TOWARDS A COMPUTERIZED DEMOGRAPHIC MICROSIMULATION MODEL FOR EGYPT : EXPERIMENTATION OF POPSIM.* (PART 1)

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INTRODUCTION

Developing countries are characterized demographically by low mortality, high fertility, and rapid growth. It is not possible to examine the behavior of their populations in the second phase through an analysis of longitudinal or historical data. One of the alternatives is to employ a simulation approach. Through which We are able to study many expected and non-experimental changes that may take place in the future.

Our concern is the population of Egypt which has increased steadily from about 10 to 30 millions in a period of 70 years (1897—1966). The rate of annual increase has also increased greatly, especially starting in the year 1947. Projections of the future estimates assert that the population will jump to about 40, 45, and 52 million in the years 1975, 1980, and 1985, respectively. This means that the population will almost double every 25 years. Fertility then must decline or population increase will put an excessive burden on all modernization plans. Continuing decline in mortality makes fertility decline even more imperative in the short as well as the long run.

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Our main objective is to develope a computerizea demographic micro-simulation model for Egypt. The reasons for developing such a model can be summarized as follows :

1. To carry out experimental work in those situations where we are denied real life experience.

2. To evaluate a hypothetical structure by building it into a model and testing if the model reacts like the real life it is imitating.

3. To obtain rapid generation, in an experimental way, the relationship between the controllable variables and uncontrollable variables, from a model derived from formal analytical relationships.

In sum, ,the model is intended as a tool for investigation and study of the effects of various forces acting on the Egyptian population.

The present report is a preliminary experimental note that summarizes our efforts for the past three months (a progress report). We decided to approach the problem in successive phasses of stages in two directions that can be joined in a later stage. These are :

1. Developing a micro-model for human reproduction for Egypt.

2. Modifying POPSIM to be applicable to Egypt.

The present report is concerning the second point. We summarize here the first two finished stages. These are :

1. Modifying POPSIM's original program to put it into an executable state; to be compatible with the ICL 1905 E Computer.

2. Preparing the INPUT data from different Egyptian sources and to put them in the required form. All estimation and approximation methods used are shown later in this report.

The results using the POPSIM modified program with Egyptian data are shown at the end of this report.

Our future plans will include several stages. We plan to modify POPSIM to be applicable to Egyptian conditions. This can be done by modifying each subroutine separately and examining mathematical distributions and the resulting parameters. We plan to use more accurate and dependable data. In addition we will include the family planning module. Later, we wish to incorporate our model for human reproduction with POPSIM.

DEVELOPING A MODEL FOR EGYPT

A variety of demographic microsimulation models have been developed in recent years, stemming from the work of Orcutt et. al. (1961) who constructed a stochastic population model as a component of a model of the U. S. economy. There are many others, Ridley and Sheps (1966), Barrett (1967), Hyrenius and Adolfsson (1946), and POPSIM that was developed jointly be the Research Triangle Institute and the Department of Biostatistics of the University of North Carolina, U.S.A.

It was decided that the proposed model to be used for Egypt should be characterized by the following features :

1. A micro-model, that generates vital events and histories for each individual in the computerized population. Macro-models consider a group of individuals having the same state at the beginning of a period and simulate how many of these will be in the different possible states at the end of a period.

2. A stochastic, not a deterministic model, where the probabilities of occurence of a vital event will depend on many characteristics (age, sex, marital status, and parity) of an individual. In fact, the stochastic aspect reflects the appropriate variation between clusters but it is deterministic regarding the within-clusters variablility.

3. A dynamic model, that allows the different sets of probabilities to change over time. A static model would actually be useless to be applied on Egypt.

4. A model that would allow us to study, in addition, the relative importance of various demographic and biological factors on natality. (This is a mean feature of REPSIM developed by Ridley and Sheps (1966)).

POPSIM satisfies the first three features. In addition, it is a two-sex model and may be used for simulating both cohort and period data. It is also self-adapting since feedback mechanisms can be incoporated into the model. But POPSIM as a mathematical model does not give enough attention to the biological aspects of natality. That is the reason we develop a mode for human reproduction paralleling our work in the present model. We intend to incorporate both models in a later stage.

There are two operating models of POPSIM at present. The closed population model requires that all marriages take place between individual members of the computer population and histories are carried in the computer as family unit. This means that the initial set of marriage partners and all offspring are also members of the computer population. The second POPSIM version is called the open model and its computer population is considered to be a random sample of indivduals selected from the total population of ivdividuals. This means that no regard is given to familial relationships.

We have confined ourselves to the open model. The open model consist of three main phases.

1. Generation of initial population.
2. Generation of vital events over time, and
3. Tabulations over time of the number of events and of the total population by age, sex, marital status, and other characteristics.

EXPERIMENTING POPSIM

The development of POPSIM was decided to be carried out into 4 phases as follows :

1. Modifying POPSIM'S orignal computer program to put it into an executable state to be compatible with the ICL 1905 E computation Center, Cairo University.
2. Preparing the input data from different Egyptian sources and to put them in the required form.
3. Making POPSIM applicable to Egyptian conditions by modifing each subroutine separately and examining mathematical distributions and the resulting parameters.

4. Evalauting and correcting the Egyptian data used as input data to the model and trying to fill the gaps in it by depending on data available from a national sample now taken place or by deparated research or by field surveys if it is necessary. This stage may be carried out parallel to the 3rd stage.

The first two phases mentioned above have been completed, and following is a brief description of these pheses.

(A) *Modifying POPSIM'S original computer program :*

The demographic micro-simulation model POPSIM consists of two distinct sections :

(1) A section which constructs sample populations with specified characteristics.

(2) A section which advances these sample population over time.

The computer programs were designed in such a way that a series of sample populations could be created and put on a magnetic tape to be used later as input to the computer program used in advancing the individual sample populations over time. First of all the original program was changed and recoded for use on ICL 1905 E computer instead of IRM 360/50 one. Then some changes were done in some subroutines and functions of the program to be put in an executable state. For example, the FUNCTION FPMCRV supplied by ICL soft ware library was used to generate uniformly random numbers distributed over the interval (0,1) instead of the FUNCTION RANDN used by the original program because it is not accepted by our machine as it contains a very large integer constant. In the same time a special function was developed for the same purpose and it was used also.

SUBROUTINE CARD was completed to record the records of each individual.

SUBROUTINE OUT was also completed to print the records on L. P. and also to print the characteristics of each population. The original program instructs the machine to read in the vector of numbers indentifying the sample populations to be processed, the size of sample population is assumed to be 1 indivdual which is not reasonable, so this part was changed to read the size of the initial population and characteristics of each individual, without skipping any data.

Then the program was tested using some hypothetical data for different simulation times.

(B) *Preparing The Input Data :*

From the first moment it is realized that the sucess of such a model for studying population dynamics in Egypt depends heavily upon the avalilability upon the avalilability of relevant input data. For The purposes of our inital purposes, we did depend only on the puplished data and no effort was model to collect more accurate data or to test the accuracy of such data.

This stage concerned with methods of estimations and approvimations employed to develope Matrices of transitional probabilities which used in the transition phase of the simulation.

The required probabilities are as follows :

1. Monthly birth probabilities for females by age, partly and marital status.
2. Monthly marriage probabilities for females by marital status and age.
3. Probabilities for assigning desired marital status to the groom given the marital status of the brids.
4. Monthly deathe probabilities by age, sex and marital status.
5. Monthly divorce probabilities for married couples by duration of marriage.

Most input data required to calculate the above probabilities are either available but not tabulated as needed, or not avaliable.

For example, although the monthly marriage probabilities for program, the first age group in availble data is $\leqslant$ 20, so we divided this age group into the requrid two age groups ($\leqslant$ 17, 18—19) by using a correction factor derived from a sample of 2010 females representative to Cairo Governorate in a fertility research.

In the case of probabilities for assigning desired marital status to the groom given the marital status of the bride, it was impossible to get this particular set of probabilities from already published data for

Egypt, so these probabilities were taken as the probabilities supplied by the program, in the same time there is no reason to expect that there probabilities would be quite different from the Egyptian one.

Calculation of monthly death probobilities by age, sex and marital status requires-as basic data-the distribution of deaths by age, sex, and marital status which are not avalilable for year 1960-our initial year-so we estimate the required data by using the correspondence data for 1962 and then obtain the expected distribution for 1960.

Finally the model was used to simulate the changes of a sample population of size 1000 for ten years and results were reasonable to some extent.

SOME SELECTED TABULATIONS

It seems clear from the above examples that much work remains before this demographic micro-simulation model can be developed which will be useful in the solution of specific population problems.

The following tables represent a summary of the output tabulations of a run of ten years using the model as presented above. An initial population of 1000 has been used.

TABLE (1)

Distribution of Children less than 10 years old by sex and in ten successive years

End of	Age																				Total	Total
year	1		1		2		3		4		5		6		7		8		9		M.	F.
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.		
0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	27	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	27	28
2	25	21	26	25	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	51	46
3	15	21	22	21	26	24	—	—	—	—	—	—	—	—	—	—	—	—	—	—	63	55
4	17	15	14	9	22	20	25	24	—	—	—	—	—	—	—	—	—	—	—	—	78	68
5	17	13	15	13	14	8	22	19	23	23	—	—	—	—	—	—	—	—	—	—	91	86
6	16	15	16	20	13	13	13	8	21	18	22	22	—	—	—	—	—	—	—	—	101	96
7	15	13	15	13	16	19	13	13	12	8	20	18	22	22	—	—	—	—	—	—	113	106
8	14	10	14	13	15	13	15	17	13	12	12	8	20	18	22	22	—	—	—	—	125	113
9	17	13	13	9	14	13	15	13	15	15	13	11	12	8	20	18	22	22	—	—	141	122
10	15	22	14	11	13	9	14	13	14	13	15	15	13	11	12	8	20	18	22	22	153	142

TABLE (2)

Distribution of Males, By Age and Marital status in the initial year and after five and tens years

Age at end of year	Marital status S.	M.	D.	W.	T	Age and end of year	Marital status S.	M.	D.	W.	T
12—9						45—49					
0	—	—	—	—	—	0	2	39	1	—	42
5	91	—	—	—	91	5	2	30	13	2	47
10	153	—	—	—	153	10	2	33	17	2	52
10—24						50—54					
0	76	21	1	—	98	0	—	33	—	2	34
5	79	22	6	—	35	5		2	29	7	—
10	—	—	—	—	—	10	1	24	13	4	4
25—29						55—59					
0	23	37	—	1	61	0	—	23	—	1	2
5	21	29	11	1	6	5	—	23	7		32
10	5	24	6	—	35	10	—	—	—	—	—
30—34						60—64					
0	10	47	1	—	58	0	1	20	—	1	22
5	13	37	9	—	49	5	—	16	4	1	21
10	19	28	11	2	60	14	—	27	6	—	33
10	19	28	11	2	60	10	—	27	6	—	33
35—39						65 +					
0	3	54	—	1	58	0	—	23	—	2	25
5	7	36	14	—	57	5	—	24	6	4	34
10	12	38	8	—	58	10	—	28	6	3	37
40—44											
0		46	—	1	49						
5	3	35	1	1	56						
10	7	3	14	—	56						

TABLE (3)

Distribution of Females by Age and Marital status in the initial year and after five and ten years.

Agc and end of year	Marital status S.	M.	D.	W.	T	Age and end of year	Marital status S.	M.	D.	W.	T
21—9						45—49					
0	—	—	—	—	—	0	1	51	1	3	56
5	86	—	—	—	86	5	—	42	—	6	48
10	142	—	—	—	142	10	—	50	1	4	55
10—24						50—54					
0	54	62	1	1	116	0	—	23	—	14	37
5	—	43	—	—	43	5	—	46	1	8	55
10	—	—	—	—	—	10	—	37	1	9	74
25—29						55—59					
0	6	57	3	1	67	0	—	13	1	21	26
5	—	70	—	—	70	5	—	19	1	14	34
10	—	42	—	—	42	10	—	43	1	10	54
30—34						60—64					
0	2	53	—	3	58	0	—	6	1	16	23
5	—	65	—	—	65	5	—	9	1	14	24
10	—	69	—	1	70	10	—	18	1	15	34
35—39						65 +					
0	—	49	3	4	56	0	—	7	—	26	33
5	—	54	—	3	57	5	—	6	1	41	48
10	—	65	—	—	65	10	—	9	2	47	58
40—44											
0	1	38	1	8	48						
5	—	53	—	3	56						
10	—	54	—	3	57						

TABLE (4)

Distribution of Married Females by parity (15-49)

Year	Parity 0	1	2	3	4	5	6	7	8	9	10	Total
0	57	87	55	29	20	4	3	1	2	0	1	259
0	57	87	55	29	20	4	3	1	2	0	1	259
1	78	123	48	36	23	3	4	1	2	0	1	312
2	55	129	55	35	25	6	4	1	2	0	0	312
3	45	127	55	37	25	6	4	1	2	0	0	288
4	35	112	62	38	23	11	3	2	2	0	0	288
5	27	104	67	44	33	14	3	2	2	0	0	285
6	16	100	63	52	21	16	4	2	2	0	0	276
7	11	87	70	46	25	17	4	3	1	1	0	265
8	9	78	64	45	29	15	6	2	2	1	0	251
9	8	62	66	49	26	16	8	3	2	0	1	241
10	8	45	66	44	35	18	9	2	2	0	1	230

TABLE (5)

Distribution of Deaths by Marital status during the ten years

	Males					Females				
Year	S	M	D	W	T	S	M	D.	W.	T
1	2	4	0	1	7	3	2	0	0	5
2	3	2	0	0	5	8	7	0	1	16
3	5	5	1	1	21	2	2	0	2	6
4	4	6	0	0	10	4	2	0	3	9
5	7	2	6	0	15	6	1	0	2	9
6	12	5	0	1	18	7	2	0	3	12
7	6	6	1	1	14	4	1	0	2	7
8	4	2	0	1	7	5	1	0	0	6
9	5	4	1	1	11	7	4	0	3	14
10	6	5	4	1	16	4	2	0	2	8

TABLE (6)

Distribution of Births by Age of Mother (for married female only) in the ten years.

Age of Mother	Year										T
	1	2	3	4	5	6	7	8	9	10	
15—19	18	4	1	0	0	0	0	0	0	0	23
20—24	12	15	3	8	7	3	1	0	1	0	50
25—29	19	20	13	15	16	16	17	9	11	12	147
30—34	7	11	7	9	14	16	10	14	17	19	124
35—39	4	2	4	3	5	3	5	3	6	10	45
40—45	0	1	0	0	1	0	0	1	0	0	3
T	60	53	28	35	43	38	32	27	35	41	392

TABLE (7)

Number of Marriages and Divorces in each of the ten years

	Marriages			Divorces		
Year	Male	Female	T	Male	Female	T
1	59	83	142	48	12	60
2	4	17	21	17	12	29
3	3	9	12	16	8	24
4	2	12	14	9	9	18
5	1	7	8	16	4	20
6	2	8	10	0	7	7
7	1	2	3	1	3	4
8	0	4	4	0	3	3
9	0	2	2	0	2	2
10	2	0	2	0	0	0
T	74	144	218	107	60	167

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