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RAPID

RESOURCES FOR AWARENESS OF POPULATION IMPACT ON DEVELOPMENT

User's Guide for the RAPID
Socioeconomic Computer Model
and the Apple II Computer

John Stover

THE FUTURES GROUP
76 Eastern Boulevard
Glastonbury, Connecticut 06033
(203) 633-3501

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I. INTRODUCTION

This user's guide describes the socioeconomic model used in the RAPID project and explains its use on the Apple II computer. Chapter II describes the model and presents the equations used to make the demographic projections and to relate them to the other sectors, economy, education, health, housing and food and agriculture. Chapter III describes the data required by the model and the preparation of the data. It also contains a sample data load sheet. Chapter IV describes the operation of the Apple II computer.

II. RAPID SOCIOECONOMIC COMPUTER MODEL

Introduction

The computer model used in the RAPID project is intended to be an important part of the RAPID presentations on the effects of rapid population growth on development. In order to fulfill this intention the model must satisfy two criteria: it must provide the information needed to demonstrate the effects of population growth on development, and it must be relatively simple.

In order to supply the information necessary for the presentation the model obviously must contain a demographic sector that is capable of projecting the size and age structure of the population under different assumptions about fertility. In addition, it must relate demographic variables to key indicators of development in several sectors, such as economics, education, agriculture, health, and housing. The demographic and related variables must be displayed in an appropriate manner to convey the message to the audience and keep their interest in the presentation. Finally, the model must be flexible enough to be used for any developing country with a minimum amount of change.

The requirement for the model to be simple results largely from the necessity of being able to explain the calculational procedures fully to a sophisticated, bur possibly nontechnical, audience in a short period of time. If the model cannot be explained quickly to a member of the audience who asks for clarification of the calculational procedures, the effectiveness of the entire presentation is likely to suffer. A sophisticated audience will not be likely to accept a conclusion about the effects of population growth on development if it cannot understand how that conclusion was obtained.

The requirement for the model to be simple also derives, in part, from the capabilities of the computer selected for use in RAPID. In order to have a truly portable computer that can be used anywhere in the world, a microprocessor-based computer, the Apple II, was selected. The model must be small enough to fit within the memory capacity of the computer and simple enough to ensure that calculations performed during the presentation will not require the audience to wait for long periods of time before seeing the results.

The model, therefore, has been designed to supply the information for a presentation in a simple and straightforward manner. In the demographic sector, for example, the usual practice is to disaggregate population by both age and sex. However, in the RAPID presentations there is no great need to be highly accurate in determining the sex ratio in the population. Thus, it is sufficient to calculate the female population as a fixed percentage of the total population and use only a one-sex model, which uses less computer memory and increases the speed of calculation. In the economic

sector, a simple national production function has been used to calculate production rather than a more complete input-output approach. This simpler approach allows the model to be explained more easily; it allows the model to be applied more readily to practically any country and it provides all the accuracy and detail that the presentation requires.

The rest of this section discusses the procedures used in each of the sectors contained in the general model. This general model is used with the data base to produce projections for any developing country. For specific country analyses that become the subject of country presentations, this general model is modified to add specific sectors of importance to a particular country.

Population Projections

The demographic sector uses a one-sex model that disaggregates the population into 16 five-year age cohorts, from 0-4 years old to 75 and over. For each age group except the 0-4 group, the population is increased by people aging into that cohort and decreased by people aging out of it and by deaths. The 0-4 age group is increased by births and decreased by aging and deaths.

Births are calculated from the total fertility rate and the age-specific distribution of fertility. Thus, the total number of births occurring at a particular time to the women of a given age is the product of the total fertility rate, the fraction of total lifetime births occurring during the given age and the number of women in that age group. The age distribution of fertility is assumed to remain constant over time, while the total fertility rate may be changed at will by the user.

Mortality is based on life expectancy and a set of model life tables. Life expectancy is determined by the model user. Age-specific mortality rates are then calculated from the appropriate Coale-Demeny West model life table for that life expectancy.

From the projections of population by age, a number of other demographi indicators are derived, including the number of births, the crude birth and death rates, and the population growth rate. The urban population is calculated from the urban population in the first year of the projection and the rate of migration from rural to urban areas. The total dependency ratio and the child dependency ratio are also calculated.

In order to ensure that the model produces accurate projections in spite of the simplifications, it was compared with a more complex model. Comparison runs were made between the RAPID model and a version of the GE TEMPO model that includes separate male and female projections, age-specific survival rates taken from country data and specified for males and females, and varying age-specific fertility schedules. Runs were made for Senegal, using identical input data for 1976 in both models. Projections were made over a 50-year period, assuming minor and major changes in the fertility rate. Comparisons of the results were made for total population, births, crude birth and death rates, urban population and labor force. In no case did the two projections differ by more than 3 percent after 50 years. This is well within the accuracy required for the RAPID project.

Demographic Equations

Births

The number of births occurring during any five-year period is determined by the total fertility rate, the distribution of fertility by age, and the number of females of fertile age.

$$BIRTHS_t = \sum_{AGE = 15-19}^{40-44} TFR_t \times \%BIRTHS_{AGE} \times \frac{(POP_{AGE,t} + POP_{AGE,t-5})}{2} \times \%FEMALE$$

Where:

$BIRTHS_t$ = Number of births from time t-5 to t.

TFR_t = Total fertility rate at time t

$\%BIRTH_{AGE}$ = The percentage of total lifetime births that occur during the five-year period specified by AGE

$POP_{AGE,t}$ = Population of five-year age cohort, AGE, at time t

%FEMALE = The percentage of the population aged 15-44 that is female

This equation calculates total births by summing the births occurring to females in each of the five-year age cohorts between 15-19 and 40-44. The total fertility rate is multiplied by the percentage of births occurring during a woman's lifetime which occur during a particular five-year period, the average population for the specified cohort, and the percentage of the population aged 15-44 that is female.

Ages 0-4

The size of the 0-4 age group is increased by births and decreased by deaths occurring during the first five years of life.

$$POP_{0-4,t} = BIRTHS_t - BIRTHS_t \times (DEATHRATE_{0-4,t} + DEATHRATE_{0-4,t-5}) /2$$

Where:

$POP_{0-4,t}$ = Population aged 0-4

$BIRTHS_t$ = Number of births occurring during the five-year period, t-5, to t

$DEATHRATE_{0-4,t}$ = The mortality rate for the first age cohort at time t

Ages 5-74

The population aged 5-74 is divided into 15 five-year cohorts, from ages 5-9 to ages 70-74. The size of each age group at any time is determined from the size of the preceding cohort (five years younger) and the percentage of that cohort that survives during the five-year period it takes to age into the next cohort. Thus, each cohort is traced as it ages with the passage of time and as some of its members die.

$$POP_{AGE,t} = POP_{AGE-5,t-5} \times SURVIVAL\ RATE_{AGE,t}$$

$$SURVIVAL\ RATE_{AGE,t} = 1 - \frac{(DEATHRATE_{AGE,t} + DEATHRATE_{AGE,t-5})}{2}$$

Where:

$POP_{AGE,t}$ = Population in AGE cohort at time t

$SURVIVAL\ RATE_{AGE,t}$ = Percentage of the population in cohort AGE-5 surviving to the next age cohort

$DEATHRATE_{AGE,t}$ = The mortality rate, the percentage of the cohort that will not survive to the next cohort

The mortality rates are determined from the Coale-Demany West model life table corresponding to the given life expectancy.

Ages 75 and Over

The size of the final age cohort, ages 75 and over, is determined by the number of people surviving from the 70-74 cohort and the number of surviving people over 75.

$$POP_{75+,t} = POP_{70-74,t} \times SURVIVAL\ RATE_{70-74,t} + POP_{75+,t} \times SURVIVAL\ RATE_{75+,t}$$

Where:

$POP_{75+,t}$ = Population aged 75 and over at time t

$POP_{70-74,t}$ = Population aged 70-74 at time t

$SURVIVAL\ RATE_{AGE,t}$ = The percentage of the population in AGE cohort surviving from time t-5 to time t

Dependency Ratio

The dependency ratio is the ratio of the population ages 0-14 and 65 and over to the population aged 15-64.

$$DEPENDENCY_t = \frac{\sum_{AGE = 0-4}^{10-14} POP_{AGE,t} + \sum_{AGE = 65-79}^{75+} POP_{AGE,t}}{\sum_{AGE = 15-19}^{60-64} POP_{AGE,t}}$$

Where:

$DEPENDENCY_t$ = Dependency ratio

$POP_{AGE,t}$ = Population in cohort AGE

Child Dependency Ratio

The child dependency ratio is the ratio of the child population (ages 0-14) to the working-age population (ages 15-64).

$$CHILD\text{-}DEP_t = \frac{\sum_{AGE = 0-4}^{10-14} POP_{AGE,t}}{\sum_{AGE = 15-19}^{60-64} POP_{AGE,t}}$$

Where:

$CHILD\text{-}DEP_t$ = Child dependency ratio

$POP_{AGE,t}$ = Population in cohort AGE

Urban Population

The urban population is calculated from the natural growth of the urban population plus the number of people migrating from rural to urban areas.

$$URBAN_t = URBAN_{t-5} \times \frac{POP_t}{POP_{t-5}} + 5 \times MIGRATION\ RATE_t \times RURAL_{t-2\ 1/2}$$

$$RURAL_{t-2\ 1/2} = RURAL_{t-5} \times \left(\frac{POP_t}{POP_{t-5}}\right)^{1/2}$$

Where:

$URBAN_t$ = The size of the urban population at time t

POP_t = The size of the total population at time t

$RURAL_t$ = The size of the rural population at time t

$MIGRATION\ RATE_t$ = The percentage of the rural population that migrates to urban area each year at time t

The first equation calculates the size of the urban population without migration by assuming that the rate of natural increase is the same as for the total population. The migration from rural areas over the five-year period is then determined by multiplying the migration rate by the average rural population over the period. The average rural population is determined by multiplying the size of the rural population at the beginning of the period by the growth of the total population from the beginning of the period to the middle of the period.

Education

The education sector projects the number of students of primary and secondary school age as well as the number enrolled in primary and secondary school.

Primary School

The number of children of primary school age is simply the population aged 5-14 multiplied by the percent of that age group that is considered to be of primary school age.

$$CPSA_t = POP_{5-14,t} \times POPA$$

Where:

CPSA = Children of primary school age

$POP_{5-14,t}$ = Population aged 5-14 at time t

POPA = Percent of population 5-14 that is considered to be of primary school age

Enrollment in primary school is equal to the number of children of primary school age multiplied by the enrollment rate for primary school.

$$PRIMEN_t = CPSA_t \times PER_t$$

Where:

PRIMEN = Primary school enrollment
CPSA = Children of primary school age
PER = Primary enrollment rate

Secondary School

Similarly, the number of children of secondary school age and enrollment in secondary school are calculated in a similar manner.

$$CSSA_t = POP_{10-19,t} \times POSA$$

$$SECEN_t = CSSA_t \times SER_t$$

Where:

CSSA = Children of secondary school age

$POP_{10-19,t}$ = Population aged 10-19 at time t

POSA = Percent of population 10-19 considered to be of secondary school age
SECEN = Secondary school enrollment
SER = Secondary school enrollment rate

Health

The health sector is used to project three variables: the number of doctors required to attain a given ratio of people per doctor, the number of hospital beds required to attain a given people-per-hospital-bed ratio and the size of one of the groups at highest health risk, mothers and children under the age of five.

Doctors and Hospital Beds

The number of doctors required to attain a given coverage is found by dividing the total population by the number of people per doctor. Similarly, the number of hospital beds required to attain a given coverage is found by dividing the total population by the number of people per hospital bed.

$$DR_t = POP_t \quad / \; POP\text{-}DR_t$$

$$HB_t = POP_t \quad / \; POP\text{-}HT_t$$

Where:

DR = Number of doctors required
HB = Number of hospital beds required
POP = Total population
POP-DR = Number of people per doctor
POP-HB = Number of people per hospital bed

High Health Risk Population

The high health risk population of mothers and children under 5 is approximated by females between the ages of 15 and 44 and children under the age of 5.

$$HRISK_t = POP_{0-4,t} + POP_{15-44,t} \times \%FEMALE$$

Where:

HRISK = Population at high health risk
$POP_{0-4,t}$ = Population aged 0-4 at time t
$POP_{15-44,t}$ = Population aged 15-44 at time t
%FEMALE = Percentage of population aged 15-44 that is female

Housing

Households

The housing sector calculates the number of households, the number of households requiring new housing and the average household size. The calculation of the number of households is based on the fact that most households are headed by males or females between the ages of 20 and 64. Thus the program determines the number of people in this age group and divides by two as a first estimate of the number of households. This first approximation is then adjusted to yield the final household figure. The adjustment factor is found by dividing the actual number of households in the base year by one-half the number of people between 20 and 64 in the base year. Thus the adjustment factor adjusts the number of households for the prevalence in a particular country of families headed by a single adult, extended families, families formed by people under the age of 20, etc.

$$HH_t = HHAF \times \sum_{20-24}^{60-64} 1/2 \times POP_{AGE,t}$$

$$HHAF = HH_1 \Big/ \sum_{AGE = 20-24}^{60-64} 1/2 \times POP_{AGE,1}$$

Where:

HH = Number of households
$HHAF$ = Household adjustment factor
$POP_{AGE,t}$ = Population of age AGE at time t
$POP_{AGE,1}$ = Population of age AGE in the base year
HH_1 = Number of households in the base year

New Housing Requirements

The number of households requiring new housing each year is found by adding the average annual growth in the number of households to the number of housing units that must be replaced each year (assumed to be 2 percent of the housing stock).

$$NHUR_t = ((HH_{t+5} / HH_{t-5}) \wedge .1 - 1) \times HH_t + HH_{t-5} \times 0.02$$

Where:

$NHUR_t$ = New housing units required at time t
HH_t = Number of households

Household Size

The average household size is determined by dividing the total population by the number of households.

$$AHHS_t = POP_t \ / \ HH_t$$

Where:

AHSS = Average household size
POP = Total population
HH = Number of households

Agriculture and Nutrition

The agriculture and nutrition sector determines the number of people per hectare of arable land, the total calorie requirements of the population, the supply of calories and the ratio of calorie supply to requirements.

People per Hectare of Arable Land

The number of people per hectare of arable land is simply the total population divided by the number of hectares of arable land.

$$PPH_t = POP_t \ / \ ARABLE_t$$

Where:

PPH = Number of people per hectare of arable land
POP = Total population
ARABLE = Number of hectares of arable land

Calorie Requirements

The determination of the number of calories required is based on the recommended number of kilocalories per person for the particular country being studied and the age-specific requirements of the rest of the population relative to the reference requirements. The reference requirements are the number of kilocalories required by a person aged 20-39 in the particular country. Kilocalorie requirements for all other age groups are determined as a fixed fraction of the reference requirements, except that per capita requirements for the ages 0-12 are assumed to be the same for each country. These requirements are given below:

AGE	KILOCALORIE REQUIREMENTS*
0-4	1400
5-9	2066
10-12	2475
13-14	60% of reference
15-19	104% of reference
20-39	100% of reference
40-49	95% of reference
50-59	90% of reference
60-69	80% of reference
70+	70% of reference

Total kilocalorie requirements are found by summing the products of the requirements for each age group and the number of people in that age group.

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*Energy and Protein Requirements, Report of Joint FAO/WHO Ad Hoc Expert Committee, FAO Nutrition Meetings Report Series, No. 52, WHO Technical Report Series No. 522, World Health Organization, Geneva, 1973.

$$KR_t = \sum_{0-4}^{75+} POP_{AGE,t} \times REQ_{AGE}$$

Where:

KR = Total kilocalorie requirements
$POP_{AGE,t}$ = Population of age AGE at time t
REQ_{AGE} = Kilocalorie requirements for age group AGE

Calorie Supply

The supply of kilocalories is approximated from the supply in the base year and the average growth in supply.

$$KS_t = KS_1 \times (1 + KSGR)^t$$

Where:

KS_t = Kilocalorie supply in year t
KS_1 = Kilocalorie supply in the base year
KSGR = Growth rate in supply

Ratio of Requirements to Supply

The ratio of requirements to supply is also calculated.

$$KRSR_t = KR_t \ / \ KS_t$$

Where:

KSRS = Kilocalorie requirements to supply ratio
KR = Kilocalorie requirements
KS = Kilocalorie supply

III. COUNTRY DATA FOR THE RAPID SOCIOECONOMIC MODEL

The form included at the end of this section is the data load sheet for the RAPID model. Most of the items on the sheet must be filled in before the data can be entered into the computer. A few items will be calculated by the data base program. If any item cannot be completed, a zero should be entered for that item to ensure that all items are interpreted correctly. Sources should be noted in the appropriate column of the load sheet. All data should be for the base year unless otherwise noted. Likely sources of data that can be used in the absence of specific country reports are noted below.

Data Sources

1. UN Demographic Yearbook, UN.
2. Selected World Demographic Indicators to 2000, UN, Population Division, and World Population Trends and Prospects by Country 1950-2000: Summary Report of the 1978 Assessment, UN, Population Division, 1979.
3. Population Projections by Age and Sex, 1950-2000, UN, Population Division.
4. World Development Indicators, World Bank.
5. World Bank Atlas, World Bank.
6. World Tables 1976, World Bank.
7. Yearbook of National Account Statistics, UN.
8. World Debt Tables, World Bank.
9. IMF Financial Statistics, IMF.
10. World Housing Survey 1974, UN, 1976.
11. The Fourth World Food Survey, UN, FAO, Rome, 1977.
12. World Fertility Patterns, A.I.D.
13. UNESCO Yearbook, UNESCO.
14. FAO Production Yearbook, FAO.

Demographic Data

Base Year. The year to which all subsequent data refer.

0. Total population five years before the base year (Source: 1).

1-16. Population by five-year cohorts for the base year. These items should sum to total population (Sources: 1, 2).

17. Total in the base year population (Source: 1).

18. Total fertility rate (Sources: 1, 2, 4).

19-24. The percentage of average lifetime births that occur during each of the age cohorts from 15-19 to 40+ (Source: 12).

25. The percent of the population 15-44 that is female (Source: 3).

26. Life expectancy (Source: 4).

27. Urban population (Sources: 1, 2).

28. Percent of rural population migrating to urban areas each year. (Source 2—this source gives the percentage of the population in urban area each year—however, the migration rate can be calculated. First calculate the average annual growth rate of the total population for 1975 to 1980. Then calculate the annual rate of growth of the urban population for the same period. Multiply the 1975 urban population by the difference between the urban population growth and the total population growth rate. Divide this number by the 1975 rural population.) Source 4, which gives the average annual growth rates of the total and urban population can also be used.

Economic Data

All economic data should be expressed in base year U.S. dollars unless otherwise specified.

29. GDP (Sources: 4, 5, 6, 9).

30. Value of capital stock in the base year. This can be estimated by multiplying GDP by the incremental capital-output ratio (ICOR). The ICOR can be found in Source 6, or calculated from Source 7. To calculate ICOR, continuous data are required on gross fixed capital formation in constant currency.

$$\text{ICOR} = \frac{\sum_{t=t_1}^{t_2} \text{Gross fixed capital formation}_t}{\text{GDP}_{t_2+1} - \text{GDP}_{t_1}}$$

The sum of gross fixed capital investment divided by the growth in GDP yields an estimate of the ICOR.

31. Total private and government consumption in the base year. (Sources: 6, 7). This should be based on an average rate of consumption for several years rather than just the figure in the base year. Calculate the average of consumption as a percent of GDP for several years and multiply this figure by GDP in the base year.

32-49. These items are not used.

50. The labor force participation rate of the population aged 15-64. The data base program will calculate this number.

51. Size of the labor force (Source: 4).

52. Employment. The best source is generally country reports. The ILO Handbook of Labor Statistics may help.

53. Employment constant. This figure represents the historical ratio of the growth in employment to the growth of capital stock. The historical increase in capital stock can be estimated by dividing gross fixed capital formation minus the consumption of fixed capital by the product of GDP and ICOR (Source: 7). The average annual increase in employment will normally have to be found in country specific sources. However, if the unemployment rate has not changed significantly, the average increase in labor force (Source: 4) can be used.

54. External public debt (Sources: 4, 8).

55. Average annual principal payments as a percent of total external debt (Sources: 4, 8).

56. Average annual interest payments as a percent of total external debt (Sources: 4, 8).

57. Average annual foreign loans received as a percent of GNP (Sources: 4, 8).

58. Average annual foreign grants received as a percent of GDP (Sources: 4, 8).

59. Rate of technical progress. Total output is calculated using a Cobb-Douglas production function.

$$GNP = A \times (1 + RTP)^{t} \times K^{a} \times E^{b}$$

Where:

A = Constant term
RTP = Annual rate of technical progress

t = Time
E = Employment
K = Capital stock
a,b = Elasticities of output with respect to capital and employment

The rate of technical progress can be calculated as follows:

RTP = Annual growth rate of GNP -
b x (annual growth rate of employment) -
a x (annual growth rate of capital stock)

60. Elasticity of output with respect to capital. If no information is available, it can be estimated as 1.0 minus b (the elasticity of output with respect to employment).

61. Elasticity of output with respect to employment. If no country data are available, the elasticity may be estimated by calculating the share of income that is paid to labor. This may be estimated by dividing compensation of employees plus 1/3 of operating surplus by national income (Source: 7) and averaging the result over a number of years.

62. Production function constant. Calculated by the data base program.

63. Capital depreciation rate. This can be estimated by dividing consumption of fixed capital by the product of GDP and ICOR (Source: 7) and averaging the result over several years.

64. Exchange rate in units of local currency per U.S. dollar (Source: 9).

76. Local currency unit. The name of the local currency unit (Source: 9).

Education Data

65. The percentage of the population aged 5 to 14 that is considered to be of primary school age (Sources: 7, 13).

66. The percentage of the population aged 10 to 19 that is considered to be of primary school age (Sources: 7, 13).

67. The primary school enrollment rate (Sources: 4, 7, 13).

68. The secondary school enrollment rate (Sources: 4, 7, 13).

Health Data

69. People per physician (Source: 4).

70. People per hospital bed (Sources: 4, 7).

Housing Data

71. Average household size (Source: 10).

Nutrition and Agriculture Data

72. Kilocalories required per reference person. Calculated by the data base program from the average kilocalorie requirement (Source: 11).

73. Food supply in kilocalories. The product of per capita supply and population (Source: 11).

74. Food supply growth rate (Source: 11).

75. Arable land in hectares (Source: 14).

These data are entered into the RAPID data through the use of the data base program. To use this program, first set up the computer in accordance with the operating instructions for the RAPID model. At Step 8, place the data base disk in the disk drive instead of the RAPID model disk (if they are different). Simply follow the instructions that appear on the screen at the conclusion of Step 8. This program allows the user to enter new data, change data and display or print the data for a particular country.

DATA LOAD SHEET

FOR THE RAPID MODEL

COUNTRY: BASE YEAR:

DEMOGRAPHIC DATA	SOURCE
0. Population 5 years before base year	
Population by Age	
1. 0-4	
2. 5-9	
3. 10-14	
4. 15-19	
5. 20-24	
6. 25-29	
7. 30-34	
8. 35-39	
9. 40-44	
10. 45-49	
11. 50-54	
12. 55-59	
13. 60-64	
14. 65-69	
15. 70-74	
16. 75+	
17. Total population (base year)	
18. Total fertility	
Fertility Age Distribution (%)	
19. 15-19	
20. 20-24	
21. 25-29	
22. 30-34	
23. 35-39	
24. 40-44	
25. Percent of 15-44 age group that is female	
26. Life expectancy	
27. Urban population	
28. Percent of rural population migrating to urban areas each year	

COUNTRY:

ECONOMIC DATA	SOURCE
29. GNP	
30. Capital stock	
31. Consumption	
50. Labor force participation rate	
51. Labor force size	
52. Employment	
53. Employment constant (E)	
54. External public debt	
55. Debt service (principal payments, % of debt)	
56. Debt interest payments (% of debt) debt)	
57. Aid inflow as % of GNP	
58. Foreign grants a % of GNP	
59. Rate of technical progress	
60. Capital elasticity	
61. Labor elasticity	
62. Production function constant	
63. Capital depreciation rate (% of capital stock)	
64. Exchange rate— currency units per $ in base year	

COUNTRY:	SOURCE
EDUCATION DATA	
65. Percent 5-14 year olds of primary school age	
66. Percent of 10-19 year olds of secondary school age	
67. Primary enrollment rate	
68. Secondary enrollment rate	
HEALTH DATA	
69. Number of people per physician	
70. Number of people per hospital bed	
HOUSING DATA	
71. Average household size	
NUTRITION AND AGRICULTURE DATA	
72. Kilocalories required per person 20-39	
73. Food supply (kilocalories)	
74. Growth rate of food supply (%/year)	
75. Arable land	
76. Local currency unit	

IV. OPERATION OF THE RAPID MODEL ON THE APPLE II COMPUTER

In order to use the RAPID model on the Apple II computer, an Apple II with 48k RAM and Applesoft BASIC are required.

Setting Up the Apple II Computer

1. The Apple II computer requires 110 VAC. If only 220 VAC is available, a 220/110 step-down transformer must be used.

2. The Apple has a three-pronged power cord that plugs into the back of the Apple (next to the on/off switch) on one end and into an electrical outlet or the transformer on the other end. A grounded (three-hole) electrical outlet should be used. If a grounded outlet is not available, the Apple should be grounded. This can be accomplished by first loosening one of the four screws on the bottom of the Apple that hold the power supply in place. Wrap the stripped end of an insulated wire around the screw and retighten the screw. Wrap the other stripped end of the wire around a good ground, such as a water pipe.

3. The Apple displays output on a color TV set. A black and white set may also be used, but, of course, the output will be only black and white.

   The American Apple can use any American standard television receiver or monitor. If a monitor is available, the black cable with large connectors on either end is used. The smaller of the two connectors plugs in the receptor labeled "video out" located on the rear panel of the computer. The other end connects to the "video in" receptor on the television.

   If a television receiver is used, the black video cable with the switch box on one end is required. The leads from the box attach to the UHF antenna terminals of the television. The other end of the cable plugs into a receptor inside the computer. In order to open the computer, lift straight up on the sides of the top at the rear of the computer. The sides should snap open, allowing the top to be removed.

* * *

WARNING - Do not remove the top while the computer is on. Be sure to turn the computer off before removing the top.

* * *

The other end of the video cable attaches to the upper receptor on the video card attached to the right side of the computer case. The television should be turned on and tuned to UHF Channel 33.

If a European Apple is used, a European PAL television receiver or monitor is required. In this case, the video card is plugged into the right-most slot at the rear of the computer. The video cable should be attached to the upper receptor on this card.

4. The Apple can be used with either disk or cassette tape for input and output. If the disk is used, the disk controller card (attached to the disk unit) should be plugged into slot 6 at the rear of the computer.

* * *

WARNING - Do not perform this operation when the computer is on. It may cause severe damage.

* * *

If a cassette tape recorder is used, the recorder connects to the Apple through the cassette interface cable. One end of the cable has plugs labeled IN and OUT and the other end has plugs labeled MIC and EAR/MON. The IN and OUT plugs should be connected to the CASSETTE IN and OUT jacks at the back of the Apple. The MIC and EAR/MON plugs connect to the corresponding jacks on the cassette recorder.

5. The Apple is turned on by moving the ON/OFF switch at the back of the Apple to the "ON" position. The power light on the keyboard will light up when the computer is receiving power. (If the Apple Plus model is being used with disk, be sure the RAPID MODEL disk is in the disk drive before turning the computer on.)

6. At this point, the TV screen should be filled with random characters. If it is not, adjust the tuning of the television. (If a new model Apple Plus is being used, the screen will display the header APPLE II. If a disk is attached, the disk will be immediately loaded. In this case, simply follow the instructions on the screen to run the model).

Loading the RAPID Program

7. Press the RESET key located in the upper right-hand corner of the keyboard. The bottom of the display should now show an asterisk and a flashing cursor.

If the disk is being used, follow Step 8, then skip the rest of this section. For cassette tape operation, skip to Step 9.

NOTE: The data for the country being studied must already be on disk or tape before proceeding beyond this point. If they are not, see the section on COUNTRY DATA FOR THE RAPID SOCIOECONOMIC MODEL.

Disk Loading

8. Place the RAPID MODEL diskette in the disk unit (with the label facing upwards and toward the front of the disk drive) and close the disk door. Then type 6[CTRL]P (RETURN). This is accomplished by pressing the 6 key, then pressing the P key while holding down the key marked CTRL and finally pressing the key marked RETURN. Now follow the instructions shown on the screen.

Cassette Loading

9. Put the tape into the cassette recorder and rewind it to the beginning of the tape. Press the button next to the digital counter on the recorder. This should set the counter to 000. Now use the FAST FORWARD button on the recorder to move the tape to number 005 or whatever beginning number is marked on the tape. This is the location of the first program to be loaded. Set the volume control to the upper middle range of the recorder, 6, if the volume scale is 0-10.

10. Enter the following command into the computer:

[CTRL] B	Entered by holding down the CTRL key and pressing the B key. Then release both keys and press the RETURN key.

The computer will respond with a bracket,]. Now enter the command

LOAD

but do not hit the RETURN key yet. Start the tape recorder by pressing the PLAY button and immediately press the RETURN button on the computer keyboard.

The first program should now be loading. The blinking cursor will disappear while the program loads. Once loading is completed, the Apple will beep and a new bracket will appear, followed by the blinking cursor. When this happens, stop the tape recorder.

11. If the program does not load, press the RESET button and try again from Step 9 with a different volume setting on the recorder.

12. If the program loads successfully, the second program can then be loaded. First press the RESET key. The computer will beep and an

asterisk will appear. Now set the recorder to the correct position for the second program. Enter the command

1800.1AE9R

but do not press the RETURN key yet. Start the tape recorder by pressing the PLAY button and immediately press the RETURN key on the computer keyboard.

13. The second program should now be loading. The blinking cursor will disappear while the program loads:

    Once the loading is completed, the Apple will beep and the cursor will appear again. When this happens, stop the recorder.

14. Now type the following command:

[CTRL] C	Entered by holding down the CTRL key and pressing the C key. Then release both keys and press the return key.

15. The program is now ready to run. Start the program by entering RUN and pressing RETURN.

Using the Program

17. The questions that appear on the screen should be self-explanatory. Remember to press the RETURN key after each response. All YES or NO questions should be answered with a Y or N.

18. If you make a typing error and realize it before you have pressed the RETURN key, you can correct it by using the arrow keys. The left pointing arrow will move the cursor backwards. It can be used to move the cursor back to the mistake. Type in the correct character and enter the rest of the line by retyping it or by using the right pointing arrow to move the cursor to the end of the line.

19. The program can be halted at any point by entering [CTRL] C and pressing the RETURN key. It can be restarted at the main option table by entering GOTO 2500. If a program error occurs, it may be possible to recover by using the GOTO 2500 command also.

20. Once the work is finished on one country, you must return to Step 7 in order to begin projections for a second country.

Economic Projections

Labor Force

The economic sector of the model is designed to show the effects of population growth on the labor force and on the growth of the economy. The size of the labor force is projected simply by assuming that a constant percentage of the population between the ages of 15 and 64 will be in the labor force at any time. Thus, to find the size of the labor force for any year the size of the population aged 15-64 is multiplied by the participation rate for this group in the base year.

In reality the participation rate for the population will change as a country modernizes. In order to understand the effects of using the simplifying assumption of constant participation rates some of the factors that affect the participation rate should be mentioned. As a country modernizes and becomes more urban the participation rate of females is generally seen to rise. This effect is even more pronounced when the birth rate drops. Thus the general model tends to underestimate the size of the female labor force for reduced fertility projections. (This effect can be taken into account for individual countries if necessary, as in the case of Jordan, for example.) Of course, the participation of females in the rural labor force is usually underestimated in official statistics so that female participation may not actually be rising with modernization although it appears to do so from the statistics.

A second effect of modernization is to increase the percentage of children in school. This effect will be more pronounced where birth rates are dropping since, if other conditions are equal, it will be easier to attain a high enrollment rate with a smaller school age population. The effect of increased schooling is to decrease the participation of school age children in the labor force. Not only is this effect seen at the primary and secondary level but also at the university level where entry into the labor force is delayed considerably because of schooling. (Although in many developing countries attendance at the university is combined with a full-time job.)

Thus the use of a constant participation rate will tend to underestimate female participation and overestimate participation by the young age groups for a projection involving reduced fertility as compared to a constant fertility projection.

The number of new job requirements each year is calculated by simply determining the increase in the size of the labor force.

GDP and GDP Per Capita

The projections of economic growth, GDP and GDP per capita, are intended to be plausible projections of growth given the conditions of the country. They are not intended to be predictions of actual future growth rates. This distinction is important because in many developing countries economic growth is

heavily dependent on prices for a few key commodities or on weather conditions. The economic projections in this model are designed only to demonstrate the effects of differing rates of population growth on economic growth given the present situation of the country and given assumptions about external aid and the rate of technical progress.

The Cobb-Douglas Production Function

In order to relate the size and rate of growth of the population to economic growth in a simple and straightforward manner a Cobb-Douglas production function is used. This function relates total output to the amount of employed labor, the size of the capital stock, and the level of technical progress. The form of the equation used here is

$$GDP = A \times (1 + RTP)^t \times K^a \times E^b$$

where:
- GDP = gross domestic product
- A = constant
- RTP = the annual rate of technical progress
- t = time
- K = the value of the capital stock
- E = the number of employed persons
- a,b = the elasticity of output with respect to capital and employment

This method of projecting economic growth is used because it is a fairly simple method that is readily understood by presentation audiences. It relates both the size of the labor force and savings to economic growth, and it includes technical progress. Its simplicity makes its use possible for practically any developing country from data that are readily available.

The production function assumes three sources of economic growth: increases in the amount of capital, increases in the size of the employed labor force, and technical progress. The exponents a and b indicate the elasticity of output with respect to capital and labor, respectively. In other words, they indicate the increase in output that will result from a given increase in capital or labor. An elasticity of .3 for capital, for example, indicates that an increase in the capital stock of 1 percent would lead to an increase in output of 0.3 percent.

Since this is a fairly simple model of economic growth it is necessary to discuss briefly how this simplification affects the projection of economic growth under conditions of rapid population growth and slow population growth, and whether or not the model is biased in favor of one or the other. Although there are many limitations to this model, there are four major areas of concern: technical progress, the quality of labor, economies of scale, and resource shifts.

Rate of Technical Progress. The simple Cobb-Douglas equation shown above assumes that technical progress is independent of changes in capital and labor. In fact, as the equation is written, technical progress really refers to anything that contributes to economic growth that is neither an increase in

capital or employment. Certainly this encompasses many forms of technical progress. For example, reorganizing the location of machines within a plant to provide a more efficient use of space and easier access to materials might increase output although the amount of capital and labor would be unaffected. Many sources of progress are embodied in the capital stock, however. A technical advance that results in a faster knitting machine, for example, will not increase output in a plant until that plant buys one of the new machines. In this case the progress is embodied in the capital equipment. For such progress a higher rate of investment will produce a more rapid introduction of new technology and, consequently, an increased rate of technical progress. Since savings, and therefore investment, are likely to be higher with slower population growth, this model underestimates the advantages of reduced population growth in the increasing economic growth.

On the other hand some people have argued that the increasing pressure on resources that accompanies population growth leads to technical progress because of new inventions arising out of necessity. It is not clear to what extent, if any, this mechanism operates in developing countries, but to the extent that it does the model is biased in favor of population growth.

Quality of Labor. Since the model considers only the size of the employed labor force it does not completely account for increases in the quality of labor. A well-educated labor force is likely to produce more than an educated one even if the size of the labor force is the same in both cases. Since the education of the labor force is generally increasing in most developing countries this effect is included in the estimate of the rate of technical progress. However, since a reduction in the rate of population growth is likely to allow a country to educate its population more effectively, the model underestimates the effects of reducing population growth on economic growth through increasing the quality of labor.

Economies of Scale. One argument that is often advanced in favor of population growth is that a larger population leads to economies of scale. Economies of scale result when a product can be produced for less cost when it is produced in large quantities. Examples of industries that have experienced significant economies of scale are electric utilities, steel production and automobile production. In addition to reducing the costs of production a large market may also make it possible to produce some items locally that would not be feasible if the market is too small. For example, very few small developing countries have local automobile manufacturing because their local markets cannot support automobile production at the level required to produce cars at a reasonable cost.

Economies of scale are included in the model through the elasticities of capital and labor and through the technical progress function. If the elasticities of capital and labor, a and b, sum to 1, the model will demonstrate constant return to scale. That is, a 10 percent increase in both capital and labor will produce a 10 percent increase in output. If a and b sum to less than 1, a 10 percent increase in both capital and labor results in an increase in output of greater than 10 percent.

In practice enough information is generally not available to estimate a and b from historical data. In that case it is generally assumed that a and b sum to 1 and give constant returns to scale. If increasing returns to scale exist in a particular economy, the rate of technical progress that is calculated from historical data will be somewhat higher than it otherwise would have been. Thus the estimate of the rate of technical progress will compensate, to a degree, for an incorrect estimate of returns to scale. However, when the model is used to project the effects of different rates of population growth, the same rate of technical progress is used for both projections. Thus, if economies of scale are actually important, the model will underestimate the effect of a larger market on economic growth.

This does not mean, however, that the model is biased in favor of low population growth in this case. The important variable in economies of scale is the size of the market, not the size of the population. A higher population growth rate will produce a larger population than a slower growth rate will, but per capita incomes are likely to be higher when population growth is reduced. Thus, the market for manufactured goods may actually be larger with reduced population growth. Therefore, the ultimate effect of ignoring economies of scale in the economic projections does not clearly bias the results in one direction or the other. It depends on the trade-off between numbers of people, per capita income, and market size.

Resource Shifts. Finally, the question of resource shifts is also ignored in the model. One way of increasing production is to shift resources from less productive activities to more productive ones. The rate of technical progress will reflect this source of growth to the extent that this has happened in the past. If the rate of population growth decreases, however, resources might be freed from social services and housing infrastructure sectors, for use in more productive sectors. If this were the case the model would underestimate the benefits of reduced population growth. Of course, the same resources might be used to improve the coverage or quality of the same services in which case there would be no bias in favor of high population growth.

Capital Stock

In order to use the Cobb-Douglas production function the model must also project the inputs to the equation. The rate of technical progress and the elasticities of output with respect to capital and labor are estimated from historical data and do not change. The size of the capital stock and the employed labor force do change over time, however, and must also be projected. The capital stock increases with investment and decreases by depreciation. The rate of depreciation is estimated from historical data. Investment in new capital is the sum of domestic investment and investment from external sources. External investment funds are made up of external aid and grants flowing into the country minus whatever principal and interest payments must be made on the external debt.

Employment

The growth of employment is determined by the growth in capital and the unemployment level. The percentage increase in the capital stock multiplied by the historical ratio of increase in employment to increases in capital stock represents the preliminary estimate of the increase in employment. This figure is then increased or decreased depending on whether unemployment is high or low. When unemployment is higher than normal, it is assumed that the cost of labor relative to capital will drop so that an increase in capital will generate a higher increase in employment than would be the case if unemployment were low. When unemployment is lower than usual the reverse is the case.

The projections of capital stock and employment are used in the Cobb-Douglas production function to determine Gross Domestic Product. GDP per capita is simply GDP divided by the total population. The economic calculations, like the demographic calculations, are done for five-year intervals.

Economic Equations

Gross Domestic Product Per Capita

$$GDP/cap_t = GDP_t / POP_t$$

where:
- GDP/cap = gross domestic product per capita
- GDP = gross domestic product
- POP = total population

Gross Domestic Product

$$GDP_t = A \times (1 + RTP)^t \times K_t^a \times E_t^b$$

where:
- GDP = gross domestic product
- A = constant
- RTP = rate of technical progress
- t = time
- K = capital stock
- E = number of employed persons
- a,b = elasticities of output with respect to capital and labor

Employment

Employment is equal to employment during the previous period multiplied by the percent change in the value of the capital stock and the ratio of increases in employment to increases in capital stock.

$$E_t = E_{t-5} \times (1 + AECR_t \times \frac{(K_t - K_{t-5})}{K_{t-5}})$$

where:
- E = number of employed persons
- AECR = adjusted employment-capital change ratio
- K = value of the capital stock

The adjusted employment-capital ratio is calculated from the historical ratio and the rate of unemployment compared with unemployment in the base period.

$$AECR_t = HECR \times (1 - E_{t-5} / LF_{t-5}) / (1 - E_1 / LF_1)$$

where:
- AECR = adjusted employment-capital ratio
- HECR = historical employment-capital ratio
- E = number of employed persons
- LF = size of the labor force

Labor Force

The size of the labor force is the participation rate multiplied by the population aged 15 to 64.

$$LF_t = PR \times \sum_{AGE=15-19}^{60-65} POP_{AGE,t}$$

where: LF = labor force
$POP_{AGE,t}$ = population of age AGE at time t
PR = participation rate of population aged 15-64

New Job Requirements

New job requirements are the annual growth in the labor force. These are calculated by multiplying the average annual growth of the labor force by the size of the labor force in the year of interest.

$$NJR_t = LF_t \times ((LF_{t+5}/LF_{t-5})^{1/10} - 1)$$

where: NJR_t = new job requirements
LF_t = labor force

Capital Stock

The size of the capital stock is increased by investment and decreased by depreciation.

$$K_t = K_{t-5} + (INV_t - DEP_t) \times 5$$

$$DEP_t = K_{t-5} \times DEPR$$

where: K = value of the capital stock
INV = investment
DEP = depreciation of the capital stock
$DEPR$ = percentage of capital stock depreciating each year

Investment

Investment is derived from domestic savings (gross domestic product minus consumption) and net external aid and grants (new aid and grants minus repayments of principal and interest payments).

$$INV_t = GDP_{t-5} - CON_{t-5} + LOANS_t + GRANTS_t - INT_t - PP_t$$

where:

INV = investment
GDP = gross domestic product
CON = consumption
LOANS = aid loans from external sources
GRANTS = aid grants from external sources
INT = interest payments on debt
PP = principal payments on debt

External Debt

Loans and grants are assumed to be a constant percentage of GDP. Interest and principal payments are a constant percentage of total external debt. External debt is increased by new loans and decreased by principal repayments.

$$DEBT_t = DEBT_{t-5} + (LOANS_t - PP_t) \times 5$$
$$LOANS_t = LP \times GDP_{t-1}$$
$$GRANTS_t = GP \times GDP_{t-1}$$
$$INT_t = IP \times DEBT_{t-1}$$
$$PP_t = PRP \times DEBT_{t-1}$$

where:

DEBT = total external debt
LOANS = external loans flowing into the country
GRANTS = external grants flowing into the country
INT = interest payment on external debt
PP = principal payments on debt
LP = percent of GDP received as loans each year
GP = percent of GDP received as grants each year
IP = percent of debt that must be repayed due to interest charges
PRP = percent of debt that must be repayed due to principal repayments

Consumption

Consumption is calculated as a function of GDP per capita. A regression equation is used to make an initial determination of consumption. Since the equation is based on data from over 100 countries the results may not exactly match actual consumption in the base year. Therefore the results of the regression equation are adjusted by the ratio of actual consumption in the base year to the predicted consumption in that year.

$$CONS_t = (85.63 - .00228 * GDP/cap_t) * CONS_1/(85.63 - .00228 \times GDP/cap_1)$$

where:

$CONS_1$ = consumption in the base year

$CONS_t$ = consumption

GDP/cap_t = GDP per capita

GDP/cap_1 = GDP per capita in the base year