An Expert' Knowledge –Based Framework for Probabilistic National Population Forecasts: The Example of Egypt

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Abstract

During the last decades many studies produced population projections for Egypt using three assumptions of variants (low, medium and high).

This approach has many problems: first, most of the decision makers when they find three or five alternatives almost automatically choose the middle one. Second, these projections are deterministic projections which do not give an appropriate indication of the uncertainty.

This paper presents the frame work of the first group of probabilistic population forecasts for Egypt 2006-2026 depending on incorporate uncertainties by using a the experts' knowledge approach.

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Introduction:

It is important for the decision maker not to depend only on deterministic population projection, or just three variants for the future, and literature discussed how it is important to incorporate the uncertainty component in the fertility, mortality and migration assumptions.

The crucial difference with respect to existing national population projections for Egypt lies in the specification, justification, and combination of alternative scenario assumptions and in the definition of the first probabilistic national population projection for Egypt.

The approach used here to produce this set of probabilistic population forecasts for Egypt is called expert's knowledge – based probabilistic forecasting. We refer here to what is called subjective or judgmental probabilities. What means that there is no perfect objective model for the definition of future trends of the three components of population change. Instead, the task is to collect the best available information to make an informed judgment about the likely uncertainty distribution of certain future demographic trends, derive the median and associated distribution from entirely different resources.

This paper presents the frame work of applying probabilistic population forecast model using An Expert' Knowledge –Based for probabilistic Population Forecasts for Egypt.

Methods of dealing with uncertainty:

There are many methods of dealing with uncertainty in forecasting future demographic trends: Scenarios, Variants, and fully probabilistic projections as for the scenarios and variants they are not associated with probabilities, in contrast, fully probabilistic forecasts provide users with probability distributions for all population parameters and all intervals of the forecast period

The literature suggests three method of dealing with uncertainty by using probabilistic approach: the first is to compute a measure of the future error from the ex-post analysis of past projection (Stoto 1983; Alho 1997; Keilman 1999;

Khan 2007). The second is to apply time series models (Lee and Tuljapurkar 1994 ; Lee 1999). The third is to have well-informed experts make assumptions based on explicitly stated sustentative arguments (Lutz, Sanderson and Scherbov 1999). These three approaches are not mutually exclusive and the first two also include experts' judgment

An Expert' Knowledge –Based Framework for Probabilistic population forecasts for Egypt:

The forecast are carried out using the cohort component method for five-year intervals and five-year age groups. 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 we gained from experts). The projections presented here are not alternative scenarios or variants, but the distribution of the results of 1,000 different cohort component forecasts. For these stochastic simulations the fertility, mortality and paths underlying the individual projection runs were derived randomly from the described uncertainty distribution for fertility and mortality

Since the cohort-component method of projection has been taken as a standard, the difference between the probabilistic approaches of population forecast means only the modelling of future fertility, mortality components.

As it was mentioned, the literatures suggests three approaches to derive assumptions a bout 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 argument – based approach. But the literatures also indicated that the three approaches are not mutually exclusive, which means forecaster can mix between two of them or even between the three methods.

Our model produces a synthesis of two approaches; mainly we start with the experts' knowledge and argument, and then incorporate the time series. The role of each approach in our model will be discussed in detail.

We start by using the expert knowledge approach to collect data on both: 1) the trends in fertility, mortality, and migration, and 2) the uncertainty range of those trends.

Expert knowledge and arguments approach refers to what is called subjective or judgmental probabilistic, that means there is no perfect objective model for the definition of future trends of the three forecast components (fertility, mortality and migration), instead the main task is to collect the best available information to make an informed judgment about the likely uncertainty distribution of certain future demographic trends.

The first step :(experts' selection) is to specify criteria to select the experts from more than one country (We decide to select national and international experts from the IUSSP members who already has a knowledge on the Egyptian demographic situation, in addition to national leaders in the field of demography). 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 that we do not deal only with national experts but also with international experts is that there are many experts deal with Egyptian demographic situation from around the world in addition to those few experts who already applied the probabilistic approach and are considered to be its pioneers and We are eager to gain experience from them in that field. And as Lutz indicates that the exclusively relying on national experts' knowledge may also not be the optimal solution (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 was what are the best assumptions we can make today about possible and likely future paths of fertility, mortality (it is important to state that the experts were not only asked to specify the increasing years in the life expectancy at birth but also they were asked to specify values for e0), and migration and there associated uncertainties, in other words we ask those experts who have a back ground in the field of fertility, mortality and migration analysis to suggest possible high and low assumptions for future fertility (TFR), mortality (e0) and net number of migrants up to year 2051 (the most likely value of TFR and e0 In Egypt of 5-year average (2016-2021) and (2046 – 2051), using an in- depth interview with national experts and send a questionnaire (including the same points) to those international experts also we design a guideline for our questionnaire to illustrate some basic statistics of a historical data on the three components that we think it will help and we use it also during the interview with national experts in case the experts want to have a look, and to guarantee a high level of accuracy.

from these expert judgments, the range of uncertainty was defined in terms of three values (the most likely value, upper, lower) for each component for a given 5 year average (2016-2021) and (2046-2051) where the area between the upper and lower values should cover 90% of all possible cases.

The experts also asked to argue their points substantively and justify their views or in other words specifying their reasons for making these assumptions.

Third step(from subjective to inter-subjective)We decide to give an equal weight to each expert, one could have weighted the individual experts from Egypt as they supposed to have more experience about demographic status in Egypt more than those international experts from out of Egypt, but we did not do that after investigated collected data because we find them similar in comparison to each other, which can be justified by the two things that we did: 1) we asked each of the international experts not to fill in our questionnaire unless he/she is already aware some how of the demographic situation in Egypt and they responded to that (some of them told us they will not fill in the questionnaire since they do not have knowledge about the demographic situation in Egypt, although most of those send a valuable advice to be followed in our statistical work) 2) we attached a guideline to our questionnaire which sheds the light on a trend of the demographic situation in Egypt that provide a helpful tool for the participants in our survey.

We go a step further in the direction of making the experts' Knowledge and arguments more objectives (by adjusting those values from the previous step using time series models).

In order to generate the required distributions for the fertility and mortality components, we adopt the method used by Lutz et al 2001, each of the demographic components (fertility TFR and mortality e0) indicated by v, that has to be forecasted for the period 1 through T, is expressed at time t as the sum of two terms, its mean at time t, ν and its deviation from the mean at time t, εt

Because of the persistence of the factors represented by the εt, we would generally expected them to be autocorrelated. two of the most commonly used methods of specifying how the εt term evolves over time is the simple autoregressive formation (AR(1)) and moving average formation of order q (MA(q)) where q is the number of lagged terms in the moving average .

It is important to clarify that the choice between the two methods (MA (q) or AR (1)) does not have to do with estimation, but rather with representation. Data do not exist that would allow the estimation of parameters of either specification neither is more theoretically correct than other.

The choice between the two, therefore, rests on which more accurately reflects arguments concerning the future. We did that exercise for each of the 21 case all over the forecasting period for both fertility and mortality components we used the moving average formation MA of order q, MA (q), where q is the number of lagged terms in moving average. We choose 41 points and found that it is the most suitable for data on TFR and life expectancy at birth for both sexes we used that and fit a new model for our 21 cases.

We go a step forward behind only fit a model for each case (21 cases) and fit a new model a gain for the averages of the 21 fitted cases(for both TFR and life expectancy at birth) that time we found autoregressive formation AR(1) is the most suitable model for our data

Also we use that model and from knowledge that we gain from literature to specify the most suitable period forecast for our data we concluded that the most perfect is to depend on our data from experts and after fitting just to 20 years (we decided to stop after 20 years according to that and Kyfitz 1981 advice not to exceed 20 years) .

We use averages and standard deviations for each year to generate 1000 random numbers for each component for each forecast year up to 2026.

UN model tables (average or general model were chosen according to the prevalence level of mortality and fertility in Egypt in order to generate ASFRs and ASMRs).

Base year and Assumptions

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

In that section we try to describe the situation at the base year of our forecasts (2006) in addition to assumptions that were derived depend on the approach which is called “expert Knowledge and argument-based probabilistic forecasting” this is followed by short summary of arguments that led to the specific assumptions made concerning the future fertility and mortality then our results will be presented.

The population data for the starting year, 2006, were taken from the Population census 2006 (conducted by the Central Agency for Public Mobilization, CAPMAS.

Table (1) Base year population by age and sex at (mid year 2006)

Age group	Males	Females	Total
0	3633952	3845872	7479824
5	3770397	3988519	7758916
10	3861504	4079031	7940535
15	3725923	3908865	7634788
20	3514248	3634987	7149235
25	3168149	3255157	6423306
30	2708330	2760848	5469178
35	2349990	2399191	4749181
40	2010731	2073323	4084054
45	1709592	1781827	3491419
50	1427938	1516610	2944547
55	1154554	1242006	2396560
60	864213	949272	1813485
65	646897	709985	1356882
70	454847	488474	943321
75+	288062	284740	572803
Total	35289327	36918707	72208034

Source: Resercher's estimation

Future fertility:

Our fertility assumptions are based on the data from EDHS 2005 (base year) and the trends in the means of the levels which have been defined by the experts for the periods 2016-2021 and 2046-2051 with interpolation in between.

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, we have 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 1.6 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.

Future mortality:

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.

Our mortality assumptions based on the data from CAPMAS 2006 (base year) and the trends in the levels have been defined for periods 2016-2021 and 2046-2051 by the experts with interpolation in between.

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 will affect the population health and cause mortality.

A very few 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 of population by 2010.

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.

Main Results

This section presents the results of 1,000 simulations run that randomly combine different fertility, mortality paths from normal distributions for each component.

Using simulation techniques we derive distributions of population size. 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 proportion of the population aged 65 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 (2) Shows selected fractiles of resulting distribution in Total size of population, it can be concluded that with probability of 90 percent the Egyptian population in 2016 will lay between 85.9 million and 87.32 million.

The results show that the total population of Egypt is likely to increase significantly over the coming 20 years from around 72 million to above 99 million, the 90 percent uncertainty range is 97.3 and 101.1 million. This means that the Egyptian population will be increased by almost 38% during the next two decades.

According to our results Egyptian population will be 88 million(between about 87.2 and 88.2 million) with 90 percent uncertainty range in 2017.

Table (2) Total population of Egypt at 90 percent confidence interval 2006-2026

year	Mean [a]	5%[b]	90%[c]
2006	72.2	72.2	72.2
2011	79.56	79.80	79.33
2016	86.66	87.32	85.99
2021	93.20	94.46	92.00
2026	99.23	101.09	97.32

. a column labeled Mean give data on the mean population size

. b and c columns labeled 5% and 90 % provide data on lower and upper bounds, respectively, of the 90 percent confidence interval;5 percent of all observations lie below the lower bound and 95 percent of all observations lie below the upper bound. All figures are based on 1,000 simulations

To characterize the results with respect to some other main indicators for example: Ageing, population under 15 years, demographic window in Egypt. figure (1) , (2) and (3) refer to the percentage of population less than 15 years, percentage of population in the age from 15 to 59 years and percentage of population in the 60 and above years, respectively.

For example about 32 percent of the population were less than 15 years in 2006, at the end of the next two decades (2026) the mean percentage falls to about 26.6 percent, with the 90 percent confidence interval laying between 25.6 and 27.8 percent. It is also noticeable that percentage of population less than 15 years does not differ by sex (almost the same for male and female).

Figure (1) Fractiles of resulting distribution for the population aged less than 15 years in Egypt 2006 - 2026

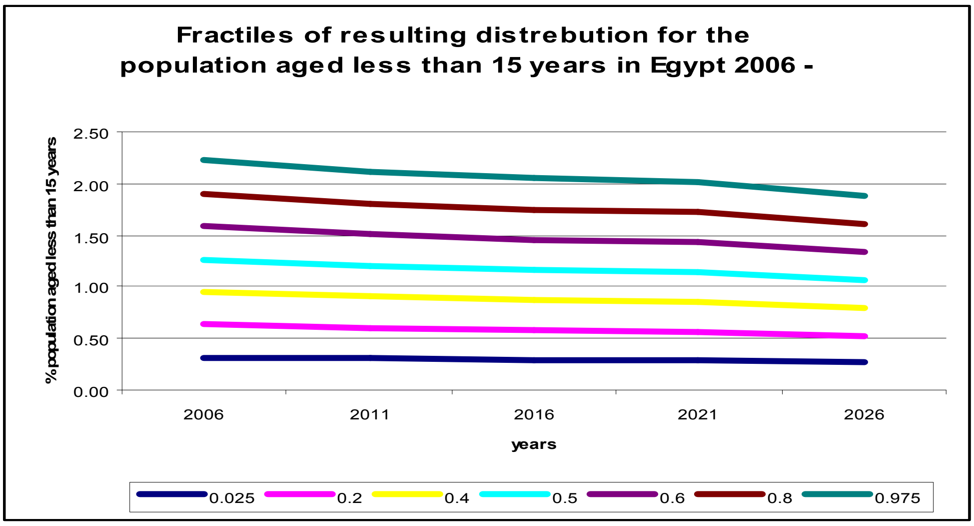


Figure (2) Fractiles of resulting distribution for the population in the age group 15 to 59 years in Egypt 2006 - 2026

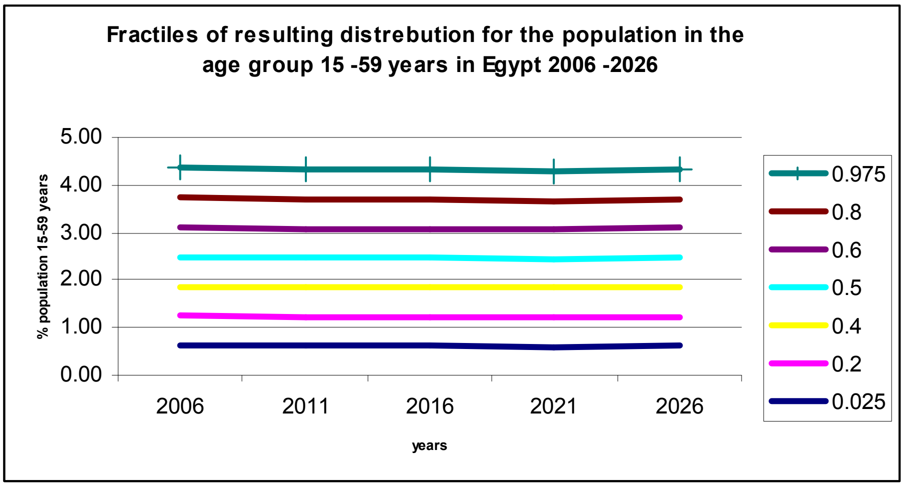
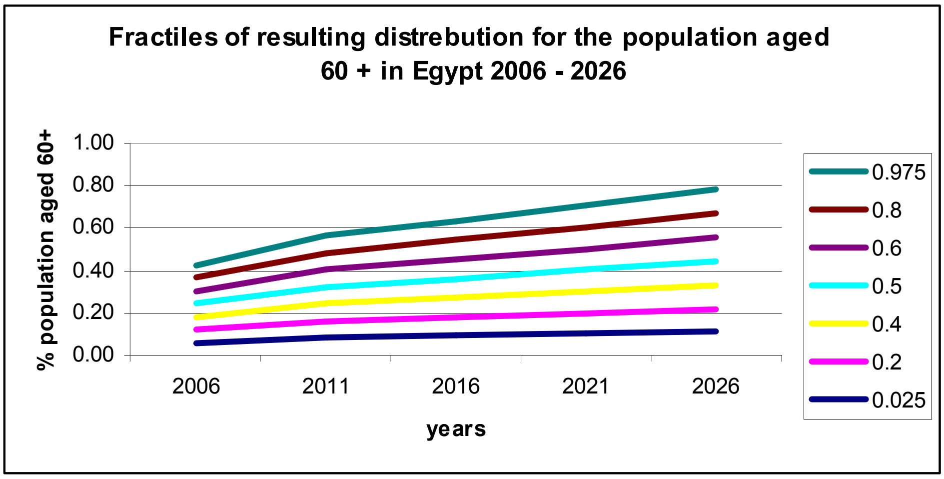


Figure (3) Fractiles of resulting distribution for the population in the age 60 + years in Egypt 2006 - 2026



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 has proposed, for the first time, a framework for the probabilistic population forecasts for Egypt. depending mainly on the Expert's knowledge and arguments Which can help to illustrate the uncertainties associated with future demographic trends and also shed the light on how will be the demographic situation in Egypt during the coming 20 years.

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