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***Research Article***

# Fertility Decline Across Regions and Socioeconomic Groups in India: Analysis of Period and Cohort Fertility Trends Through Age-Period-Cohort (APC) Models

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**Abstract**

This paper first investigates the trends in the period and cohort total fertility rates across regions and socioeconomic groups in India. Next, the age-period-cohort models are applied to assess the relative importance of period and cohort factors in fertility decline in India across regions and socioeconomic groups in India. The birth history data from the three rounds of National Family survey (NFHS 1, 2 & 3) is used to estimate the period and cohort total fertility rates. The period fertility rates are estimated for the period 1981-2006 and cohort fertility rates are estimated for women born between 1945 and 1965. Bayesian APC models are used to analyze the significance of period and cohort factors. Results show that both period and cohort fertility declined across all the subpopulations; however, there were remarkable differentials in pace and magnitude. The result from the APC models showed that fertility decline in India is primarily determined by the period factors; however, for north-east region of India, cohort factors were significant in determining the fertility trends.

## Introduction

A number of studies have documented trends and differentials in period fertility for India and its states (Adlakha & Kirk 1974; Jain & Adlakha., 1982; Preston & Bhat 1984; Rele, 1987; and SRS Bulletins). Long term trends in fertility show impressive decline in fertility in India during 1971-2015. Recent estimates of total fertility rates suggest that fertility in India is at the verge of replacement level (RGI, 2013). However, fertility decline is not uniform across all the states and socioeconomic spectrum of India. Total Fertility Rate (TFR) in India is declining with divergent destinies across states, rural-urban and socio-economic groups (Guilmoto and Rajan, 2001; Visaria, 2004; James and Nair, 2005; Kulkarni and Alagarajan, 2005; Alagarajan and Kulkarni, 2008). However, the long term trends of fertility across various social categories such as education, religion and caste are not well documented for India.

Further, the historical prominence of period measures in describing fertility trends in India and across world is due to the fact that period measures require less detailed data. Also, period measures especially total fertility rate (TFR) is considered relevant from the policy and program perspectives as they describe reproductive behaviour of the contemporary periods. However, several researchers have argued that period measures of fertility may provide misleading picture of fertility levels and trends, because, changes in cohort fertility timing are manifested as changes in period quantum (Hajnal, 1947, Ryder, 1964).

Also, the period TFR is not completely standardized for comparison as it ignores the parity composition of women in the population. Compared with cohort measures, the period fertility measures fluctuate more. This is because changes in the timing of cohort fertility distort period measures of fertility level. Therefore, in the wake of limitation of period fertility measures in understanding fertility levels, it becomes important to examine cohort trends for additional insights.

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First, fertility is affected by cohort factors because it depends on the reproductive history and life-cycle stage. Second, cohorts are distinctive, socially and demographically, and their distinctiveness persists through time. Thirdly, theories of fertility are formulated in a cohort framework. Researchers also argued that the cohort framework is the natural and essential way to approach behaviour, such as family formation, that takes place over time.

Despite these advantages of cohort measurement of fertility, cohort measures have several limitations of their own. The first and foremost is that cohort measures can be calculated only at the end of reproductive period of respective women cohorts and it is difficult to obtain data readily available for such calculations. Also cohort measures describe fertility of past which may not be relevant for analyses for contemporary policy perspectives. Secondly, the previously discussed advantages may not always hold true in practice. However, a simultaneous assessment of period and cohort fertility levels complements each other well and is expected to provide additional insights into the dynamics of fertility transition in a population

In India, the period measures have been extensively used to describe fertility but use of cohort measures have been limited. The lack of studies on cohort fertility estimates are to be attributed to the absence of detailed data, necessary for calculation of cohort fertility rates. Recently, making use of birth history data from NFHS-1, 2 and 3, Pasupuleti and Pathak (2010) have estimated cohort fertility rates for India and its broad regions. However, they did not estimate cohort fertility rates for other subpopulations of India. As reflected in period measures, women of different social stratum may have followed different trajectories during fertility transition in India and therefore, it becomes necessary to examine the cohort fertility rates for women of different social categories.

Comparatively, several statistical evidences using age-period-cohort models have shown that period is the prime source of variation in the fertility rates. The fertility decline is affected by both changes in cohort and period factors. In India as well as other countries, most of the policies and programmes formulated to contain fertility are designed to have immediate and direct effects which cut across the cohorts. Also, there are policies for social development like promotion of women’s education, employment opportunities and empowerment of women and increase in the age at marriage that affect the fertility indirectly and generally bring about changes in proximate determinants of fertility through cohorts.

Thus, it becomes important to empirically examine if fertility decline is more associated with cohort changes or period changes (Nı´ Bhrolchaı´n, 1992). The age-period-cohort (APC) analysis of fertility provides more comprehensive analytical tool for such an exploration. APC analysis elsewhere in other countries has revealed that period factors had more prominent effect on fertility decline than cohort factors (Pullum, 1980; Rindfuss et al., 1988; Kye, 2012). However, in India, a comprehensive exploration of age, period and cohort effects of fertility has not been undertaken.

Building on the above discussion, this paper aims to estimate and describe the fertility experience of Indian women from both period and cohort perspective across major regions and selected population subgroups: type of place of residence, caste, religion and level of education. The paper is comprised of three subsections. First, the period total fertility rates have been estimated for India and regions, also by major socioeconomic categories. Secondly, the cohort total fertility rates have been estimated for India and subgroups of the population. Lastly, we used age-period-cohort (APC) analysis to assess the effects of age, period and cohort on the fertility trends in India. Also, the analysis in this paper sets up the context for the examination of tempo effects in period fertility trends in India and its subpopulations in the subsequent papers.

## Materials and Methods

### Data Sources

This study uses birth history data from the three rounds of nationally representative National Family Health Survey (NFHS) conducted in 1992-93, 1998-99 and 2005-06 successively.The birth history data was collected for 89,777 ever married women of age 13-49 in NFHS-1; for 90,303 ever-married women of age 15-49 in NFHS-2 and; for 1,24,385 women of age 15-49 in NFHS-3.

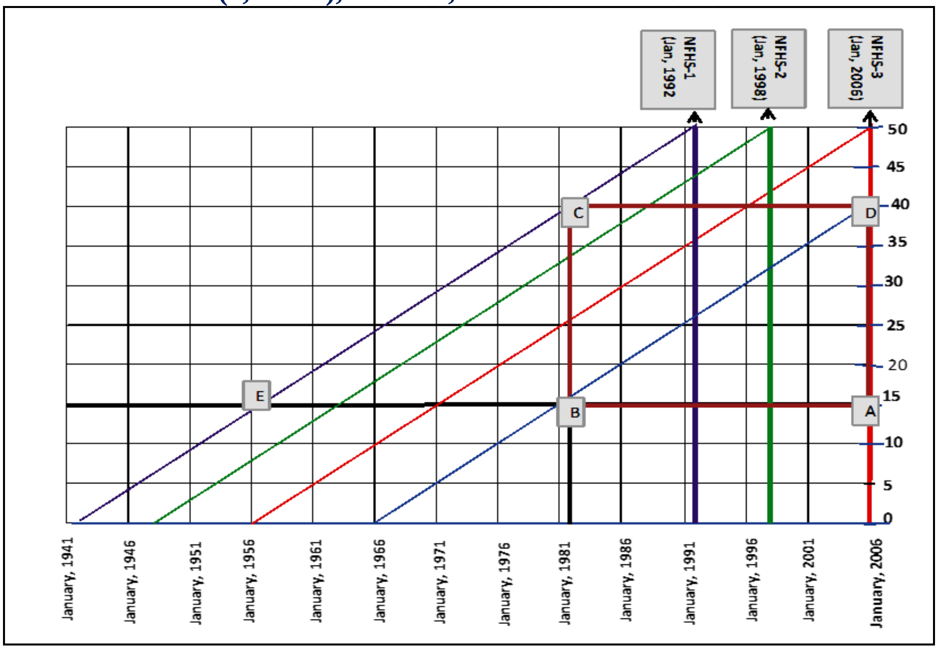
## Methodology

### *Estimation of period fertility rates*

The availability of full birth histories from the three successive NFHS rounds with substantial overlaps among them offers a unique opportunity to estimate fertility trends for a longer period of time; over 25 years of 1981-2006 during which most of fertility decline occurred in India. We seize the opportunity to merge the data from retrospective birth histories of the three rounds of NFHS. Thus, for some years there was data from only one round of NFHS survey and for others data was available from all three rounds of NFHS surveys. The combined birth histories have been aggregated into a single event-exposure file with multiple periods of exposure and each period of exposure being each calendar year (From January 1$^{st}$ to December 31$^{st}$). In the process, we have retained the normalized weights. Since, we do not have a common date of interview for all the women enumerated in a survey, the creation of event-exposure format data for each calendar year becomes difficult. Therefore, to overcome such computational difficulties, the data was censored to the 1st January before the beginning of the survey to obtain a single date of reference for all the women interviewed in a survey. The date of reference is taken to be 1$^{st}$ January, 1992 for women interviewed in NFHS-1, 1$^{st}$ January, 1999 for women interviewed in NFHS-2 and 1$^{st}$ January 2006 for the women from NFHS-3. The following lexis diagram depicts the structure of pooled birth history data from the three rounds of NFHS 1, 2, 3 (1992-93, 1998-99, 2005-06).

In the figure1, the red triangle represents the data from NFHS-3, green triangle represents data from NFHS-2, and the purple triangle shows data from the NFHS-1. It is evidentfrom the figure that due to limiting the age of respondents to be 49 years at the time of survey, the fertility rates cannot be calculated for all the ages for prior years of survey. The birth histories of women in the reproductive ages provide a full account of fertility rates up to age 40 for the 10 years prior to the survey, and since most of births (usually more than 90 percent) occur before age 40, the cumulated fertility up to age 40 can be effectively used as an approximation to the TFR. Therefore, the period of observation for estimating fertility measures is effective from 1$^{st}$ January, 1981 to 1$^{st}$ January 2006 representing a total duration of 25 years. The rectangle ABCD shows the area for which we have complete data on births and exposure of women up to age 40 for years 1981 to 2006. The cohort fertility rates could also be estimated from this data as shown in the figure that we have data on births up to age 40 for the cohorts falling in the parallelogram CDBE.

**Figure 1: Lexis diagram showing the information available from pooled birth histories of NFHS (1, 2 & 3), 1992-93, 1998-99 and 2005-06**



For the estimation of period fertility, person years of exposures of women to child birth were calculated by single years of ages of women and calendar years and births were tabulated by the calendar years and ages of mothers. The age specific fertility rates are then obtained for each calendar year by dividing the births tabulated by age of mothers and calendar years by the person years of exposure for respective years.

Notably, the fertility estimates from birth history data are biased because the sample is representative of women in the reproductive ages at the time of survey and it ignores the women who were in the reproductive ages in the past but not at the time of survey. This bias can be controlled to some extent by calculating the fertility up to specific ages of women for which the data is available. However, the bias is not completely removed because the calculation excludes the women of reproductive ages who died during the period.

### *Estimation of cohort fertility rates*

The cohorts from pooled birth history data are formed based on "year of birth" of women. Since, we have formed cohorts from the pooled birth history from the three NFHS rounds, some cohorts would have women from all the three rounds of NFHS, some from 2 rounds NFHS and some cohorts would have women from only one round of NFHS survey. After creating the single year cohorts, we have calculated the number of births to a cohort of women for each single year of age (that is 12 months period). The denominator for these women cohorts remains constant for each age group as same number of women is being followed at each age. The cohort age specific birth rates are calculated by dividing the weighted number of birth in each age group by the weighted number of women in that cohort.
Since the estimation of cohort fertility is based on retrospective birth history data from cross sectional survey, it does not include fertility history of women who died or have migrated. Therefore, the estimation is based on the assumption that there is no differential fertility between women interviewed in the survey and those who have died or emigrated, and who are therefore not sampled in the survey.

### *Age-Period-Cohort Analysis*

The data for the analysis of age, period and cohort effects of fertility in India comes from the exposure of women and births calculated by age of women and calendar years for the estimation period fertility. For the estimation of period fertility, exposure and number of births are calculated for single year age and 5 year moving quinqunnium of calendar years with one year shift. In all, there were twenty five single year age group (15 to 39) and twenty one periods (1981-86, 1982-87, …., 2001-06). Based on the number of age groups and time periods, the number of cohorts was forty five as shown in the following formula.

$$\text{Number of cohorts} = (\text{Number of age groups} - \text{Length of ageroup}) + \text{Number of periods}$$

$$(25-1)+21=45$$

In this analysis, I have used Bayesian Age Period Cohort model. Bayesian APC models have been described in Berzuini and Clayton (1994), Besag et al. (1995) and Knorr-Held and Rainer (2001). The analysis is performed using BAMP software developed by Schmid &Knorr-Held (2007). BAMP assumes a hierarchical model with a binomial model in the first-stage (Knorr-Held and Rainer, 2001).

### Regions and social characteristics considered in the study

*Formation of regions:* In this study, we used regions instead of state level analysis because sample size was not adequate for the estimation of fertility trends at the state level. Moreover, for the calculation of order specific fertility rates required for the estimation of tempo effects, sample size would have been further reduced. Therefore, we chose to carry out the analysis at the broader level of geographical region. The regions are formed according to the classification scheme adopted in National Family Health Survey to form six different regions. These are: North, Central, East, North-East, West and South. States grouped into different regions are listed below:

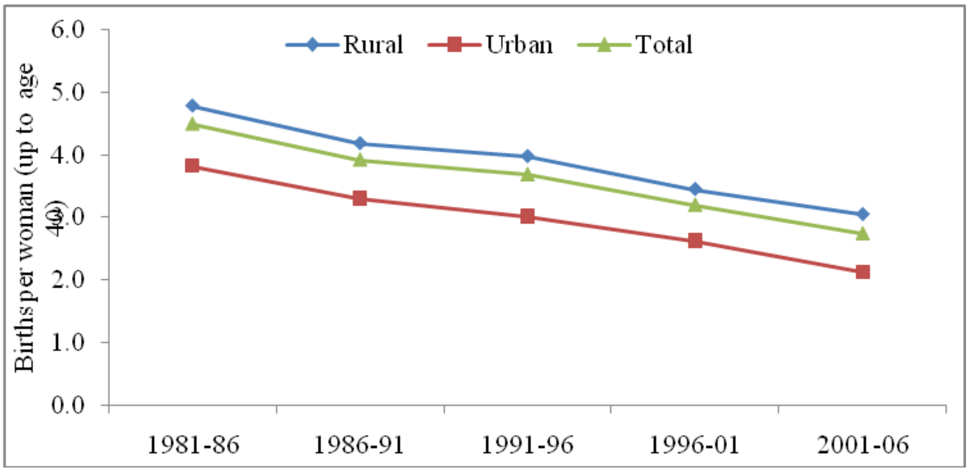
*North:* Jammu & Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi and Rajasthan
*Central:* Madhya Pradesh (Including Chhattisgarh) and Uttar Pradesh (Including Uttarakhand)
*East:* Bihar (Including Jharkhand), West Bengal, Orrisa
*North-East:* Assam, Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Tripura, Nagaland and Mizoram
*West:* Gujrat, Maharashtra, Goa
*South:* Tamil Nadu, Kerala, Karnataka and Andhra Pradesh
*Social characteristics:* The social characteristics considered in this analysis are: education, caste and religion. Women's years of schooling is used as measure of education which is subdivided into four categories: no schooling, 1-5 years of schooling, 6-9 years of schooling and 10+ years of schooling. Caste of women has three broad categories: ST, SC and Other. The religion of women is categorized into three broad groups: Hindu, Muslim and Other.

## Results

### *Period fertility estimates*

This section presents estimates of total fertility rates (TFRs) during 1981-2006usingpooled birth history data from three successive rounds of NFHS (1992-93, 1998-99 & 2005-06). As described in the methods section, the period total fertility rates are calculated for women up to age 40. Figure2 presents the cumulated fertility of women up to age 40 (TFR(40)) for mutually exclusive quinquennial periods of 1981-86 , 1986-90,…,2001-06 for total and by place of residence in India.

**Figure 2: Estimates of trends in TFR(40) for the mutually exclusive quinquennium of calendar years, India, India urban and India rural 1981-2006**




The results reveal that total fertility rate in India has declined substantially from around 4.5 births per women up to age 40 in 1981-86 to 2.8 in 2001-06 registering a decline of 1.8 births per woman during a span of 25 years. For women in rural areas, the total fertility rate (TFR(40)) up to age 40 declined from 4.8 in 1981-1986 to 3.1 in 2001-06 while for women in urban areas TFR(40) declined from 3.8 to 2.1 during the same period. It's worth noting that the speed of fertility decline in rural and urban areas has been almost similar during the period 1981 to 2006 maintaining a difference of around 0.9 births per woman throughout the 25 years of observation. Overall, urban areas have been clearly ahead of rural areas in fertility transition.

Figure 3.3 presents the estimates of total fertility rate up to age 40 for India and rural and urban India based on the calculation of age specific exposures and events for moving quinquennial periods of calendar years with one year shift: 1981-86, 1982-1987,….., 2001-2006. The calculation of fertility rates for moving quinquennium is facilitated by the fact that we could calculate the event and exposure from the combined birth histories of three rounds of NFHS for each calendar year. One advantage of this approach compared with calculating fertility rates for mutually exclusive periods is that this approach provides fairly reliable estimates of the annual change in the levels. Comparison of the estimates from the two approaches show that the estimates from these two approaches are same, but, the second approach is more useful as it facilitates assessment of annual change in the fertility rates and other derived indices such as mean and variance of fertility schedules. In the following sections, therefore, we present results based on the calculations for moving quinquennial periods, 1981-86, 1982-87, …, 2001-06.

**Figure 3: Estimates of trends in TFR(40) for the moving quinquennium of calendar years with the shift of one calendar year, India, urban India and rural India, 1981-2006**

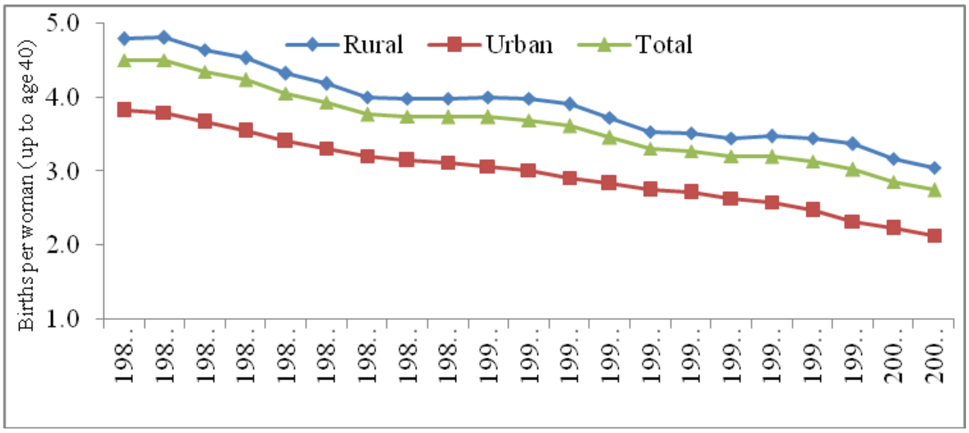
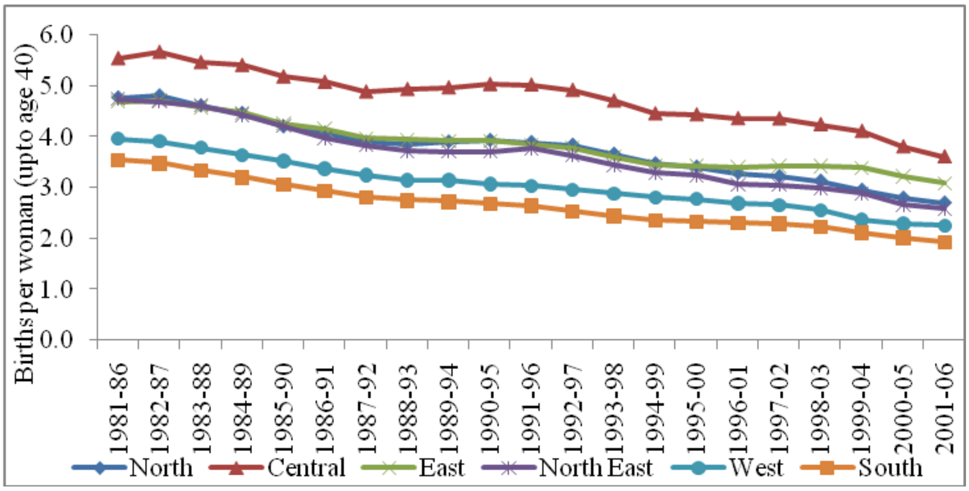



Figure 4 presents the estimated trends of total fertility rates (TFR) up to age 40 by regions of India for moving quinquennial periods of calendar years (1981-1986, 1982-1987,….,2001-06) during 1981-2006. The fertility trends from the figure 4 show that fertility declined substantially in all the six regions of India. Women in south region had the lowest and in central region had the highest total fertility rates throughout the period of 1981-2006. The women in western region closely followed the women of southern region in fertility trends with slightly high TFR throughout the period of 1981-2006. Women of other three regions namely north, east and north-east had more or less similar fertility levels until early 1990s and thereafter woman in north and north-east regions depicted slightly higher decline in the fertility levels.

**Figure 4: Estimates of trends in TFR(40) for the moving quinquennium of calendar years with the shift of one calendar year byregions of India, 1981-2006**

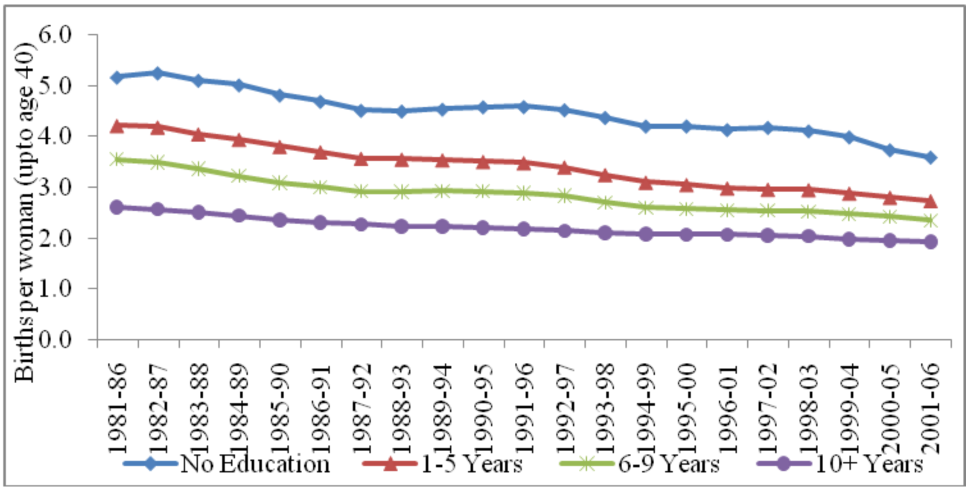



*Trends of period total fertility rates by years of schooling, caste and religion*

In this section, we present the estimates of TFR(40) for women from selected social categories of the population, specifically by years of schooling, caste groups and religion. Figures5, 6 and7 present the trends in the TFR40 during 1981 to 2006 by years of schooling, caste and religion respectively.

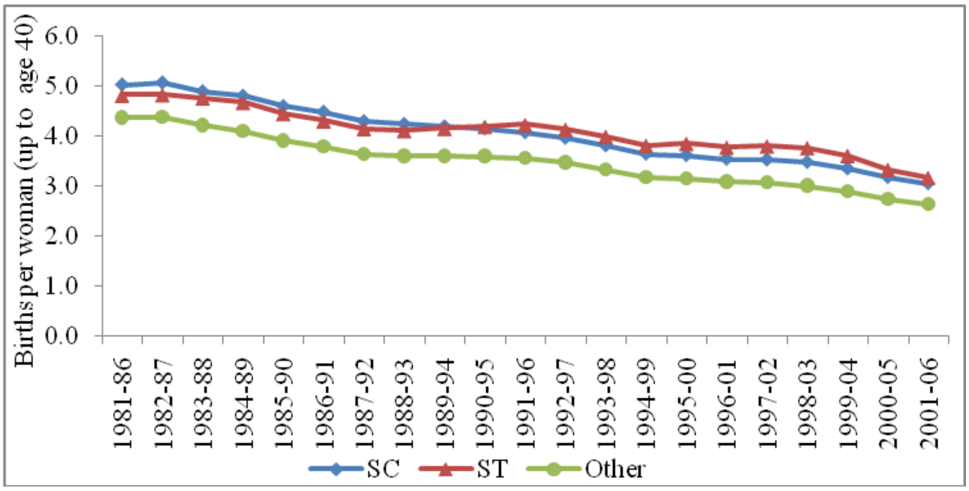
A clear educational gradient of fertility decline in India is evident from the figure 3.5, where for each successive increase in the women's years of schooling, fertility levels (measured by TFR(40)) are lower. Moreover, woman with no education have registered highest decline in TFR(40) from 5.2 in 1981-86 to 3.6 births per woman in 2001-06; whereas, the woman with 10+ years of schooling registered lowest decline (from 2.6 to 1.9 births per woman before age 40) during the same period. The difference in TFR(40) between women from no schooling category and 10+ years schooling category declined from 2.6 in 1981-86 to 1.7 in 2001-06.

**Figure 5: Estimates of trends in TFR(40) for the one year moving quinquennium of calendar years by women's education categoriesin India, 1981-2006**



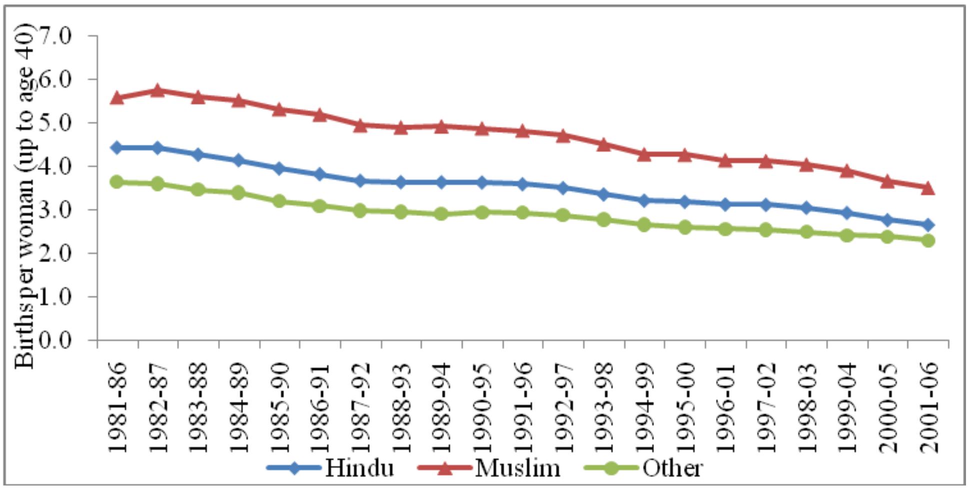

The estimates of period total fertilityrates by caste (figure 6) show that period fertility levels for women from SC and ST caste have been more or less similar throughout the period of 1981-2006. The difference in TFR(40) between women of SC/ST and 'other' caste remained considerable with slight decline in the difference during 1981-2006. Women from all the casteswitnessed remarkable decline in fertility during the period of 1981-2006.

**Figure 6: Estimates of trends in TFR(40) for the one year moving quinquennium of calendar years by caste in India, 1981-2006**




The estimates of period total fertility rates by religion show that Muslim women had highest fertility levels followed by Hindu and 'other' religion women throughout the period of 1981-2006 (figure 7). Moreover, Muslim women witnessed the highest while ‘other’ religion women the least decline in total fertility rates during the same period.

**Figure 7: Estimates of trends in TFR(40) for the one year moving quinquennium of calendar years by religion in India, 1981-2006**



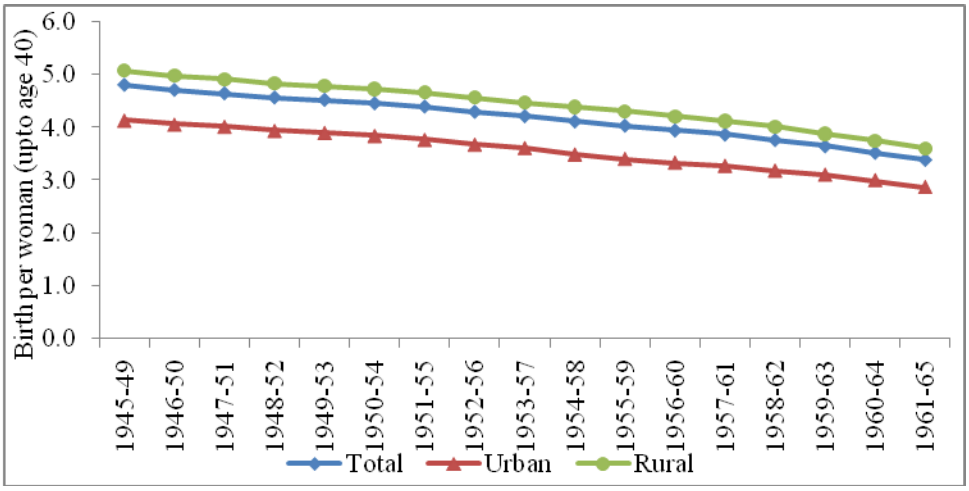

## Cohort fertility estimates

This section presents the estimates of cohort total fertility rate up to age 40 (CTFR (40)) for India, its regions and socioeconomic categories. The cohort total fertility ratesare calculated as the number of children born per women up to age 40 for the cohorts. The CTFR40 is calculated for 5 year moving birth cohorts with one year shift.

*Trends of cohort total fertility rates for India and by place of residence*

Figure 8 shows cohort total fertility rate (CTFR(40)) for the 5 year moving cohorts (with one year shift) of women born between 1945 and 1965 for India and its rural and urban areas. The urban and rural residence is decided based on the type of locality at the time of survey.

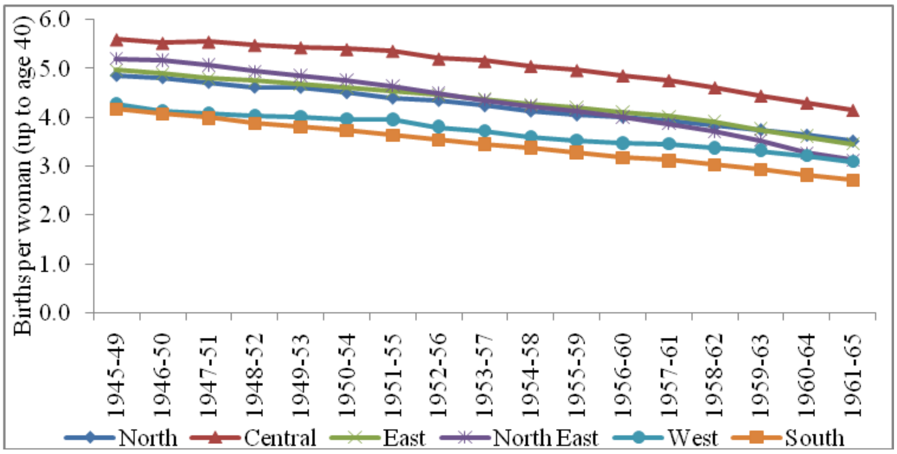
**Figure 8: Estimates of trends in completed cohort fertility rate of women upto age 40 for 5 year moving birth cohorts for, India, India rural and India urban**




Results showed that CTFR(40) number of children born per women up to age 40 in India-declined from 4.8 births per woman for cohort born in 1945-49 to 3.4 births per woman for the cohort born in 1961-65 registering a decline of 1.4 births per women. Women cohorts residing in rural areas at the time of survey consistently had higher number of births per women up to age 40 than their urban counterparts. The CTFR(40) for rural women declined from 5.1 for cohort born in 1945-49 to

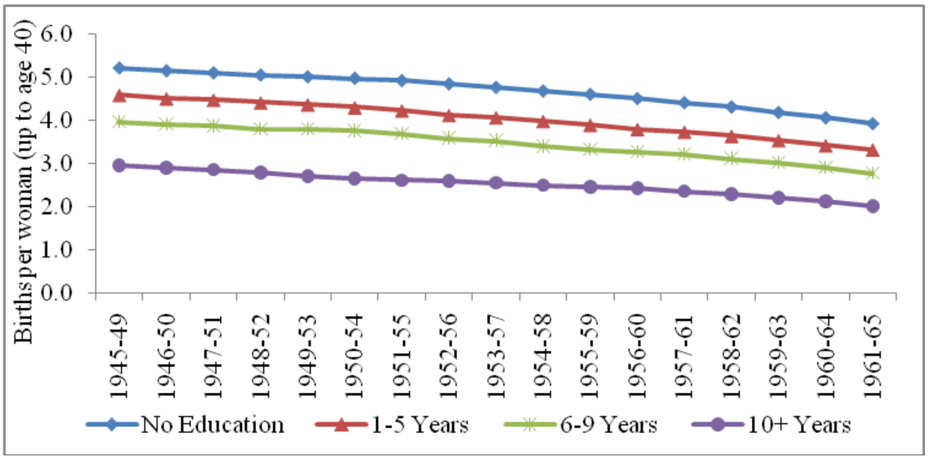
3.6 for cohort born in 1961-65. Similarly, for urban areas women cohorts born in 1945-49 had CTFR(40) of 4.1 births per women which declined to 2.9 for the cohort of women born in 1961-65. A very important pattern to observe was that CTFR(40) for the rural women cohorts was closer to the national level CTFR(40) throughout the successive cohorts of women born during 1945- 1965. This pattern was maintained with almost parallel distance from the urban cohorts which indicates similar speed of decline in cohort fertility for women from both urban and rural areas. Figure 9 shows estimated trends in the cohort total fertility rates by broad regions of India for the moving 5 year birth cohorts of 1945-49, 1946-50,…..,1960-64, 1961-65.

**Figure 9: Estimates of trends in cohort total fertility rate of women uptoage 40 for 5 year moving birth cohorts by regions of India**




The regional differnces in the trends of cohort total fertility rates are quite evident forwomen from all the regions of north, central, east, north-east, west and south. Women from all regions witnessed a linear decline in the cohort total fertility rates upto age 40 over succesitve cohorts.The results further depict that cohorttotal fertility rates upto age 40 was lowest for women in southern India while it was highest for the women in central region of India. Among the other four reigons,women from north and east region had almost similar levels of cohort total fertility rates for all the successive cohorts. The women from northeast region registered highest decline in CTFR(40) from 5.2 births per woman for the cohort born in 1945-49 to 3.1 birth per woman up to age 40 for the cohort born in 1961-65. The women in western region saw least decline in the CTFR(40) with a decline from 4.3 births per woman up to age 40 for 1945-49 cohort to 3.1 births per woman up to age 40 for the cohort born in 1961-65.

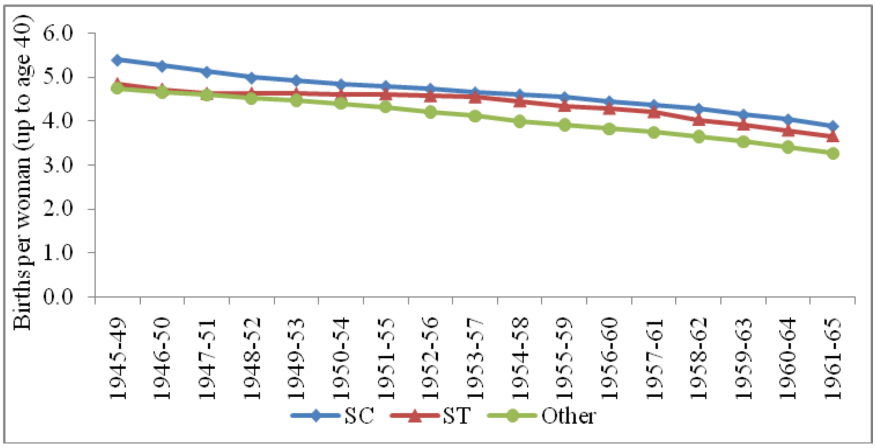
**Figure 10: Estimates of trends in cohort total fertility rate of women up to age 40 for 5 year moving birth cohorts by women's education categories in India**



The trends in cohort total fertility rates for women cohortsby women's education categories, caste and religion are presented in the figures 10, 11 and 12 respectively. Results in figure 10 show that for women with no schooling the CTFR(40) declined from 5.2 for cohort born in 1945-49 to 3.9 for cohort born in 1961-65 whereas, for the women with 10+ years of education CTFR(40) declined from 2.9 for cohort of 1945-49 to 2.0 births per woman up to age 40 for cohort born in 1961-65.

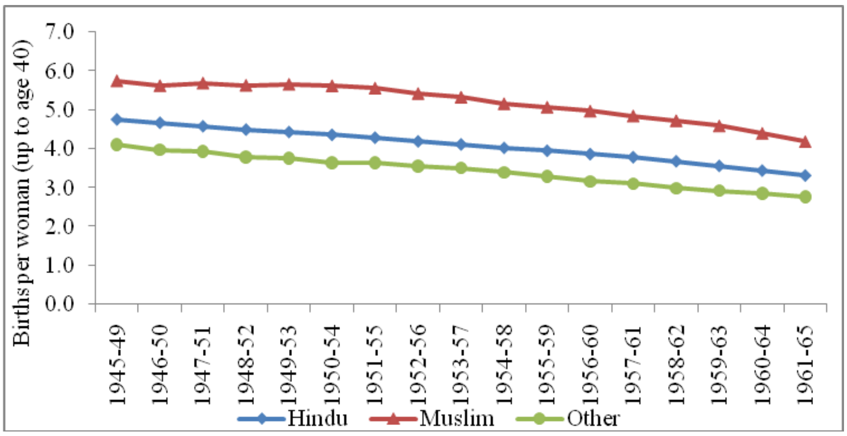
The cohort total fertility rates (CTFR(40)) declined for women of all caste (figure 3.11), but the pace of decline varied. However, compared with difference in cohort total fertility rates by other characteristics like education or religion , the caste differentials were less pronounced.

**Figure 11: Estimates of trends in cohort total fertility rate of women upto age 40 for 5 year moving birth cohorts by caste in India**




The results show that SC women had consistently high CTFR(40) than women of ST and 'other' caste. Further, the CTFR40 for women of'other'caste declined liniearly while for the women of ST, the decline in CTFR40 was not linear and it registered least decline in CTFR(40), a decline of 1.2 births per woman. Figure 12 presents the cohort total fertility rates(CTFR(40)) for cohorts of women from different religions in India: Hindu, Muslim and Others. The results depict remarkable differntials in cohort total fertility rates up to age 40 by religon. Muslim women cohorts had highest levels of fertility for all the cohorts born between 1945 and 1965 whereas women from 'other' religon had the lowest. Hindu women cohorts born during 1945-65 had fertility levels somewhat in the middle. The results show that cohort fertility declined for women of all religion and the decline in cohort total fertility rates was more or less similar.

**Figure 12: Estimates of trends in cohort total fertility rate up to age 40 for 5 year moving birth cohorts of women by religion in India**



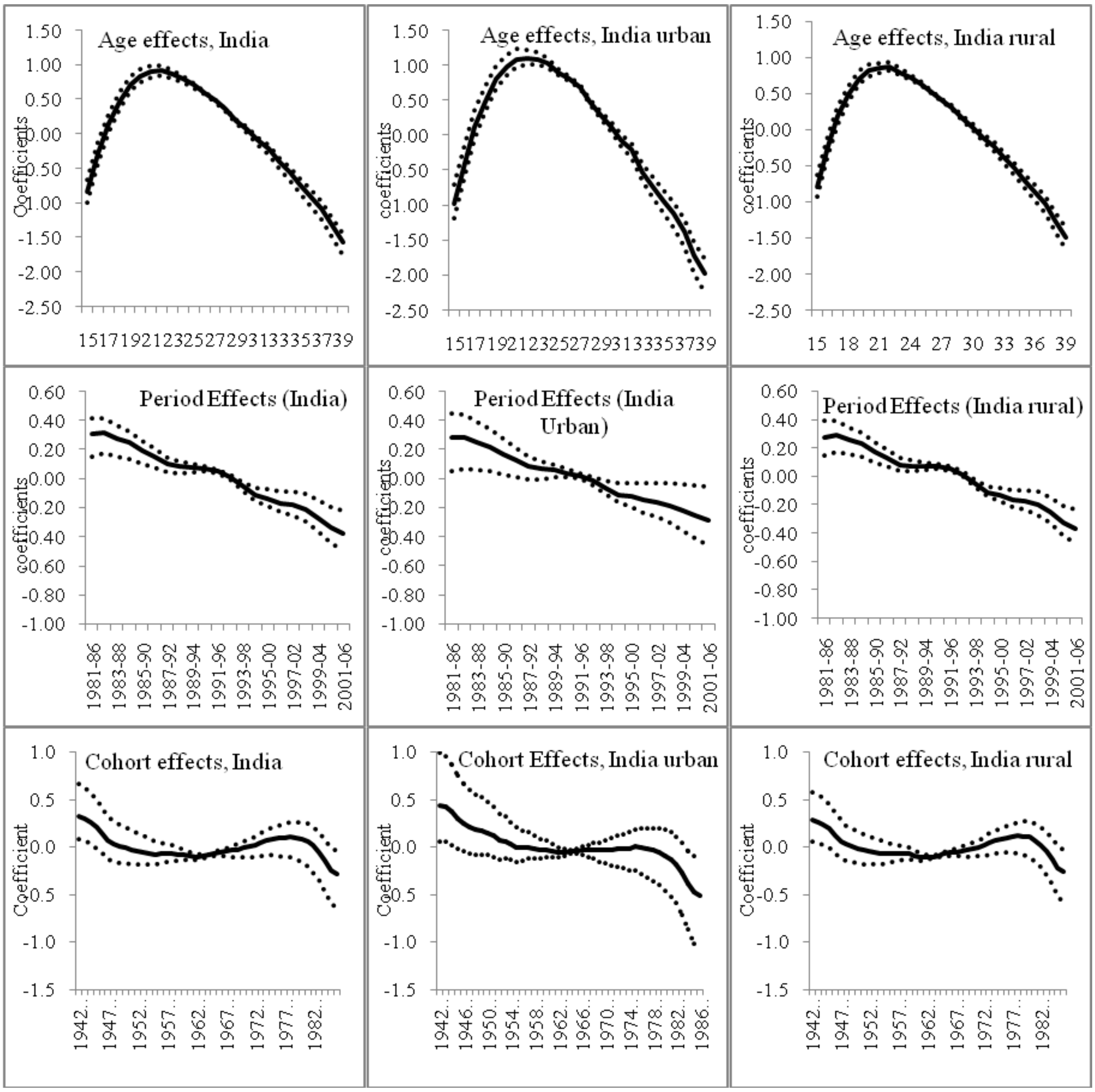
***The Age, Period and Cohort (APC) Effects of fertility***

The analysis of Age, Period and Cohort effects is carried out for India and across regions and socioeconomic categories of India.

*Age, Period and Cohort effects of fertility in India, urban India and rural India*

Figure 13 displays the age, period and cohort effects-estimated as the median of posterior sample-with 90% credible interval for India, urban India and rural India. Analyses for urban and rural areas are conducted separately. The solid line depicts estimates of the effects and dotted lines represent 90% credible interval.

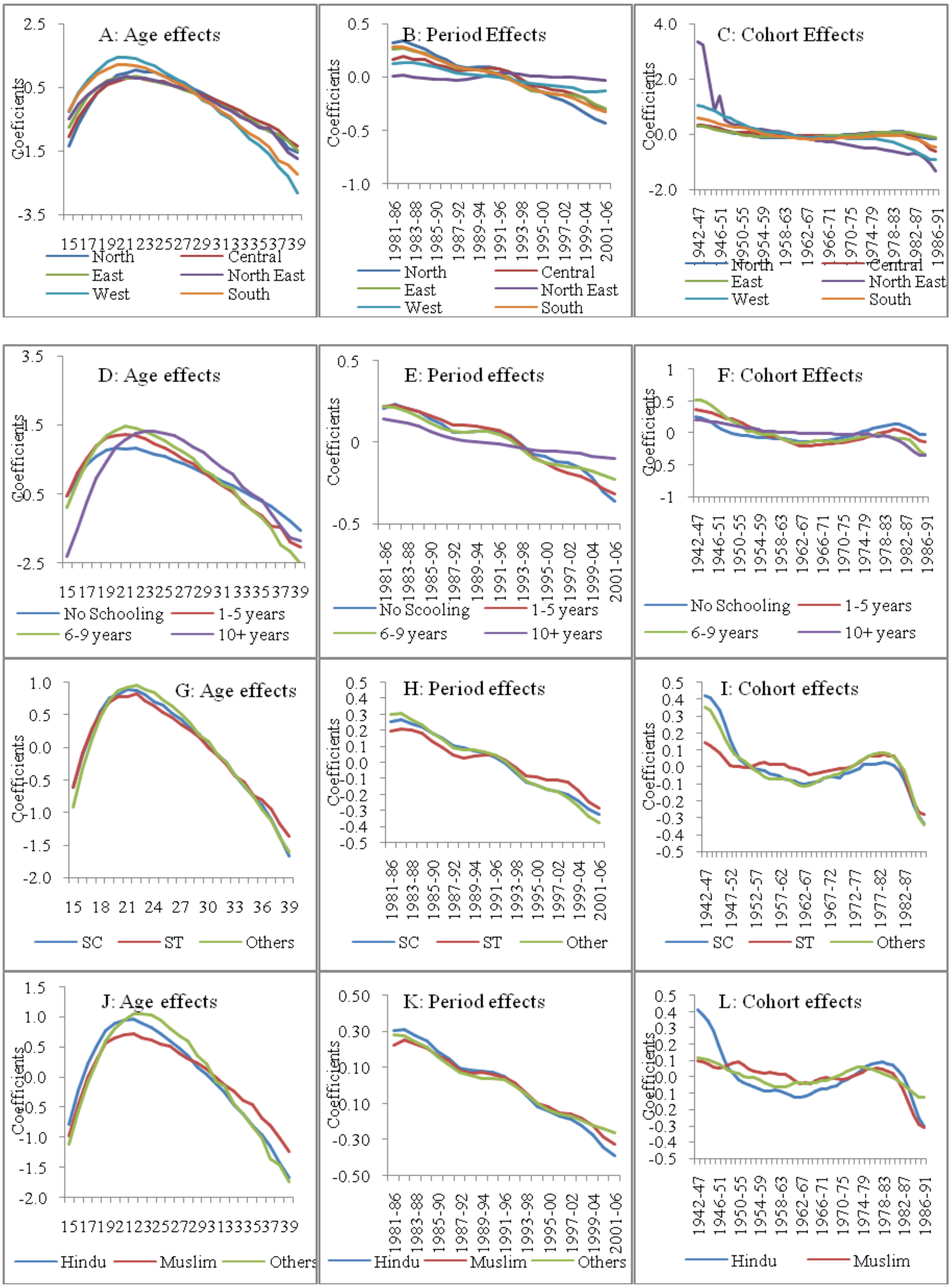
**Figure 13: Estimates of age effects from the Bayesian APC model for India, urban India and rural India, 1981-2006**




The coefficients for age effects were significant for India and both urban and rural areas. Further, a comparative assessment of age effects of fertility for urban and rural areas indicate differential age pattern of fertility in rural and urban areas with urban areas having lower fertility in older ages (after 30) and higher fertility in the ages 20 to 30 years. Results further show that period effects affected fertility in India significantly for most of the period. Also, the period coefficients declined almost consistently to become negative indicating that period effects had a declining effect on fertility in India during 1981-2006. A comparison of period effects in rural and urban areas depict that period effects were more prominent in the rural areas as they had sharper declining trend. The cohort effects of fertility for India were not statistically significant. Therefore, the fertility decline in India is primarily driven by the period effects.

*Age, Period and Cohort effects of fertility by regions, women's years of schooling, caste and religion in India*

**Figure 14: Estimates of age, period and cohort effects from the Bayesian APC model for regions and socioeconomic groups of India**



Panel A of the figure show age effects were almost similar for north, central, east and north-east regions, whereas the age effects for west and south regions of India were similar with these two regions indicating lower fertility at the older ages (after 30s). Panel B shows the period effects for all the six regions. The results show that period effects were significant, and clearly influenced fertility decline for all the regions except north-east region of India. For north-east region, the period effects hovered around zero over the periods. Contrarily, the cohort effects for all regions except north-east region were insignificant and hovered around zero while for north-east region the cohort effects were significant. Thus, in the north-east region, fertility decline is characterized by cohort effects while for other regions the fertility decline is driven by the period effects.

The age, period and cohort effects for educational categories are presented in panels D, E and F of figure 14. Panel D of the figure shows a very distinct age patterns of fertility by education categories. For women with no-schooling, spread of fertility over reproductive ages was highest with lower fertility in the ages before age 35 and higher fertility levels in the older ages (after age 35). Among women with 10+ years of schooling, the fertility level in the younger ages was lowest. The age pattern of fertility was similar among women with education 1-5 years and 6-9 years. The period effects were significant for women of all education categories (Panel E), but cohort effects (Panel F) were not. However, the magnitude of effects varied across educational categories where women with 10+ years of schooling showed the least period effects. The results by categories of caste show that period effects were statistically significant, whereas the cohort effects were not significant for all the categories of caste. The age patterns and the period effects were similar for all three categories of caste (panel G, H, and I respectively). Results did not reveal notable difference in the age, period and cohort effects of fertility across religions in India (panels J, K and L respectively).

## Discussion

In this paper, we described the fertility decline in India through estimation of period and cohort total fertility rates and analyzing of age, period and cohort effects by region and women's socioeconomic characteristics namely years of schooling, caste and religion.

The regional and socioeconomic differentials in period total fertility rates from this study corroborate with the findings from other studies; however, there is no study except Pashupaleti and Pathak (2011) to compare the estimates of cohort fertility rates across regions and socioeconomic spectrum. Notably, our estimates of socioeconomic and regional pattern of cohort total fertility rates are similar to the period total fertility rates. Lower total fertility rates for urban than rural areas are in line with the estimates from SRS. Several other studies for period before the advent of SRS in India too have documented lower fertility rates for urban areas (Das Gupta et al., 1955; Dandekar and Dandekar, 1953; Sovani and Dandekar, 1955; Robinson, 1961; Pathak and Murthy, 1987, Rele, 1987).

The regional estimates of total fertility rates depicted remarkable regional variation in the both period and cohort fertility trends, where south Indian states have the lowest, central Indian regions have highest and other four regions have total fertility rates in between. Such patterns suggest that fertility heterogeneity is not restricted to North-South dichotomy, though heterogeneity in fertility among other regions is not as pronounced as it is for North-south divide.  Similar regional differential in fertility levels and trends have also previously been noted in several studies using variety of data sources (Rele, 1987; Bhat and Rajan, 1990; Kulkarni and Alagrajan 1995; Rayappa and Prabhakara, 1996; Guilmoto and Rajan,1998). Both period and cohort total fertility rates were lower for women with higher education. This finding is in line with the fact that female education emerged to be prime determinant of fertility decline across socioeconomic spectrum in India ((Dreze and Murthy 2001; Basu, 2002; Bhat, 2002Murthi et al., 1995; Basu, 1992; Vlassoff, 1996).

Beyond this, total fertility rates declined faster for uneducated women than that for their counterparts with higher education which corroborates with findings of pronounced adoption of family planning particularly female sterilization by the uneducated women in India (McNay et al., 2003; Arokiasamy, 2009). The differentials in total fertility rates by caste and religion were also similar to those documented in several previous studies (Davis 1951; Visaria, 1974;

Balasubramanian, 1984; Das and Pandey, 1985; Bhat and Zavier, 2004; Kulkarni & Alagranajn, 2005) where women of SC/ST caste and Muslim religion have higher fertility rates. Socioeconomic and cultural differences across caste and religion categories are often cited as the prime reason for the differentials in fertility levels which is termed as 'characteristics hypothesis', however, these differentials are not completely explained by the differences in socioeconomic characteristics (Visaria, 1974; Shariff, 1996; Kulkarni & Alagranajn, 2005; Bhat and Zavier 2005).

## Conclusions

In conclusion, our estimates of both period and cohort fertility rates from the pooed birth history data of three rounds of NFHS reveal major decline in fertility in India consistent with the trends from India's sample registration system data. Urban areas had lower fertility than rural areas and the former registered higher decline during the period of 1981-2006. Among the regions, south had lowest and central region had the highest period and cohort fertility rates and north-east registered sharpest decline in both period and cohort total fertility rates. Estimates of period total fertility rates by education categories showed convergence in fertility trends where women with no schooling witnessed highest decline and those with 10+ years of schooling showed least decline. By caste, period fertility for SC and ST women was almost similar throughout 1981-2006 while women of other caste had the lowest fertility. By religion, Muslim women had highest period and cohort fertility followed by women of Hindu and 'other' religion. However, the period fertility declined faster for Muslim women than for other religions. The analysis of Age, Period and Cohort effects showed that period effects were significant in determining fertility trends in India, whereas cohort effects turned out to be insignificant. However, cohort effects were significant and period effects were insignificant in the north-east region. For other socioeconomic categories, the age, period and cohort effects varied substantially and period effects were significant in determining fertility decline.

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