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Pattern of fertility rate in India: With special emphasis on age-specific determinant

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Abstract
Human fertility is a very complex socio-cultural physiological phenomenon which needs not only one but many disciplinary approach for its study to have insight into its total reality. It is one of the three most crucial demographic factors that govern the pace of population dynamics and determines the demographic feature of any country. Because of its essential role in shaping the demographic profile to a great extent, it has appealed many sociologist, demographers for study of human reproduction. Precise estimates of human fertility are very important for formulation, implementation and execution of diversified development plans and family welfare programs. Study of fertility aroused attention to try to understand the dynamics of change in population composition and vital rates because it is one of the positive vital forces mainly responsible for higher rate of population growth. The paper is concerned with the study of age- specific fertility levels in India using a mathematical model. A skew-logistic distribution based fertility model has been used to capture the prevailing fertility pattern of Indian sates. The relevant data have been extracted from National Family Health Survey -4 (NFHS-4). The paper also focuses to develop certain new methodologies and incorporating concepts of stochastic modeling and other statistical tools for better understanding of human fertility behavior.

Keywords: human fertility, age level, skew-logistic distribution function

Introduction

Demography is the scientific study of population structure and change. “As modern society becomes even more complex, it becomes increasingly important to measure accurately all aspects of change in the population and estimates what its future size composition might be.” Over the last few decades a substantial increase in population growth all over the world has drawn attention of the demographers, policy makers and other social scientists. The rapid growth of population, especially, in developing and under developed countries has increased effort among scientists to understand the dynamics of population change because of its relationship with socio-economic development of the society as well as of the country. The demographic changes indicate not only change in the population size but also in its composition, distribution and the related development process. Fertility, mortality and migration are considered as three basic components of such changes of a country.

Fertility analysis is more complex than mortality and migration analysis in several aspects. “In demography fertility refers to the actual bearing of children, the reproductive performance measured in terms of live births, whereas, the fecundity is the biological capacity to bear children or reproductive potential.” Fertility is a statistical concept with social relevance, whereas fecundity (physiological capacity of a female to reproduce a live birth) is a biological concept. Fecund females may experience some temporary infecundity, whereas the term sterility refers to a female’s permanent inability to conceive under any circumstances. Lifetime sterility is usually called primary sterility. Among non-sterile individuals, fecundity varies with age. In particular, fecundity is restricted to the period between two-age dependent process, which is menarche and menopause. This period is referred as the reproductive span. Age is thus, an important dimension of the fertility analysis. “In recent years a considerable variation in the pattern of fertility is observed in data sets for populations of developed and developing countries. This variation is related to the form of the fertility curve. While the standard fertility pattern is a bell shaped one, roughly symmetrical though sharper in its left part around its peak placed in an age around 25” [1].

The other way of fertility analysis deals with graduating the fertility pattern through mathematical curves. Due to its simplicity, the modeling of fertility pattern through different mathematical curves have attracted the interest of demographers and still the researcher who were working in the field of demography are using different mathematical curve to graduate the trend of fertility analysis. Among other reasons, the interest in fertility modeling through curves is due to the fact that it is helpful in population projection, which is very useful for government planning. Fertility analysis plays an important role to measure the intensity of population growth. The standard fertility shape depicts according to age. It is of zero value before the age of 14 years, but start increasing and have positive values between 15-19 age group, it becomes maximum between 20-29 age group and then start decline slowing and reaches almost zero by the age of 50 years [2].

Review of Literature

In literature, a variety of mathematical and stochastic models have been proposed which have described the reproductive pattern of human population. Among the models used for representing the age-specific fertility pattern of populations, that do not show high early-age-specific fertility, several authors have provided models with accurate is to the one-year age-specific fertility distributions. “ These include the Coale-Trussell function

(Coale and Trussell (1974, 1978)), the Beta and Gamma distributions equivalent to the Pearson Type I and III curves respectively (Hoem *et al*. (1981)), the Hadwiger distribution (Hadwiger (1940); Gilje (1969); Yntema (1969)), and cubic Splines Gilks (1986).Additionally fertility analysis have been done using some other curves such as Pearson Type I curve Mitra (1967), Romaniuk (1973) and Type III curves Nurul Islam and Mallick (1987), the Brass procedures Brass (1974, 1978),the Gompertz curve Wunsch (1966); Murphy and Nagnur (1972); Farid (1973) and polynomial Models Brass (1960).” [2]The total fertility rate for the period 1991-96,it is evaluated as 2.86 from the census data while that from the Indian registry system data it comes out to be 2.81. This shows a very similar level of estimated total fertility rate from the two sets of data sources. If the mean age of fertility is larger than the modal age, the distribution of age specific fertility rates can be reasonably well approximated by using the Pearsonian Type I curve Verma and Loh (1992). The models described above worked well for the data on single year age specific fertility rates, where there are a lot of information and variations (fluctuations) too.

The skew normal distribution and its generalization Azzalini (1985, 2005) have been also suggested. “Initially a three parameter skew normal probability density function is denied where the skewness parameter allows the function to be asymmetric, like many fertility patterns. A skew normal distribution can be generalized by adding a further parameter to allow for a bimodal shape.” Some other mathematical Models have been developed to find out the fertility pattern with the help of the information of grouped age specific fertility rates. The grouped age specific fertility rate is more reliable because generally digit preference is available in the age of the females data and second advantage of this type of data is that it is easy accessible. For the grouped age specific data polynomial fitting have been done by demographers and the most recent work in this direction has been done for fitting age specific marital fertility rates of Bangladesh by Islam (2009) using polynomial model approach. India is a very vast country and has cultural, social and other diversity and thus taking India as a whole to analyses fertility pattern through a model is not quite justified.

Methodology

A fertility model based on skew-logistic distribution function has been used in this paper. Standard logistic distribution is symmetric about 0. The fertility pattern is somewhat skewed in shape and hence a skew-symmetric distribution can be expected to provide good fitting of such skewed pattern. To check the suitability of the model, data of National Family Health Survey-4, conducted in 2015-2016 have been utilized.[3] The model, used in this paper is flexible in a sense that it can be used for unimodal as well as multimodal fertility pattern. In Indian scenario, the observed fertility pattern has one model at age 20-24 in some parts and 25-29 in others. The skew-logistic distribution provides nice fitting for Indian fertility schedule. The parameters of this fertility model involve no complex estimation procedure.

Age: Specific Fertility Rate Pattern Models

The typical fertility curve is generally bell-shaped, which peaks when women are of childbearing age, that is, 25 years old. "The fertility level starts slowly around the age of 15, which is the beginning of the childbearing age. It peaks among women in the 25 to 30 age group. After that, it starts to decline and has a very low value for women after the age of 35. Ends at 49, the end point of the procreation period. "
The general form of a fertility curve is given as follows Hoem *et al*. (nineteen eighty one):

$$g\,(x;\,R,\,\theta^2,\,\theta^3,...,\,\theta^r) = R.h\,(x;\,\theta^2,\,\theta^3,...,\,\theta^r)$$

Where h (x; 2, 3,...,r) represents the probability density function on the real line, θs are the model parameters, R is the total fertility rate (TFR). The use of different functions in place of h (x; 2, 3, ..., r) as Beta and Gamma in different fertility models has been proposed by other authors such as Coale and Trussell (1974, 1978), Inverse Gaussian, Hadwiger (1940); Hinde and Mturi (2000); Hindin (2000) Distribution of Hadwiger Hadwiger (1940), Gilje (1969), Yntema (1969). Many of these models represent the unimodal fertility model and show a very good fit to fertility rates from one year to the next. In addition to the above functions, Mitra (1967); Romaniuk (1973) Pearson Mitra Type I Curve (1967) Romaniuk (1973) .Islam and Rashid (2004), Brass Brass (1974), Brass (1978), Gompertz Murphy and Nagnur (1972) and the polynomial models of brass (1960) have also been applied to real data. Islam (2009) suggested "a polynomial third-degree model adapted to the fertility model of Bangladesh".

$$f(x) = a + bx + cx^2 + dx^3$$

Asili *et al*. (2014) to adjust the bimodal model of "age-specific fertility rates in Ireland and Greece" used the asymmetric logistic model. The beauty of a fertility model based on asymmetric density is that it can adapt effectively to unimodal, bimodal and multimodal fertility models. The skewness parameter can change the symmetrical curve into an asymmetrical curve if necessary. Initially, it has three parameters, the number of asymmetry parameters can be increased accordingly to fit the curve to multimodal fertility schedules. Thus, asymmetric models are flexible enough to accommodate a wide variety of fertility patterns. The models proposed previously are reliable, but they are very complex to estimate the parameter or parameters of the model. In this article, to study India's age-specific fertility model, we use the asymmetric logistic probability distribution [4].

Skew: Logistic Distribution Based Fertility Model

Azzalini (1985) proposed a “formula for skewing the symmetric distribution” which is given a:

$$f_s(x) = 2g(x)\,G(w(x))$$

Where, “*g(x)* is any symmetric probability density function, G(w) is the cumulative distribution function of symmetric density and $f_s(x)$ is the density function for any odd function *w(x).*”The cumulative distribution function and probability density function of standard skew logistic distribution are as follows:

$$\text{“}F(x) = 1/1+\exp(-x);\ X \in R$$
$$f(x) = \exp(-x)/\,(1+\exp(-x))^2;\ X \in R\text{”}$$

Putting *f(x)* in place of *g(x)* and *F(x)* in place of *G(x)* and *w(x)* = x in the probability density function of skew symmetric density we get the skew-logistic density function as follows:

$$f_{sl} = 2e^{-x} / (1+e^{-x})^2 (1+e^{-\alpha x}); X Є R$$

where α is the skewness parameter.
Transforming *x* in to *y-μ/σ*, μ is the location parameter and σ is the scale parameter:

$$f_{sl} (y; \alpha,\mu,\sigma) = 2\sigma^{-1}e^{(y-\mu)/\sigma} / (1+e^{-(y-\mu)\sigma})^2 (1+e^{-\alpha(y-\mu)\sigma})$$

The above skew-logistic density is used to model the fertility pattern of India as it is observed that the Indian fertility curve has only one mode for almost all states, so this model would be appropriate for Indian fertility schedule. For estimating the parameters of fitted model the method of non-linear least square has been used. The estimated parameters are obtained by minimizing the residuals sum of squares which is mathematically represented by the following equation:

$$r_x = (g(x)-f(x))^2$$

for $x = a,\ldots, b$ where a and b are the lower and upper age limits of reproductive age span respectively, *g(x)* is the fertility rate at age x obtained by the proposed model and *f(x)* is the real or observed fertility rate at age *x*. "Indian states have very diverse fertility pattern. States like Uttar Pradesh has high age-specific fertility rates for women in all reproductive age-groups while on the other hand states like Sikkim has low age-specific fertility rates for women belonging to each age-group in reproductive age span. Some states like Bihar, Jammu & Kashmir, Meghalaya, Nagaland and Manipur have highest value of ASFR for females in age group 25-29 years while others have observed highest ASFR in age group 20-24 years. For the analysis as well as comparison purpose states are divided into two broad categories based on their value of TFR being high or low as compared to TFR for India which is 2.2 (NFHS-IV). Further, some states have almost equal ASFR in the age groups 20-24 and 25-29 years. The fertility patterns exhibited in these states have a flat peak."

Conclusion

The fertility model based on the asymmetric logistic distribution in this document conforms to the actual fertility data of all the states of India. The data was taken from the National Family Health Survey-IV (NFHS-IV). NFHS-4 provides data related to fertility, mortality, contraceptive use, maternal and child health, reproductive health, HIV / AIDS and awareness, the nutritional status of women and children in 29 states and 7 territories. the union, as well as in India in general. According to NFHS 4, some states of India such as Bihar, Jharkhand, Uttar Pradesh, Meghalaya, Manipur and Uttar Pradesh have a very high fertility rate, ie TFR> 2.5 while other states such as Goa, Kerala, Haryana, Sikkim and Tripura have a low fertility levels ie TFR <2.5. Some states such as West Bengal have a high level of fertility for women in the early age group, that is, with an age range of 15 to 19 years, may be due to the predominant custom of early marriage in these state. According to NFHS 4, the highest level of fertility is observed in women in the age group of 20 to 24 years and the lowest in the age group of 45 to 49 years. The pattern of ASFR is unimodal for all states, increases slowly after 15 years, reaches its peak for women in the age group of 20 to 24 years, and then again begins to decrease sharply and reaches zero for women. Women after 50 years years. These states have a different level of fertility in different age groups. Among these states, Uttar Pradesh has the highest level of fertility and Kerala has the lowest prevailing fertility level. It is also noted that although Meghalaya and Uttar Pradesh have an almost equal TFR level, their ASFR for different age groups is totally different. It is clearly evident that the real and estimated fertility are very close to each other, which demonstrates the good adaptation of the model to the fertility program of India. The quality of fit of any model can be verified by various techniques and tools. The quality of the demographic models depends not only on the quality of the data but also on the demographic explanation of the parameters used in the model. The parameters of Skew's logistic model are not directly explained. The location parameter and the scale parameter are not the mean of the distribution. The advantage of using a logistic bias model is that it can be adjusted to a variety of fertility patterns observed in the human population. It is equally appropriate for a unimodal and multimodal fertility calendar.

References

1. Abadian, S. Women's autonomy and its impact on fertility. World development. 1996; 24(12):1793-1809.
2. Azzalini A. A class of distributions which includes the normal ones. Scandinavian journal of statistics, 1985; 171-178.
3. IIPS. *National Family Health Survey (NFHS-4), 2015-16,* International Institute for Population Sciences, Mumbai, India, 2017.
4. Sheps MC. Effects on family size and sex ratio of preferences regarding the sex of children. Population Studies. 1963; 17(1):66-72.
5. Sheps MC. An analysis of reproductive patterns in an American isolate. Population Studies. 1965; 19(1):65-80.
6. Singh K, Suchindran C, Singh R. Smoothed breastfeeding durations and waiting time to conception. Social biology. 1990; 41(3-4):229-239.
7. Singh S, Bhaduri T. Maximum likelihood estimates for the parameters of a continuous time model for first conception. Demography 9(2):249-255).
8. Srinivasan K. The open birth interval as an index of fertility. Journal of Family Welfare. 1966; 13(2):40-44).
9. Tietze SL, Lincoln R. The effect of breastfeeding on the rate of conception. In Fertility Regulation and the Public Health, pp. 333{338. Springer, 1987.
10. Verma R, Loh S. Evaluation of persoonia type I curve of fertility by age of mother for Canada, provinces and territories, 1980. In Canadian
11. Population Society meeting, Charlottetown, PEI, 1992.
12. Yadava R. A probability model for the number of births. In Seminar Volume in Statistics. Varanasi, India: Banaras Hindu University. 1990; 85:90.