Introduction

1.1 Need to investigate cohort fertility patterns of Indian women

Since the last four to five decades, many studies have discussed fertility levels, trends and differentials in India, its states and regions (Adlakha et al., 1974; Registrar General of India 1976; Jain et al., 1982; Bhat et al., 1984; Preston et al., 1984; Chaudhry 1987; Rele 1987; Visaria et al., 1994; Bhat 1994; Guilmoto et al., 1998, 2001; Guilmoto 2000 etc). But, all these studies have been restricted to period approach to fertility change. The reasons might be: (1) periodic fertility indicators are relatively easy to estimate and are useful for pragmatic reasons and (2) Sample Registration System (SRS), the most important demographic data source of India, provides information only on the periodic indicators of fertility. However, it is well known that Total Fertility Rate (TFR), the most widely used period fertility indicator, is sensitive to tempo effects (Hajnal, 1947; Whelpton 1954; Ryder 1956, 1959, 1964, 1980, 1983; Brass 1991; Bongaarts and Feene 1998; Van Imhoff 2001; Kohler and Ortega 2002a). Apart from that, the TFR is a hypothetical measure of fertility as no real group of women has experienced or will necessarily experience the age specific fertility rates of a particular calendar year from which the TFR is calculated. The simplicity and wide availability of the TFR have contributed to a neglect of some deficiencies in this fertility indicator (Bongaarts and Feene 1998). Though several alternative periodic fertility indices exist in the demographic literature there is no common agreement for the usage of these indices (Brass 1990; Le Bras 1997; Bongaarts and Feeney 1998; Kohler and Philipov 2001; Philipov and Kohler 2001). On the other hand, cohort fertility measures such as Cohort Total Fertility Rate (CTFR) are free from tempo effects and they correspond to real cohorts of people. If one’s intention is to study fertility trends then a cohort approach is arguably better as these measures are more consistent than period fertility indicators (Hajnal 1947; Ryder 1956, 1959, 1964). It is generally perceived that cohort fertility measures are of less use for policy considerations. It is our contention that given the availability of survey data such as the demographic health surveys that are carried out in
many parts of the world, policy makers can also take lessons from the fertility experience of cohorts currently aged 30, 25, etc. For instance, the information on percentage of the women sterilized, percent using various methods of contraception, number of children already born, and such parameters for these women are useful inputs for policy considerations. Therefore, the availability of a detailed cohort fertility study, studying the actual fertility experience of people born in various calendar years, not only gives a better picture of fertility change but also can call for policy interventions if needed.

1.2. Literature review

Apart from knowledge deficit on fertility patterns of Indian women cohorts, there are few theoretical and empirical issues on which the present thesis aimed to work. To provide better background to these theoretical and empirical issues, the literature review has been divided into two sections. In Section I, problems associated with the measurement of current fertility are discussed and also the problems associated with the usage of existing fertility models are discussed. Additionally, the need and the scope to build simple models for the distribution of number of children and age at various order births is discussed. In Section II, conflicting studies in the relationship between women autonomy and their reproductive behaviour are discussed. Additionally, knowledge deficit on the changing dynamics of tubal sterilization practice in Indian women is discussed. Also, the need to work on these issues is stressed, simultaneously.

1.2.1 Section I

1.2.1.1 Problems associated with the measurement of current fertility

Broadly there are two different ways to measure fertility level in a population. They are period approach and cohort approach. Of these two ways, period approach is the simplest and the oldest. In this approach fertility is measured on the basis of data on number of births during a particular time period. There are many period fertility measures in the demographic literature. Of them, Crude Birth Rate (CBR), Gross Reproduction Rate (GRR), Net Reproduction Rate (NRR) and TFR are the widely used ones. Out of these,
TFR is the most popular one as it has nice demographic interpretation. TFR can be interpreted as the average number of child births expected from a woman if she gives births according to the age specific fertility rates of a particular calendar year without dying during the entire reproductive period (i.e. 15 to 49 years).

But, TFR is a hypothetical measure of fertility and can change for a variety of reasons (Brolchan, 2011). For example, if in a year women delay childbearing fertility rates will depress; and in a year when childbearing is accelerated fertility will rise. Typically, TFR consist of both quantum and tempo components. Bongaarts and Feeney (1998) have defined the quantum component as the TFR that would have been observed in the absence of changes in the timing of childbearing during the period in which the TFR is measured. The tempo component equals the distortion that occurs due to changes in the timing of childbearing.

Age Specific Fertility rate (ASFR) can be decomposed into birth order components and hence the TFR. TFR can be re-written as $TFR = TFR1 + TFR2 + TFR3 + \ldots\ldots$. Where, TFR1, TFR2, TFR3 and so on are the birth order components. Like the TFR, the first-order component (TFR1) gives the average number of first order births a woman would have by age 50 years if she bear first births at the age-specific rates observed in a given year or period. It was found by Whelpton (1954) that during the late 1940s and early 1950s the TFR1 exceeded 1, which may mean that women on average had more than one first birth, which is impossible. This is caused by the changes in the tempo of childbearing. The interpretations of TFR1, TFR2, ... are thus misleading. Hence, the interpretation of TFR is suspicious. Other period fertility measures such as GRR and NRR also suffer from the same tempo effects. The problem with the usage of CBR is that a particular value of it say 40 (40 live births per 1000 population) is small or big can not be understand immediately, unlike a TFR of 1 is immediately understand as low fertility.

Despite the widespread agreement about the relevance of distortions due to changes in timing of child bearing, an appropriate way of measuring and adjusting for these changes remains controversial (Brass 1990; Le Bras 1997; Bongaarts and Feeney 1998; Lesthaeghe and Willems 1999; Van Imhoff and Nico Kielman 2000; van Imhoff and Keilman 2000; Kim and Schoen 2000; Bongaarts and Feeney 2000, 2006; Kohler and
Unlike period fertility indicators, cohort fertility indicators do not suffer from any of the above problems. Therefore, when detailed data is available cohort approach to study fertility change is arguably better.

1.2.1.2 Problems associated with the usage of existing fertility models

A great amount of research has been undertaken in the last 70 years to find some simple and suitable way to describe the age pattern of fertility. Both theoretical and empirical approaches have been developed and used to mimic fertility schedules. The Coale and Trussell (Coale et al., 1974) and the Brass's relational Gompertz model (Brass 1980, 1981) represent a combination of theoretical and empirical approaches in modeling fertility schedules. But, these models are found to have shape limitation, hence their application is very limited (Schmertmann 2003). Theoretical or analytical models that are added in the course of time includes Hadwiger model (Hadwiger 1940), Beta model (Hoem et al., 1981), Gamma model (Hoem et al., 1981), Peristera-Kostaki model-I, II & III (Peristera et al., 2007), Gompertz model (Gompertz 1825), Quadratic spline model (Mc Neil et al., 1977), Cubic spline model (Hoem and Rennermalm 1978; Gilks 1986) and Constrained Quadratic Splines (CQS) model (Schmertmann 2003, 2005). Two common characteristics of all the analytical fertility models are (1) they are all nonlinear in nature and (2) not all parameters have clear demographic interpretation. Since these models are non-linear in nature, therefore, a poor initial guess of parameter estimates for solving the least square equations of these models in order to get final parameter estimates (least square equations of any non-linear model being not in closed form some kind of iterative algorithm has to be used to obtain the final parameter estimates, starting with an initial guess of parameter estimates) may lead to unusual final parameter estimates. The disadvantage of having uninterpretable parameters in a model may lead to another disadvantage by making it difficult to guess their initial parameters estimates either with common sense (i.e. subjectively) or on observing the empirical fertility distribution. Apart from that, the validity of the final parameter estimates cannot be judged properly.
1.2.1.3 Timing of various order births

Studies on age at various order births and their distributions have special importance in demography. This is because 1) they will dictate birth intervals, which in-turn influence the health of both the mothers and their children (Cleland and Sathar 1984; Alam 1995; Koenig et al., 1990; Curtis, Diamond and McDonald 1993; Alam 1995; Rousso et al., 2002; King 2003), 2) they will dictate the overall timing of the birth of children, which will in-turn will effect population growth (Frejka 1973; Bongaarts and Greenhalgh 1985; Rajaretnam 1990) and 3) they will affect period fertility indicators (Newell 1988). In-spite of such a great importance, there are very little efforts to study timing of various order births and their distributions. Though few demographers have attempted at modelling birth intervals (which can help to understand age at various order births, when age at first birth is known), but, mostly they were confined themselves to the distribution of first birth interval only (Singh 1964; Singh and Singh 1983; Bhattacharya et al., 1989; Nath et al., 1993; Nath, Land, and Goswami 1999). Given the availability of detailed maternity histories of women, in the form of National Family Health Surveys (NFHSs), there is good scope to build both probabilistic and deterministic models to better understand the timing of various order births. For instance; the classical approach in modelling fertility schedules can be extended to birth order specific fertility schedules and the distribution of number of children and age at various order births can easily derived, without any sort of assumptions.

1.2.2 Section II

1.2.2.1 Changes in the dynamics of tubal sterilization practice

In most parts of the India, contraceptive use means sterilization. People hardly know any traditional contraceptive method. Even the Indian government has given an undue importance to sterilization. Hence, it is the dominant contraceptive method in the country today. Particularly, females are the main users of it. Tubal sterilization or female sterilization accounts for more than 70% of all the contraceptive methods, couples use in the country (IIPS 1995; Koenig 1999; IIPS and ORC Macro 2000; IIPS and Macro International 2007). Tubal sterilizations have steadily risen from less than 1% in 1960 to the present date. According to the latest National Family Health Survey, about 37% of
women in the reproductive period are protected by sterilization (IIPS and Macro International 2007). But, this percentage masks wide variation in tubal sterilization practice across the ages (different cohorts) hence not very informative. Actually, for better understanding of changes in the dynamics of tubal sterilization practice it is essential to study how the tubal sterilization practice has changed over cohorts and what changes have occurred in the age pattern of acceptance of it. Trends in the dynamics of tubal sterilization practice, the method that contributed significantly to reduce fertility in India (Pathak et al. 1998), are of considerable importance to policy makers, health workers and researchers. A detailed study on tubal sterilization trends over cohorts along with the corresponding changes in the age pattern of acceptance of it is expected to offer better explanation for variation in fertility level across the regions of India and also by many other characteristics. It will also help to understand the changes in couples planning regarding their family size and the timing of the decision to end their reproductive period, from older cohorts to the current ones. It will also help to understand the increasing participation of women in the work force in the country.

1.2.2.2 Role of autonomy of women on their fertility behaviour

Women’s autonomy is “the extent to which women exert control over their own lives within the families in which they live, at a given point in time” (Jejeebhoy 2000: 205). Research since the mid 1980’s has found that women autonomy results in reduced fertility, improved child nutrition and better living conditions for women (Balk 1994; Basu 1992; Basu and Basu 1991; Dyson and Moore 1983; Murthy, Guiio and Dre’z 1995; Bloom, Wypij and Das Gupta 2001; Portela and Samtarelli 2003; Mullany et al. 2005; Basu and Koolwal 2005; Gupta and Yesudian 2006). However, few studies have found that autonomy of women do not have any influence on their reproductive behaviour when other influencing factors are controlled (Morgan, Stash et al. 2002; Muntaz and Salway 2005). Also, the general perception that autonomy of women is one of the mechanisms of how education influences contraceptive use in developing countries (Mason 1987; Cleland, Kamal and Sloggett 1996) has been found invalid in certain contexts (Saleem and Bobak 2005). A part of this confusion and conflicting results may be due to the methodological differences in some of the earlier studies that have used one or more of
women's education, age at marriage and labour force participation as surrogates of woman autonomy. The reasons why they should not be used as proximities or surrogates, while linking woman’s autonomy and reproductive behaviour, are given in great detail in Agarwala and Lynch (2006). Also, the usual way of construction of autonomy index - summing of various elementary components of autonomy by giving equal weights to all (Morgan and Niraula 1995; Hashemi, Schuler and Riley 1996; Jejeebhoy 2000) - may not provide very appropriate measure for autonomy. This is because some components influence woman’s confidence (and hence autonomy) more than others. Therefore, differential weighting is desired in accordance with the practical importance of various dimensions of autonomy, while forming autonomy index. Given the lack of clarity (as a result of conflicting studies) in the relationship between women’s autonomy and their reproductive intentions and outcomes, it is desirable to re-investigate this issue by properly constructing an autonomy index. Testing the role of empowerment of women on various aspects of reproductive behaviour may open new channels through which high fertility in India, particularly in the Central India and the East India, can be brought down to replacement level fertility.

1.3 Objectives of the present thesis

Given the knowledge deficit on cohort fertility patterns of Indian women, problems associated with the usage of existing fertility models, scope to propose simple models for the distribution of number of children and age at various order births, and scope to improve our understanding over the changing dynamics of tubal sterilization practice in India and the relationship between women autonomy and their reproductive behaviour the present thesis aims to work on these issues with the following specific objectives.

1. To come up with fertility models, with all its parameters having clear demographic interpretation and can provide good fit to fertility schedules.

2. To investigate cohort fertility patterns of Indian women by their socio-economic characteristics.
3. To propose probabilistic models for the distribution of age at various order births and to use them in Indian case for studying spatial pattern in the distribution of age at various order births.

4. To propose models for investigating the changes in the age pattern of acceptance of tubal sterilization and to explain regional variation in fertility in terms of variation in the tubal sterilization practice.

5. To investigate the relationship between the autonomy of women and their reproductive issues such as children ever born, ideal number of children, son preference and the usage of contraceptive methods.

1.4 Data

Data of all the three National Family Health Surveys (NFHSs), conducted in India during 1992-1993, 1998-1999 and 2005-2006 and commonly referred as NFHS-1, NFHS-2 and NFHS-3 respectively, have been used in this study. These surveys (NFHSs) provide a rich source of data on health and demographic conditions of people in the country. Details regarding NFHS design and other relevant information can be found from National Family Health Survey reports (IIPS, 1995; IIPS and ORC Macro, 2000; IIPS and Macro International, 2007).

1.5 Chapter outline

Chapter 1: Introduction

It is an introductory chapter consisting of introduction, review of literature, objectives of the present study and sources of data.

Chapter 2: Special form of Gompertz model and its application to cohort fertility schedules

A brief discussion on several existing fertility models has been presented in this chapter. Their drawbacks are highlighted and a special form of Gompertz model has been
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proposed. Advantages of the proposed model and fit wise comparison with other models are given.

Chapter 3: Cohort fertility patterns by socio-economic characteristics of women

In this chapter, a six parameter special form of Gompertz model has been proposed and made use of for quantification of the fertility behavior of the cohorts of Indian women by their socio-economic characteristics.

Chapter 4: Distribution of number of children and age at various order births

In this chapter, we have proposed a simple analytical framework to model the distribution of number of children and age at various order births, by using age - birth order - specific fertility rates. The proposed framework has been made use of to study pattern of giving various order births in India and its different regions. The proposed framework has also been validated with cross-sectional birth order specific fertility schedules from other countries such as United States of America, Russia, and etc.

Chapter 5: Changes in the dynamics of tubal sterilization practice and its link with regional variation in fertility level

In this chapter, we have proposed models for tubal sterilization schedules (we refer set of age specific sterilization rates as tubal sterilization schedule, throughout this study) and used them to study changes in the dynamics of tubal sterilization practice in India and its different regions. We have also measured the duration of reproductive period averted due to tubal sterilization, across the regions of India and over cohorts, and used it to explain regional variation in fertility level in the country.

Chapter 6: Women autonomy and reproductive behavior

In this chapter, an index of autonomy has been constructed based on the information collected on the freedom enjoyed by woman in taking decisions regarding movement, health care and management of household finance. This index has been used to investigate (1) level of autonomy of women by their socio-economic and cultural characteristics, (2) the linkage between women’s autonomy and their reproductive issues such as children ever born, ideal number of children, son preference and practice of contraceptive methods.

Chapter 7: Overall summary and recommendations

This chapter summarizes the important findings and discusses the relevant policy implication emerging from this thesis.

Chapter 1