 (2.833)	0.779	1.81
Transport	-256.2927	-1.29566 (-0.472)	0.13272 (1.881)	0.626	2.60
Services	-168.1228	-0.26181 (-0.215)	0.08840 (0.855)	0.864	1.42

a/ Estimated by ordinary least squares (OLS).
b/ t values are shown in parentheses.

1. National projection

The calculations presented in this example will be based on the inputs contained in table 103, which shows projected levels of value added by industry, along with selected estimates of the log-linear employment-value added functions presented in tables 90 and 93. For all industries except construction and trade, the estimates of the coefficients refer to the functions that do not include the time variable. For the construction and trade industries, the estimates of the coefficients refer to the functions which include the time variable. The functions used in this example were calibrated as explained in annex I. The value added levels are given for dates five years apart, starting with the initial year of the projection, which is denoted as year 0.

(a) Employment by industry

To derive the levels of employment by industry for a given date using log-linear functions, one could first obtain the logarithms of employment levels by evaluating the estimates of those functions for that date. This is done by using the logarithms of the levels of value added for the date, if necessary, along with appropriate value of the time variable.

In the case of log-linear functions without the time variable, the logarithms of the levels of employment are obtained as indicated by equation (9), while in the case of log-linear functions with time included, they are derived as shown by equation (13). Table 104 illustrates how the logarithms of the levels of employment by industry for the end of the projection interval 0-5 are calculated using log-linear functions, first without and then with the time variable.6/

In particular, the log of the employment level for each industry in year 5 (column 7), except that for the construction or trade industry, is obtained by adding the adjusted intercept coefficient (column 2) to the product of the estimate of the value added coefficient (column 3) and the logarithm of the projected level of value added in year 5 (column 5). For example, the logarithm of the level of employment in agriculture in year 5, 7.65296, is calculated as follows:

$$7.65296 = 5.78334 + 0.32625 \cdot \ln(308.2), \tag{9}$$

where 5.78334 is the adjusted intercept coefficient for agriculture, 0.32625 is the estimate of the value added coefficient for this industry, and 308.2 is the projected value added in agriculture for year 5.

The logarithm of the level of employment for the construction or trade industry in year 5 (column 7) is obtained by adding the adjusted intercept coefficient for the industry (column 2) to a sum of two products. The first product is that of the estimate of the value added coefficient for the

Table 103. Inputs for projecting employment, by industry: entire country

Industry	Value added in year					Estimates of the coefficients of log-linear employment-value added functions		
	0	5	10	15	20	Adjusted intercept	Value added	Time variable
	(millions of LCUs a/)							
Agriculture	273.1	308.2	347.8	392.5	443.1	5.78333	0.33	
Mining	2.9	4.0	5.5	7.6	10.4	1.07529	0.87	
Manufacturing	140.4	212.7	322.5	489.3	742.7	2.68799	0.56	
Utilities	21.2	31.9	48.0	72.5	109.4	0.40971	0.80	
Construction	25.6	31.5	38.9	48.0	59.3	-99.37402	0.08	0.05240
Trade	59.0	85.1	122.9	177.6	256.7	-58.24014	0.31	0.03120
Transport	56.0	73.0	95.3	124.4	162.5	0.79301	0.96	
Services	312.5	464.3	691.2	1031.2	1541.4	2.68876	0.64	

a/ Local currency units.

Table 104. Deriving employment, by industry: entire country, year 5

Industry	Estimates of the coefficients of log-linear employment-value-added functions			In year 5			
	Adjusted intercept	Value added	Time variable	Value added a/ (millions of LCUs e/)	Value of time variable b/	Logarithm of projected employment c/	Projected employment d/ (thousands of persons)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agriculture	5.78333	0.326		308.2		7.65	2106.9
Mining	1.07529	0.865		4.0		2.28	9.8
Manufacturing	2.68799	0.564		212.7		5.71	301.6
Utilities	0.40971	0.802		31.9		3.19	24.2
Construction	-99.37402	0.079	0.052	31.5	1985	4.93	138.6
Trade	-58.24014	0.311	0.031	85.1	1985	5.07	159.7
Transport	0.79301	0.960		73.0		4.91	136.0
Services	2.68876	0.637		464.3		6.60	734.4

a/ From table 103.
b/ Based on assumption that 1980 is the initial year of the projection period.
c/ (Col. 2) + (Col. 3) . (ln(Col. 5)) + (Col. 4) . (Col. 6).
d/ Antiln(Col. 7).
e/ Local currency units.

construction or trade industry (column 3) and the logarithm of the projected level of value added in year 5 for this industry (column 5). The second product is that of the estimate of the time variable coefficient for the industry (column 4) and the value of the time variable for year 5 (column 6). For example, the log of employment level for construction industry in year 5, 4.93134, is obtained as:

$$4.93134 = -99.37402 + [0.07935 \cdot \ln(31.5)] + [0.05241 \cdot (1980 + 5.0)], \quad (13)$$

where -99.37402 is the adjusted intercept coefficient for the industry, and 0.07935 and 31.5 are, respectively, the estimate of the value added coefficient and the projected level of value added for year 5. The estimate of the time variable coefficient is 0.05241, while 1980 is assumed to be the initial year of the projection period and 1985 is the last year of the projection interval, 0-5 (year 5).

Once the logarithms of the levels of employment by industry are obtained for a given date, it is then necessary to take the antilogarithms of those results in order to derive from them the levels of employment. Thus, for year 5, the level of employment in each industry (column 8) is obtained by taking the antilogarithm of the result obtained by evaluating the function for that date (column 4). For example, the level of employment in agriculture in year 5, 2,106.9, is obtained as:

$$2{,}106.9 = \text{antiln } (7.65296), \quad (14)$$

where 7.65296 is the logarithm of the level of employment in agriculture in year 5.

Performing the calculations illustrated for year 5 for dates five years apart over the entire projection period produces the projected levels of employment by industry for the entire period, which are shown in table 105.

(b) Other results 7/

Other results that are useful in planning can be obtained as part of a projection at the national level. These include various aggregates, indicators of the structure of and the rates of growth of employment.

(i) Employment aggregates

The employment aggregates that can be derived from the projections by industry include total employment along with employment in various sectors at dates five years apart. They also include increases in total employment and employment by sector over the intervening projection intervals.

Table 105. Projected employment, by industry: entire country

(Thousands of persons)

Industry	Year				
	0	5	10	15	20
Agriculture	2025.4	2106.9	2191.6	2279.9	2371.8
Mining	7.5	9.8	12.9	16.9	22.1
Manufacturing	238.6	301.6	381.4	482.4	610.3
Utilities	17.4	24.2	33.6	46.7	65.1
Construction	104.9	138.6	183.1	242.0	319.8
Trade	121.9	159.7	209.3	274.3	359.5
Transport	105.3	136.0	175.7	226.9	293.2
Services	570.7	734.4	946.2	1220.8	1576.8

a. Total employment

Total employment at the end of a given projection interval is obtained by aggregating the projected levels of employment by industry. Total employment in year 5, 3.611.2, is computed by adding the projected levels of employment by industry. This number is shown in table 106 (in the column corresponding to year 5) along with other results derived for the entire 20-year projection period. The increase in total employment over this period is indicated in figure XXII.

b. Employment by sector

Employment in the primary, secondary and the tertiary sector can be obtained by aggregating employment projected for various industries, ranging from agriculture to services, using appropriate aggregation rules.

Employment in the primary sector in year 5, 2,116.7, is obtained as:

$$2{,}116.7 = 2{,}106.9 + 9.8, \tag{15}$$

where 2,106.9 and 9.8 are, respectively, projected levels of employment in agriculture and mining.

Employment in the secondary sector in year 5, 464.4, is obtained as:

$$464.4 = 301.6 + 24.2 + 138.6, \tag{16}$$

where 301.6, 24.2 and 138.6 are, respectively, projected levels of employment in manufacturing, utilities and construction.

Employment in the tertiary sector in year 5, 1,030.1, is obtained as:

$$1{,}030.1 = 159.7 + 136.0 + 734.4, \tag{17}$$

where 159.7, 136.0 and 734.4 are, respectively, projected levels of employment in trade, transportation and services.

Employment by sector obtained for different dates over the projection period is presented in figure XXIII.

c. Growth in total employment

The growth in total employment over a given projection interval equals the difference between total employment at the end of the interval and total

Table 106. Employment aggregates, structure and rates of growth: entire country

Indicators	Year 0	5	10	15	20
Employment aggregates (thousands of persons)					
Levels of employment					
Total	3191.8	3611.2	4133.8	4789.9	5618.6
Primary	2032.9	2116.7	2204.5	2296.8	2394.0
Secondary	360.9	464.4	598.1	771.1	995.1
Tertiary	798.0	1030.1	1331.2	1722.0	2229.5
Growth in employment					
Total		419.4	522.7	656.0	828.7
Primary		83.8	87.8	92.3	97.2
Secondary		103.5	133.7	173.0	224.0
Tertiary		232.2	301.1	390.8	507.5
Indicators of employment structure					
Proportions of total employment by sector					
Primary	0.64	0.59	0.53	0.48	0.43
Secondary	0.11	0.13	0.14	0.16	0.18
Tertiary	0.25	0.29	0.32	0.36	0.40
Rates of growth of employment (percentage)					
Total		2.50	2.74	2.99	3.24
Primary		0.81	0.82	0.82	0.83
Secondary		5.17	5.19	5.21	5.23
Tertiary		5.24	5.26	5.28	5.30

Figure XXII. Total employment

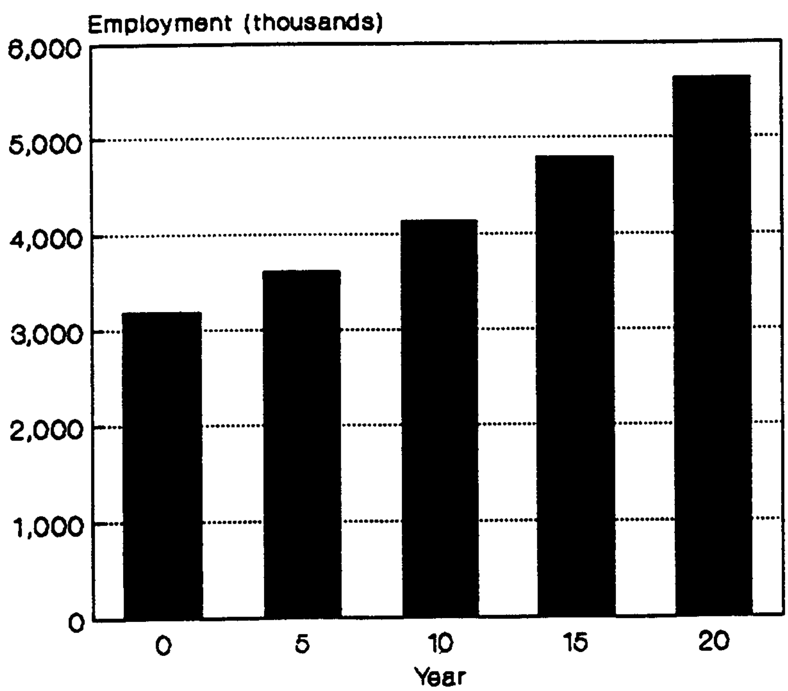
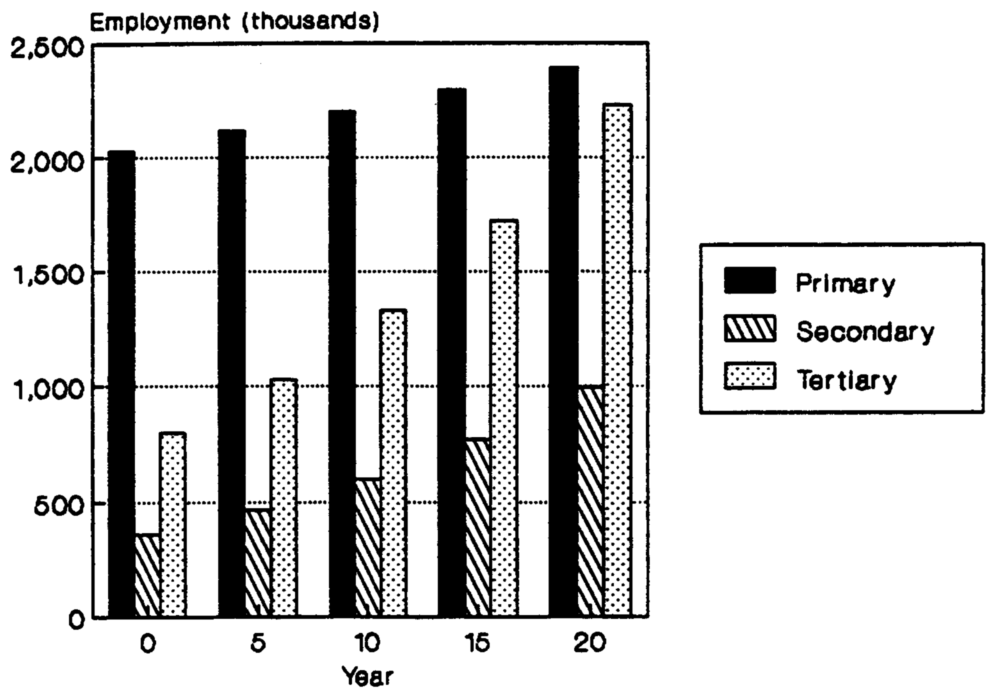


Figure XXIII. Employment: primary, secondary and tertiary sectors



employment at its beginning. For the interval 0-5, the growth in total employment 419.4, is obtained as:

$$419.4 = 3{,}611.2 - 3{,}191.8, \tag{18}$$

where 3,191.8 and 3,611.2 are, respectively, total employment at the beginning and the end of the interval (shown in columns corresponding to years 0 and 5 respectively).

d. Growth in employment by sector

The increase in employment over the interval 0-5 in various sectors is obtained as follows:

Growth of employment in the primary sector, 83.8, is:

$$83.8 = 2{,}116.7 - 2{,}032.9, \tag{19}$$

where 2,032.9 and 2,116.7 are, respectively, the levels of employment in the primary sector in years 0 and 5;

Growth of employment in the secondary sector, 103.5, is:

$$103.5 = 464.4 - 360.9, \tag{20}$$

where 360.9 and 464.4 are the levels of employment in the secondary sector in years 0 and 5; and

Growth of employment in the tertiary sector, 232.2, is:

$$232.2 = 1{,}030.1 - 798.0, \tag{21}$$

where 798.0 and 1,030.1 are the levels of employment in the tertiary sector in years 0 and 5.

(ii) Indicators of the structure of employment

Indicators of the structure of employment that can be calculated as part of an employment projection include proportions of total employment found in each sector.

a. Proportions by sector

For the end of the interval 0-5, these proportions are obtained as follows:

The proportion of employment in the primary sector, 0.59, is:

$$0.59 = 2{,}116.7 \ / \ 3{,}611.2, \tag{22}$$

where 2,116.7 and 3,611.2 are, respectively, employment in the primary sector and the total employment;

The proportion of employment in the secondary sector, 0.13, is:

$$0.13 = 464.4 \ / \ 3{,}611.2, \tag{23}$$

where 464.4 is employment in the secondary sector;

The proportion of employment in the tertiary sector, 0.29, is:

$$0.29 = 1{,}030.1 \ / \ 3{,}611.2, \tag{24}$$

where 1,030.1 is employment in the tertiary sector.

(iii) Rates of growth of employment

The rates of growth of employment can be calculated for total employment and for employment in each sector.

a. Rate of growth of total employment

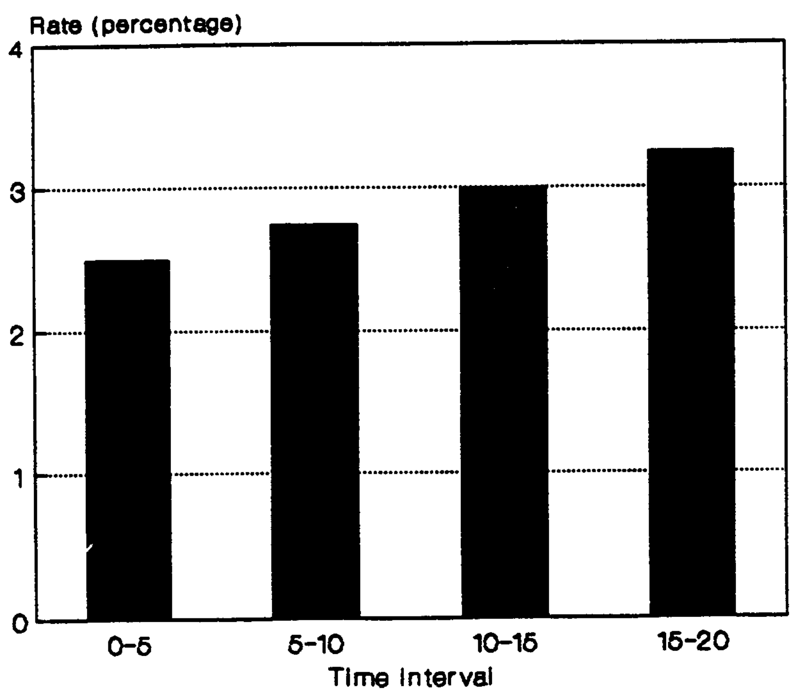
If growth in employment is assumed to occur over discrete intervals, the average annual growth rate of total employment for a given interval is obtained using the geometric growth rate formula. For the projection interval 0-5, this annual growth rate, 2.50 per cent (table 106), is obtained as follows:

$$2.50 = [\ (3{,}611.2 \ / \ 3{,}191.8)^{1/5} - 1 \ ] \cdot 100, \tag{25}$$

where 3,191.8 and 3,611.2 are the levels of total employment in years 0 and 5, respectively, and 5 is the length of the interval.

Rates of growth of total employment over the 20-year projection period, which were computed using the geometric rate formula, are shown in figure XXIV.

Figure XXIV. Rate of growth in total employment



If the planner assumes that growth in employment is continuous, the average annual growth rate of total employment for a given interval is obtained by substituting the same data as above in the exponential growth rate formula. For the projection interval 0-5, this annual growth rate, 2.47 per cent, is obtained as follows:

$$2.47 = [\ \ln (3{,}611.2 \ /\ 3{,}191.8) \ /\ 5\ ] \cdot 100. \tag{26}$$

b. Rates of growth of employment by sector

Assuming discrete growth, the rates of increase in employment by sector for the interval 0-5 are calculated as follows:

The annual rate of growth of employment in the primary sector, 0.81 per cent, is calculated as follows:

$$0.81 = [\ (2{,}116.7 \ /\ 2.032.9)^{1/5} - 1\ ] \cdot 100, \tag{27}$$

where 2.032.9 and 2,116.7 are the levels of employment in the primary sector in years 0 and 5, respectively;

The rate of growth of employment in the secondary sector, 5.17 per cent, is calculated as:

$$5.17 = [\ (464.4 \ /\ 360.9)^{1/5} - 1\ ] \cdot 100, \tag{28}$$

where 360.9 and 464.4 are the levels of employment in the secondary sector in years 0 and 5;

The rate of growth of employment in the tertiary sector, 5.24, is obtained as:

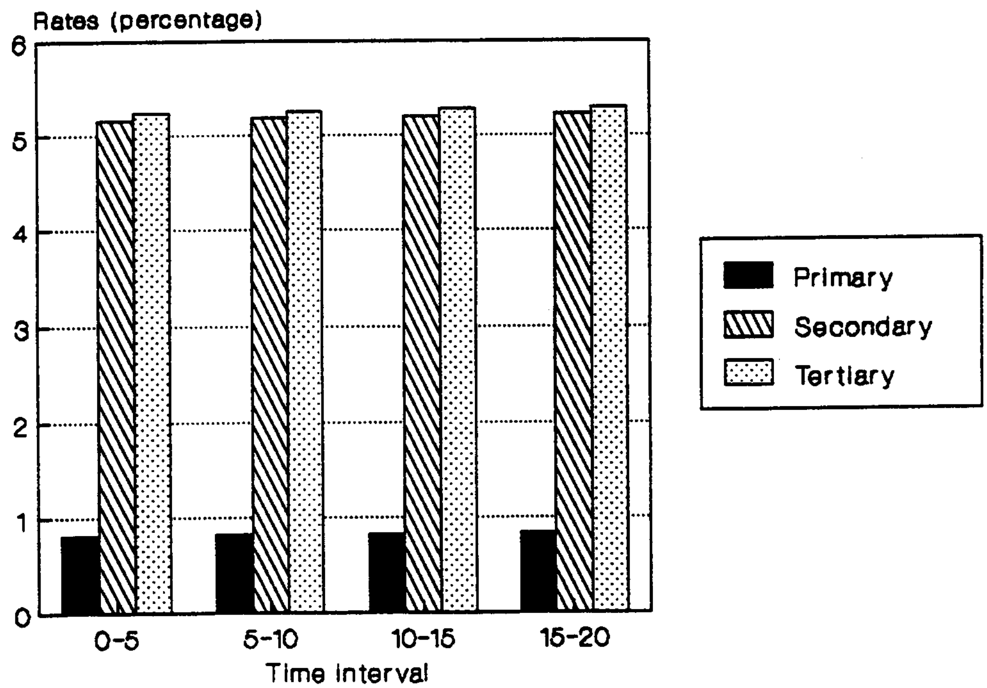
$$5.24 = [\ (1{,}030.1 \ /\ 798.0)^{1/5} - 1\ ] \cdot 100, \tag{29}$$

where 798.0 and 1,030.1 are the levels of employment in the tertiary sector in years 0 and 5.

Rates of growth of employment in primary, secondary and tertiary sectors over the 20-year projection interval are shown in figure XXV.

If continuous growth is assumed, rates of employment by sector would be calculated using the exponential growth rate formula. The calculations would be performed by steps indicated by equations (30) through (32).

Figure XXV. Rates of growth of employment: primary, secondary and tertiary sectors



(iv) Labour market balances

If projections of the labour force are available, it is possible to calculate the level of excess demand for or excess supply of labour. Also, it is possible to calculate the excess demand for or excess supply of labour as a percentage of the level of labour supply. The calculations are based on the projected total labour force, diminished where necessary by the size of non-civilian employment and the projected total employment as indicators of the labour supply and the labour demand. In order to illustrate these calculations, we shall use projections of the total labour force and of total employment (shown, respectively, in tables 107 and 108) along with the illustrative projections of non-civilian employment, which are shown in table 107. The calculations are illustrated for the end of the projection interval 0-5 using tables 107-108.

The civilian labour force for the end of the 0-5 interval, 3,615.4, can be calculated as follows:

$$3{,}615.4 = 3{,}651.9 - 36.5, \qquad (33)$$

where 3,651.9 and 36.5 are the projected total labour force and the projected non-civilian employment for year 5, shown in columns 2 and 3. The calculated civilian labour force for year 5 is shown in column 4.

The excess supply of labour for the same date, 4.2, is calculated as follows:

$$4.2 = 3{,}615.4 - 3{,}611.2, \qquad (34)$$

where 3,615.4 is the civilian labour force and 3,611.2 is the total employment shown in columns 4 and 5, respectively.

The excess supply expressed as a percentage of the civilian labour force at the end of the 0-5 interval, 0.12 is:

$$0.12 = (4.2 \;/\; 3{,}615.4) \cdot 100. \qquad (35)$$

This ratio is shown in column 7.

2. Urban-rural projection

The procedure for projecting employment for urban and rural areas using employment-value added functions is similar to that for the country as a whole. This example will illustrate a method by which such a projection can be prepared using the inputs shown in tables 109 and 110, which indicate for

Table 107. Projected non-civilian employment: entire country

(Thousands of persons)

Year (1)	Non-civilian employment (2)
0	32.5
5	36.5
10	41.5
15	47.4
20	53.8

Table 108. Labour market balances: entire country

Year	Total labour force a/	Non-civilian employment b/	Civilian labour force c/	Total employment d/	Excess supply/demand e/	Excess supply/demand f/
	(thousands of persons)					(percentage of civilian labour force)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	3251.5	32.5	3219.0	3191.8	27.2	0.85
5	3651.9	36.5	3615.4	3611.2	4.2	0.12
10	4147.8	41.5	4106.3	4133.8	-27.5	-0.67
15	4735.4	47.4	4688.0	4789.9	-101.9	-2.17
20	5377.4	53.8	5323.6	5618.6	-295.0	-5.54

a/ From table 37, "Labour force (Total)".
b/ From table 107.
c/ (Col. 2) - (Col. 3).
d/ From table 106, "Levels of employment (Total)".
e/ (Col. 4) - (Col. 5).
f/ ((Col. 6)/(Col. 4)) . (100).

Table 109. Inputs for projecting employment, by industry: urban areas

	National value added in year					Estimates of the coefficients of linear employment-value added functions		
	0	5	10	15	20	Adjusted intercept	Value added	Time variable
	(millions of LCUs a/)							
Agriculture	273.1	308.2	347.8	392.5	443.1	2645.31363	0.14	-1.34421
Mining	2.9	4.0	5.5	7.6	10.4	2.08799	1.47	
Manufacturing	140.4	212.7	322.5	489.3	742.7	68.35567	0.97	
Utilities	21.2	31.9	48.0	72.5	109.4	190.82840	0.66	-0.09610
Construction	25.6	31.5	38.9	48.0	59.3	-6696.75995	-1.07	3.43951
Trade	59.0	85.1	122.9	177.6	256.7	-17.22250	2.28	
Transport	56.0	73.0	95.3	124.4	162.5	10.28867	1.63	
Services	312.5	464.3	691.2	1031.2	1541.4	115.98101	0.82	

a/ Local currency units.

Table 110. Inputs for projecting employment, by industry: rural areas

	National value added in year					Estimates of the coefficients of linear employment-value added functions		
	0	5	10	15	20	Adjusted intercept	Value added	Time variable
	(millions of LCUs a/)							
Agriculture	273.1	308.2	347.8	392.5	443.1	1228.49142	2.86	
Mining	2.9	4.0	5.5	7.6	10.4	-0.90547	0.66	
Manufacturing	140.4	212.7	322.5	489.3	742.7	2.51193	0.26	
Utilities	21.2	31.9	48.0	72.5	109.4	1225.68768	0.87	-0.62630
Construction	25.6	31.5	38.9	48.0	59.3	-23.58472	1.53	
Trade	59.0	85.1	122.9	177.6	256.7	-27.23500	0.74	
Transport	56.0	73.0	95.3	124.4	162.5	-524.85848	-0.07	0.26871
Services	312.5	464.3	691.2	1031.2	1541.4	20.54159	0.60	

a/ Local currency units.

urban and rural areas projected levels of value added along with selected estimates of linear employment-value added functions. The selected functions come from tables 94 and 95, along with tables 99 and 100. The intercepts have been adjusted as described in annex I.

The example will focus on the calculations that are unique to linear functions and those related to an urban-rural projection of employment. As in the previous example, it will be assumed that growth in employment occurs over discrete time intervals.

(a) Employment by industry

For any given date, such as the end of the projection interval 0-5, the levels of employment in urban and rural areas, by industry, are obtained from calculations that are similar to those employed in making the national projection. In the urban-rural projection, however, these calculations are performed for either area. If linear employment-value added functions are used, the levels of employment are obtained directly by evaluating the relevant functions. Thus, the levels of employment obtained using the linear functions for the end of the interval 0-5 for the urban areas are calculated as illustrated in table 111.

For example, the levels of employment in urban manufacturing in year 5, 275.6, is:

$$275.6 = 68.35568 + 0.97430 \cdot 212.7, \tag{36}$$

where 68.35568 is the adjusted intercept coefficient of the employment-value added function for manufacturing in urban areas respectively. The coefficient of the value added variable of this function is 0.97430 and the projected level of the national value added for this industry for year 5 is 212.7.

The level of employment in urban agriculture in year 5, 19.4, is calculated as follows:

$$19.4 = 2{,}645.31363 + [0.13728 \cdot 308.2] + [(-1.34421) \cdot (1980 + 5)], \tag{39}$$

where 2,645.31363 is the adjusted intercept coefficient of the function for urban agriculture. The coefficient of the value added variable in this function is 0.13728 and the projected level of value added for urban agriculture for year 5 for the entire country is 308.2. The coefficient of the time variable is -1.34421, while 1985 (= 1980 + 5) is year 5 of the projection period, the initial year of which is assumed to be 1980.

Table 111. Deriving employment, by industry: urban areas, year 5

Industry	Estimates of coefficients of linear employment-value added functions			In year 5		
	Adjusted intercept	Value added	Time variable	National value added a/ (LCUs d/)	Value of time variable b/	Projected employment c/ (thousands of persons)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture	2645.31363	0.137	-1.344	308.2	1985	19.4
Mining	2.08799	1.466		4.0		8.0
Manufacturing	68.35567	0.974		212.7		275.6
Utilities	190.82840	0.665	-0.096	31.9	1985	21.3
Construction	-6696.75995	-1.072	3.440	31.5	1985	96.9
Trade	-17.22250	2.279		85.1		176.8
Transport	10.28867	1.628		73.0		129.2
Services	115.98101	0.818		464.3		495.7

a/ From table 109.
b/ Based on assumption that 1980 is the initial year of the projection period.
c/ (Col. 2) + (Col. 3) . (Col. 5) + (Col. 4) . (Col. 6).
d/ Local currency units.

Projected levels of employment by industry for urban and rural areas at dates five years apart can be found by performing these calculations for the relevant dates over the projection period, starting with the initial year of the projection. Those levels can be further aggregated across the two locations to obtain the levels of employment, by industry, for the entire country. Tables 112 through 114 display urban, rural and national projected levels of employment, by industry, respectively.

(b) Other results 8/

An urban-rural projection of employment involves calculations of all those additional results that can be obtained as part of the national projection. Those results, which refer to urban and rural areas as well as the entire country, include various employment aggregates and indicators of employment structure and growth, as well as labour market balances. They can be derived by means of steps illustrated above in connection with the national projection. The results also include proportions of employment which are urban and rural.

Figure XXVI indicates projected levels of total employment for urban and rural areas and for the entire country, which are obtained in this illustrative projection.

(i) Proportions urban and rural

These proportions can be obtained for total employment and for employment by sector.

a. Proportions of total employment

The proportion of total employment that is urban for the end of the projection interval is calculated as a ratio of total employment in the urban areas to the total employment in the entire country for the date. For the end of the interval 0-5, the proportion of total employment that is urban, 0.32, is obtained as:

$$0.32 = 1,222.9 - 3,765.7, \qquad (49)$$

where 1,222.9 is total employment in the urban areas and 3,765.7 is total employment for the entire country.

The proportion of total employment that is rural, 0.68, is calculated as a complement of the proportion urban:

$$0.68 = 1 - 0.32, \qquad (50)$$

Table 112. Projected employment, by industry: urban areas

(Thousands of persons)

Industry	Year 0	5	10	15	20
Agriculture	21.3	19.4	18.1	17.5	17.7
Mining	6.4	8.0	10.2	13.2	17.3
Manufacturing	205.1	275.6	382.6	545.1	792.0
Utilities	14.6	21.3	31.5	47.3	71.3
Construction	86.1	96.9	106.2	113.6	118.7
Trade	117.2	176.8	263.0	387.7	567.9
Transport	101.4	129.2	165.5	212.9	274.9
Services	371.6	495.7	681.4	959.5	1376.8

Table 113. Projected employment, by industry: rural areas

(Thousands of persons)

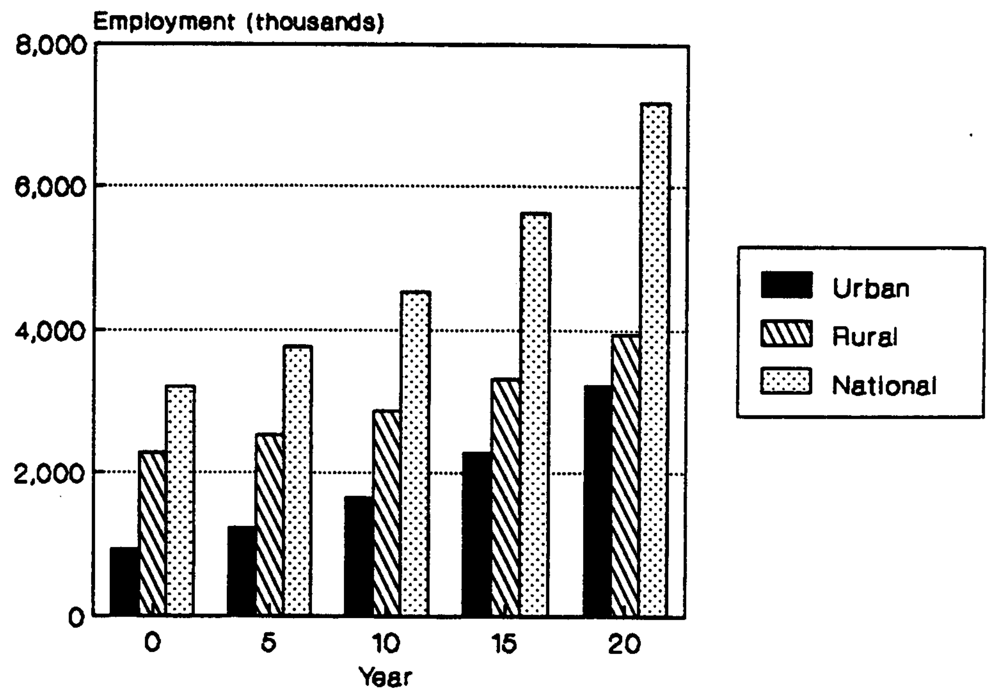
Industry	Year 0	5	10	15	20
Agriculture	2008.3	2108.4	2221.6	2349.3	2493.7
Mining	1.0	1.7	2.7	4.1	5.9
Manufacturing	38.6	57.2	85.5	128.4	193.6
Utilities	4.1	10.4	21.3	39.6	68.7
Construction	15.5	24.7	36.0	49.9	67.2
Trade	16.6	36.0	64.2	104.8	163.6
Transport	3.0	3.1	2.8	1.9	0.4
Services	209.5	301.2	438.4	644.0	952.4

Table 114. Projected employment, by industry: entire country

(Thousands of persons)

Industry	Year 0	5	10	15	20
Agriculture	2029.6	2127.8	2239.6	2366.8	2511.4
Mining	7.4	9.7	12.9	17.2	23.2
Manufacturing	243.8	332.9	468.1	673.5	985.6
Utilities	18.8	31.6	52.9	86.8	140.1
Construction	101.6	121.6	142.1	163.5	185.9
Trade	133.7	212.8	327.2	492.5	731.5
Transport	104.4	132.3	168.3	214.9	275.3
Services	581.1	797.0	1119.8	1603.5	2329.2

Figure XXVI. Total employment: urban, rural and national



where 0.32 is the proportion urban.

These proportions, along with all other results for the entire country excepting the labour market balances, are shown in table 117. Similar results for urban and rural areas are shown in tables 115 and 116. Labour market balances for urban and rural areas and the entire country were calculated using, among other things, illustrative projected levels of non-civilian employment, which are shown in tables 118 through 120. The results relating to the labour market balances are shown, respectively, in tables 121 through 123.

Proportions of total employment for the 20-year projection period that are urban and rural are shown in figure XXVII.

b. Proportions of employment by sector

Proportions of employment for the end of the interval 0-5, that are urban, can be calculated by sector as follows:

The proportion of employment in the primary sector that is urban, 0.01, is obtained as:

$$0.01 = 27.4 / 2{,}137.5, \tag{51}$$

where 27.4 is employment in the primary sector in the urban areas and 2,137.5 is employment in the primary sector in the entire country;

The proportion of employment in the secondary sector that is urban, 0.81, is:

$$0.81 = 393.7 / 486.0, \tag{52}$$

where 393.7 is employment in the secondary sector in the urban areas and 486.0 is employment in the secondary sector in the entire country;

The proportion of employment in the tertiary sector that is urban, 0.70, is calculated as:

$$0.70 = 801.8 / 1{,}142.1, \tag{53}$$

where 801.8 is employment in the tertiary sector in the urban areas and 1,142.1 is employment in the tertiary sector in the entire country.

Proportions of employment, by sector, that are rural can be obtained as complements of proportions of employment, by sector, that are urban:

Table 115. Employment aggregates, structure and rates of growth: urban areas

Indicators	Year 0	5	10	15	20
Employment aggregates (thousands of persons)					
Levels of employment					
Total	923.7	1222.9	1658.5	2296.8	3236.6
Primary	27.7	27.4	28.3	30.7	35.0
Secondary	305.8	393.7	520.3	706.0	982.1
Tertiary	590.2	801.8	1109.9	1560.1	2219.6
Growth in employment					
Total		299.2	435.6	638.3	939.9
Primary		-0.3	0.9	2.4	4.3
Secondary		87.9	126.6	185.7	276.1
Tertiary		211.6	308.2	450.2	659.4
Indicators of employment structure					
Proportions of total employment by sector					
Primary	0.03	0.02	0.02	0.01	0.01
Secondary	0.33	0.32	0.31	0.31	0.30
Tertiary	0.64	0.66	0.67	0.68	0.69
Rates of growth of employment (percentage)					
Total		5.77	6.28	6.73	7.10
Primary		-0.23	0.65	1.65	2.67
Secondary		5.18	5.73	6.29	6.82
Tertiary		6.32	6.72	7.05	7.31

Table 116. Employment aggregates, structure and rates of growth: rural areas

Indicators	Year 0	5	10	15	20
<u>Employment aggregates (thousands of persons)</u>					
Levels of employment					
Total	2296.7	2542.8	2872.4	3322.0	3945.5
Primary	2009.3	2110.2	2224.3	2353.4	2499.5
Secondary	58.3	92.3	142.8	217.9	329.5
Tertiary	229.1	340.3	505.3	750.7	1116.4
Growth in employment					
Total		246.1	329.6	449.5	623.5
Primary		100.9	114.1	129.1	146.2
Secondary		34.0	50.5	75.1	111.6
Tertiary		111.3	165.0	245.4	365.7
<u>Indicators of employment structure</u>					
Proportions of total employment by sector					
Primary	0.87	0.83	0.77	0.71	0.63
Secondary	0.03	0.04	0.05	0.07	0.08
Tertiary	0.10	0.13	0.18	0.23	0.28
<u>Rates of growth of employment (percentage)</u>					
Total		2.06	2.47	2.95	3.50
Primary		0.98	1.06	1.13	1.21
Secondary		9.62	9.13	8.82	8.62
Tertiary		8.24	8.23	8.24	8.26

Table 117. Employment aggregates, structure and rates of growth: entire country

	Year				
	0	5	10	15	20
Employment aggregates (thousands of persons)					
Levels of employment					
Total	3220.4	3765.7	4530.9	5618.8	7182.1
Primary	2037.0	2137.5	2252.5	2384.0	2534.5
Secondary	364.1	486.0	663.1	923.9	1311.6
Tertiary	819.2	1142.1	1615.3	2310.8	3336.0
Growth in employment					
Total		545.3	765.3	1087.8	1563.3
Primary		100.6	115.0	131.5	150.5
Secondary		121.9	177.1	260.8	387.7
Tertiary		322.9	473.2	695.5	1025.1
Indicators of employment structure					
Proportions of total employment by sector					
Primary	0.63	0.57	0.50	0.42	0.35
Secondary	0.11	0.13	0.15	0.16	0.18
Tertiary	0.25	0.30	0.36	0.41	0.46
Indicators of employment distribution					
Proportions urban					
Total	0.29	0.32	0.37	0.41	0.45
Primary	0.01	0.01	0.01	0.01	0.01
Secondary	0.84	0.81	0.78	0.76	0.75
Tertiary	0.72	0.70	0.69	0.68	0.67
Proportions rural					
Total	0.71	0.68	0.63	0.59	0.55
Primary	0.99	0.99	0.99	0.99	0.99
Secondary	0.16	0.19	0.22	0.24	0.25
Tertiary	0.28	0.30	0.31	0.32	0.33
Rates of growth of employment (percentage)					
Total		3.18	3.77	4.40	5.03
Primary		0.97	1.05	1.14	1.23
Secondary		5.94	6.41	6.86	7.26
Tertiary		6.87	7.18	7.42	7.62

Table 118. Projected non-civilian employment: urban areas

(Thousands of persons)

Year (1)	Non-civilian employment (2)
0	29.3
5	32.9
10	37.4
15	42.6
20	48.4

Table 119. Projected non-civilian employment: rural areas

(Thousands of persons)

Year (1)	Non-civilian employment (2)
0	3.3
5	3.7
10	4.2
15	4.7
20	5.4

Table 120. Projected non-civilian employment: entire country

(Thousands of persons)

Year (1)	Non-civilian employment (2)
0	32.5
5	36.5
10	41.5
15	47.4
20	53.8

Table 121. Labour market balances: urban areas

Year	Total labour force a/	Non-civilian employment b/	Civilian labour force c/	Total employment d/	Excess supply/ demand e/	Excess supply/ demand f/
	(thousands of persons)					(percentage of civilian labour force)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	968.3	29.3	939.0	923.7	15.3	1.63
5	1383.8	32.9	1350.9	1222.9	128.0	9.48
10	1881.1	37.4	1843.7	1658.5	185.2	10.05
15	2438.7	42.6	2396.1	2296.8	99.3	4.15
20	3032.4	48.4	2984.0	3236.6	-252.6	-8.47

a/ From table 46, "Labour force (Total)".
b/ From table 118.
c/ (Col. 2) - (Col. 3).
d/ From table 115, "Levels of employment (Total)".
e/ (Col. 4) - (Col. 5).
f/ ((Col. 6)/(Col. 4)) . (100).

Table 122. Labour market balances: rural areas

Year	Total labour force a/	Non-civilian employment b/	Civilian labour force c/	Total employment d/	Excess supply/ demand e/	Excess supply/ demand f/
	(thousands of persons)					(percentage of civilian labour force)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	2282.6	3.3	2279.3	2296.7	-17.4	-0.76
5	2269.1	3.7	2265.4	2542.8	-277.4	-12.25
10	2268.5	4.2	2264.3	2872.4	-608.1	-26.86
15	2298.6	4.7	2293.9	3322.0	-1028.1	-44.82
20	2344.1	5.4	2338.7	3945.5	-1606.8	-68.70

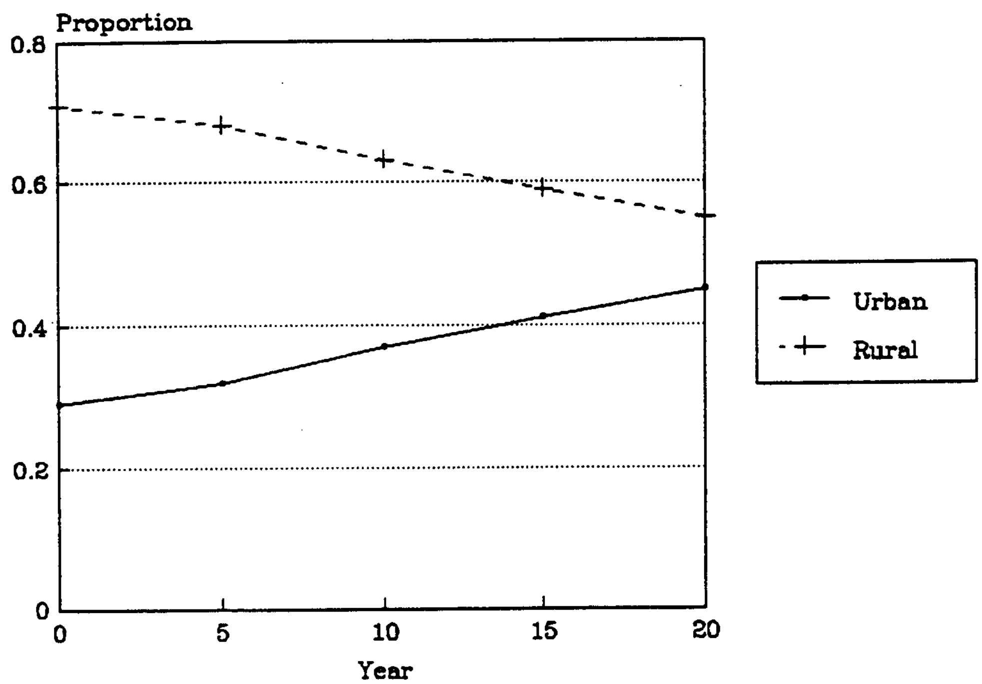
a/ From table 47, "Labour force (Total)".
b/ From table 119.
c/ (Col. 2) - (Col. 3).
d/ From table 116, "Levels of employment (Total)".
e/ (Col. 4) - (Col. 5).
f/ ((Col. 6)/(Col. 4)) . (100).

Table 123. Labour market balances: entire country

Year	Total labour force a/	Non-civilian employment b/	Civilian labour force c/	Total employment d/	Excess supply/ demand e/	Excess supply/ demand f/
	(thousands of persons)					(percentage of civilian labour force)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0	3250.9	32.5	3218.4	3220.4	-2.0	-0.06
5	3652.9	36.5	3616.4	3765.7	-149.3	-4.13
10	4150.2	41.5	4108.7	4530.9	-422.2	-10.28
15	4737.3	47.4	4689.9	5618.8	-928.9	-19.81
20	5376.5	53.8	5322.7	7182.1	-1859.4	-34.93

a/ From table 48, "Labour force (Total)".
b/ From table 120.
c/ (Col. 2) - (Col. 3).
d/ From table 117, "Levels of employment (Total)".
e/ (Col. 4) - (Col. 5).
f/ ((Col. 6)/(Col. 4)) . (100).

Figure XXVII. Proportions of total employment: urban and rural



The proportion of employment in the primary sector that is rural, 0.99, is:

$$0.99 = 1 - 0.01, \tag{54}$$

where 0.01 is the proportion of employment in the primary sector that is urban;

The proportion of employment in the secondary sector that is rural, 0.19, is:

$$0.19 = 1 - 0.81, \tag{55}$$

where 0.81 is the proportion of employment in the secondary sector that is urban;

The proportion of employment in the tertiary sector that is rural, 0.30, is:

$$0.30 = 1 - 0.70, \tag{56}$$

where 0.70 is the proportion of employment in the tertiary sector that is urban.

The proportions of employment, by sector, that are urban and rural for the entire projection interval are shown in table 117.

In addition to proportions of employment by sector, table 117 shows other projection results for the entire country. The results in this table were obtained from those for the urban and rural areas, shown respectively in tables 115 and 116, derived in the course of preparing the urban-rural projection of employment. The results for the entire country (table 117) differ from those obtained as part of the national projection (table 106). This is due to differences in inputs used in the national and urban-rural projections.

E. Summary

This chapter has described the method for preparing employment projections using employment-value added functions by industry to make national or urban-rural projections. As part of the description of the method, procedures used in making both national and urban-rural projections were presented. In addition, types of inputs required by the method were described, and preparation of the inputs was discussed. Lastly, examples were given of a national projection using a log-linear employment-value added function and an urban-rural projection using a linear employment-value added function. A complete listing of the outputs that can be generated by the method is shown in box 25.

Box 25

Outputs of the method for making employment projections using employment-value added functions

1. Employment by industry (national or urban, rural and national)

2. Employment aggregates (national or urban, rural and national)

Levels of employment:

Total

Primary sector
Secondary sector
Tertiary sector

Growth in employment:

Total

Primary sector
Secondary sector
Tertiary sector

3. Indicators of the structure of employment (national or urban, rural and national)

Proportions of employment, by sector:

Primary sector
Secondary sector
Tertiary sector

4. Indicators of the urban-rural distribution of employment (national only; if urban and rural employment is being projected)

Proportions of employment urban:

Total

Primary sector
Secondary sector
Tertiary sector

(continued)

Box 25 (continued)

Proportions of employment rural:

Total

Primary sector
Secondary sector
Tertiary sector

5. Rates of growth of employment (national or urban, rural and national)

Total

Primary sector
Secondary sector
Tertiary sector

6. Labour market balances (national or urban, rural and national)

Excess supply of or excess demand for labour

Percentage excess supply of or excess demand for labour

F. Notation and equations

1. Indices, variables and special symbols

(a) List of indices

i = 1,...,I	are industries of the nation's economy
k = 1,2	are urban and rural locations
t	is the year of the projection period
t'	is the calendar year
$\bar{t}'$	is the calendar year designated as the initial year of the projection period

(b) List of variables

CLF(t+5)	is the civilian labour force at the end of the interval
EGREM	is the average annual exponential growth rate of total employment for the interval
EGREMP	is the average annual exponential growth rate of employment in the primary sector for the interval
EGREMS	is the average annual exponential growth rate of employment in the secondary sector for the interval
EGREMT	is the average annual exponential growth rate of employment in the tertiary sector for the interval
EM(i,k,t')	is the employment in industry i in location k in year t'
EM(i,k,t+5)	is the employment in industry i in location k at the end of the interval
EM(i,t')	is the employment in industry i in year t'
EM(i,t+5)	is the employment in industry i at the end of the interval
EM(k,t+5)	is the total employment in location k at the end of the interval

EM(t+5)	is the total employment at the end of the interval
EMGR	is the growth of total employment during the interval
EMP(k,t+5)	is the employment in the primary sector in location k at the end of the interval
EMP(t+5)	is the employment in the primary sector at the end of the interval
EMPGR	is the growth of employment in the primary sector during the interval
EMS(k,t+5)	is the employment in the secondary sector in location k at the end of the interval
EMS(t+5)	is the employment in the secondary sector at the end of the interval
EMSGR	is the growth of employment in the secondary sector during the interval
EMT(k,t+5)	is the employment in the tertiary sector in location k at the end of the interval
EMT(t+5)	is the employment in the tertiary sector at the end of the interval
EMTGR	is the growth of employment in the tertiary sector during the interval
EX(t+5)	is the excess supply of labour (if positive) or excess demand for labour (if negative) for the end of the interval
GGREM	is the average annual geometric growth rate of total employment for the interval
GGREMP	is the average annual geometric growth rate of employment in the primary sector for the interval
GGREMS	is the average annual geometric growth rate of employment in the secondary sector for the interval
GGREMT	is the average annual geometric growth rate of employment in the tertiary sector for the interval
LF(t+5)	is the total labour force at the end of the interval

NEM(t+5)	is the non-civilian employment at the end of the interval
PEMP(t+5)	is the proportion of employment in the primary sector at the end of the interval
PEMPRUR(t+5)	is the proportion of employment in the primary sector which is rural at the end of the interval
PEMPURB(t+5)	is the proportion of employment in the primary sector which is urban at the end of the interval
PEMRUR(t+5)	is the proportion of total employment which is rural at the end of the interval
PEMS(t+5)	is the proportion of employment in the secondary sector at the end of the interval
PEMSRUR(t+5)	is the proportion of employment in the secondary sector which is rural at the end of the interval
PEMSURB(t+5)	is the proportion of employment in the secondary sector which is urban at the end of the interval
PEMT(t+5)	is the proportion of employment in the tertiary sector at the end of the interval
PEMTRUR(t+5)	is the proportion of employment in the tertiary sector which is rural at the end of the interval
PEMTURB(t+5)	is the proportion of employment in the tertiary sector which is urban at the end of the interval
PEMURB(t+5)	is the proportion of total employment which is urban at the end of the interval
PEXL(t+5)	is the excess supply of labour or excess demand for labour as a percentage of the total labour force at the end of the interval
VA(i,t')	is the value added in industry i in year t'
VA(i,t+5)	is the value added in industry i at the end of the interval

(c) <u>List of special symbols</u>

a(i)	is the intercept coefficient of the linear or non-linear employment-value added function for industry i
a(i,k)	is the intercept coefficient of the linear or non-linear employment-value added function for industry i in location k
a*(i)	is the estimate of the intercept coefficient of the linear or non-linear employment-value added function for industry i
a*(i,k)	is the estimate of the intercept coefficient of the linear or non-linear employment-value added function for industry i in location k
antiln	is the antilogarithm of the natural logarithm
b(i)	is the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i
b(i,k)	is the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i in location k
b*(i)	is the estimate of the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i
b*(i,k)	is the estimate of the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i in location k
c(i)	is the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i
c(i,k)	is the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i in location k
c*(i)	is the estimate of the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i

c*(i,k)	is the estimate of the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i in location k
e	is the base of the natural logarithm
I	is the number of industries
Ip	is the number of industries in the primary sector
Is	is the number of industries in the secondary sector
ln	is the natural logarithm
[lna(i)]*	is the estimate of the logarithm of the intercept coefficient of the non-linear function for industry i
u(i,k,t')	is the random disturbance term for industry i in location k in year t'
u(i,t')	is the random disturbance term for industry i in year t'

2. Equations

B. The technique

1. Overview

(a) Employment-value added functions, by industry

(i) Functions without the time variable

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t'); \qquad i = 1,\ldots,I \tag{1}$$

$$EM(i,t') = a(i) \cdot VA(i,t')^{b(i)}; \qquad i = 1,\ldots,I \tag{2}$$

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t'); \qquad i = 1,\ldots,I \tag{3}$$

(ii) Functions with the time variable

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + c(i) \cdot t'; \qquad i = 1,\ldots,I \tag{4}$$

$$EM(i,t') = a(i) \cdot VA(i,t') \cdot e^{[c(i)\ .\ t']}; \qquad i = 1,\ldots,I \tag{5}$$

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + c(i) \cdot t'; \qquad i = 1,\ldots,I \tag{6}$$

(b) Employment by industry

(i) Functions without the time variable

$$EM(i,t+5) = a^*(i) + b^*(i) \cdot VA(i,t+5); \qquad i = 1,\ldots,I \tag{7}$$

$$EM(i,t+5) = a^*(i) \cdot VA(i,t+5)^{b^*(i)}; \qquad i = 1,\ldots,I \tag{8}$$

$$\ln EM(i,t+5) = [\ln a(i)]^* + b^*(i) \cdot \ln VA(i,t+5); \qquad i = 1,\ldots,I \tag{9}$$

$$EM(i,t+5) = \mathrm{antiln}[\ \ln EM(i,t+5)\ ]; \qquad i = 1,\ldots,I \tag{10}$$

(ii) Functions with the time variable

$$EM(i,t+5) = a^*(i) + b^*(i) \cdot VA(i,t+5) + c^*(i) \cdot (\bar{t}'+t+5); \qquad i = 1,\ldots,I \tag{11}$$

$$EM(i,t+5) = a^*(i) \cdot VA(i,t+5)^{b^*(i)} \cdot e^{[c^*(i).(\bar{t}'+t+5)]}; \quad i = 1,\ldots,I \tag{12}$$

$$\ln EM(i,t+5) = [\ln a(i)]^* + b^*(i) \cdot \ln VA(i,t+5) + c^*(i) \cdot (\bar{t}'+t+5); \quad i = 1,\ldots,I \tag{13}$$

(c) <u>Other results</u>

(i) <u>Employment aggregates</u>

a. <u>Total employment</u>

$$EM(t+5) = \sum_{i=1}^{I} EM(i,t+5) \tag{14}$$

b. <u>Employment by sector</u>

i. <u>Employment in the primary sector</u>

$$EMP(t+5) = \sum_{i=1}^{Ip} EM(i,t+5) \tag{15}$$

ii. <u>Employment in the secondary sector</u>

$$EMS(t+5) = \sum_{i=Ip+1}^{Ip+Is} EM(i,t+5) \tag{16}$$

iii. <u>Employment in the tertiary sector</u>

$$EMT(t+5) = \sum_{i=Ip+Is+1}^{I} EM(i,t+5) \tag{17}$$

c. Growth in total employment

$$EMGR = EM(t+5) - EM(t) \quad (18)$$

d. Growth of employment by sector

$$EMPGR = EMP(t+5) - EMP(t) \quad (19)$$

$$EMSGR = EMS(t+5) - EMS(t) \quad (20)$$

$$EMTGR = EMT(t+5) - EMT(t) \quad (21)$$

(ii) Indicators of the structure of employment

a. Proportions by sector

$$PEMP(t+5) = EMP(t+5) \ / \ EM(t+5) \quad (22)$$

$$PEMS(t+5) = EMS(t+5) \ / \ EM(t+5) \quad (23)$$

$$PEMT(t+5) = EMT(t+5) \ / \ EM(t+5) \quad (24)$$

(iii) Rates of growth of employment

a. Rate of growth of total employment

$$GGREM = [\ (\ EM(t+5) \ / \ EM(t) \ )^{1/5} - 1 \ ] \cdot 100 \quad (25)$$

$$EGREM = [\ \ln \ (\ EM(t+5) \ / \ EM(t) \ ) \ / \ 5 \ ] \cdot 100 \quad (26)$$

b. Rates of growth of employment by sector

$$GGREMP = [\ (\ EMP(t+5) \ / \ EMP(t) \ )^{1/5} - 1 \ ] \cdot 100 \quad (27)$$

$$GGREMS = [(EMS(t+5) / EMS(t))^{1/5} - 1] \cdot 100 \qquad (28)$$

$$GGREMT = [(EMT(t+5) / EMT(t))^{1/5} - 1] \cdot 100 \qquad (29)$$

$$EGREMP = [\ln (EMP(t+5) / EMP(t)) / 5] \cdot 100 \qquad (30)$$

$$EGREMS = [\ln (EMS(t+5) / EMS(t)) / 5] \cdot 100 \qquad (31)$$

$$EGREMT = [\ln (EMT(t+5) / EMT(t)) / 5] \cdot 100 \qquad (32)$$

(iv) Labour market balances

$$CLF(t+5) = LF(t+5) - NEM(t+5) \qquad (33)$$

$$EXL(t+5) = CLF(t+5) - EM(t+5) \qquad (34)$$

$$PEXL(t+5) = [EXL(t+5) / CLF(t+5)] \cdot 100 \qquad (35)$$

3. Urban-rural level

(a) Employment-value added functions by industry

(i) Functions without the time variable

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t'); \qquad (36)$$

$$i = 1,\dots,I;$$

$$k = 1,2$$

$$EM(i,k,t') = a(i,k) \cdot VA(i,t')^{b(i,k)}; \qquad (37)$$

$$i = 1,\dots,I;$$

$$k = 1,2$$

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t'); \qquad (38)$$

$$i = 1,\ldots,I;$$

$$k = 1,2$$

(ii) <u>Functions with the time variable</u>

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + c(i,k) \cdot t'; \qquad (39)$$

$$i = 1,\ldots,I;$$

$$k = 1,2$$

$$EM(i,k,t') = a(i,k) \cdot VA(i,t')^{b(i,k)}\, e^{[c(i,k) \cdot t']}; \qquad (40)$$

$$i = 1,\ldots,I$$

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + c(i,k) \cdot t'; \qquad (41)$$

$$i = 1,\ldots,I;$$

$$k = 1,2$$

(b) <u>Employment by sector</u>

(i) <u>Functions without the time variable</u>

$$EM(i,k,t+5) = a^*(i,k) + b^*(i,k) \cdot VA(i,t+5); \qquad (42)$$

$$i = 1,\ldots,I;$$

$$k = 1,2$$

$$EM(i,k,t+5) = a^*(i,k) \cdot VA(i,t+5)^{b^*(i,k)}; \qquad (43)$$

$$i = 1,\ldots,I;$$

$$k = 1,2$$

$$\ln EM(i,k,t+5) = [\ln a(i,k)]^* + b^*(i,k) \cdot \ln VA(i,t+5); \quad (44)$$

$i = 1,\ldots,I;$

$k = 1,2$

$$EM(i,k,t+5) = \text{antiln}[\ \ln EM(i,k,t+5)\ ]; \quad (45)$$

$i = 1,\ldots,I;$

$k = 1,2$

(ii) Functions with the time variable

$$EM(i,k,t+5) = a^*(i,k) + b^*(i,k) \cdot VA(i,t+5) + c^*(i,k) \cdot (\bar{t}'+t+5); \quad (46)$$

$i = 1,\ldots,I;$

$k = 1,2$

$$EM(i,k,t+5) = a^*(i,k) \cdot VA(i,t+5)^{b^*(i,k)} \cdot e^{[c^*(i,k)\ \cdot\ (\bar{t}'+t+5)]}; \quad (47)$$

$i = 1,\ldots,I;$

$k = 1,2$

$$\ln EM(i,k,t+5) = [\ln a(i,k)]^* + b^*(i,k) \cdot \ln VA(i,t+5) \quad (48)$$

$+ c^*(i,k) \cdot (\bar{t}'+t+5);$

$i = 1,\ldots,I;$

$k = 1,2$

(c) Other results

(i) Proportions of employment, urban and rural

a. Proportions of total employment

$$PEMURB(t+5) = EM(1,t+5)/EM(t+5) \quad (49)$$

$$PEMRUR(t+5) = 1 - PEMURB(t+5) \tag{50}$$

b. Proportions of employment by sector

$$PEMPURB(t+5) = EMP(1,t+5)/EMP(t+5) \tag{51}$$

$$PEMSURB(t+5) = EMS(1,t+5)/EMS(t+5) \tag{52}$$

$$PEMTURB(t+5) = EMT(1,t+5)/EMT(t+5) \tag{53}$$

$$PEMPRUR(t+5) = 1 - PEMPURB(t+5) \tag{54}$$

$$PEMSRUR(t+5) = 1 - PEMSURB(t+5) \tag{55}$$

$$PEMTRUR(t+5) = 1 - PEMTURB(t+5) \tag{56}$$

C. The inputs

1. Types of inputs required

2. Preparation of the inputs

(a) Estimates of the co-efficients of employment-value added functions

(i) Time series data

(ii) Estimation procedures

a. National level

i. Functions without the time variable

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + u(i,t'); \tag{57}$$

$$i = 1,\ldots,I$$

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + u(i,t'); \qquad i = 1,\dots,I \tag{58}$$

$$a^*(i) = \text{antiln}[\text{Ina}(i)]^*; \qquad i = 1,\dots,I \tag{59}$$

ii. <u>Functions with the time variable</u>

$$EM(i,t') = a(i) + b(i) \cdot VA(i,t') + c(i) \cdot t' + u(i,t'); \qquad i = 1,\dots,I \tag{60}$$

$$\ln EM(i,t') = \ln a(i) + b(i) \cdot \ln VA(i,t') + c(i) \cdot t' + u(i,t'); \qquad i = 1,\dots,I \tag{61}$$

(b) <u>Urban-rural level</u>

i. <u>Functions without the time variable</u>

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + u(i,k,t'); \qquad i = 1,\dots,I; \quad k = 1,2 \tag{62}$$

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + u(i,k,t'); \qquad i = 1,\dots,I; \quad k = 1,2 \tag{63}$$

$$a^*(i,k) = \text{antiln}[\ \ln a(i,k)\ ]^*; \qquad i = 1,\dots,I; \quad k = 1,2 \tag{64}$$

ii. **Functions with the time variable**

$$EM(i,k,t') = a(i,k) + b(i,k) \cdot VA(i,t') + c(i,k) \cdot t + u(i,k,t'); \quad i = 1,\dots,I; \quad k = 1,2 \tag{65}$$

$$\ln EM(i,k,t') = \ln a(i,k) + b(i,k) \cdot \ln VA(i,t') + c(i,k) \cdot t + u(i,k,t'); \quad i = 1,\dots,I; \quad k = 1,2 \tag{66}$$

Notes

1/ Throughout this chapter, "value added" will refer to value added measured in constant prices.

2/ This is equivalent to assuming that the average ratio of employment to value-added equals the marginal ratio of employment to value-added.

3/ Much of the material presented in this section is similar to that given in chapter VI, section B.2(c). The reader who is familiar with its content may wish to skip the present section.

4/ Much of the material presented in this section is similar to that given in chapter VI, section B.3(c). The reader who is familiar with it may wish to skip the present section.

5/ Values assigned to the time variable were 1968 through 1978.

6/ The employment-value added functions used in this and the following example were estimated, among other things, from the time series on employment shown in tables 86 and 88, which are expressed in units of 1,000 employed persons. Therefore, the levels of employment in these illustrative examples will be given in thousands of employed persons.

7/ Much of the material presented in this section is similar to that given in chapter VI, section D.1(c). The reader who is familiar with it may wish to skip the present section.

8/ Much of the material presented in this section is similar to that given in chapter VI, section D.2(c). The reader who is familiar with its content may wish to skip the present section.

Annex I

PROCEDURE TO CALIBRATE EMPLOYMENT-VALUE ADDED FUNCTIONS

A planner may wish to make adjustments in the estimated employment-value added functions by industry, so that they will accurately predict employment by industry for a given historical year or time period on the basis of the value added levels for that year or period. These adjustments, which are normally referred to as "calibration" may be employed, for example, where the functions are to be used to make projections of employment that originate in the given historical year or period to which the data used to estimate the functions refer, rather than in the later, initial year of the plan.

Calibrating employment-value added functions may involve adjustments in estimates of the intercept coefficients, or in estimates of the partial coefficients or both. Since adjustments in the intercept coefficients are more straightforward than those in the partial coefficients, calibration is often restricted to intercepts. Therefore, this annex will describe how the intercept coefficients of employment-value added functions of different forms can be calibrated by first describing the calibration procedure and then selectively illustrating its application.

A. The procedure

The principles of adjusting the intercept coefficients of employment-value added functions are the same, irrespective of the type of functions involved. The steps make use of the estimates of the partial coefficients of the functions, as well as the observed levels of employment and value added, for the selected year or time period. The actual steps involved in adjusting the intercepts vary, however, depending on the type of functions estimated and used in the projections, as well as whether those functions are for the entire country or for urban and rural areas.

1. National level

This section will describe the procedure as it applies to functions estimated for the entire country, first to those without the time variable and then to the functions with this variable. Subsequently, the procedure applicable to the urban-rural level will be explained.

(a) Functions without the time variable

The method used to obtain adjusted intercepts will vary depending on the whether the functions are linear, non-linear or log-linear.

(i) In the case of linear functions, they are calculated as follows:

$$[a^*(i)]' = EM(i,t') - b^*(i) \cdot VA(i,t'); \qquad (1)$$

$$i = 1,\ldots,I,$$

where:

$i = 1,\ldots,I$	are industries in the nation's economy,
I	is the number of industries,
t'	is the given calendar year,
$EM(i,t')$	is the observed employment in industry i in year t',
$VA(i,t')$	is the observed value added in industry i in year t',
$[a^*(i)]'$	is the adjusted intercept coefficient of the linear employment-value added functions for industry i, and
$b^*(i)$	is the estimate of the partial coefficient of the value added variable in the linear employment-value added function for industry i.

(ii) In the case of non-linear functions having the multiplicative form, adjusted intercepts can be obtained as follows:

$$[a^*(i)]' = EM(i,t') \; / \; [\; VA(i,t')^{b^*(i)} \;]; \qquad (2)$$

$$i = 1,\ldots,I,$$

where:

$[a^*(i)]'$	is the adjusted intercept coefficient of the non-linear employment-value added function for industry i, and
$b^*(i)$	is the estimate of the partial coefficient of the value added variable in the non-linear employment-value added function for industry i.

(iii) If adjusted intercepts of log-linear employment-value added functions are needed, they can be obtained as follows:

$$[[\ln a(i)]^*]' = \ln EM(i,t') - b^*(i) \cdot \ln VA(i,t'); \qquad (3)$$

$$i = 1,\ldots,I,$$

where:

ln — is the natural logarithm, and

$[[\ln a(i)]^*]'$ — is the adjusted logarithm of the intercept coefficient of the non-linear employment-value added function for industry i.

If the planner wishes to perform adjustments in the intercept coefficients using data for a few or several years rather then a single year, the adjustments can be also made using expressions shown in equation (1) through (3). In that instance, the observed levels of employment and value added used would be mean levels of employment and value added for several years centred on one particular year, t'.

(b) Functions with the time variable

If the functions include a time variable, the calculation of adjusted intercepts would also involve the use of a suitable value for the time variable.

(i) In the case of linear functions with the time variable, the adjusted intercepts would be:

$$[a^*(i)]' = EM(i,t') - [\ b^*(i) \cdot VA(i,t') + c^*(i) \cdot t'\ ]; \qquad (4)$$

$$i = 1,\ldots,I,$$

where:

$c^*(i)$ — is the estimate of the partial coefficient of the time variable in the linear employment-value added function for industry i.

(ii) If adjusted intercepts of non-linear functions with the time variable which have the multiplicative form are sought, they would be obtained as:

$$[a^*(i)]' = EM(i,t') \,/\, [\ VA(i,t')^{b^*(i)} \cdot e^{(c^*(i) \cdot t')}\ ]; \qquad (5)$$

$$i = 1,\ldots,I,$$

where:

$c^*(i)$ is the estimate of the partial coefficient of the time variable in the non-linear employment-value added function for industry i.

(iii) In the case of log-linear employment-value added functions, adjusted intercepts can be obtained as follows:

$$[[\ln a(i)]^*]' = \ln EM(i,t') - [\ b^*(i) \cdot \ln VA(i,t') + c^*(i) \cdot t'\ ]; \qquad (6)$$

$$i = 1,\ldots,I.$$

1. Urban-rural level

If time series data on employment and value added are available for urban and rural areas by industry, such data could be used to estimate employment-value added functions for the two locations by industry. After estimating the functions, the intercept coefficients could be adjusted using the estimates of the partial coefficients and the observed levels of employment and value added for a given year or time period. Depending on the type of functions estimated, those adjustments could be performed using urban-rural equivalents of steps described in equations (1) through (6).

In some countries, time series on value added by industry will not be available for urban and rural areas. To estimate and use employment-value added functions for urban and rural areas, it may be necessary to estimate functions that relate employment in urban and rural areas by industry to the value added at the national level by industry. The procedure for adjusting the intercept coefficients of such functions is described below.

(a) Functions without the time variable

(i) In the case of linear employment-value added functions that do not include the time variable, adjusted intercepts are obtained as follows:

$$[a^*(i,k)]' = EM(i,k,t') - b^*(i,k) \cdot VA(i,t'); \qquad (7)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

k = 1,2	are urban and rural locations,
EM(i,k,t')	is the observed employment in industry i in location k in year t',
[a*(i,k)]'	is the adjusted intercept coefficient of the linear employment-value added function for industry i in location k, and
b*(i,k)	is the estimate of the partial coefficient of the value added variable in the linear employment-value added function for industry i in location k.

(ii) Adjusted intercept coefficients of the non-linear employment-value added functions that do not include the time variable would be obtained as:

$$[a^*(i,k)]' = EM(i,k,t') \;/\; [\; VA(i,t')^{b^*(i,k)} \;]; \qquad (8)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

[a*(i,k)]'	is the adjusted intercept coefficient of the non-linear employment-value added functions for industry i in location k, and
b*(i,k)	is the estimate of the partial coefficient of the value added variable in the non-linear employment-value added function for industry i in location k.

(iii) Adjusted intercept coefficients of the log-linear employment-value added functions that do not include the time variable can be derived as:

$$[[\ln a(i,k)]^*]' = \ln EM(i,k,t') - b^*(i,k) \cdot \ln VA(i,t'); \qquad (9)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$[[\ln a(i,k)]^*]'$ is the adjusted logarithm of the intercept coefficient of the log-linear employment-value added function for industry i in location k.

(b) Functions with the time variable

(i) For employment-value added functions which include the time variable, adjusted intercepts in the linear functions would be obtained as follows:

$$[a^*(i,k)]' = EM(i,k,t') - [\ b^*(i,k) \cdot VA(i,t') + c^*(i,k) \cdot t'\ ]; \qquad (10)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$c^*(i,k)$ is the estimate of the partial coefficient of the time variable in the linear employment-value added function for industry i in location k.

(ii) In the case of non-linear employment-value added functions, adjusted constants can be obtained as:

$$[a^*(i,k)]' = EM(i,k,t') \ /\ [\ VA(i,t')^{b^*(i,k)} \cdot e^{(c^*(i,k)\ \cdot\ t')}\ ]; \qquad (11)$$

$$i = 1,\ldots,I;$$

$$k = 1,2,$$

where:

$c^*(i,k)$ is the estimate of the partial coefficient of the time variable in the non-linear employment-value added function for industry i in location k.

(iii) In the case of log-linear functions, adjusted constants can be obtained as:

$$[[\ln a(i,k)]^*]' = \ln EM(i,k,t') - [\ b^*(i,k) \cdot \ln VA(i,t') + c^*(i,k) \cdot t'\ ]; \quad i = 1,\ldots,I; \quad k = 1,2. \tag{12}$$

B. Illustrative examples of calibration

The examples presented below will not attempt to exhaustively illustrate the procedure to calibrate all employment-value added functions, which include linear, non-linear and log-linear functions, with and without the time variable, for the entire country and urban and rural areas. Rather they will show how to calibrate the functions that were employed in chapter VII in order to illustrate their use in preparing employment projections. In particular, the first example will show how to derive adjusted intercept coefficients for log-linear employment-value added functions for the entire country by industry, two of which include the time variable. The second example will indicate the way to obtain adjusted intercepts for linear functions for urban and rural areas, by industry, several of which include the time variable. Both examples will use as inputs, the observations on employment and value added for 1978, which are shown in tables 86 through 88.

1. National level

This example will indicate how to calibrate estimates of country-level log-linear employment-value added functions without the time variable for all industries except construction and trade (the unadjusted coefficients are shown in table 90), and with the time variable for these two industries (the unadjusted coefficients are shown in table 92). The adjusted intercepts for these functions will be derived using estimates of the partial coefficients of those functions along with the levels of employment and value added by industry for 1978 which are shown in tables 86 and 87.

Table 124 illustrates the calculation of the adjusted logarithms of intercepts for the functions in question. The adjusted logarithm of intercept coefficient (column 7) for any industry (other than the construction or trade industry) is obtained as the difference between the logarithm of the observed level of employment for the industry in 1978 (column 6) and the product of the estimated value added coefficient (column 2) and the logarithm of the observed level of value added for the industry in 1978 (column 4).

The adjusted logarithm of the intercept coefficient (column 7) for the construction or trade industry is obtained as the difference between the logarithm of the observed level of employment for the industry in 1978 (column 6) and the sum of two products. The first product is obtained by multiplying the estimated value added coefficient for the construction or trade industry (column 2) by the logarithm of the observed level of value added for the industry in 1978 (column 4). The second product is the result of multiplying the time variable coefficient for the industry (column 3) by the value of the time variable for year 1978 (column 5).

Thus, the adjusted logarithm of the intercept in the function for agriculture, 5.78334, is obtained as follows:

$$5.78334 = \ln(1{,}994.0) - 0.32625 \cdot \ln(260.3), \qquad (3)$$

where 1,994.0 is the employment in agriculture in 1978, while 0.32625 and 260.3 are, respectively, the estimate of the value added coefficient for agriculture and the value added in agriculture in 1978.

The adjusted logarithm of the intercept in the function for construction, -99.37402, is calculated as:

$$-99.37402 = \ln(93.8) - [\ 0.07935 \cdot \ln(23.5) + 0.05241 \cdot 1978\ ], \qquad (6)$$

where 93.8 is the employment in construction in 1978, while 0.07935 and 23.5 are, respectively, the estimate of the value added coefficient for construction and the value added in this industry in 1978. 0.05241 is the estimate of the time variable coefficient for the construction industry and 1978 is the value of the time variable.

1. <u>Urban-rural level</u>

This example shows how to calibrate estimates of linear employment-value added functions for urban and rural areas by industry, some of which exclude the time variable while others include it. Among the functions for urban areas, the functions for mining, manufacturing, trade, transport and services do not include the time variable (table 93), while those for agriculture,

Table 124. Computing adjusted intercept coefficients of selected log-linear functions, by industry: entire country, year 1978

Industry	Estimates of partial coefficients: Value added a/	Estimates of partial coefficients: Time variable b/	In year 1978: Value added c/	In year 1978: Value of time variable	In year 1978: Employment d/	Adjusted intercept coefficient e/
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture	0.32625		260.3		1994.0	5.78333
Mining	0.86530		2.6		6.7	1.07529
Manufacturing	0.56365		118.9		217.3	2.68799
Utilities	0.80202		18.0		15.3	0.40971
Construction	0.07934	0.052	23.5	1978	93.8	-99.37402
Trade	0.31107	0.031	50.9	1978	109.4	-58.24014
Transport	0.96016		50.3		95.1	0.79301
Services	0.63680		266.9		516.2	2.68876

a/ All industries except construction and trade: from table 90, col. 3; construction and trade industry: from table 93, col. 3.
b/ From table 93, col. 4.
c/ From table 87, year 1978.
d/ From table 86, year 1978.
e/ All industries except construction and trade: (ln(Col. 6)) - ((Col. 2) . (ln(Col. 4))); construction and trade: (ln(Col. 6)) - ((Col. 2) . (ln(Col. 4)) + (Col. 3) . (Col. 5)).

utilities and construction include it (table 97). Among the functions for rural areas, those for agriculture, mining, manufacturing, construction, trade and services do not include the time variable (table 94), whereas those for utilities and transport include it (table 98). To derive adjusted intercepts for these functions, estimates of the partial coefficients of those functions will be used along with the levels of employment and value added by industry for 1978 (tables 87 and 88).

Tables 125 and 126 illustrate calculations of the adjusted intercepts for the functions in question. The adjusted intercept coefficient (column 7) for each industry having a function that excludes the time variable is obtained as the difference between the observed level of employment for the industry in urban or rural areas in 1978 (column 6) and the product of the estimated value added coefficient (column 2) and the observed level of national value added for the industry in 1978 (column 4).

The adjusted intercept coefficients (column 7) for each industry having a function which includes the time variable are obtained as the difference between the observed level of employment for the industry in urban or rural areas in 1978 (column 6) and the sum of two products. The first product is derived by multiplying the estimated value added coefficient for the industry (column 2) by the observed level of national value added for the industry in 1978 (column 4). The second product is obtained by multiplying the time variable coefficient for the industry (column 3) and the value of the time variable for year 1978 (column 5).

For example, the adjusted intercept coefficient in the function for urban mining, 2.08799, is obtained as follows:

$$2.08799 = 5.9 - 1.46616 \cdot 2.6, \tag{7}$$

where 5.9 is the employment in urban mining in 1978, while 1.46616 and 2.6 are, respectively, the estimate of the value added coefficient for urban mining and the national value added in mining in 1978.

The adjusted intercept in the function for urban agriculture, 2,645.31363, is calculated as:

$$2{,}645.31363 = 22.2 - (\ 0.13728 \cdot 260.3 + (-1.34421) \cdot 1978\ ), \tag{10}$$

where 22.2 is the employment in urban agriculture in 1978, while 0.13728 and 260.3 are, respectively, the estimate of the value added coefficient for urban agriculture and the national value added in agriculture in 1978. -1.34421 is the estimate of the time variable coefficient for the urban agriculture and 1978 is the value of the time variable.

Table 125. Computing adjusted intercept coefficients for selected linear functions, by industry: urban areas, year 1978

Industry	Estimates of partial coefficients: Value added a/	Estimates of partial coefficients: Time variable b/	In year 1978: National value added c/	In year 1978: Value of time variable	In year 1978: Employment d/	Adjusted intercept coefficient e/
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture	0.13728	-1.344	260.3	1978	22.2	2645.31363
Mining	1.46615		2.6		5.9	2.08799
Manufacturing	0.97430		118.9		184.2	68.35567
Utilities	0.66476	-0.096	18.0	1978	12.7	190.82840
Construction	-1.07195	3.440	23.5	1978	81.4	-6696.75995
Trade	2.27942		50.9		98.8	-17.22250
Transport	1.62845		50.3		92.2	10.28867
Services	0.81798		266.9		334.3	115.98101

a/ Mining, manufacturing, trade, transport and services: from table 94, col. 3; agriculture, utilities and construction: from table 99, col. 3.
b/ From table 99, col. 4.
c/ From table 87, year 1978.
d/ From table 88, urban, year 1978.
e/ Mining, manufacturing, trade, transport and services: (Col. 6) - ((Col. 2) . (Col. 4)); agriculture, utilities and construction: (Col. 6) - ((Col. 2) . (Col. 4) + (Col. 3) . (Col. 5)).

Table 126. Computing adjusted intercept coefficients for selected linear functions, by industry: rural areas, year 1978

Industry	Estimates of partial coefficients		In year 1978			Adjusted intercept coefficient e/
	Value added a/	Time variable b/	National value added c/	Value of time variable	Employment d/	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Agriculture	2.85558		260.3		1971.8	1228.49142
Mining	0.65595		2.6		0.8	-0.90547
Manufacturing	0.25725		118.9		33.1	2.51193
Utilities	0.87432	-0.626	18.0	1978	2.6	1225.68768
Construction	1.53126		23.5		12.4	-23.58472
Trade	0.74332		50.9		10.6	-27.23500
Transport	-0.07479	0.269	50.3	1978	2.9	-524.85848
Services	0.60456		266.9		181.9	20.54159

a/ Agriculture, mining, manufacturing, construction, trade and services: from table 95, col. 3; utilities and transport: from table 100, col. 3.

b/ From table 100, col. 4.

c/ From table 87, year 1978.

d/ From table 88, rural, year 1978.

e/ Agriculture, mining, manufacturing, construction, trade and services: (Col. 6) - ((Col. 2) . (Col. 4)); utilities and transport: (Col. 6) - ((Col. 2) . (Col. 4) + (Col. 3) . (Col. 5)).

C. Notation and equations

1. Indices, variables and special symbols

(a) List of indices

i = 1,...,I	are industries of the nation's economy
k = 1,2	are urban and rural locations
t'	is the given calendar year

(b) List of variables

EM(i,k,t')	is the observed employment in industry i in location k in year t'
EM(i,t')	is the observed employment in industry i in year t'
VA(i,t')	is the observed value added in industry i in year t'

(c) List of special symbols

[a*(i)]'	is the adjusted estimate of the intercept coefficient of the linear or non-linear employment-value added function for industry i
[a*(i,k)]'	is the adjusted estimate of the intercept coefficient of the linear or non-linear employment-value added function for industry i in location k
b*(i)	is the estimate of the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i
b*(i,k)	is the estimate of the partial coefficient of the value added variable in the linear or non-linear employment-value added function for industry i in location k
c*(i)	is the estimate of the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i
c*(i,k)	is the estimate of the partial coefficient of the time variable in the linear or non-linear employment-value added function for industry i in location k

I	is the number of industries
ln	is the natural logarithm
[[lna(i)]*]'	is the adjusted estimate of the logarithm of the intercept coefficient of the non-linear employment-value added function for industry i
[[lna(i,k)]*]'	is the adjusted estimate of the logarithm of the intercept coefficient of the non-linear employment-value added function for industry i in location k

2. Equations

A. The procedure

1. National level

(a) Functions without the time variable

$$[a^*(i)]' = EM(i,t') - b^*(i) \cdot VA(i,t'); \qquad (1)$$

$$i = 1,\dots,I$$

$$[a^*(i)]' = EM(i,t') \,/\, [\, VA(i,t')^{b^*(i)} \,]; \qquad (2)$$

$$i = 1,\dots,I$$

$$[[\ln a(i)]^*]' = \ln EM(i,t') - b^*(i) \cdot \ln VA(i,t'); \qquad (3)$$

$$i = 1,\dots,I$$

(b) Functions with the time variable

$$[a^*(i)]' = EM(i,t') - [\, b^*(i) \cdot VA(i,t') + c^*(i) \cdot t' \,]; \qquad (4)$$

$$i = 1,\dots,I$$

$$[a^*(i)]' = EM(i,t') \,/\, [\, VA(i,t')^{b^*(i)} \cdot e^{(c^*(i) \cdot t')} \,]; \qquad (5)$$

$$i = 1,\dots,I$$

$$[[\ln a(i)]^*]' = \ln EM(i,t') - [\ b^*(i) \cdot \ln VA(i,t') + c^*(i) \cdot t'\ ]; \quad i = 1,\ldots,I \tag{6}$$

2. Urban-rural level

(a) Functions without the time variable

$$[a^*(i,k)]' = EM(i,k,t') - b^*(i,k) \cdot VA(i,t'); \quad i = 1,\ldots,I; \quad k = 1,2 \tag{7}$$

$$[a^*(i,k)]' = EM(i,k,t') \ /\ [\ VA(i,t')^{b^*(i,k)}\ ]; \quad i = 1,\ldots,I; \quad k = 1,2 \tag{8}$$

$$[[\ln a(i,k)]^*]' = \ln EM(i,k,t') - b^*(i,k) \cdot \ln VA(i,t'); \quad i = 1,\ldots,I; \quad k = 1,2 \tag{9}$$

(b) Functions with the time variable

$$[a^*(i,k)]' = EM(i,k,t') - [\ b^*(i,k) \cdot VA(i,t') + c^*(i,k) \cdot t'\ ]; \quad i = 1,\ldots,I; \quad k = 1,2 \tag{10}$$

$$[a^*(i,k)]' = EM(i,k,t') \,/\, [\, VA(i,t')^{b^*(i,k)} \cdot e^{(c^*(i,k)\, \cdot\, t')} \,]; \quad i = 1,\ldots,I; \quad k = 1,2 \tag{11}$$

$$[[\ln a(i,k)]^*]' = \ln EM(i,k,t') - [\, b^*(i,k) \cdot \ln VA(i,t') + c^*(i,k) \cdot t' \,]; \quad i = 1,\ldots,I; \quad k = 1,2 \tag{12}$$

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