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Marital Fertility Transition in India: 1985-2017

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Abstract

This paper analyses fertility transition in currently married women in India during 1985-2018 on the basis of the data available through the official sample registration system of India. The analysis reveals near stagnation during 1996-20014 and increase in marital fertility in the country and in most of its states. The analysis also reveals that there has been an increasing concentration of fertility of currently married woman younger ages of the reproductive period that may have resulted in temporary increase in marital fertility. In order to ensure transition in marital fertility, fertility regulation efforts in India should focus on 'practicing' family planning rather than 'treating' high fertility.

1 Introduction

In societies where almost all births occur within the institution of marriage, fertility depends upon two factors: 1) fertility of currently married women or marital fertility; and 2) proportion of women who are currently married. Both these factors vary by the age of women so that fertility is a multiplicative combination of the two (Bongaarts, 1978). Factors that influence marital fertility are essentially different from factors that determine the proportion of women who are currently married. Any analysis of fertility transition should, therefore, be carried out in terms of marital fertility transition and the change in the proportion of women who are currently married. Such a desegregated analysis may be useful from programme perspective as interventions that induce transition in marital fertility are different from interventions that influence the proportion of women who are currently married. The proportion of women who are currently married is also influenced by the disruption of marriage because of spouse mortality, divorce and separation. On the other hand, the primary determinant of marital fertility is contraceptive use. Changes in the incidence of abortion and duration of breast feeding may also induce a change in marital fertility, although their contribution is small relative to that of contraceptive use in contemporary societies.

In this paper, we analyse marital fertility transition in India during 1985-2018. The analysis is relevant because promoting contraceptive use to regulate fertility of currently married women has been the mainstay of fertility reduction efforts in India. India was the first country in the world to adopt an official population policy and launch an official family planning programme way back in 1952. There has, however, never been any attempt to analyse transition in fertility of currently married women. All studies on fertility transition in India have focused on fertility of all women - currently married or currently not married (Mohanty et al, 2016; 2019; Spoorenberg and Dommaraju, 2012). The total fertility rate (TFR) in India is estimated to have decreased from 4.2 live births per woman of reproductive age during 1985-87 to 2.2 live births per woman of reproductive age during 2016-18. This decrease in TFR has been cited as the evidence that planned family planning efforts in the country have been successful, although, these efforts have been targeted towards currently married women only. The discourse on fertility transition in India overlooks the fact that the total marital fertility rate (TMFR) has decreased only marginally from 5.5 live births per currently married woman of reproductive age during 1985-87 to 4.8 live births per currently married woman of reproductive age during 2016-18 and it has shown an increasing trend in recent years (Government of India, 2020). The increase in TMFR raises concerns about the effectiveness of family planning efforts in the country in regulating fertility of currently married women.

The paper is organised as follows. The next section of the paper describes the methodology adopted for analysing marital fertility transition. The paper analyses the change in both level and age schedule of marital fertility. Section three of the paper describes the data used in the analysis. We have used official estimates of TMFR and age-specific marital fertility rates available through India's official Sample Registration System. Results of the analysis are presented in section four while the last section discusses the implications of the analysis from the perspective of the effectiveness of family planning efforts in regulating fertility of currently married women. The paper emphasises the need of promoting the 'practice' of family planning among currently married women rather than 'treating' high fertility.

2 Method

The analysis is based on the estimates of average annual number of live births per currently married woman of reproductive age. If g_i denotes the average annual number of births per currently married women of age *i*, then average annual number of live births per currently married woman of reproductive age (15-49 years) is given by

$$g = \frac{1}{35}\sum_{i=15}^{49} g_i \qquad (1)$$

We measure marital fertility transition in terms of temporal trend in g using the joinpoint regression analysis (Kim at al, 2000; Kim et al, 2004). The underlying assumption of the joinpoint regression analysis is that the trend is not uniform over the transition period but is different in different temporal segments of the transition period. The joinpoint regression analysis first identifies time point(s) or joinpoint(s) at which the trend has changed. If there is no change in the trend, joinpoint regression analysis reduces to simple linear regression analysis. If there is a change in the trend, the joinpoint regression analysis analyses the trend in different temporal segments separately. The joinpoint regression analysis provides a transition model that best summarises the trend and hence the transition (Marrot, 2010).

The joinpoint regression analysis requires identification of joinpoint(s) in advance. Methods to identify joinpoint(s) include permutation test method (Kim et al, 2000) and methods based on the Bayesian information criterion (Kim et al, 2009; Kim and Kim, 2016; Zhang and Siegmund, 2007). The grid search method (Lerman, 1980) is used for identifying joinpoint(s). This method allows a joinpoint to occur exactly at time t. A grid is created for all possible positions of joinpoint or combination of joinpoints. The model is then fitted for each possible position of joinpoint(s) and position with minimum sum of squared error (SSE) is selected. It is, however, not necessary that slopes of all temporal segments are statistically significantly different from zero. The identification of joinpoint(s) only implies that the model with these joinpoints has a better fit than all other models.

The joinpoint regression model is defined as

$$\ln g_i = \alpha + \beta_1 t_1 + \delta_1 u_1 + \delta_2 u_2 + \ldots + \delta_j u_j + \varepsilon_i \qquad (2)$$

where

$$u_j = \begin{cases} (t_j - k_j) & \text{if } t_j > k_j \\ 0 & \text{otherwise} \end{cases}$$

and $k_1 < k_2 \ldots\ldots < k_j$ are joinpoints. Actual calculations are carried out using Joinpoint Regression Program Version 4. (National Cancer Institute, 2018). The software fits the simplest joinpoint regression model that data allow but requires specification of minimum (0) and maximum number of joinpoints (>0) in advance. The programme starts with minimum number of joinpoints (0, which is a straight line) and tests whether more joinpoint(s) are statistically significant and must be added to the model (up to the pre-specified maximum number of join points). The test of significance is based on a Monte Carlo Permutation method (Kim et al, 2000).

On the basis of equation (2), the annual percent change (APC) in a temporal segment j of the transition period can be calculated as

$$APC_j = (e^{\beta_j} - 1) \times 100 \quad (3)$$

where β_j is the slope during temporal segment *j*. Estimation of APC for each temporal segment provides a complete characterisation of the trend. Based on APCs, average annual percent change (AAPC) for the entire transition period can be calculated as weighted average of APCs with weights equal to the length of the APC interval. AAPC is the summary measure of the trend over the transition period and has the advantage that it is not based on the assumption that the trend is linear. AAPC can also be used to characterise a short segment based on the joinpoint model fit over a much longer series (Clegg et al, 2009).

Since, *g* is the un-weighted average of g_i, the change in *g* can be decomposed in terms of the change in g_i. It can be shown that

$$g^2 - g^1 = \nabla g = \bar{g}_i^2 - \bar{g}_i^1 = \frac{1}{n}\sum_{i=1}^{n} g_i^2 - g_i^1 \quad (4)$$

Equation (4) is true by definition so that naive regression or correlation approaches, which ignore the sum constraint, are potentially problematic in analysing the contribution of the change in g_i to the change in *g* (Poorter and Werf, 1998; Wright and Westoby, 2001). A more appealing approach is to decompose the variance of ∇g in terms of variances and covariances in ∇g_i (Preston, 1994). It can be shown that

$$Var(\nabla g) = \sum_i Var(\nabla g_i) + \sum_i \sum_{\substack{j \\ i \neq j}} Cov(\nabla g_i, \nabla g_j) \quad (5)$$

where *Var* denotes variance and *Cov* denotes covariance. The decomposition given by equation (5) is exact and permits estimating the contribution of the variation in ∇g_i to the variation in ∇g.

One potential problem in using equation (5) is that the covariance terms in equation (3) may be negative so that the algebraic sum of variance and covariance terms may be zero or close to zero which may not reflect the true importance of the relative contribution of variation in g_i to variation in *g*. This problem can be addressed by using absolute values of covariance terms (Horvitz, Schemske and Caswell, 1997; Rees et al, 2010; Rees, Grubb and Kelly, 1996). If $T_{\nabla g}$ denotes the sum of all variance terms and absolute values of all covariance terms in equation (5), then

$$T_{\nabla g} = \sum_i Var(\nabla g_i) + \sum_i \sum_{\substack{j \\ i \neq j}} \left| Cov(\nabla g_i, \nabla g_j) \right| \quad (6)$$

The relative importance of the variation in ∇g_i to variation in ∇g may then be obtained as

$$I_i = \frac{Var(\nabla g_i) + \sum_{\substack{j \\ i \neq j}} \left| Cov(\nabla g_i, \nabla g_j) \right|}{T_{\nabla g}} \quad (7)$$

where I_i denotes the relative importance of variation in ∇g_i. $T_{\nabla g}$ is equal to $Var(\nabla g)$ when all covariance terms in equation (5) are positive.

The transition in marital fertility is associated with the change in the age schedule of marital fertility. We analyse the change in the age schedule of g following the relational approach. This approach is based on the constant shape assumption which implies that the age schedule of g at any point in time can be transformed into the age schedule of g at any other point in time by either inflating or deflating or by shifting the age schedule to higher or lower ages or both (Bongaarts and Feeney, 2006). Two theoretical lines have been put forward (Petrioli, 1975; 1983). One uses the Gompertz or Weibull function while the other is based on the log-logistic function (Menchiari, 1988). In this paper, we model age schedule of g by using the Gompertz transformation.

Let $c_i=g_i/g$ and C_i denote the sum of c_i up to age i. If $\Gamma(i)$ represents the Gompertz's function, then the transformation

$$\Gamma(i) = -ln(-ln(C_i)), \quad (8)$$

is linear in i. In other words,

$$\Gamma(i) = a + bi \quad (9)$$

Let $\Gamma^o(i)$ is the Gompertz transformation of C_i at time 0 and $\Gamma^t(i)$ is the Gompertz transformation of C_i at time t. Then, $\Gamma^o(i)$ and $\Gamma^t(i)$ can be related through the following equation

$$\Gamma^t(i) = \alpha_t + \beta_t \, \Gamma^o(i) \quad (10)$$

where parameters α_t and β_t establish the link between the age schedule of g at time 0 and at time t. The parameter α_t reflects the location of age schedule at time t relative to time 0. When $\alpha_t= 0$, the location of the two age schedules is the same. When $\alpha_t<0$, the location of age schedule at time t is older than that at time 0 so that the mean of the age schedule at time t is higher than that at time 0. The converse is true for $\alpha_t>0$.

The parameter β_t, on the other hand, may be interpreted as reflecting the spread of the age schedule at time t relative to that at time 0. However, $\beta_t=1$ does not necessarily mean that the variance of the age schedule at time t is the same as the variance of the age schedule at time 0. This is true only when $\alpha_t=0$ (United Nations, 1983). When $\beta_t>1$, the age schedule at time t is steeper than that at time 0. Conversely, $\beta_t<1$ indicates that the age schedule at time t is flatter than that at time 0. It has been shown that α_t and β_t can be linked to the median age and inter-quartile range of the age schedule so that they reflect the change in the age schedule of g at time t relative to that at time 0 (Yi et al, 2000).

Relational models are commonly used in demographic research. Brass (1975) was the first to apply the relational approach for fitting life tables by using the logit transformation and extended it for fitting fertility schedules by using the Gompertz transformation (Brass, 1980; Booth 1984). The approach has also been used in developing migration models (Zaba, 1987) and analysing age-period-specific fertility; first marriage; divorce; and remarriage (Yi et al, 2000). It has been suggested that when the age schedule to be fitted and the reference age schedule have some proximity, the relational approach gives a good fit and the parameters of the model are more accurate (Yi et al, 2000).

2. Data

The analysis is based on annual estimates of average annual number of live births per currently married woman of seven quinquinnials age-groups of the reproductive period available through the Sample Registration System for the period 1985-2018 for the country and for its 15 states. The 15 states included in the analysis account for almost 90 per cent population of the country at the 2011 population census. These estimates suggest that the average annual number of live births in India decreased from 158 live births per 1000 currently married women of reproductive age during 1985-87 to 137 live births per 1000 currently married women of reproductive age during 2016-18. Marital fertility has varied widely across the states currently as well as in the past. During 1985-87, the average annual number of live births per 1000 currently married women of reproductive age varied from 135 in Tamil Nadu to 199 in Assam. During 2016-18, the average annual number of live births per 1000 currently married women of reproductive age varied from 101 in Karnataka to 190 in Uttar Pradesh. The difference between the maximum and minimum average annual number of live births across states increased from 65 live births per 1000 currently married women during 1985-87 to 89 live births per 1000 currently married women which indicates divergence in marital fertility transition across states. The inter-state coefficient of variation in average annual number of live births per currently married woman also increased from 0.117 during 1985-87 to 0.204 during 2016-18 which confirms divergence in marital fertility transition across states.

Data on fertility available from the Sample Registration System are generally regarded to be accurate, although, studies indicate some under-reporting of live births which, varies from state to state. An investigation carried out during 1980-81 found that around 3.1 per cent live births were omitted at the national level (Government of India, 1983). Another similar enquiry conducted in 1985 found that the omission rate had decreased to 1.8 per cent but varied from state to state (Government of India, 1988). Mari Bhat (2002) had estimated that the system had missed about 7 per cent of births but there was no substantial change in the completeness. Recently, Yadav and Ram

(2015) have estimated an under-reporting of 2 per cent births 1991-2000 and 3 per cent during 2001-2011.

Data available from the sample registration system are also known to be associated with annual fluctuations of unknown origin. To eliminate these fluctuations, it is the customary use three-years moving average, instead of the annual estimates available through the system. We have also followed the same convention in the present analysis. Thus, the estimate of average annual number of live births per currently married woman of reproductive age for the year 1986, actually refers to the un-weighted average of the average annual number of live births per currently woman for the years 1985, 1986 and 1987, etc.

Among the states included in the present analysis, the administrative boundaries of three states - Bihar, Madhya Pradesh and Uttar Pradesh - have changed in the year 2000 so that estimates of average annual number of live births per currently married woman of reproductive age prior to the year 2000 in these states are not strictly comparable to the estimates after the year 2000. It is, however, assumed that the change in the administrative boundaries has only a marginal effect on the transition in marital fertility in these states.

3 Marital Fertility Transition

Figure 1 depicts the trend in average annual number of live births per currently married woman of reproductive age (*g*) along with the trend in the average annual number of live births per woman (currently married and currently not married) of reproductive age (*f*) in India. The diverging trend in *g* and *f*, particularly after 1995-97, is very much visible from the figure. In recent years, *g* has increased, rather rapidly, but *f* continued to decrease, albeit, at a slower pace. The figure suggests that the temporal decrease in *f* has virtually become independent of the trend in g recent years. It is also obvious from the figure that marital fertility transition in the country has not followed a linear (on a log scale) trend. Rather, the trend has changed many times during the period under reference. This observation is supported by the joinpoint regression analysis which suggests that the trend in *g* appears to have changed four times during 1986-2017 (Table 1). The table also confirms that the transition in marital fertility appears to have reversed during 2014-17. Moreover, the APC was not statistically significantly different from 0 during 1996-2002 indicating stalling of marital fertility transition. If the APC recorded during 1986-96, would have been sustained after 1996, then *g* would have been decreased to 93 live births per 1000 currently married women by 2017. Similarly, if APC recorded during 2002-05 could have been sustained, *g* would have been decreased to 97 live births per 1000 currently married women by 2017.

Table 1 also shows that fertility transition has been different in currently married women of different ages. The AAPC in fertility of currently married women aged 15-19 years and 20-24 years has not been found to be statistically significantly different from 0 indicating stalling of transition in fertility of young currently married women. This means that transition in marital fertility in the country has primarily been confined to currently married women aged, at least, 25 years. Another important observation of table 1 is that fertility increased in currently married women of all age groups in the recent past with the increase being the most rapid in currently married women aged 15-19 years. The table also indicates that stalling of marital fertility transition during 1996-02 was primarily due to the stalling of fertility transition in currently married women aged 15-19 years during 1996-99 and currently married women aged 20-24 years during 1998-2002. Similarly, the slowdown in marital fertility transition during 2005-14 was primarily due to stalling of fertility transition in women aged 25-29 years during 2006-2014. Transition in fertility of currently married women aged 15-19 years also stalled during 2011-15 while transition in fertility of currently married women aged 20-24 years reversed during this period.

Among different states of the country, the AAPC has not been statistically significantly different from 0 in seven states which indicates stalling of marital fertility transition (Table 2). In other states, marital fertility transition has been the most rapid in West Bengal but the least rapid in Rajasthan during the period under reference as reflected through AAPC. The AAPC, however, masks the volatility in the trend and, therefore, does not fully characterise the marital fertility transition. There is, in fact, no state in the country where g decreased throughout the period under reference. More importantly, there is no state where g decreased in recent years. It increased statistically significantly in 11 states and remained stagnant in 4 states in recent years.

The change in the fertility of currently married women (g) is the algebraic sum of the change in the fertility of currently married women of different ages (g_i) so that inter-state variation in the change in g can be decomposed into inter-state variation in the change in g_i. This decomposition exercise suggests that inter-state variation in the change in $g_{15\text{-}19}$ has been the most important contributor to the inter-state variation in the change in g followed by the inter-state variation in the change in $g_{20\text{-}24}$ (Table 3). The joinpoint regression analysis reveals that $g_{15\text{-}19}$ decreased statistically significantly in only 5 states; increased statistically significantly in 2 states and remained stagnant in the remaining states (Table 4). Similarly, $g_{20\text{-}24}$ decreased statistically significantly in only 7 states but remained stagnant in the remaining states. By comparison, $g_{30\text{-}34}$ decreased statistically significantly in 11 states; $g_{35\text{-}39}$ decreased statistically significantly in 13 states; and $g_{40\text{-}44}$ decreased statistically significantly in 12 states. The joinpoint regression analysis also confirms that marital fertility transition in the country has virtually been confined largely to the transition in the fertility of currently married women aged 30-44 years and there has been a reversal in fertility transition in currently married women aged 15-19 years.

The differing trend in the fertility of currently married women of different age implies that the age schedule of marital fertility has also changed. Application of the relational Gompertz model reveals that the parameter α increased rapidly in India during 1986-2012 with a trough during 1993-96 but decreased after 2012. An increase in α indicates that the age schedule of marital fertility has increasingly turned skewed to the left. On the other hand, a decrease in α after 2012 reflects the increase in fertility of currently married women of all ages. As the result, the mean age of marital fertility schedule in the country decreased from around 26.1 years around 1986 to less than 23.6 years around 2012 but increased to almost 24 years around 2017.

The parameter β also increased during 1986-2012 but decreased thereafter. This means that the concentration of fertility around the mean age of marital fertility schedule increased up to 2012 but decreased thereafter. The decrease in parameter β after 2012 again confirms an increase in the fertility of currently married women in different ages. The increase in both α and β also implies that marital fertility in India has increasingly been concentrated in the young currently married women which has implications for marital fertility transition. It is well-known that the shift in the age schedule of marital fertility towards the left and the associated decrease in the mean age of marital fertility schedule leads to a temporary increase in marital fertility which contributes to slowing down marital fertility transition (Bongaarts and Feeney, 2006). The temporary increase in marital fertility can be checked by postponing births by young currently married women. There is, however, little evidence the postponement of births by young currently married women as there has been virtually no transition in the fertility of currently married women aged 15-19 years and 20-24 years during the period under reference.

The change in the age schedule of marital fertility has also been different in different states of the country. The parameter α was higher in 2017 relative to 1986 in all but two states - Kerala and Tamil Nadu. Similarly, the parameter β was higher in 2017 relative to 1986 in all but one state - Punjab. More than 70 per cent of the decrease in marital fertility in Kerala is attributed to the decrease in the fertility of currently married women aged 15-24 years whereas in Bihar, Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh, fertility of currently married women aged less than 25 years has increased, instead decreased. In these states, the decrease in marital fertility has been the result of the decrease in the fertility of currently married women aged 25 years and above only so that there has been an increase in the concentration of births in young currently married women resulting in a temporary increase in marital fertility and slowing down the marital fertility transition. All these states, except Gujarat, are categorised as high fertility states of the country and fertility, in these states, continues to remain well above the national average. In three states - Bihar, Gujarat and Uttar Pradesh, the average annual number of live births per currently married woman has increased in 2017 relative to the average annual number of live births per currently married woman in 1986.

6 Discussions and Conclusions

The present analysis is probably the first to analyse marital fertility transition in India. The analysis is relevant as India's family planning efforts have always been directed towards regulating fertility of currently married women and, therefore, transition in marital fertility reflects more appropriately, the effectiveness of family planning efforts, especially, planned family planning efforts, in regulating fertility of currently married women. However, the impact of these efforts has always been analysed in the context of the transition in the fertility of all women - currently married or currently not married - which is also influenced by the change in the proportion of women who are currently married. When the attention is focused on the transition in marital fertility, the analysis raises concerns about the effectiveness of family planning efforts, especially, planned family planning efforts, in regulating fertility of currently married women. Marital fertility transition in the country appears to have resulted in an increase in the concentration of fertility in young currently married women leading to a decrease in the mean age of child bearing of currently married women and a temporary increase in marital fertility.

The marital fertility transition in India appears to be an artifact of the typical child bearing regime in which couples terminate childbearing at young ages so that childbearing gets concentrated in the early years of the reproductive period (Knodel, 1987). The evolution of this regime has roots in the official approach towards family planning in India that have always emphasized on stopping births to reduce fertility of currently married women in an attempt to curb population growth. The evidence of this regime is reflected in the contraceptive method mix which remains heavily skewed towards permanent methods at the cost of temporary or spacing methods and which has largely remained unchanged for more than two decades (Chaurasia, 2020). In order to make sure that a decrease in marital fertility is not associated with a decrease in the mean age of child bearing among currently married women and a temporary increase in marital fertility, it is imperative that there must be postponement of births by young currently married women through the use of modern spacing methods of contraception. There is, however, little evidence of such a trend in contraceptive practice in the country. Contraception in India continues to be dominated heavily by permanent methods.

The stagnation of marital fertility transition in India during 1996-2002 appears to be associated with the policy shift in the official family planning efforts. In 1996, the target-based approach of planning and implementing official family planning efforts in the country were replaced by a community needs assessment-based approach. Moreover, family planning services were subsumed in the reproductive and child health programme which led to substantial dilution of official family planning efforts (Chaurasia and Singh, 2014). The return of targets in the form of centrally-defined expected level of achievement in 2002 did accelerate marital fertility transition but only for a short period as the launch of National Rural Health Mission in 2005 put family planning at the back burner (Chaurasia and Singh, 2014). The residual attention to family planning appears to have been continued after the introduction of the RMNCH+A strategy directed towards improving health of mothers and children (Government of India, 2013) so that fertility of currently married women increased irrespective of their age. The strategy aimed at achieving the replacement fertility by 2017 but was conspicuously silent about transition in the fertility of currently married women. The continued high fertility of currently married women has implications for the health of both women and children. A currently married woman in India is expected to produce close to 5 children during her entire reproductive life at the prevailing levels of marital fertility and this number is increasing in recent years. In such a high marital fertility regime, improving health of mothers and children is going to remain a major public health challenge.

In the end, the present analysis highlights the need of reinvigorating family planning efforts, especially, official family planning efforts in the country so as to ensure an accelerated transition in the fertility of currently married women. These efforts must be directed towards practicing family planning to regulate fertility of currently married women rather than treating high marital fertility. High marital fertility can be treated through a birth stopping strategy. The problem with this strategy, however, is that it does not address the problem of concentration of fertility in young currently married women and hence a temporary increase in marital fertility. The temporary increase in marital fertility can be checked only when young currently married women postpone their birth so that the mean age of child bearing does not decrease with the decrease in marital fertility.

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Table 1
Annual percent change (APC) in average annual number of live births per currently marries women of different age groups in India 1985-2018. Results of the joinpoint regression analysis.

<table>
<tr><th rowspan="2">Age
(AAPC)</th><th colspan="32">Year</th></tr>
<tr><th>86</th><th>87</th><th>88</th><th>89</th><th>90</th><th>91</th><th>92</th><th>93</th><th>94</th><th>95</th><th>96</th><th>97</th><th>98</th><th>99</th><th>00</th><th>01</th><th>02</th><th>03</th><th>04</th><th>05</th><th>06</th><th>07</th><th>08</th><th>09</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th></tr>
<tr><td>15-49 (-0.453*)</td><td colspan="10">-1.648*</td><td></td><td colspan="5">0.001</td><td></td><td colspan="2">-2.202*</td><td></td><td colspan="8">-0.290*</td><td></td><td colspan="3">4.021*</td></tr>
<tr><td>15-19 (0.542)</td><td colspan="7">-0.870*</td><td></td><td colspan="2">-4.851*</td><td></td><td colspan="2">3.099</td><td></td><td colspan="11">1.011*</td><td></td><td colspan="3">-1.258</td><td></td><td colspan="2">11.421*</td></tr>
<tr><td>20-24 (0.010)</td><td colspan="12">-0.503*</td><td></td><td colspan="3">1.704</td><td></td><td colspan="2">-1.701</td><td></td><td colspan="12">0.397*</td></tr>
<tr><td>25-29 (-0.525*)</td><td colspan="6">-2.011*</td><td></td><td colspan="9">-0.526*</td><td></td><td colspan="3">-2.429*</td><td></td><td colspan="7">-0.296</td><td></td><td colspan="3">4.551*</td></tr>
<tr><td>30-34 (-1.331*)</td><td colspan="6">-3.356*</td><td></td><td colspan="2">0.446</td><td></td><td colspan="5">-2.910*</td><td></td><td colspan="10">-3.576*</td><td></td><td colspan="5">7.331*</td></tr>
<tr><td>35-39 (-2.905*)</td><td colspan="9">-3.796*</td><td></td><td colspan="5">-1.939*</td><td></td><td colspan="3">-8.364*</td><td></td><td colspan="3">-4.101*</td><td></td><td colspan="2">-6.653*</td><td></td><td colspan="5">8.980*</td></tr>
<tr><td>40-44 (-3.885*)</td><td colspan="7">-4.108*</td><td></td><td colspan="2">-0.710</td><td></td><td colspan="8">-5.911*</td><td></td><td colspan="6">-9.647*</td><td></td><td colspan="2">9.480*</td><td></td><td colspan="2">3.750*</td></tr>
<tr><td>45-49 (-4.276*)</td><td colspan="8">-6.249*</td><td></td><td colspan="9">-2.874*</td><td></td><td colspan="4">-8.621*</td><td></td><td colspan="2">-18.56</td><td></td><td colspan="5">10.954*</td></tr>
</table>

Remark: Dark-shaded cells are joinpoints.
Light-shaded cells are periods when APC and AAPC are not statistically significantly different from 0.
* APC and AAPC are statistically significantly different from 0 at p=0.05

Source: Author’s calculations

Table 2

APC and AAPC in average annual number of live births per current married women aged 15-49 years in different states of India, 1985-2018. Results of joinpoint regression analysis

<table>
<tr><th rowspan="2">India/State (AAPC)</th><th colspan="32">Year</th></tr>
<tr><th>86</th><th>87</th><th>88</th><th>89</th><th>90</th><th>91</th><th>92</th><th>93</th><th>94</th><th>95</th><th>96</th><th>97</th><th>98</th><th>99</th><th>00</th><th>01</th><th>02</th><th>03</th><th>04</th><th>05</th><th>06</th><th>07</th><th>08</th><th>09</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th></tr>
<tr><td>Andhra Pradesh (-0.967*)</td><td colspan="5">-4.179*</td><td></td><td colspan="5">-2.113*</td><td></td><td colspan="4">0.482</td><td></td><td colspan="8">-1.077*</td><td></td><td colspan="6">1.914*</td></tr>
<tr><td>Assam (-0.583*)</td><td colspan="9">-1.620*</td><td></td><td colspan="6">0.119</td><td></td><td colspan="2">-3.879*</td><td></td><td colspan="2">-0.078</td><td></td><td colspan="6">-2.378*</td><td></td><td colspan="2">13.136*</td></tr>
<tr><td>Bihar (0.013)</td><td colspan="10">-1.702*</td><td></td><td colspan="3">1.564</td><td></td><td colspan="6">-1.410*</td><td></td><td colspan="3">1.766</td><td></td><td colspan="2">-2.596</td><td></td><td colspan="3">7.676*</td></tr>
<tr><td>Gujarat (0.086)</td><td colspan="7">-1.972*</td><td></td><td colspan="2">-3.265*</td><td></td><td colspan="2">2.592*</td><td></td><td colspan="10">-0.453*</td><td></td><td colspan="4">2.285*</td><td></td><td colspan="2">6.499*</td></tr>
<tr><td>Haryana (-0.992*)</td><td colspan="12">-1.692*</td><td></td><td colspan="4">0.487</td><td></td><td colspan="5">-1.488*</td><td></td><td colspan="2">-3.720*</td><td></td><td colspan="2">2.560*</td><td></td><td colspan="2">-0.033</td></tr>
<tr><td>Karnataka (-1.246)</td><td colspan="3">-0.423</td><td></td><td colspan="6">-2.998*</td><td></td><td colspan="4">0.643</td><td></td><td colspan="12">-1.539*</td><td></td><td colspan="3">0.219</td></tr>
<tr><td>Kerala (-0.037)</td><td colspan="7">-3.889*</td><td></td><td colspan="3">1.437</td><td></td><td colspan="4">-1.592</td><td></td><td colspan="2">4.099</td><td></td><td colspan="9">-0.428</td><td></td><td colspan="2">11.176*</td></tr>
<tr><td>Madhya Pradesh (-0.300)</td><td colspan="11">-1.178*</td><td></td><td colspan="3">1.135</td><td></td><td colspan="3">-2.231*</td><td></td><td colspan="7">-0.349</td><td></td><td colspan="4">2.799*</td></tr>
<tr><td>Maharashtra (-0.721*)</td><td colspan="22">-1.561*</td><td></td><td colspan="4">-3.611*</td><td></td><td colspan="4">5.530*</td></tr>
<tr><td>Odisha (-0.795*)</td><td colspan="18">-1.215*</td><td></td><td colspan="13">-0.211</td></tr>
<tr><td>Punjab (-0.726)</td><td colspan="9">-1.781*</td><td></td><td colspan="6">1.014</td><td></td><td colspan="2">-6.000</td><td></td><td colspan="5">0.162</td><td></td><td colspan="3">-6.339*</td><td></td><td colspan="2">12.533*</td></tr>
<tr><td>Rajasthan (-0.588*)</td><td colspan="2">-2.877</td><td></td><td colspan="3">0.156</td><td></td><td colspan="3">-2.366*</td><td></td><td colspan="2">0.487</td><td></td><td colspan="13">-1.250*</td><td></td><td colspan="4">3.217*</td></tr>
<tr><td>Tamil Nadu (-0.671*)</td><td colspan="8">-2.839*</td><td></td><td colspan="3">-0.544</td><td></td><td colspan="3">2.999</td><td></td><td colspan="2">-1.746</td><td></td><td colspan="6">1.033*</td><td></td><td colspan="5">-0.926</td></tr>
<tr><td>Uttar Pradesh (0.154)</td><td colspan="7">-0.340</td><td></td><td colspan="2">-2.487</td><td></td><td colspan="4">1.125*</td><td></td><td colspan="4">-1.860*</td><td></td><td colspan="7">0.490*</td><td></td><td colspan="3">4.988*</td></tr>
<tr><td>West Bengal (-1.007*)</td><td colspan="11">-2.910*</td><td></td><td colspan="4">0.120</td><td></td><td colspan="3">-4.487*</td><td></td><td colspan="5">-0.523*</td><td></td><td colspan="2">-5.199*</td><td></td><td colspan="2">18.512*</td></tr>
</table>

Remark: Dark-shaded cells are joinpoints.
Light-shaded cells are periods when APC and AAPC are not statistically significantly different from 0.
* APC and AAPC are statistically significantly different from 0 at p=0.05

Source: Author’s calculations

Table 3
Decomposition of the inter-state variance in the change in average annual number of live births per currently married woman of reproductive age, 1985-87 through 2015-17.

Age	Variance-covariance matrix							Total
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	
15-19	0.0030	0.0010	0.0003	-0.0000	-0.0004	-0.0003	-0.0002	0.0033
20-24	0.0010	0.0011	0.0003	-0.0001	-0.0002	-0.0002	-0.0002	0.0018
25-29	0.0003	0.0003	0.0003	0.0002	0.0000	-0.0000	-0.0000	0.0011
30-34	-0.0000	-0.0001	0.0002	0.0002	0.0002	0.0001	0.0000	0.0006
35-39	-0.0004	-0.0002	0.0000	0.0002	0.0002	0.0001	0.0001	0.0000
40-44	-0.0003	-0.0002	-0.0000	0.0001	0.0001	0.0001	0.0001	-0.0001
45-49	-0.0002	-0.0002	-0.0000	0.0000	0.0001	0.0001	0.0001	-0.0002
Total	0.0033	0.0018	0.0011	0.0006	0.0000	-0.0001	-0.0002	0.0064
	51.32	27.35	16.84	9.12	0.08	-0.90	-3.81	100.00
	Variance-absolute covariance matrix							
15-19	0.0030	0.0010	0.0003	0.0000	0.0004	0.0003	0.0002	0.0053
20-24	0.0010	0.0011	0.0003	0.0001	0.0002	0.0002	0.0002	0.0031
25-29	0.0003	0.0003	0.0003	0.0002	0.0000	0.0000	0.0000	0.0012
30-34	0.0000	0.0001	0.0002	0.0002	0.0002	0.0001	0.0000	0.0008
35-39	0.0004	0.0002	0.0000	0.0002	0.0002	0.0001	0.0001	0.0013
40-44	0.0003	0.0002	0.0000	0.0001	0.0001	0.0001	0.0001	0.0009
45-49	0.0002	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0007
Total	0.0053	0.0031	0.0012	0.0008	0.0013	0.0009	0.0007	0.0133
%	39.72	23.44	8.82	6.32	9.52	6.80	5.37	100.00

Source:Author's calculations

Table 4
AAPC in average annual number of live births in currently married women of different age groups during 1985-2018 in different states.

State	Age						
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Andhra Pradesh	-1.139*	0.060	-0.725*	-2.517*	-4.758*	-5.085*	-2.249
Assam	0.866	-1.135*	-1.003*	-1.363	-2.665*	-4.561*	2.183
Bihar	1.827	0.554	0.018	-0.698	-3.035*	-4.372*	-6.227*
Gujarat	2.137*	-0.204	-0.559*	-1.277*	-2.431*	-3.052*	-2.668*
Haryana	-0.966*	-0.567*	-0.446	-1.370*	-3.288*	-3.461*	-3.368*
Karnataka	-1.294*	-0.940*	-0.632	-1.510*	-3.243*	-5.247*	-4.494
Kerala	0.866	-0.751*	-0.346	0.617*	-0.383	-2.620*	-4.361
Madhya Pradesh	0.705	0.127	-0.110	-1.445*	-2.900*	-4.201*	-5.083*
Maharashtra	-0.824*	-0.575	-0.720*	-1.089*	-2.017*	-2.639	-2.370
Odisha	-0.518	-0.415*	-0.837*	-1.474*	-2.800*	-2.526	-2.965
Punjab	0.601	-0.736*	-1.128*	-1.285*	-2.218*	-1.678	-0.146
Rajasthan	0.760	0.207	-0.592*	-1.014*	-2.997*	-4.278*	-5.158*
Tamil Nadu	-1.368*	-0.094	-0.124	-0.671	-2.072*	-5.610*	-2.865*
Uttar Pradesh	1.880*	0.767	-0.173	1.092*	2.445	-2.977	-4.054*
West Bengal	0.810	-0.977*	-2.434*	-3.057*	-4.975*	-5.558*	-4.496*

* Statistically significantly different from 0 at p=0.05.

Table 5
Indicators of the change in the age pattern of average annual number of live births per currently married woman of reproductive age in India and states, 1985-2017.

Year	India	Andhra Pradesh	Assam	Bihar	Gujarat	Haryana	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Odisha	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	West Bengal
									Parameter α							
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.021	0.040	0.003	0.014	-0.004	0.034	0.032	0.041	0.025	0.047	0.011	0.077	0.043	0.032	0.019	0.001
1988	0.022	0.081	-0.011	0.005	-0.017	0.038	0.046	-0.022	0.014	0.045	0.018	0.098	0.076	-0.000	0.010	-0.005
1989	0.036	0.101	0.013	0.015	0.003	0.069	0.064	-0.033	0.034	0.043	0.019	0.107	0.085	0.006	0.003	0.026
1990	0.046	0.124	0.038	0.024	0.034	0.104	0.091	-0.057	0.036	0.001	0.038	0.100	0.079	0.012	0.007	0.051
1991	0.074	0.115	0.091	0.038	0.056	0.169	0.125	-0.008	0.097	0.010	0.069	0.131	0.106	0.033	0.028	0.091
1992	0.081	0.192	0.111	0.043	0.027	0.169	0.134	-0.098	0.110	-0.004	0.066	0.172	0.134	-0.005	0.037	0.110
1993	0.080	0.225	0.069	0.004	0.014	0.164	0.071	-0.163	0.123	0.038	0.058	0.171	0.088	-0.006	0.008	0.098
1994	0.049	0.277	0.059	-0.037	-0.009	0.140	0.059	-0.138	0.105	0.053	0.003	0.138	0.023	-0.052	-0.028	0.098
1995	0.037	0.260	0.068	-0.071	-0.043	0.159	0.066	-0.078	0.094	0.094	-0.006	0.154	-0.030	-0.047	-0.057	0.125
1996	0.034	0.257	0.125	-0.027	-0.058	0.133	0.110	-0.076	0.098	0.100	-0.015	0.158	0.024	-0.067	-0.055	0.168
1997	0.065	0.242	0.134	0.020	-0.026	0.174	0.147	-0.148	0.127	0.096	0.017	0.293	0.053	-0.067	-0.017	0.204
1998	0.086	0.317	0.147	0.037	0.017	0.195	0.184	-0.236	0.134	0.083	0.063	0.296	0.090	-0.100	0.013	0.232
1999	0.109	0.355	0.175	0.066	0.028	0.267	0.227	-0.325	0.145	0.097	0.075	0.388	0.114	-0.186	0.045	0.263
2000	0.128	0.427	0.197	0.068	0.064	0.300	0.233	-0.318	0.175	0.132	0.085	0.367	0.142	-0.111	0.066	0.293
2001	0.146	0.486	0.224	0.103	0.075	0.308	0.240	-0.399	0.200	0.161	0.050	0.402	0.160	-0.075	0.082	0.308
2002	0.176	0.592	0.256	0.121	0.101	0.357	0.259	-0.361	0.232	0.191	0.046	0.443	0.194	-0.026	0.097	0.337
2003	0.204	0.587	0.235	0.145	0.147	0.387	0.274	-0.343	0.224	0.236	0.085	0.450	0.222	-0.086	0.145	0.373
2004	0.223	0.537	0.187	0.145	0.210	0.433	0.296	-0.187	0.225	0.264	0.101	0.475	0.259	-0.054	0.187	0.418
2005	0.245	0.424	0.200	0.139	0.276	0.431	0.339	-0.094	0.231	0.265	0.142	0.455	0.297	-0.032	0.231	0.468
2006	0.271	0.417	0.297	0.187	0.308	0.447	0.367	-0.090	0.257	0.265	0.143	0.480	0.337	0.033	0.254	0.501
2007	0.308	0.426	0.353	0.231	0.331	0.480	0.327	-0.201	0.296	0.297	0.191	0.464	0.375	0.021	0.289	0.528
2008	0.321	0.448	0.313	0.273	0.360	0.513	0.249	-0.249	0.325	0.273	0.199	0.476	0.376	-0.011	0.328	0.505

Year	India	Andhra Pradesh	Assam	Bihar	Gujarat	Haryana	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Odisha	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	West Bengal
2009	0.344	0.420	0.294	0.319	0.354	0.537	0.069	-0.308	0.368	0.251	0.261	0.495	0.405	0.018	0.385	0.551
2010	0.344	0.277	0.284	0.368	0.349	0.469	0.173	-0.249	0.399	0.148	0.272	0.501	0.400	0.022	0.432	0.566
2011	0.368	0.253	0.382	0.432	0.385	0.437	0.217	-0.338	0.451	0.121	0.330	0.491	0.449	0.043	0.503	0.599
2012	0.375	0.079	0.451	0.501	0.430	0.391	0.259	-0.279	0.475	0.038	0.327	0.478	0.470	0.015	0.545	0.570
2013	0.344	0.077	0.445	0.463	0.434	0.375	0.287	-0.307	0.474	0.076	0.300	0.356	0.479	0.059	0.511	0.569
2014	0.323	0.231	0.330	0.425	0.410	0.349	0.235	-0.284	0.466	0.071	0.257	0.255	0.495	0.121	0.515	0.569
2015	0.274	0.275	0.235	0.390	0.362	0.240	0.063	-0.338	0.424	0.084	0.209	0.124	0.458	-0.014	0.497	0.488
2016	0.299	0.259	0.363	0.496	0.441	0.134	0.040	-0.213	0.397	0.050	0.199	0.272	0.474	-0.079	0.538	0.538
2017	0.266	0.156	0.439	0.502	0.486	0.025	-0.087	-0.129	0.277	-0.027	0.124	0.206	0.375	-0.277	0.497	0.673
									Parameter β							
1986	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1987	1.015	1.021	0.971	1.015	1.008	0.996	0.988	0.978	1.015	0.983	1.027	0.972	1.007	1.031	1.004	1.007
1988	1.026	1.047	0.976	1.025	1.022	1.009	0.995	1.000	1.055	0.998	1.035	0.991	1.018	1.056	0.999	1.013
1989	1.021	1.084	0.947	1.050	1.023	1.019	1.017	1.014	1.059	1.033	1.039	1.055	1.018	1.089	0.997	1.021
1990	1.019	1.105	0.950	1.060	1.022	1.031	1.034	1.066	1.065	1.097	1.013	1.141	1.025	1.114	1.006	1.001
1991	1.017	1.119	0.925	1.068	1.035	1.000	1.061	1.131	1.045	1.113	1.021	1.123	1.020	1.156	0.999	1.002
1992	1.030	1.121	0.939	1.100	1.055	1.016	1.072	1.204	1.061	1.116	1.036	1.096	1.047	1.190	1.011	1.001
1993	1.080	1.148	0.915	1.127	1.088	1.030	1.107	1.266	1.040	1.099	1.029	1.096	1.034	1.178	1.007	1.040
1994	1.094	1.169	0.886	1.157	1.077	1.056	1.121	1.201	1.056	1.081	1.036	1.090	1.055	1.175	1.017	1.068
1995	1.095	1.242	0.870	1.158	1.081	1.068	1.161	1.180	1.050	1.086	1.053	1.070	1.043	1.192	1.016	1.100
1996	1.071	1.336	0.893	1.183	1.073	1.088	1.214	1.184	1.111	1.089	1.103	1.087	1.083	1.244	1.036	1.145
1997	1.075	1.459	0.913	1.162	1.091	1.111	1.233	1.282	1.109	1.118	1.110	1.107	1.092	1.292	1.039	1.145
1998	1.088	1.412	0.915	1.151	1.095	1.119	1.266	1.350	1.131	1.144	1.098	1.235	1.104	1.316	1.058	1.148
1999	1.090	1.416	0.918	1.140	1.107	1.111	1.265	1.408	1.109	1.161	1.088	1.218	1.116	1.409	1.062	1.124
2000	1.106	1.408	0.955	1.171	1.094	1.105	1.297	1.377	1.127	1.145	1.111	1.272	1.113	1.339	1.072	1.150
2001	1.122	1.468	0.982	1.187	1.115	1.123	1.319	1.448	1.141	1.125	1.159	1.266	1.139	1.328	1.080	1.200
2002	1.128	1.466	0.984	1.196	1.131	1.137	1.364	1.414	1.162	1.121	1.186	1.259	1.135	1.321	1.084	1.245

Year	India	Andhra Pradesh	Assam	Bihar	Gujarat	Haryana	Karnataka	Kerala	Madhya Pradesh	Maharashtra	Odisha	Punjab	Rajasthan	Tamil Nadu	Uttar Pradesh	West Bengal
2003	1.121	1.473	0.914	1.138	1.136	1.120	1.386	1.419	1.152	1.146	1.104	1.242	1.134	1.333	1.079	1.231
2004	1.121	1.464	0.896	1.126	1.091	1.136	1.351	1.341	1.154	1.155	1.077	1.163	1.118	1.323	1.092	1.195
2005	1.125	1.530	0.882	1.111	1.079	1.161	1.366	1.317	1.130	1.195	1.072	1.131	1.099	1.305	1.101	1.185
2006	1.164	1.606	0.916	1.172	1.069	1.275	1.383	1.327	1.166	1.231	1.131	1.115	1.131	1.342	1.147	1.241
2007	1.177	1.689	0.931	1.182	1.105	1.259	1.508	1.372	1.185	1.251	1.134	1.175	1.149	1.387	1.143	1.284
2008	1.200	1.681	0.922	1.213	1.129	1.299	1.578	1.383	1.244	1.302	1.136	1.230	1.190	1.418	1.157	1.352
2009	1.207	1.698	0.913	1.213	1.142	1.299	1.843	1.404	1.252	1.293	1.145	1.246	1.199	1.380	1.153	1.368
2010	1.252	1.775	0.920	1.271	1.144	1.410	1.727	1.399	1.271	1.376	1.179	1.255	1.262	1.381	1.205	1.383
2011	1.303	1.796	0.939	1.340	1.162	1.364	1.686	1.476	1.309	1.350	1.215	1.274	1.308	1.386	1.255	1.409
2012	1.355	1.966	0.976	1.428	1.223	1.383	1.695	1.436	1.365	1.409	1.257	1.270	1.367	1.431	1.296	1.486
2013	1.333	1.840	1.043	1.512	1.255	1.299	1.402	1.372	1.320	1.298	1.198	1.186	1.344	1.311	1.271	1.444
2014	1.308	1.442	1.191	1.606	1.237	1.309	1.306	1.319	1.271	1.241	1.174	1.131	1.327	1.191	1.246	1.329
2015	1.280	1.294	1.174	1.677	1.177	1.283	1.261	1.260	1.254	1.128	1.133	1.025	1.311	1.167	1.225	1.263
2016	1.291	1.279	1.031	1.562	1.155	1.284	1.279	1.252	1.324	1.134	1.168	0.978	1.325	1.205	1.260	1.240
2017	1.258	1.240	0.969	1.473	1.110	1.207	1.280	1.219	1.336	1.142	1.141	0.979	1.321	1.217	1.247	1.201

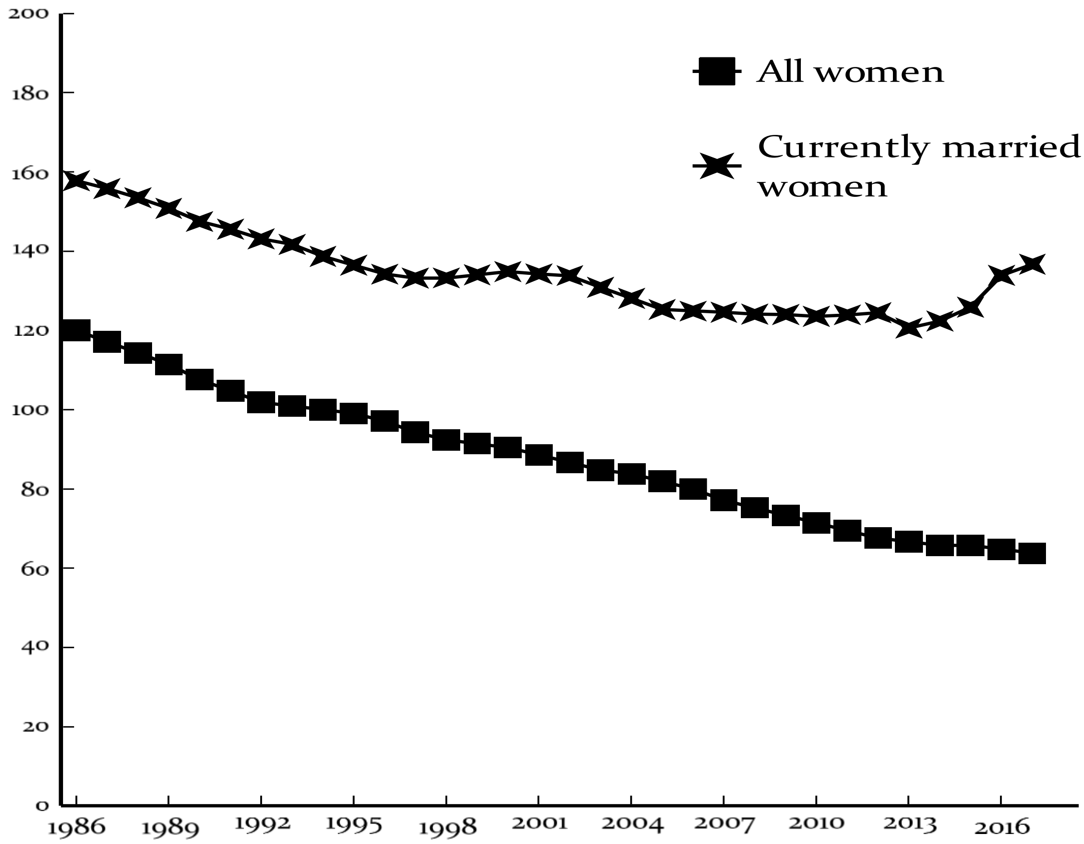

Figure 1: Average annual number of live births per 1000 women and per 1000 currently married women in India, 1986-2017