Tools for Manpower Planning

The World Bank Models

Volume I

Technical Presentation of the Models

Ismail Serageldin
Bob Li

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Foreword

The explosion of international migration in the Middle East and North Africa Region in the 1970s was a major development on the international economic scene with profound implications for both the labor-importing and the labor-exporting countries. The World Bank undertook a research study on the subject in 1978 under the leadership of Ismail Serageldin and his group of committed colleagues in the Technical Assistance and Special Studies Division of the EMENA Projects Department. The study was completed in 1981 and the Report has been widely disseminated. It has been published in book form this year. 1/

The set of simulation models developed by the Technical Assistance and Special Studies Division and elaborated during the research project has been applied to study manpower problems and planning issues in several countries and proven to be a useful tool for manpower planning. The wide availability and a full description of these models is important and to be welcomed.

Vinod Dubey

Chief Economist

Europe, Middle East and North Africa Region

May 1983

1/ Ismail Serageldin, James A. Socknat, Stace Birks, Bob Li, and Clive Sinclair, Manpower and International Labor Migration in the Middle East and North Africa (Oxford University Press for the World Bank, 1983).

Preface

This document, published in four volumes as part of the World Bank's staff working papers, is intended to set forth the mathematical formulation of the Bank's various Manpower Planning Models, most of which have now been used in a number of countries and studies, but whose technical documentation was not hitherto available to the public.

Applied Models are living entities, constantly changing and (we hope) improving to meet the new requirements introduced by their users. The present publication must therefore be seen as a snapshot in time, but one which presents the interested user with the opportunity of reviewing the technical documentation as well as the user's guides as they stand at the beginning of 1983. They are not likely to change significantly until a new round of intensive applications produces a new generation.

The technical presentation provides, for completeness, a detailed discussion (pp. 98-132) of a simultaneous procedure method for the migration model. This has not been implemented to date, partly because time and resources constraints prevented its complete development and elaboration, but it nevertheless sketches out the likely direction of our next round of research and development efforts, planned for 1983/84.

It is important to emphasize, however, that while we were the main protagonists in the development of these models, the work would not have been possible without the support, guidance and incisive comments of many colleagues in and outside the Bank. To all of them we owe a great debt of intellectual and moral gratitude. We emphasize, however, that any errors or shortcomings in the present manuscript are purely our own.

Among those in the Bank who provided constant support and encouragement during the six year life of these manpower planning efforts, of which this document is just a small part, we must thank in particular Mr. Vinod Dubey, Chief Economist of the EMENA region, whose constant personal and technical support from the earliest days to the present have made this task possible. The long-term study efforts have also benefitted from the strong support of Messrs. R. Chaufournier, Vice-President of EMENA; and M.P. Benjenk, currently Vice-President, External Relations and formerly Vice-President of EMENA; and Messrs. A. David Knox, currently Vice-President for West Africa (formerly Projects Director, EMENA); A. Karaosmanoglu, currently Vice-President for East Asia and Pacific (formerly Director of Programs, EMENA), and M.P. Bart, Director of Programs, EMENA; and A.S. El Darwish, Director of Projects, West Africa (formerly Assistant Director of Projects, EMENA); and especially Messrs. R. Picciotto, Director of Projects, EMENA; and J.J. Stewart, Assistant Director of Projects, EMENA. A special mention is also needed of the support given by Mr. D. Avramovic when he was Director of the Bank's Development Economics Department, and Mr. S. Acharya when he was Research Advisor.

Many colleagues from the Bank have contributed valuable comments and insights to the general studies of which these Models were the central part, among these we must name S. Birks, C. Blitzer, F. Colaco, Z. Ecevit, I. Hume, J.P. Jallade, T. King, G. Pennisi, R. Prosser, N. Sherbiny, C. Sinclair, J. Socknat, and M. Wilson. The computer related work was ably done by Peter and Tom Wolfe (Consultants). Earlier versions were programmed by A. McClinton of the Phoenix Corporation. Applications on various countries were undertaken with the support of G. Cima, B. Krishna, B. Smith, M. Pemmarazu, M. Youssef, and M. Allak.

Among the colleagues from the academic world, special thanks are due to the contributions of Professors I. Sirageldin (Johns Hopkins University), C.S. Kelly (Ohio State University), R. Davis and W. Alonso (both of Harvard University), and the late Arthur Smithies (Harvard University).

Finally, Professor John Kantner (Johns Hopkins University) and Mr. Mervin E. Muller (Senior Advisor to the Vice-President and Controller) reviewed this manuscript, and Mr. R. Wolfe (Consultant) provided editorial support. To each and everyone our thanks and appreciation.

Ismail Serageldin and Bob C. Li

The World Bank
Washington, D.C.
May 1983

NOTE

The purpose of this series of World Bank Staff Working Papers is to describe the structure, input, output, use and operation of the World Bank manpower forecasting Models, implemented for IBM 370 systems.

Staff of the Technical Assistance and Special Studies (TASS) Division of the World Bank are available, under appropriate arrangements, to discuss with potential users the collection and preparation of required input data for running the models. In some cases, the TASS Division can also conduct short orientation and training sessions on the capabilities and operation of the models.

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PART I

INTRODUCTION

0.1 This paper describes the manpower model which has been developed by the Technical Assistance and Special Studies Division of the Europe, Middle East, and North Africa Projects Department of the World Bank, with the problems of both labor importing and exporting countries in mind. The principal applications for planners are: (1) to forecast manpower requirements (national and expatriate) required to meet specific sectoral output targets; and (2) to identify and isolate specific problems in the supply of manpower through simulation of flows of students and trainees through the education and training system in the light of such modifiable parameters as participation, repetition and dropout rates, and qualifications required to enter programs. The system also permits the planner to set specific manpower targets through an allocation submodel, such as maximizing the number of nationals in certain occupational categories in a given sector or optimizing the allocation of qualified labor to occupations in those sectors of the economy which are considered as having a high priority. Since the model incorporates sectoral production targets, together with certain assumptions about productivity growth for the sectors concerned, the model can also be used to estimate what production levels might be achieved in given sectors, working with existing and likely indigenous manpower stocks but with certain limits, if so desired, placed on the growth or overall numbers of expatriate manpower.

The model consists of three interrelated simulation models (with optimization capabilities) that relate economic growth, education and training, labor force, unemployment, and the importation/exportation of labor. The three models are a country-specific model, an expanded country model that analyses by region within a specific country, and an

international labor migration model that quantifies labor flows between countries.

The Country /model, which the World Bank has used to analyze manpower problems in more than 10 countries, has been adopted and used by five governments (Saudi Arabia, Kuwait, Tunisia, Algeria, and Portugal) and is presently being considered by a number of other governments in the Middle East and North Africa for adoption as a planning tool in their own agencies.

0.2 The Country-Specific Model

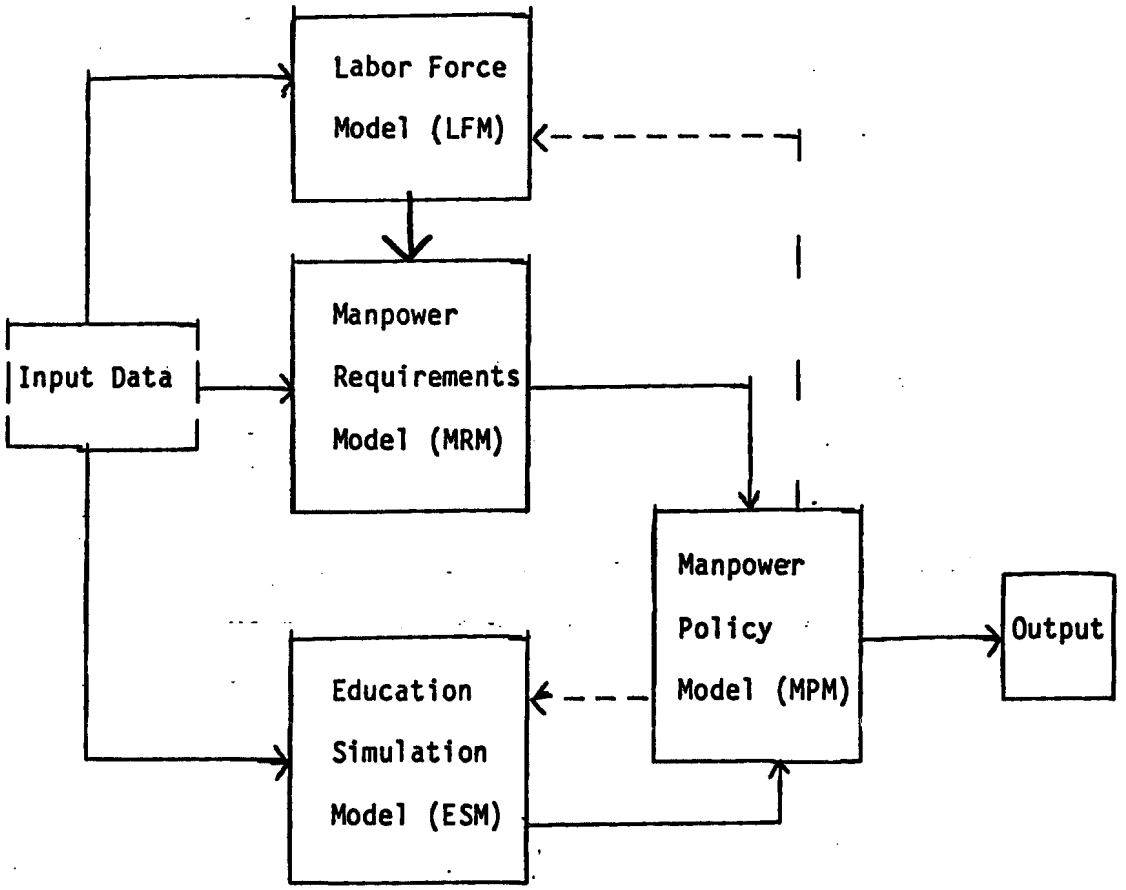
The country model relates growth, education, labor supply and requirements, and the need for nonnational members of the labor force on a national basis. The model provides for a basic flow in input data in a simultaneous process to three submodels: The labor force model (LFM); the manpower requirements model (MRM); and the education simulation model (ESM). The LFM is linked to the MRM; and both are linked along with the ESM to the fourth submodel, the manpower policy model (MPM), which, in turn, generates both output and feedback to earlier stages.

A basic tool for articulating the coherent human resources development strategy represented by the country model is the sector/occupation matrix (SOM). This joins with the four submodels to provide the fifth basic component of the country model. The matrix is defined by economic activity by sector (rows) and by varying occupations (columns).

A simplified schema of the model is shown below in figure 0-1.

Figure 0-1

Country-Specific Model



0.3 Submodels of the Country-Specific Model

The basic characteristics of the four submodels mentioned above are as follows:

Manpower Requirements Model (MRM)

The MRM requires specification of sector production targets (usually on the basis of a development plan). Its principal function is to calculate occupational requirements in the light of assumptions about initial productivity in the base year and productivity growth. Requirements are then expressed in terms of educational qualifications. For example, senior technical occupations may be regarded as requiring a science or math-based degree or, a more specific example, an agricultural project manager would require a higher agricultural qualification.

Labor Force Model (LFM)

The LFM identifies available national labor force at the beginning of each simulation year by occupation within sector and applies an attrition rate. (Eventually, a promotion filter, or lateral transfer may be incorporated in later versions of the model to take account of movement upwards in the occupational structure); next, the LFM takes account of available new labor force entrants from the ESM, after applying a participation filter (for example, not all outputs from lower secondary girls' programs will enter the labor force--some will marry). The output of the LFM is the net supply of manpower for the simulation year.

Education Simulation Model (ESM)

The ESM simulates flows of students and trainees through the system on the basis of initial enrollments and assumptions about participation rates (e.g., percentage of girls and boys in a program, of an age group, or of graduates entering a course from a previous one, such as percentage of primary graduates going to either lower secondary general or into the labor force), repetition rates, and dropout rates. These parameters can be changed to reflect educational policy decisions such as: higher

participation of girls in a given program; increased flows from secondary to vocational/technical programs, or specification of particular proportions of upper secondary school entrants to literary and science-oriented courses; introduction of "automatic promotion," or limiting of repetition to a minimum number of times. For the purpose of flows to the labor force, the model considers any year of program as an exit point (each program year is called a "course") classifying leavers in two ways (boy/girl; completer/dropout).

Manpower Policy Model (MPM) and Sector Occupation Matrix (SOM)

The MPM allocates supply from the labor force and from the ESM to the overall SOM according to specific priorities. For example, in allocating manpower with professional qualifications and senior technical qualifications--e.g., engineers--a priority might be assigned to those occupational categories within the oil industry and within other sectors considered as strategically important, such as public utilities or communications, depending on the country. The MPM can also be set to maximize the number of nationals employed in a specific occupation within a sector. In a case where supply is greater than demand, the participation and repetition coefficients in the ESM will have to be adjusted. Alternatively, the planner may adjust entry requirements elsewhere, introducing alternative follow-on courses. In cases where supply is less than demand, the most critical priorities will be satisfied first. Where priorities are equal and supply insufficient, allocation between occupation/sector cells is made on the basis of each cell's net requirements weighted by the degree of nationalization already obtained.

The allocation of expatriates to the SOM cells is made by a linear programming model (LPM) which can respect these constraints. Because the model as a whole accommodates up to ten nationalities or national groups and there are 234 cells in the SOM, the total variables are 2,340. To make allocation less complex, the SOM has been partitioned into critical skill areas. For example, a "partition" might be managerial and senior technical posts in three key sectors. The LPM allocates available expatriate labor to the most critical partition, then operating within the previously mentioned constraints, then proceeds to the next partition, working with a supply which has been reduced in the previous allocation steps. The process continues until all the residual requirements in the SOM have been satisfied.

4.4 The Expanded Model

The expanded model extends the methodology used in the country model to produce analyses of interregional (within country) labor flows. In the expanded model, there are two major stages of analysis: local analyses, or within regional analyses; and global analyses, which are national analyses within a specific country, in which various local analyses are taken into account in the overall allocation of manpower surplus and deficit in the country.

After all localities or regions in a global unit have gone through their individual local analyses, the global analysis will reallocate pooled leakages from each locality to various other localities, in accordance with a transition matrix or matrices, and will also estimate corresponding

changes in population and enrollments due to labor force migration. The global analysis will then estimate expatriate requirements, taking into account existing available local nationals and expatriates residing in the global unit.

Q.5 The Migration Model

In order to deal with the problems of local flows between countries in a supranational region, it is not sufficient to juxtapose country-specific models. The interaction effects also need to be identified and modeled.

The migration model simulation is designed to consider a region of countries, and to determine the pattern of migration of laborers resulting from imbalance in labor supplies and requirements among the countries. Each country has labor requirements (divided into sectors and occupations) determined from user-specified data covering target outputs, productivities, growth, and other national economic goals. Labor availability is determined for each country from user-supplied information about the educational system, existing labor stocks, attrition and sector/occupation distribution, in conjunction with carryover information from the previous simulation year.

The simulation combines information about labor supplies and demands in the regional countries with user-specified data ranking attractiveness of countries to laborers, restrictions imposed by countries on nonnational participation in their labor forces, and other constraints. From these input data and constraints, a pattern of labor allocation is determined which includes local allocation of each national labor force, as well as migration of nationals to other countries. Remaining deficiencies in labor supplies are assumed to be filled by expatriates from an undivided source called "rest of the world."