Probabilistic population forecasts for Egypt[1]

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Abstract

Considering the importance of population forecast, as a basic tool for a wide range of decision makers and planners, this paper produces probabilistic population forecasts for Egypt during the period starting from 2006 to 2051. It depends-mainly on experts' knowledge and arguments which can help to illustrate the uncertainties associated with future demographic trends.
The results show that the total population of Egypt is likely to increase significantly over the coming 20 years, from about 73 million to over 100 million (97.12 and 103.5 million), with 95 percent uncertainty range).

Key words: Fertility, mortality, probabilistic, forecasts, Egypt

Résumé

Etant donnée l'importance de la prévision démographique, comme outil de base pour un large éventail de décideurs et de planificateurs, ce document présente des projections probabilistes de la population égyptienne de 2006 à 2051. Celles-ci se basent principalement sur les connaissances des experts et leurs arguments qui permettent d'illustrer les incertitudes liées aux évolutions démographiques futures. Les résultats montrent que la population totale de l'Egypte est susceptible d'augmenter de manière significative au cours des 20 prochaines années d'environ 73 millions à plus de 100 millions, la marge d'incertitude au seuil de 95% allant de 97,12 à 103,5 millions.

Mots clés: fertilité, mortalité, probabiliste , previsions , L'Egypte

Introduction

Population projections are the basic tools for a wide range of decision makers and planners in many sectors: education, health, manpower, human development and services in any country.

Population projections may be defined as the numerical outcome of a particular set of assumptions regarding the future population; a forecast may be defined as a projection that is selected as the one most likely to provide an accurate prediction of the population so that it represents a specific viewpoint regarding the validity of the underlying data and assumptions, accordingly a forecast reflects a judgment, and its credibility can be proven by future events. (Siegle *et al*., 2004).

1. This paper is derived from PhD work on "Probabilistic Population Forecasts for Egypt", Institute of Statistical Studies and Research, Cairo University, 2009.

The traditional way to forecast future population is always based on assumptions of three variants (low, medium and high□ This approach is incomplete because it ignores uncertainties in mortality, fertility and migration assumptions, it is also incomplete in the sense that it ignores uncertainties in mortality and migration, even if it provides variants for fertility; it lacks such variants for mortality and migration components.

Sources of uncertainty associated with traditional method are for example: Accuracy of data, accuracy of parameters estimates and structural changes in society specifically the rapid increase entry of women into the labour force market.

During the last decades, many studies have been produced about population projections for Egypt using three assumptions or variants (low, medium and high□ These projections were deterministic projections which did not give an appropriate indication of the uncertainty.

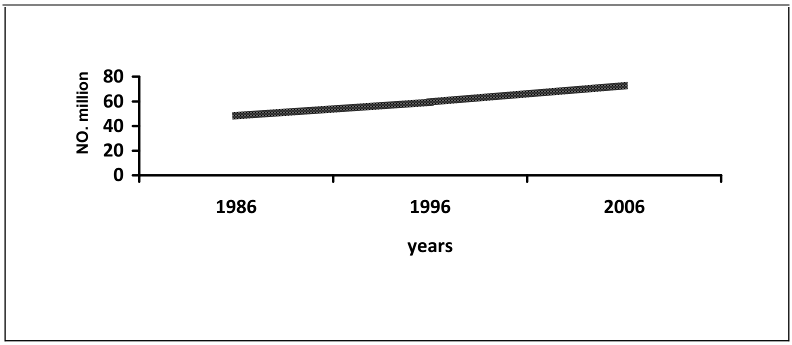
This paper attempts to avoid the problem of uncertainty of the traditional approach by stating probabilities. In other words, it provides probabilistic population forecasts for Egypt (200□-2051□ depending on incorporation of uncertainties in fertility and mortality components.

Egypt demographic profile

This section aims at presenting a summary of the demographic situation in Egypt during the last two decades in order to help understanding the past and current population situation as a base for forecasting future trends.

Population growth

The population of Egypt accounts for one-fourth of the population in the Arab world. Population size is increased almost by 50% between 198□ and 200□, from about 48 million to about 73 million in 200□.



Source: Central Agency for Public Mobilization and Statistics, annual statistical year book 2006.

Figure 1 Trend of total population in Egypt 198□ - 200□

Fertility in Egypt

Fertility is one of the most important demographic variables. It contributes to the determination of the rate of population growth. During the past two decades, fertility in Egypt had decreased by approximately two births from about 5 to 3 births. There are two main phases in the fertility decline in Egypt; in the first phase, fertility declined significantly during the period between 1980 and the mid of 1990's from 5.3 children per woman (1979-1980□to 3.3 children per woman (1993-1995□; and the second phase is the period between 1995 and 2008, when the trend in fertility has declined slowed down, from 3.□ to 3 children per woman. (EDHS, 2008□

Mortality in Egypt

Like fertility, mortality is a basic component of population growth. Levels of mortality in Egypt during the last two decades in terms of life expectancy at birth show that life expectancy for males increased from □0.5 years in 198□ to □9.2 in 200□ and for females it increased from □3.5 years to 73.□ years during the same period. It is important to correlate the improvement in life expectancy at birth for both sexes to the improvement in the health and medical sector; the strong evidence is the significant decline in the infant mortality rate, IMR, from 95.1 and 93.4 for males and females, respectively to 33.5 and 23.4 between the two periods: (1978-1988□ and (1998-2008□ as revelled by Egypt Demographic and Health Surveys in 1988 and 2008.

Population by level of education

One of the most important factors of the development components is the education status of the population, in addition to the significant role that education attainment plays, it is associated with many other factors, ranging from reproductive behaviour, use of contraceptives, health of children and morbidity, and mortality.

To study the pattern of education status during the last two decades, we used the census data for the years (198□-199□-200□□ for those people 10+ years- old. Table (1□reveals that the percent of illiterate has declined significantly during the period (198□-200□□ from about 50% of population aged 10 + years to about 30%, specifically for females it declined from more than □2% to about 37%. For those who have completed the secondary or higher education stage, it is clear that there is an increasing trend; the percentage had doubled during the last two decades from 1□% to about 38%, but for females the percentage had doubled 3 times in 200□ in comparison to 198□.

Table 1 Population distribution by level of education and sex in Egypt 198□-200□

Year	Illiterate			Read & Write			Basic Education			Secondary +		
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
198□	37.□	□2.8	49.9	24.0	15.0	19.□	17.0	11.5	14.2	21.4	10.7	1□.3
199□	29.1	50.3	39.4	22.7	14.□	18.7	19.□	15.□	17.7	28.□	19.5	24.2
200□	22.4	37.3	29.7	13.4	10.5	12	20.8	18	19.4	42.1	33.5	38

Source: Central Agency for Public Mobilization and Statistics, Census for Population and Houses 1986, 1996, and 2006

Participation in labour force

Another important factor which has a significant role in the development status is the participation in labour force. Although that factor influences development in general, for both male and female, it has a significant influence on the pattern of fertility and hence the age structure, specifically female participation in labour force. Although the participation in labour force among population aged 15 + seemed to be stable during the last two decades (at about 45% of total and more than 70% of males□ the situation for female participation is different, the percent of females aged 15+ in labour force almost doubled from about 10% to 1□% during the period 198□ to 200□.

Literature review and theoretical framework

The traditional way of providing population projections and dealing with uncertainty using three variants has been criticised by many researchers as was clarified by Kefitz 1972, Lee 1998, NRC 2000, Lutz and Goldstein 2004. They stated that the official population forecasting agencies traditionally have provided three variants: low, medium and high. Users invariably have chosen the medium variant as a forecast, and often interpret the high and low variants as probability statement. In addition to that those forecasts asses the uncertainty surrounding the middle, or preferred, forecast by using high and low versions. Each scenario, or set of assumptions underlying one of these three versions, contains an assumed trajectory for the three components "fertility, mortality and migration". However, these scenario-based indications of uncertainty have certain serious problems:

- no probability is attached to their high and low ranges and they are internally inconsistent in the sense that they misrepresent the relative uncertainty in different measures such as population size. In other words, examples of the sources of uncertainty are accuracy of data used and parameter estimates.

Currently there is an increasing concern about the accuracy of population forecasts, although a large number of forecast users seem to be satisfied with the currently used scenarios and variants but a growing number of users would prefer to have information about the range of uncertainties. In many contexts, uncertainties concerning each of the three components "fertility, mortality and migration" are so large that it would be inappropriate to disregard any of them.

The current practice of providing "High" and "Low" variants to communicate uncertainty around the medium projection suffer from several problems; the most important are:

- in many cases variants only address fertility uncertainty, ignoring mortality and migration uncertainty. The variants approach is unspecific about the probability range covered by "High" and "Low" variants, and these variants typically do not allow for temporal fluctuations such as baby booms that can produce bulges in structure age.

Quantifying this uncertainty is helpful to users of projection results because it focuses their attention on alternative population futures that may have different implications and helps them decide what forecast horizon to take seriously, although current forecast uncertainty is expressed by three variants high, medium and low but no specific probability is attached to the range.

In order to deal with problems of the traditional approach which depends mainly on providing three variants to deal with uncertainty, demographers suggested some solutions as clarified by Ahlburg, *et al.*, 1992, Pflaumer 1988 and (Lutz *et al.*, 1999). They stated that the population forecasters have lagged behind their colleagues in other areas of forecasting with respect to attention to measures of forecast accuracy and the development of probabilistic interval forecasts.

There are three major ways of dealing with uncertainty in forecasting future demographic trends: scenarios, variants, and fully probabilistic projections. Scenarios are "if-then" statements that may correspond to specific consistent stories, they are not associated with probabilities of any sort .On the other hand, fully probabilistic forecasts (whether they are based on expert's opinion, ex post error analysis and time series models) provide users with probability distributions for all population parameters and all intervals of the forecast period

First method which depends mainly on expert's opinion has been applied for the first time in 199[illegible], when Lutz, *et al.*, introduced the first group of probabilistic population projections for the world regions; they proposed and implemented a new method for dealing with the uncertainty of future population sizes and called it "Probabilistic population projections based on expert opinion". The main difference between this method and the two probabilistic population projection methods (time series and ex-post error analysis) is the use of expert opinion both on the future courses of fertility, mortality, and migration, and on the extent of their uncertainty. The main idea is to obtain information from the experts not only on fertility, mortality, and migration trends, but also on the uncertainty of the trends, by bringing information from experts who are specialist in different fields; then the opinions of the experts were translated into the high and low values that constituted 90 percent confidence intervals for total fertility rate, life expectancy, and migration in the period 2030-2035 and extended to 2100, based on the data for the year 1995 as the base year.

The first national probabilistic population projection was done for Austria. This approach proposes an expert-based probabilistic method that seems to meet important criteria for successful application to national and international projections after the application of this method on the 13 world regions. Mainly researcher depended on the alternative assumptions defined by the Austrian Statistical Office. Assumptions were defined in the usual way by discussing in an inter-agency meeting proposals prepared by the projections unit. The researcher tries to answer a main question:

> Can the expert–based probabilistic scenario approach be generally recommended to national statistical institutes?

The answer is that when recommending the change of a long- established tradition, it is possible for such efforts to be successful. However, the new practice must have clear advantages as compared to the current one; it should be consistent with other work done by the producing institution. The new approach should be practical for both users and producers. (Lutz, *et al.*, 1997)

Second method of probabilistic population forecasts which depends mainly on ex post error analysis has been applied by many demographers on different areas for examples; Keyfitz (1981) and Stoto (1983) analyzed for various countries of the world the errors in projected population growth rates in the projections made by the UN during the period from 1950s to 19[illegible]0s. The main findings are that errors varied strongly by region and by base year: regions in which population growth was high had large errors. In 2000 NRC applied this methodology and produced a probability distribution for the UN medium scenario for population of individual countries, regions, and the world to 2050 based on analysis of errors in previous UN projections.

Third method which depends mainly on time series to produce probabilistic population forecasts has been applied by Lee and Tuljapurkar (1994), who were pioneers in developing a stochastic population projection model for the United States, which combined exogenous (expert) assumptions about the future trends in the demographic components with stochastic short-term variations derived from the statistical analysis of past US time series drawing on earlier time series models on fertility (Lee 1993) and mortality (Lee and Carter 1992).

So far For Egypt there is no probabilistic model for population forecasts, so based on literatures and in order to gain advantages of that approach, this paper proposes a shift from deterministic population projection to probabilistic population projection, namely using expert opinion, see figure (2[illegible]

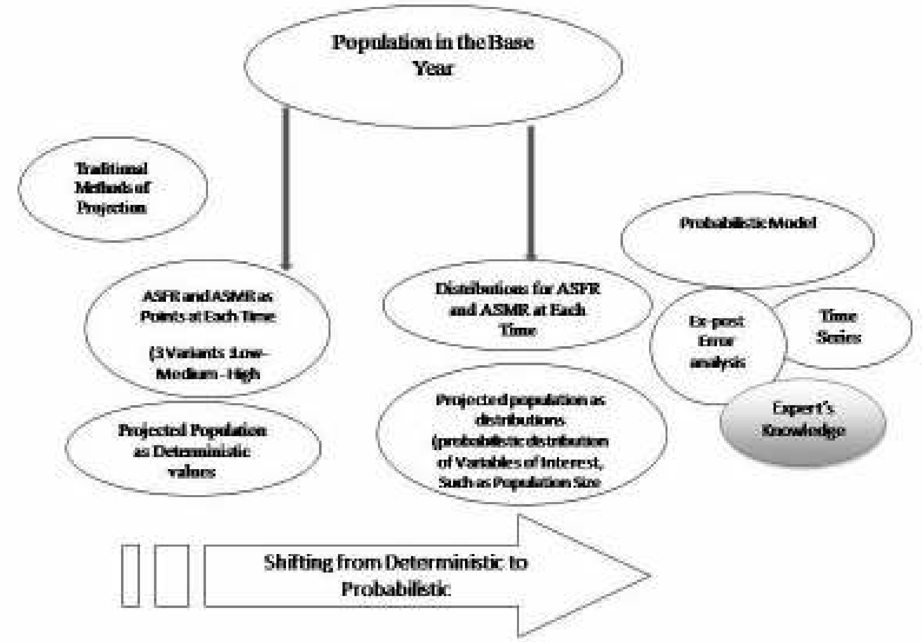


Figure 2 A conceptual Framework for the Proposed Methodology Shifting From Deterministic to Probabilistic Population Projection

Methodology and data

Probabilistic forecast means to quantify the uncertainties involved in the forecast. Basically, the cohort component population forecasts approach begins with a population in the base year (200[illegible]and moves forward in time using age-specific birth and death rates, when those rates, at each period are given as distributions rather than points, the forecast becomes probabilistic. The outputs of probabilistic forecasts are distributions of variables of interest, such as population size, at each time period.

The method of describing the uncertainty in population forecasting based on the construction of confidence intervals has two main kinds:

1. the so-called empirical confidence intervals mainly based on the errors of past population projections; and can be used to construct confidence intervals for future population, if there is no substantial change in the forecasting method.
2. model – based confidence intervals that rest either on time series models or on demographic mod-

els(cohort –component models) which are based on the idea that age- specific fertility and mortality rates are random variables (these assumptions imply that the population size at a certain time is a random variable, too, as its distribution). (Pflaumer, 1988)

The role of experts in defining uncertainty is a key role in all population forecasting; in some cases, this role is only to choose the model and its parameters and the reference data from which the estimate should be drawn. In other cases, experts do more than that; they make assumptions about the likely future level of demographic component or limit the range of the future values (minimum or maximum fertility)as well as the associated uncertainty.

Since the cohort-component method of projection has been taken as a standard, the difference between the probabilistic approaches to population forecasts means only the modelling of future fertility, mortality and migration components. (Lutz *et al*., 2003)

As mentioned in the literature, there are three approaches to derive assumptions about future range of uncertainty of the components:

a. Compute measure of the future error by using the ex-post error analysis.
b. Apply time series model.
c. Expert knowledge approach. Those three approaches are not mutually exclusive.

In this paper the forecasts are carried out using the cohort component method. The population is calculated by age and sex, based on the assumptions of fertility and mortality rates, (migration assumed to be zero according to the advice of experts). This method is used to calculate the population by age and sex as it changes from one year to the next, being subject to a set of assumed age- specific fertility and mortality rates. The forecasts presented here produce neither one such cohort – component projection nor a small number of alternative scenarios or variants, but rather the distribution of the results of 1000 different cohort component projections. For these stochastic simulations, the fertility and mortality paths underlying the individual projection runs were derived randomly from the "expert-defined" uncertainty distributions for fertility and mortality.

We start by using the expert argument- based approach to collect data on both:

1. the trends in fertility, mortality
2. the uncertainty range of those trends.

Experts' knowledge approach combining the subjective probability distributions of a number of experts to form one joint predictive probability distribution determines the danger of individual bias. (Lutz *et al*., 1999)

The First Step (experts' selection) Is to specify criteria to select the experts from more than one country. Selection includes international experts from the IUSSP members who already have knowledge of the Egyptian demographic situation, in addition to national leaders in the field of demography. So the experts involved in this study are specialists in population forecasting as well as leading demographers from different parts of the world.

The main objective behind not dealing only with national experts but also with international experts is that there are many experts dealing with Egyptian demographic situation around the world in addition to those few experts who already apply the probabilistic approach and are considered to be its pioneers. We are eager to gain experience from them in that field, as well as what we learn from literature that exclusively relies on national experts' knowledge may not be the optimal solution. Also literatures state that when experts' judgment is exclusively or mostly in - house or taken from a single source that will reflect in perceptual errors that affect the forecasts; accuracy has been shown to improve when the judgments of several experts are averaged. (Lutz *et al*., 2003□ The exercise was carried out in close collaboration with 21 national and international population experts.

Second Step: (experts' knowledge and arguments□ the main question in this context is the best assumptions about possible and likely future paths of fertility and mortality. Those experts who have a background in the field of demography were asked to suggest possible high and low assumptions for future fertility (TFR□ mortality (e0□up to the year 2051 (the most likely value of TFR , e0 in Egypt of 5-year average for the two periods (201□-2021□and (204□ – 2051□in addition to lower and upper bounds.

We used an in-depth interview with national experts and sent a questionnaire (including the same points□to the international experts; we also designed a guide for our questionnaire to illustrate some basic statistics of historical data on the three components that we think will help; we attached it to our questionnaire to international experts and used it also during the interviews with national experts in case the experts wanted to have a look.

From those experts' judgments, the range of uncertainty was defined in terms of three values (the most likely value, upper and lower bounds□ for each component for a given 5-year average for the two periods (201□-2021□and (204□-2051□ where the area between the upper and lower values should cover 90% of all possible cases. The experts also were asked to argue their points substantively and justify their views or in other words specify their reasons for making these assumptions.

We have decided to give an equal weight to each expert; we thought of differentiating between data collected from national and international experts (a different weight is given to the individual experts from Egypt as they are supposed to have more experience on demographic situation in Egypt than those international experts from outside Egypt□ However, we did not do that after we had investigated collected data, because we found them similar in comparison to each other. This can be justified as follows:

1. We asked each of the international experts not to fill our questionnaire unless he/she is already aware some how of the demographic situation in Egypt and they responded to that (many of them said they would not fill the questionnaire since they did not have knowledge about the demographic situation in Egypt, although most of those provided a valuable advice to be followed in our statistical work□
2. We attached a guide to our questionnaire which shed light on a

trend of the demographic situation in Egypt and an indication to the MDGs that provides a useful tool for the participants in our survey.

In order to generate random TFR and life expectancy (male and female□paths into the future we have chosen a simple procedure of random lines (or piece-wise linear paths□ normal distributions are used to specify random lines that confirm to the 90 percent confidence intervals . We use the data given by the 21 experts for the three components (TFR, e0 male and e0 female□ then we generate a random value for each component (TFR, e0 M, and e0 F□to be used in our probabilistic model using the following formula to express the i[th] random TFR at time j:

$$TFR_{i,j} = u_J + x_i \cdot \frac{\nabla j}{3.29}$$

Where x_i is the i^{th} draw from a standard normal distribution, u_i is the most likely value at time j, and the difference between the high and low value at time j, is Δ_j

And we do the same for the other component (e0 male and female□

$$e^{0(m)}{}_{i,j} = u_j + x_i \cdot \frac{\nabla j}{3.29}, and \cdot e^{0f} = u_j + x_i \cdot \frac{\nabla j}{3.29}$$

And 3.29 is the difference between the upper and lower bounds of the 90 percent confidence interval for the normal distribution. After generating the random paths we used the cohort component method to obtain the whole set of 1000 random projections. By adopting this model we avoid the problem of autocorrelation and we have the ability to produce probabilistic projection up to 2051.

Table 2 Base year population by age and sex in Egypt at (Mid-year 200□□

Age group	Males	Females	Total
0	3□33952	3845872	7479824
5	3770397	3988519	775891□
10	38□1504	4079031	7940535
15	3725923	39088□5	7□34788
20	3514248	3□34987	7149235
25	31□8149	3255157	□42330□
30	2708330	27□0848	54□9178
35	2349990	2399191	4749181
40	2010731	2073323	4084054
45	1709592	1781827	3491419
50	1427938	151□□10	2944547
55	1154554	124200□	239□5□0
□0	8□4213	949272	1813485
□5	□4□897	709985	135□882
70	454847	488474	943321
75+	2880□2	284740	572803
Total	**35289327**	**36918707**	**72208034**

Source: Researcher's estimation

Base year and assumptions

This section provides a concise description of the assumptions and a summary of the arguments that led to the choice of these assumptions.

In this section, we try to describe the situation at the base year of our forecasts (200□□in addition to assumptions that were derived depending on "experts' knowledge and argument-based probabilistic forecasting". This is followed by a brief summary of arguments which led to the specific assumptions made concerning the future fertility and mortality. The population data for the starting year, 200□, were taken from the Population Census 200□, and then we smoothed the age pattern using Population Analysis Spreadsheets.

Experts' knowledge and arguments for the future fertility and mortality in Egypt

This section sheds light on the assumptions of the future fertility and mortality which we collect from experts and the associated arguments

Fertility assumptions

Experts stated that the primary basis for the assumptions, that fertility in Egypt will continue to fall, is confirmed by the theory of demographic transition, which suggests that once countries enter the secular fertility decline, fertility will continue to fall until levels at or below replacement level are reached.

Key elements of the assumptions lie in the timing of the onset of the fertility transitions, the pace of fertility decline, and the level of fertility after completion of the transition. Most of the uncertainty is due to the speed of the fertility decline and to the assumed level of post-transitional fertility.

Experts argued and justified their knowledge by some specific points: since the economic activity of women in Egypt is increasing gradually, the TFR will decrease over the coming years; in addition to that many experts pointed toward lower fertility mainly because of raising the age at first marriage in the Egyptian society, even in the rural areas, as a result of the high unemployment rate.

The future expected improvement in the contraceptive technologies may result in further fertility declines; furthermore, the effect of the high expected rise in the urbanization trend and increase in educational attainment, and the elimination of the gender gap specifically by 2015 (MDGs□ Also, there are a very few number of experts who are very ambitious and assume that TFR in Egypt may be 2.2 or 2.4 by 2018, and about 1.4 or 1.□ by 2048; they justify that by the acceleration of the participation and the growing role of women in the labour force market and high level of education for women.

The majority of experts also shed light on the role of government policies and family-planning programs. Experience with such programs has shown that, over several decades, they can have an important effect if they are well integrated into other government policies and particularly if the socioeconomic development of the population has reached a point at which limitation of family size is considered advantageous and a real option by sizable segments of the population.

Mortality assumptions

Mortality conditions at one point in time can be conveniently summarized by life expectancy at birth, an indicator that results from a life table, based on all age-specific mortality rates observed at that time. In this section, this indicator is used to define mortality assumptions.

Experts indicated that the public health, nutrition, economic development, and modern education are the key determinants of mortality decline.

Health conditions in the developing regions (including Egypt) have generally experienced very impressive improvements since World War II, which will continue in the future. Life expectancy in all developing countries has increased.

Also, the majority of experts stated that the high level of health conditions in Egypt nowadays and for the coming decades will not guarantee life expectancy more than about 73 years in 2018 and about 82 in 2048, because of the side effects correlated with the urbanisation and industrials which will result in pollution and will affect the population health and cause mortality.

A very small number assumed that Egypt can achieve a high level of life expectancy at birth because of the growing improvement in the health conditions and because of the health insurance system which will cover all the members of the population.

Experts also argued that their assumptions of life expectancy at birth for Egypt are based on education as a crucial element in the development process; it plays a very important role, specifically with the education of mothers and raising awareness to protect children and respectively reduce the infant mortality rates.

Results

Table (3) shows selected percentiles of resulting distribution, The results show that the total population of Egypt is likely to increase significantly over the coming 20 years from around 73 million to above 99 million, the 95 percent uncertainty range is 97.12 and 103.5 million (based on the piecewise linear approach). This means that the Egyptian population will increase by more than 3[illegible]% during the next two decades.

It is also noticed that although it is a national population strategy goal for Egypt to achieve 2.1 children as a total fertility rate by 2017, our results reveals that the TFR in 2017 will be about 2.55 and between (2.33 and 2.77) with 95 percent uncertainty range. We have to remind ourselves that most of experts or almost all of them did not expect to achieve that goal. Although probabilistic population forecasting originally focused on population size, it is increasingly used in the analysis of future patterns of age structure; it can also provide data on the population aged [illegible]5 and older as well as population less than 15 years and some other important indicators that help to study specific criteria for the population in Egypt like aging and time for demographic window.

Table 4 presents probabilistic distributions for population size by sex, the results show that by the year 202[illegible] the total number of males will be between 49.19 and 52.53 million with 95% probability, this number will grow to be between 5[illegible].78 million and 70.13 million by 2051. As for females the results reveal that by the year 202[illegible] number of total females will be between 47.9 million and 51.1 million which will grow to

Table 3 Probabilistic Distributions for Population Size Based on Piecewise Linear Approach for Egypt from 2011 to 2051

	Million								
Percentiles	2011	201□	2021	202□	2031	203□	2041	204□	2051
					Total				
2.5	79.75	8□.59	92.14	97.12	101.□□	105.70	109.07	111.□0	113.05
20	79.85	87.05	93.30	99.03	104.31	109.21	113.58	117.13	119.80
40	79.90	87.31	93.88	99.9□	105.□2	110.99	115.97	120.15	123.43
□0	79.95	87.53	94.43	100.84	10□.90	112.73	118.18	123.01	127.12
80	80.00	87.7□	94.98	101.70	108.04	114.39	120.37	125.82	130.54
97.5	80.09	88.20	9□.09	103.50	110.□0	117.79	124.87	131.72	137.89
Mean	79.92	87.41	94.15	100.38	10□.23	111.84	117.0□	121.□4	125.32
Coefficient of	0.00	0.00	0.01	0.02	0.02	0.03	0.03	0.04	0.05

Source: Researcher's estimation based on Experts' knowledge.

be between 5□.1 million and □8.2 million by 2051 with 95% probability. Population less than 15 years will be between 20.47 and 31.27 million with 95% probability, with amen of 25.□4 million which will represent only about 20.5% of total population by 2051 (figure 2□

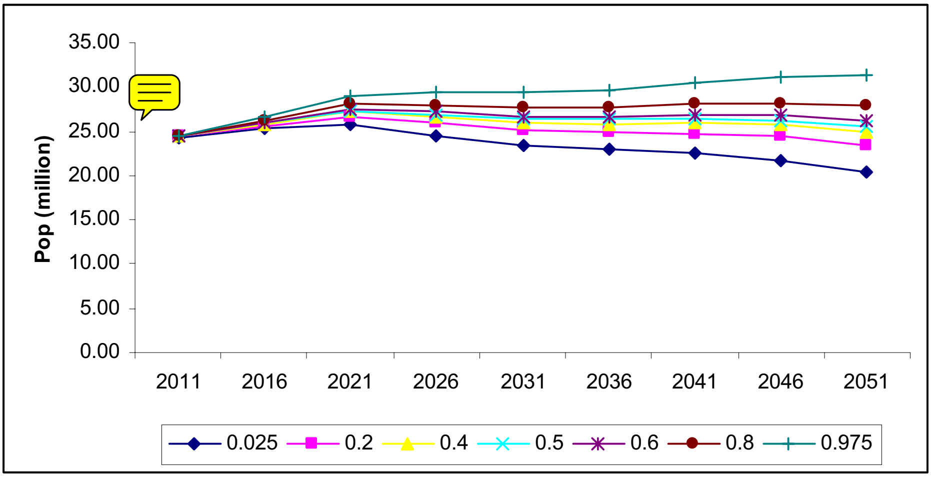
As for the working age group (15-□4□ which is about more than 45 million in 200□, it is expected for that age group to be between 77 million and 87 million with 95% probability by 2051.

The □5+ age group is expected to grow from about 3 million to between 7.35 and 7.72 by 202□ and grow to be between 1□.81 million and 18.59 million with 95% probability. Egyptian society will be changed to be an aged society. In 200□, about □ percent of the population was □0 years and above; almost by 2021, the Egyptian society will characterized as an aged society, since the population aged □0 and above will reached a mean of about 10 percent of total population. According to literature, the society considered to be aged if the percentage of population in the age □0 and above is 10 percent.

Table 4 Probabilistic Distributions for Population Size by Sex for Egypt from 2011 to 2051 (Piecewise Linear Approach□

Million									
Percentiles	2011	201□	2021	202□	2031	203□	2041	204□	2051
Males									
2.5	40.□4	43.98	4□.73	49.19	51.40	53.37	55.00	5□.14	5□.78
20	40.□9	44.23	47.32	50.15	52.75	55.19	57.37	59.15	□0.45
40	40.72	44.3□	47.□4	50.□□	53.47	5□.15	58.□2	□0.72	□2.37
□0	40.74	44.47	47.91	51.09	54.08	5□.99	59.72	□2.14	□4.17
80	40.77	44.59	48.21	51.58	54.77	57.91	□0.92	□3.□□	□□.04
97.5	40.82	44.84	48.80	52.53	5□.13	59.79	□3.45	□□.94	70.13
Mean	40.73	44.41	47.7□	50.8□	53.77	5□.5□	59.1□	□1.43	□3.28
Coefficient of Variation	0.001	0.005	0.011	0.017	0.022	0.029	0.03□	0.044	0.053
Females									
2.5	39.1	42.□	45.4	47.9	50.3	52.3	54.1	55.4	5□.1
20	39.2	42.8	4□.0	48.9	51.5	54.0	5□.2	58.1	59.5
40	39.2	43.0	4□.3	49.3	52.2	54.9	57.4	59.5	□1.2
□0	39.2	43.1	4□.5	49.7	52.8	55.7	58.4	□0.8	□2.8
80	39.2	43.2	4□.8	50.2	53.4	5□.5	59.5	□2.3	□4.□
97.5	39.3	43.4	47.3	51.1	54.□	58.3	□1.8	□5.2	□8.2
Mean	39.20	43.00	4□.39	49.52	52.47	55.29	57.91	□0.23	□2.0□
Coefficient of Variation	0.001	0.005	0.011	0.01□	0.021	0.027	0.034	0.042	0.050

Source: Researcher's estimation based on Experts' knowledge.



Source: Researcher's estimation based on Experts' knowledge.

Figure 3 Fractiles of resulting distribution for the population aged less than 15 years in Egypt 2011 - 2051

Demographic transition is a process of four main stages: first (both mortality and fertility rates are very high, so the total population growth rate is low); second phase (mortality rates tend to decline due to improvements in medicine and public health, so total population growth rate significantly increases, and young cohorts are dependent and need large expenditures to provide them with their needs from education, food, health and so on. So the dependency ratio tends to increase dramatically to be a heavy burden on the economy; after that this generation itself reaches the prime reproductive years; so even if total fertility rates have been reduced to the replacement level, the population will continue to grow until the members of the first generation and successive generations have passed through their prime reproductive years. This process is called "population momentum". In the third stage, fertility rates begin to decline. The main features of that stage are: lower population growth rate and significant change in the age structure so that it will shift from a young structure to one in which the working age population is predominant, so young cohorts become adult and have the ability to work and earn income. Hence, the dependency ratio tends to decline. During that stage, the economy has a *unique opportunity* to boost economic growth; this opportunity is available only for a limited time that the change in the age structure as a result of decline fertility will create a one time demographic gift (Nassar, *et al.*, 200□□

Our results shed light on a very important thing which is the time that Egypt will gain that unique opportunity "*Demographic window*". According to its definition and characteristics of starting decline in population under 15 years, starting time of decline in the natural rate of increase and starting time of the population increase in the working age group (15- □4□ our results show that the date of the occurrence of the three criteria at once and then the demographic window is expected to be opened by 2022.

Conclusion

Population projections are considered to be the basic tools for a wide range of decision makers and planners in many sectors: education, health, manpower, human development and services in any country. This paper produces probabilistic population projection for Egypt for the period 200□ to 2051.

Most of researchers depend on the traditional or deterministic approach, in other words they must make assumptions about unknown future. There are many ways of making these assumptions and in general different assumptions will result in different future population sizes.

The current practice of providing high and low variants to communicate uncertainty around the medium projection suffer from several drawbacks. The most important are:

1. in many cases variants only address fertility uncertainty, ignoring mortality and migration uncertainty.
2. the variants approach is unspecific about the probability range covered by high and low variants.
3. the variants do not allow for temporal fluctuations such as baby boom.

This paper produces probabilistic population forecasts for Egypt. Depending mainly on the Experts' knowledge and arguments which can help to illustrate the uncertainties associated with future demographic trends and also sheds light on how the demographic situation in Egypt will be during the coming 45 years. The paper applies a methodology for using judgment in making probabilistic projections for Egypt. The main idea was to collect knowledge and associated arguments from 21 experts (national and international□ By adopting piecewise linear paths model, we avoid the problem of autocorrelation and we have the ability to produce probabilistic projection up to 2051.

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