TREND OF SYNTHETIC PARITY PROGRESSION RATIO (SPPR) OF INDIA: EVIDENCE FROM NATIONAL FAMILY HEALTH SURVEYS

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Abstract

Fertility dynamics have been studied in this paper from 1977 to 2015. Regional fertility changes are analyzed using all four rounds of National Family Health Survey (NFHS) data. Synthetic Parity Progression Ratios (SPPR) and Total fertility rate (based on PPR) are used to analyze the fertility trend. Except for first parity, there is a decline in second and higher order birth of all the six regions. Reduction of third and higher order birth is the main reason for this decline.

Key Words: Birth Order, Parity, SPPR, TFR.

1. Introduction

India is the second most populous countries in the world. From the very start, rapidly increasing population is the prime concern of India. Various plans adopted to tackle the problem by fertility reduction through which population stabilized. There are numerous family planning programs, but the most recent one is the National Population Policy 2000. The medium-term goal is to bring the Total Fertility rate (TFR) to replacement levels by the year 2010, and long term goal is to achieve a stable population by 2045.

According to Sample Registration System (SRS), TFR of India in 2010 is 2.5 which shows that NPP 2000 fails to achieve TFR goal. As a result of the various program implementation and initiatives of the Government, the country's Total Fertility Rate (TFR) declined to 2.2 in 2016 (NFHS-4). India is one of the largest countries in the world comprising 29 states and seven union territories, with 2.1 billion population (according to Census 2011).

India is well known for its demographic diversity. Several demographers and population scientists state that the south has low fertility in comparison of high fertility of the north and the central. This comparison is not limited to the north and south, but other regions have their importance. Trend and level of fertility are declined in almost all parts of India with varying pace. In this paper, fertility changes in the various

regions of India are studied with the help of parity progression ratios (PPR) for 39 years from 1977 to 2015. Spoorenberg (2010) studied national-level fertility change in India using PPR. Trend and level of population's fertility are defined as how women space their children and number of women proceeds to the next parity. Fertility behaviour of a population caused by unexpected behaviour of fertility and reduction of births at different birth-orders can be well understood with the help of Parity progression ratios (PPRs).

Mathematically Parity Progression Ratio (PPR) is the probability that a female after delivering birth of any particular birth order will ever proceed to the next birth. Spoorenberg (2012) calculated PPRs using three rounds of National Family Health Survey (NFHS) data for six regions in India and analyzed regional patterns of PPRs. This paper extends works of Spoorenberg (2012) using all four rounds of NFHS data. Total fertility rate (TFR) based on PPR has been calculated in this paper for a better understanding of fertility decline. Some corrections also have been done in data shorting according to the Indian context.

2. Data

For the study of fertility change, National Family Health Survey (NFHS) data have been used. NFHS is large scale survey in India which collects information on various health and demographic characteristics. A large number of women (aged 15-49) along with their complete birth history are included in the sample. It is initiated by the Ministry of Health and Family Welfare (MOHFW), Government of India, and coordinated by the International Institute for Population Sciences (IIPS), Mumbai. Till now, four rounds of survey have been conducted. NFHS-1 was conducted in 1992-93, NFHS-2 in 1998-99 NFHS-3 in 2005-06 and NFHS-4 in 2015-16. The detailed description regarding NFHS can be found in NFHS reports and data-set. From birth history data, a different order of birth and their count are sorted for the study.

For analysis, whole data are divided into 6 Regions. Classification of the regions is adopted as Zonal council of India defines. Five Zonal Councils of India expect North- East was set up vide Part-III of the States Re-organization Act, 1956 and North Eastern Council was set up under the North Eastern Council Act, 1972. These regions include states and exclude Union Territories.

The present composition of each region is as follows:

- The East comprising the States of Bihar, Jharkhand, Orissa, and West Bengal
- The West comprising the States of Goa, Gujarat, and Maharashtra.
- The North comprising the States of Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan.
- The South comprising the States of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana.
- The Central comprising the States of Chhattisgarh, Uttarakhand, Uttar Pradesh and Madhya Pradesh.
- The North-East comprising the States of Assam, Arunachal Pradesh, Manipur, Tripura, Mizoram, Meghalaya, Nagaland and Sikkim.

The brief description of the regions is given below

East Region: Most of the region lies in the Indo-Gangetic plain. According to NFHS 4 data, fertility varied from 1.77 (children per women in West Bengal) to 3.41 (in Bihar). Bihar has high TFR which is far away from replacement level. In West Bengal, it is below replacement level. Low TFR in West Bengal may be due to two-child norm.

West Region: All three states of this region are the coastal states. Maharashtra and Gujarat are the hubs of business and industries due to which a lot of migration takes place to earn livelihood. The western region is the region of low fertility rate. According to NFHS 4, TFR varies from 1.66 (children per women) in Goa to 2.03 in Gujarat.

North Region: This region comprises mountains as well as desert. There is also a variety of climate and culture difference. According to NFHS 4, Total Fertility Rate varies from 2.4 children per women in Rajasthan to 1.62 in Punjab. But there is one thing that is common among all states is low sex-ratio. In Census 2011, Haryana has the lowest sex ratio of 879 females per 1000 males, and Himachal Pradesh has 972 sex ratio. This low sex ratio may be due to son preference and forced or induced abortion.

South Region: This region covers the peninsular Deccan Plateau. Literacy rates of the south are very high as compared to other parts of India i.e., around 80 per cent can read and write. The fertility rate is below replacement level, varies from 1.7 children per women in Tamil Nadu to 1.87 in Andhra Pradesh. This low fertility may be due to the high literacy rate and low infant mortality rate.

Central Region: This region is the most populous in India.TFR varies from 2.23 in Chhattisgarh to 2.74 in Uttar Pradesh according to NFHS 4.There is a decline of fertility in this region from the last decade. According to NFHS data, the fertility declined from 4.06 children per women to 2.74. Infant mortality is also very high in this region.

Northeast Region: This is the east most region of India. Prior to inclusion of Sikkim in this region, it was popularly known as a land of seven sisters or seven sisters state. The population density is not even in the region. Sixty-eight per cent of the total population of Northeast is living in Assam only. Sikkim has fertility below replacement level with 1.17 children per woman according to NHFS 4 data whereas, with 3.04 TFR, Meghalaya has high fertility.

3. Methodology

To study fertility change at the regional level, period parity progressions ratios (PPPR) are used. Parity Progression Ratio (PPR) is a useful method to study fertile change. PPR is used to understand the birth spacing pattern and reduction of the number of births at various birth- order i.e., fertility-limiting behaviours. In 1950s, the idea of PPR was initially pointed out by French demographer Louis Henry. Later on, it was independently originated by Feeney1983, Feeney and Yu 1987, and NiBhrolchain1987. Large data of retrospective survey are required for calculation of PPRs. PPRs apply to a long time period before the survey date because of the wait for more for $(i+1)^{th}$ birth to occur. Due to this, censoring and selection occur. The birth data

used in the calculation are not recent and occurred several years before the survey time. For accounting censoring and recent estimate, Hinde1998 proposed a new method for calculation of PPR in which calculation based on $(i+1)^{th}$ (not on $(i)^{th}$) births occur in a particular year to women who had their $(i)^{th}$ birth in a range of previous year. The new method is adapted from Feeney and Yu (1987) and Bhrolch´ain (1987). Hinde called this new method as Synthetic Parity Progression Ratios (SPPR).

SPPR is the progression from $(i)^{th}$ to $(i+1)^{th}$ birth, denoted by α_i, which is defined as

$$\alpha_i = 1 - (1 - q_0^*).(1 - q_1^*).(1 - q_2^*) \tag{1}$$

where q_x^*, is series (analogous to the q^x used in the analysis of mortality) which is computed as follow.

$$q_j^* = \frac{n_{(i)}^{th}}{N - n_{(i+1)}^{th}} \tag{2}$$

$n_{(i)}^{th}$ = Number of women who had their $(i)^{th}$ birth in the xth year before the current year and had their $(1+i)^{th}$ birth in the current year.

N = Total number of women who had a $(i)^{th}$ birth in the xth year before the current year.

$n_{(i+1)}^{th}$ = Number of these women who have already had their $(1+i)^{th}$ birth before the start of the current year.

We have also checked the relationship between Parity Progression Ration (PPR) and Total Fertility Rate (TFR).TFR is the total number of children born to a woman in her reproductive span. TFR is calculated with the help of PPR and called it TFR_{PPR}. It is defined as

$$TFR_{PPR} = \alpha_0 + \alpha_0\alpha_1 + \alpha_0\alpha_1\alpha_2 + \ ... ... \tag{3}$$

3.1   Illustration of SPPR method
An example is taken from the data analysis section to explain the estimation of PPR by using SPPR. The example is taken from the East region of NFHS 4 data, and we have calculated SPPR from 0th to 1st birth. The data presented in Table 1 is used for illustration. This table is a cross table of women, who had a first marriage in a given year according to the year in which they had their first birth before the survey date. Using Table-1, q_j^* values are obtained with equation: 2 from each row. The value q_j^* of a given year is obtained by dividing the number of first births in the column for that year by the number of women who had not yet had a first birth by the start of the year. Thus for 2015, we have

$$q_0^* = \frac{\text{number of women who had their first birth in 2015}}{\text{number of women who had their first marriage in 2015}}$$

$$= \frac{127}{3031} = 0.0419$$

and

$$q_1^* = \frac{\text{number of women who had their first birth in 2015}}{\text{number of women who had their first marriage in 2014} - \text{number of women who had their first birth in 2014}}$$

$$= \frac{1111}{3827 - 162} = 0.3031$$

Similarly, all other values of q_j^* are calculated. The values of q_j^* are based on each value of j, on the different groups of women, sorted according to the year in which they had their first marriage. Once values of q_j^* are calculated, SPPR can be calculated by using equation 1. In the calculation of PPR, first birth after ten years of marriage is neglected. Once SPPR is calculated, TFR based on PPR can be calculated with the equation 3.

Year of first marriage	Number of women having first marriage	Number of women having first child in relevant year							
		2001	2002	2003	2004	2005	2006	2007	2008
2001	3027	110	991	867	375	202	138	70	53
2002	3097	1	129	1019	816	432	230	130	86
2003	3043	0	0	128	1068	833	377	195	128
2004	3106	0	0	0	112	1115	844	406	207
2005	3652	0	0	0	0	138	1193	1008	507
2006	3200	0	0	0	0	0	142	1103	859
2007	3497	0	0	0	0	0	0	137	1346
2008	3360	0	0	0	0	0	0	0	141
2009	3547	0	0	0	0	0	0	0	0
2010	3867	0	0	0	0	0	0	0	0
2011	3767	0	0	0	0	0	0	0	0
2012	3801	0	0	0	0	0	0	0	0
2013	3689	0	0	0	0	0	0	0	0
2014	3827	0	0	0	0	0	0	0	0
2015	3031	0	0	0	0	0	0	0	0
									Continue….

Year of first marriage	Number of women having first marriage	Number of women having first child in relevant year						
		2009	2010	2011	2012	2013	2014	2015
2001	3027	39	18	13	7	13	3	7
2002	3097	54	40	24	14	4	7	1
2003	3043	68	45	31	15	8	3	4
2004	3106	136	76	28	18	14	7	5
2005	3652	273	137	81	61	32	24	4
2006	3200	432	223	120	69	39	34	11
2007	3497	954	422	222	114	60	33	19
2008	3360	1247	953	373	209	93	68	18
2009	3547	119	1468	924	430	203	105	24
2010	3867	0	127	1475	1058	490	237	58
2011	3767	0	0	149	1571	945	493	120
2012	3801	0	0	0	172	1617	958	280
2013	3689	0	0	0	0	146	1688	615
2014	3827	0	0	0	0	0	162	1111
2015	3031	0	0	0	0	0	0	127

Table 1. Data of East Region (NFHS 4) for estimating SPPR

4. Data Analysis

The technique of SPPR and TFR apply to 6 regions of India, and the calculation results show a declining trend of fertility. SPPR from zero parity to first parity depicted in figure 1. The overall trend is fairly stable, but it is slightly increased in the south, northeast, east and north whereas the west is decreased by 0.01 and central is unaltered. From figure 2, the progression from Parity 1 to parity 2, shows a stable and high trend in NFHS 1 and NFHS 2.There is stepped decline in NFHS 3, which declined further in NFHS4.The range of decline is around 84 per cent in the northeast and south to around 93 per cent in central and east.

A high declining trend started from progression to parity 3 (figure3).Only 30 per cent women in the south and 40 per cent women in west proceed to third parity. The central region stands with 63 per cent women who opt for third birth whereas east and northeast are in the vicinity of 60 percent. Progression to parity 4 in figure 4 shows that around 50 per cent women opt for 4th birth in the central, northeast and east region. The

highest decline in parity 4 is in the south with 21 per cent, followed by the west with 34 per cent and north by 42 per cent.

For progression to parity 5, figure 5 shows decline in all regions but an irregular pattern of decline is also observed. This regular pattern may be due to the small sample size of higher order birth. Total Fertility rate (TFR_{PPR}) presented in Table 1 and Figure 6, show a declining trend in all regions. According to Table 1, south achieves replacement level 2006 and a further decline to 1.71 in 2015. West was reaching to replacement level in 2015. North is also reaching around replacement level with 2.2. The central region has the highest level of TFR, with 2.58 followed by east and northeast.

5. Conclusion

Census 2011 concluded that the population of India is 1.2 billion with a decline in fertility since 1970. In the last forty-years, population of India declined with varied pace, which is supported by the findings of this paper. This paper explains various aspects of regional variation in India. Third and above parity show a distinct difference in progression. The fertility level of high fertility regions also declines with time, which is the main contributor to population growth. Reduction of third and higher order birth may be the plausible reason for the decline. Latest government figures concluded that females are opting for fewer children, i.e., two children norm has become common in practice, which is also evident in this study. Causes and factors associated with fertility decline are not studied in this paper. If causes and factors are studied, the results will give more insights.

YEAR	EAST	WEST	NORTH	SOUTH	CENTRAL	NORTHEAST
1977	4.15	3.61	4.29	3.39	4.35	4.14
1978	4.18	3.69	4.13	3.59	4.38	4.04
1979	4.06	3.58	4.17	3.53	4.36	4.02
1980	4.14	3.69	4.30	3.60	4.48	4.03
1981	4.09	3.65	3.67	3.50	4.40	3.92
1982	4.19	3.78	4.26	3.50	4.41	3.96
1983	4.05	3.59	3.84	3.39	4.22	3.89
1984	4.07	3.54	4.02	3.42	4.29	3.92
1985	4.00	3.35	3.84	3.30	4.17	3.94
1986	3.97	3.28	3.68	3.29	4.20	3.89
1987	3.93	3.25	3.82	3.17	4.15	3.91
1988	3.86	3.09	3.54	2.97	4.03	3.83
1989	3.66	3.04	3.02	2.82	3.89	3.51
1990	3.36	2.88	3.13	2.71	3.71	3.27
1991	3.22	2.95	3.28	2.76	3.79	3.11
1992	3.18	2.95	3.34	2.55	3.66	3.18
1993	3.55	3.02	3.63	2.82	3.99	3.65
1994	3.48	2.95	3.44	2.72	4.04	3.59
1995	3.25	2.89	3.28	2.63	3.71	3.50
1996	2.97	2.74	3.11	2.47	3.45	3.32
1997	2.85	2.74	3.06	2.44	3.25	3.17
1998	2.88	2.74	3.13	2.43	3.38	3.07
1999	3.28	2.82	3.16	2.60	3.78	3.54
2000	3.26	2.70	3.20	2.61	3.72	3.53
2001	3.14	2.57	2.97	2.48	3.59	3.34
2002	3.03	2.52	3.06	2.39	3.48	3.17
2003	2.97	2.49	2.92	2.31	3.40	3.09
2004	2.91	2.45	2.90	2.29	3.35	3.02
2005	2.90	2.43	2.84	2.30	3.34	3.02
2006	3.28	2.59	2.86	2.17	3.46	3.24
2007	3.26	2.52	2.87	2.18	3.40	3.21
2008	3.24	2.47	2.88	2.19	3.36	3.20
2009	3.21	2.49	2.81	2.19	3.28	3.11
2010	3.14	2.46	2.65	2.15	3.22	3.02
2011	3.02	2.41	2.56	2.12	3.13	2.86
2012	2.96	2.36	2.56	2.10	3.07	2.77
2013	2.89	2.36	2.53	2.11	2.99	2.68
2014	2.88	2.35	2.52	2.12	2.94	2.66
2015	2.52	2.14	2.22	1.71	2.58	2.47

Table 2. TFR based on PPR in various regions of India from 1977 to 2015

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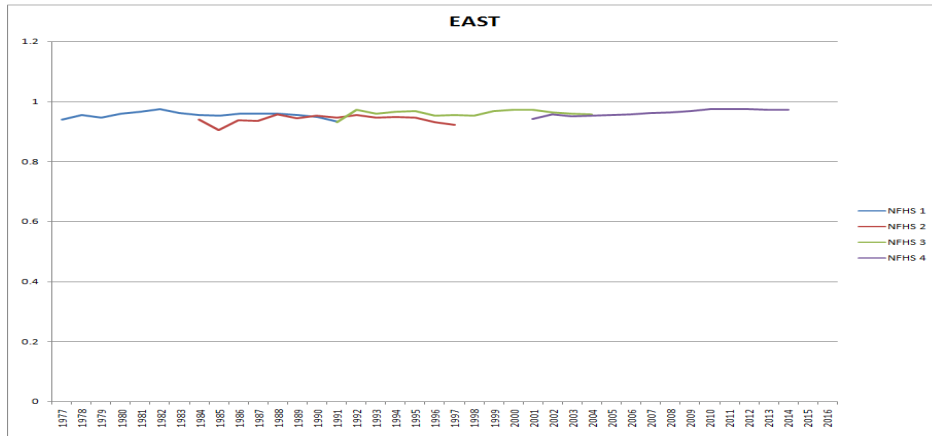
Figure 1.1: SPPRs from 0th to 1st birth of East Region
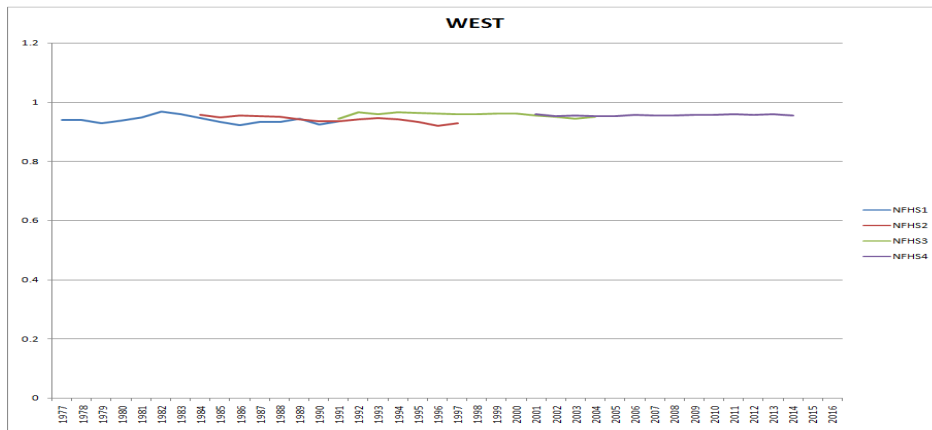
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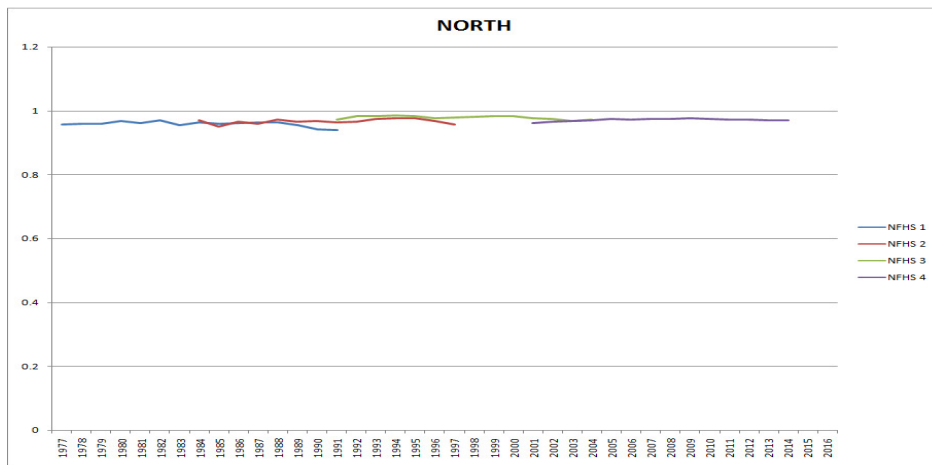
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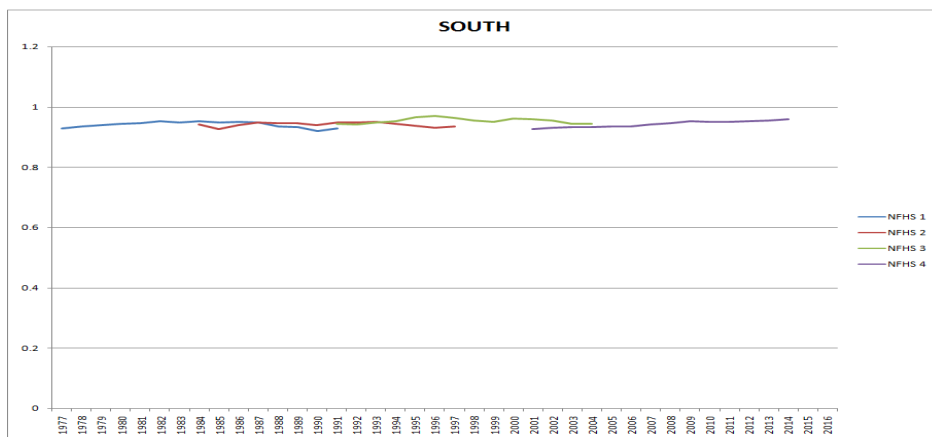
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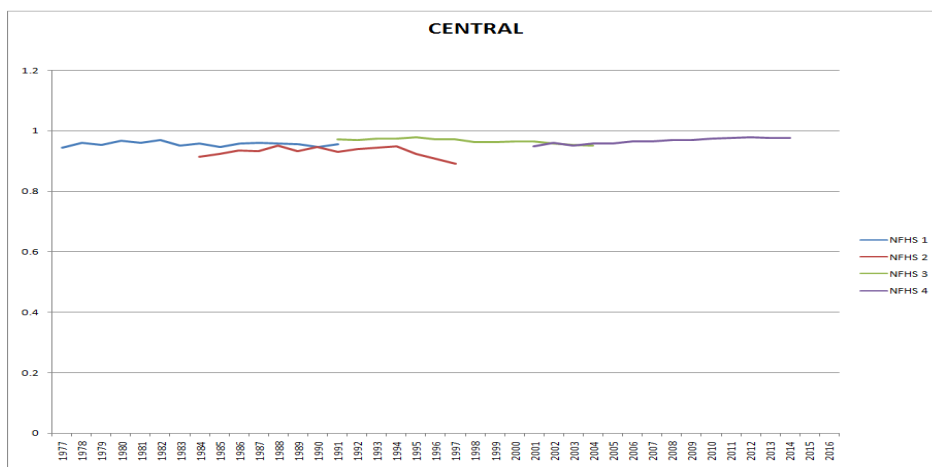
Figure 1.5: SPPRs from 0th to 1st birth of Central Region
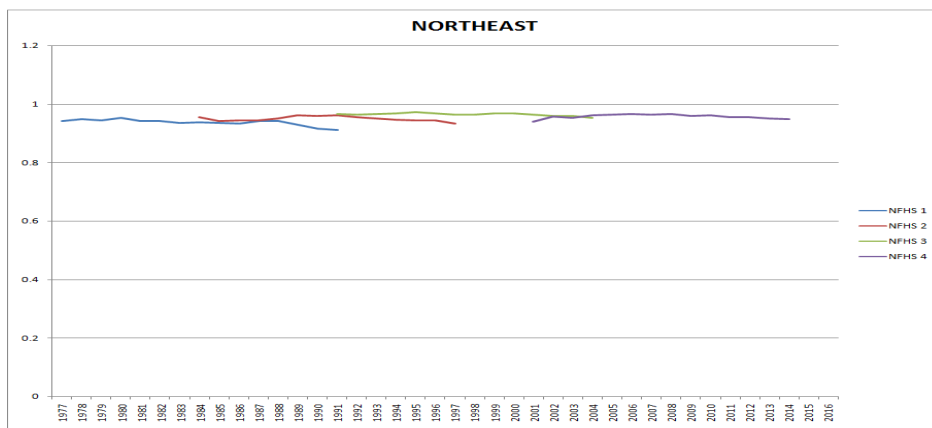
Figure 1.6: SPPRs from 0th to 1st birth of Northeast Region
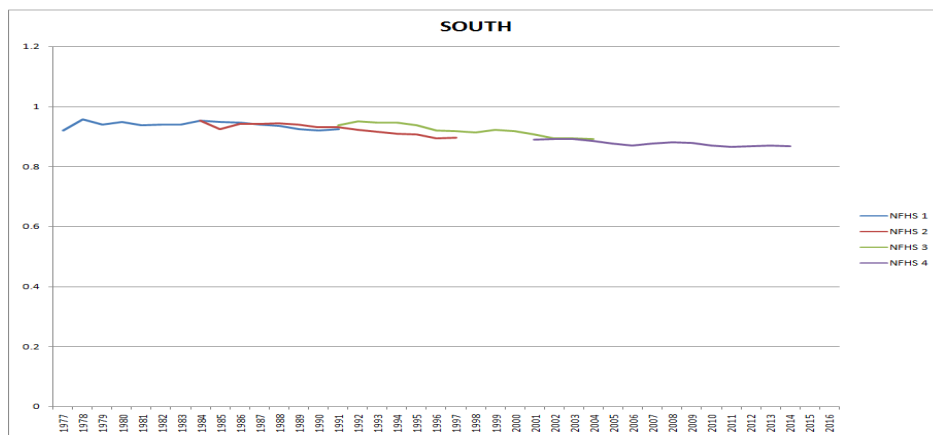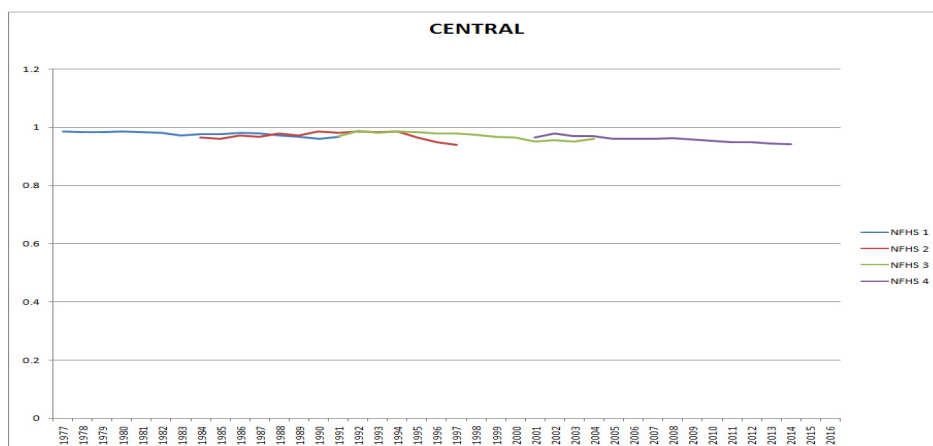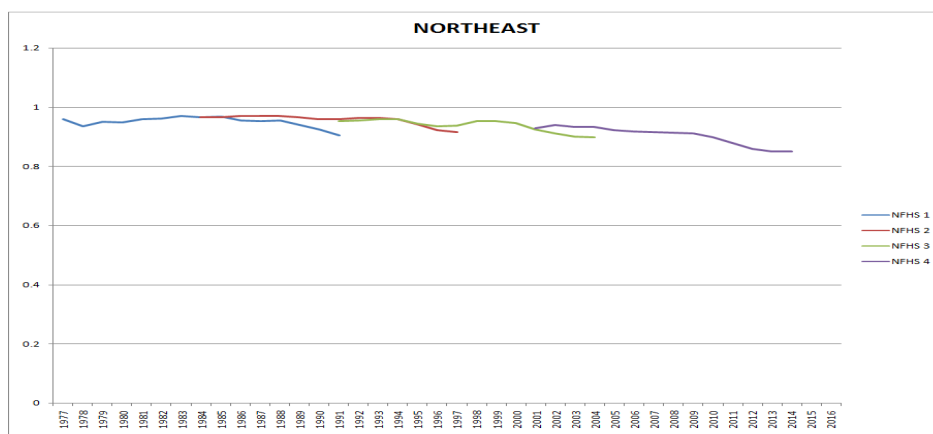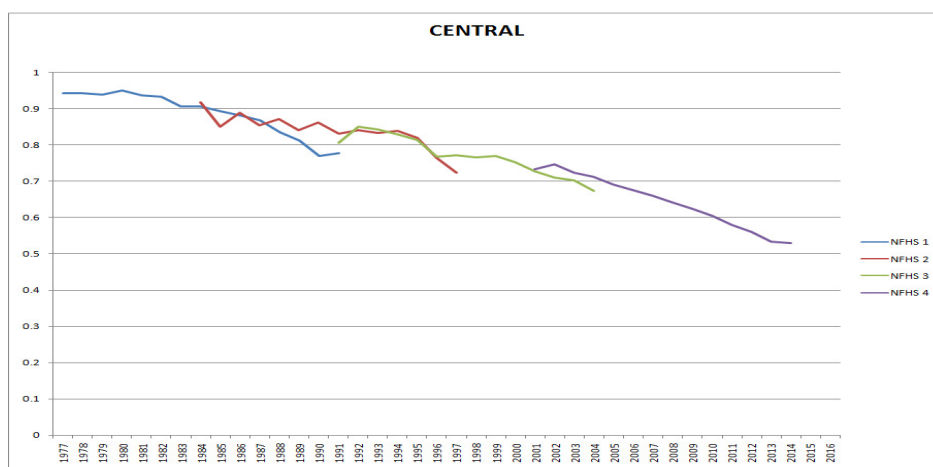**Figure 1: SPPRs from 0th to 1st birth (three-year moving average)**

Figure 2.1: SPPRs from 1st to 2nd birth of East Region

Figure 2.2: SPPRs from 1st to 2nd birth of West Region

Figure 2.3: SPPRs from 1st to 2nd birth of North Region

Figure 2.4: SPPRs from 1st to 2nd birth of South Region

Figure 2.5: SPPRs from 1st to 2nd birth of Central Region

Figure 2.6: SPPRs from 1st to 2nd birth of Northeast Region
**Figure 2: SPPRs from 1st to 2nd birth (three-year moving average)**
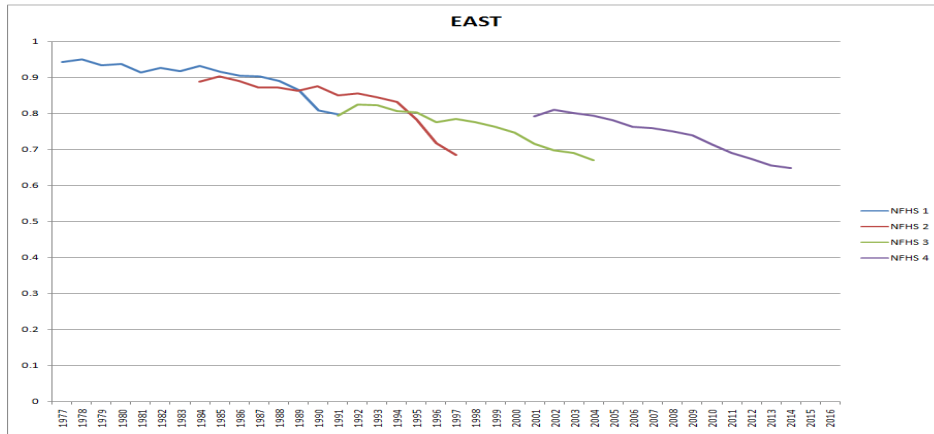
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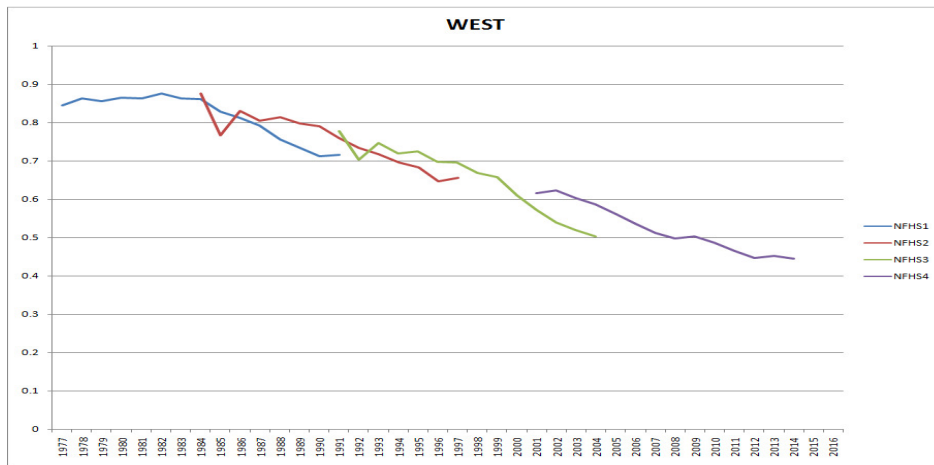
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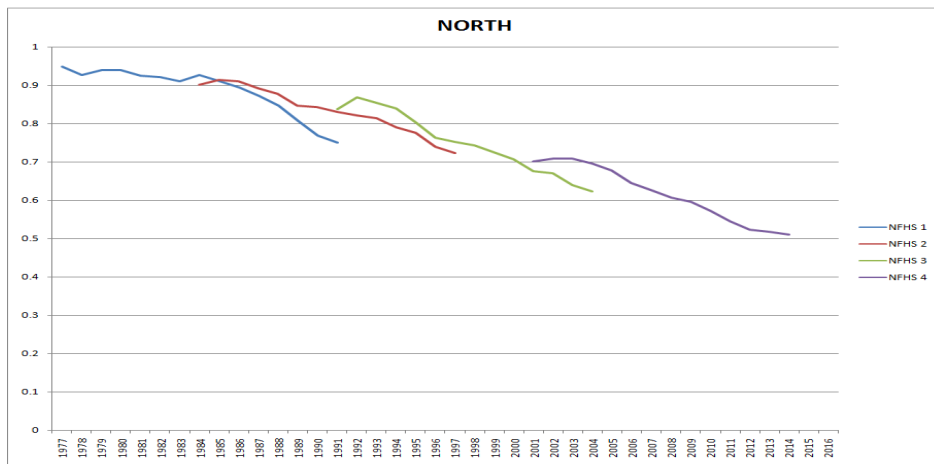
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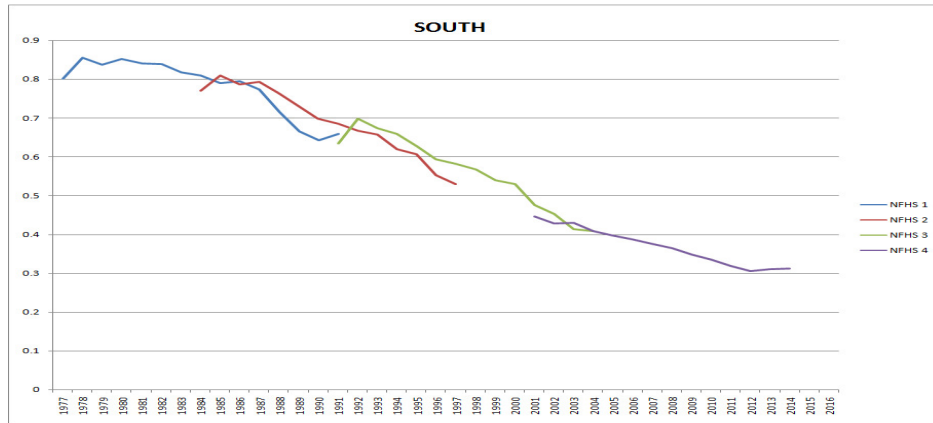
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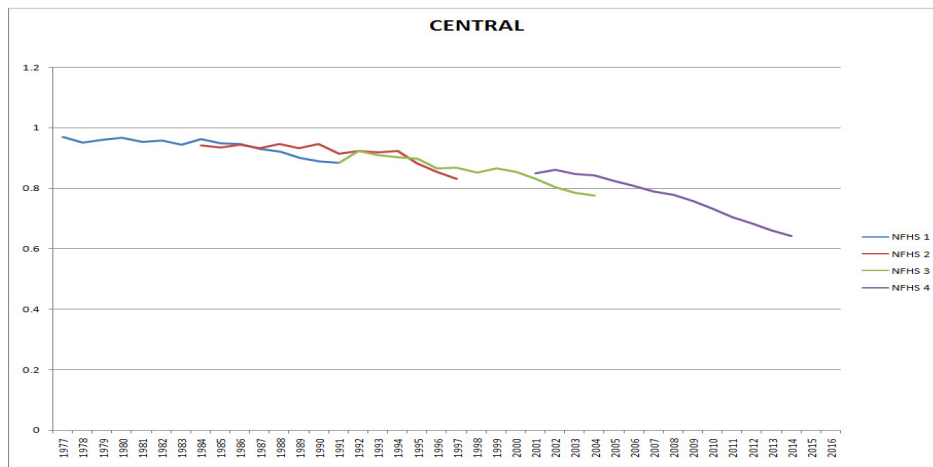
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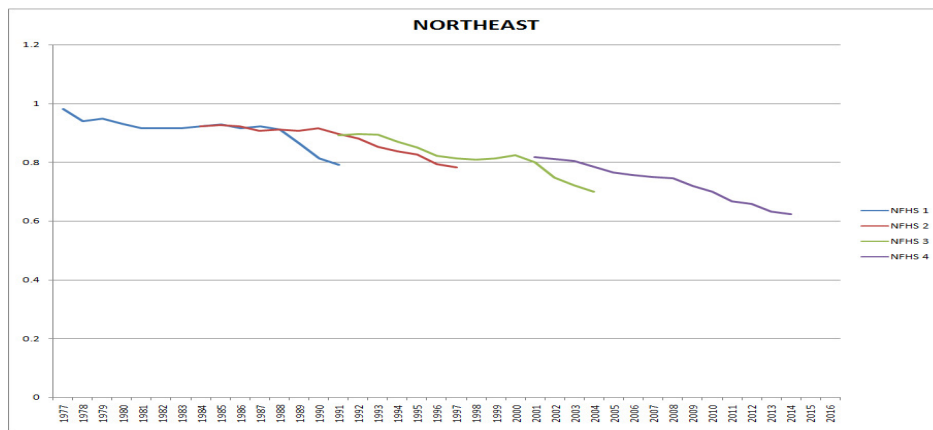
Figure 3.6: SPPRs from 2nd to 3rd birth of Northeast Region
Figure 3: SPPRs from 2nd to 3rd birth (three-year moving average)
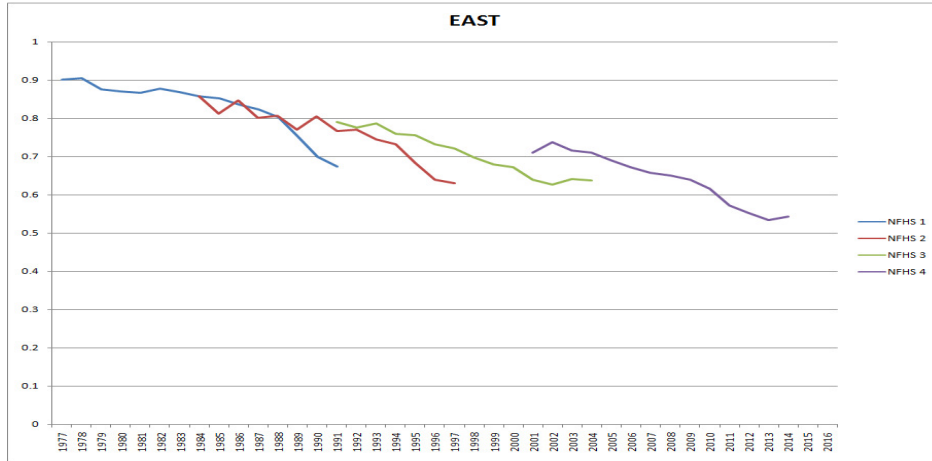
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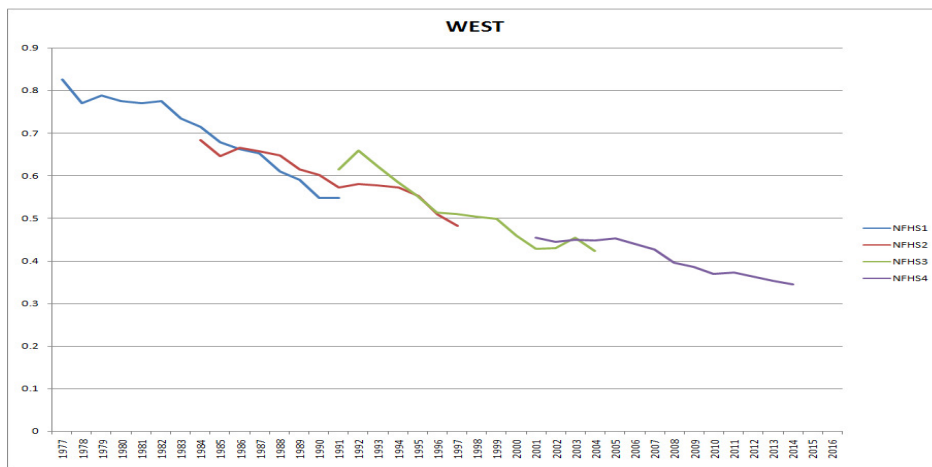

Figure 4.2: SPPRs from 3rd to 4th birth of West Region
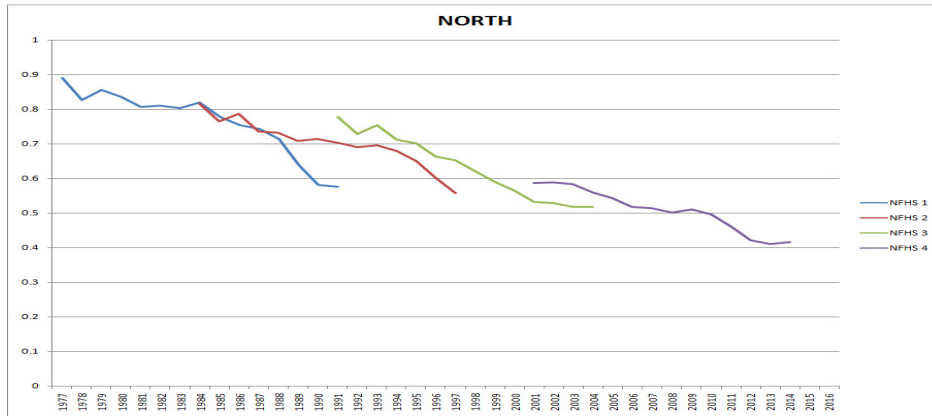
Figure 4.3: SPPRs from 3rd to 4th birth of North Region
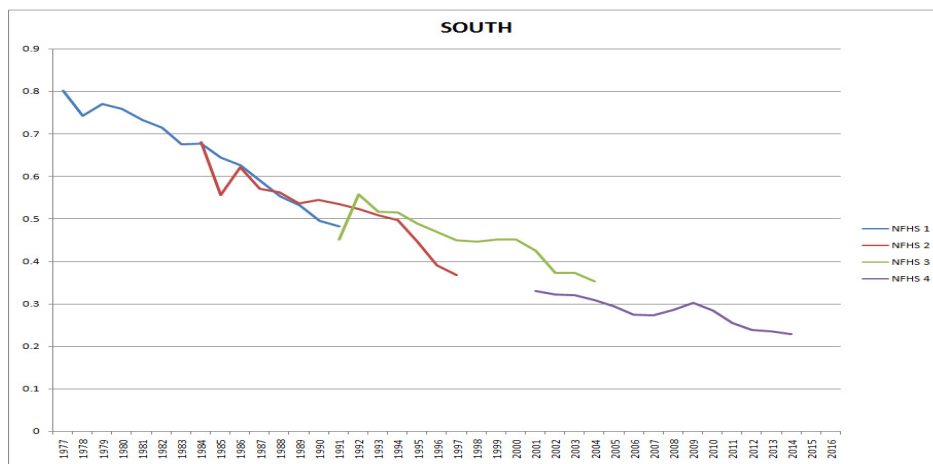
Figure 4.4: SPPRs from 3rd to 4th birth of South Region

Figure 4.5: SPPRs from 3rd to 4th birth of Central Region
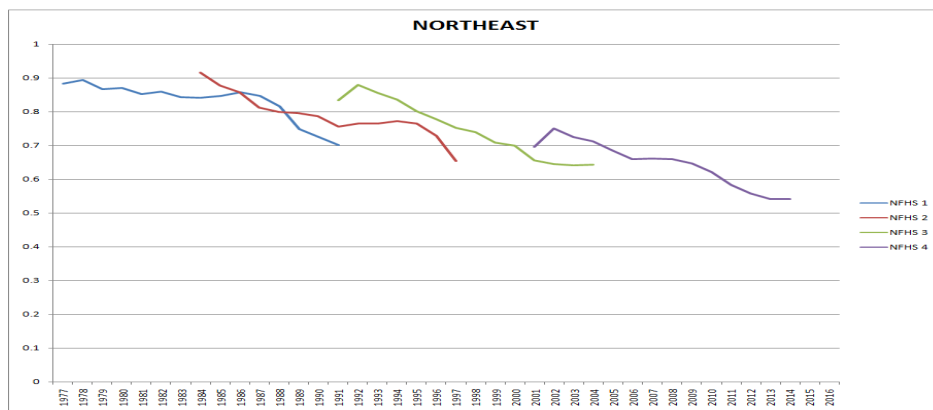
Figure 4.6: SPPRs from 3rd to 4th birth of Northeast Region
Figure 4: SPPRs from 3rd to 4th birth (three-year moving average)
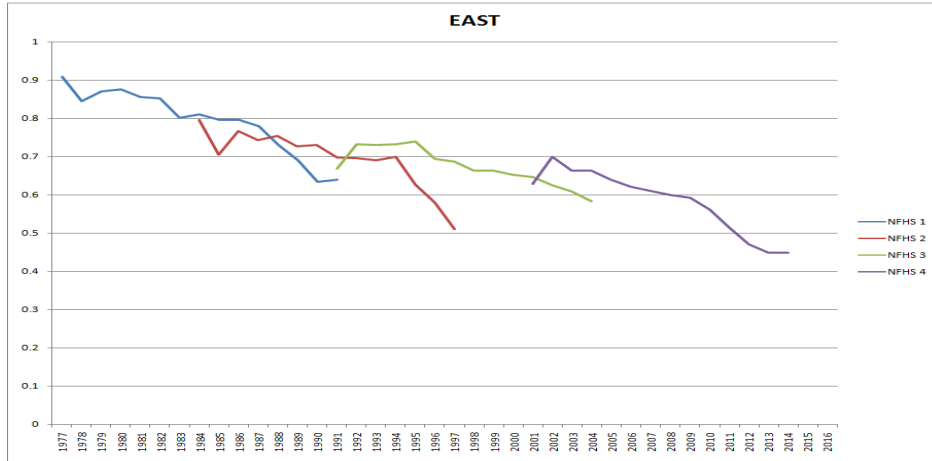
Figure 5.1: SPPRs from 4th to 5th birth of East Region
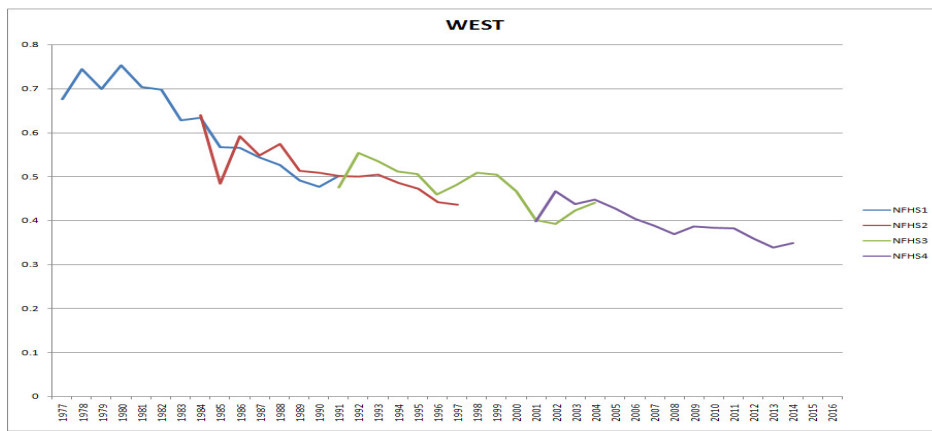
Figure 5.2: SPPRs from 4th to 5th birth of West Region
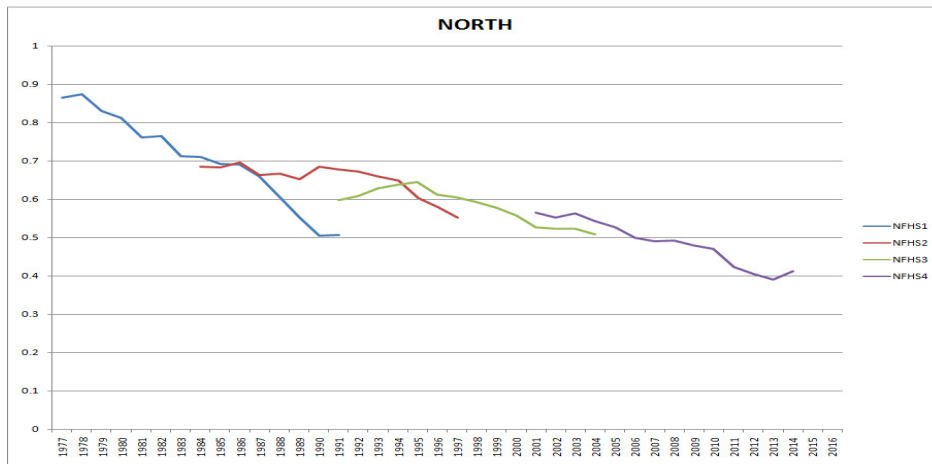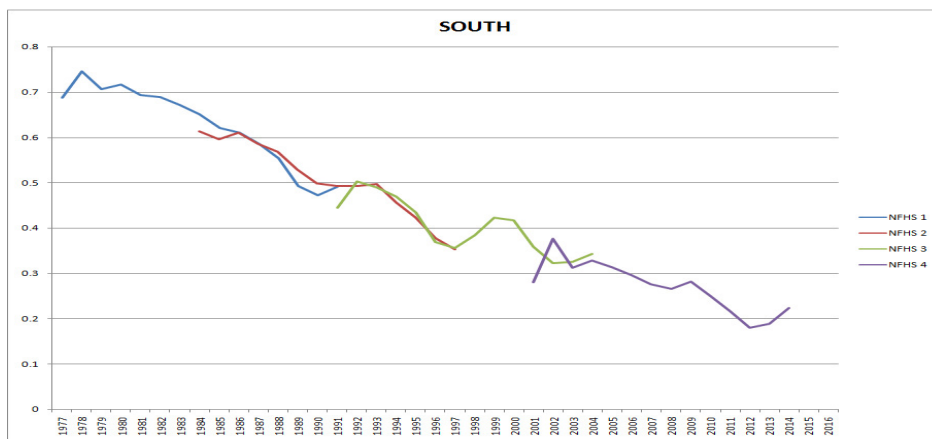

Figure 5.3: SPPRs from 4th to 5th birth of North Region
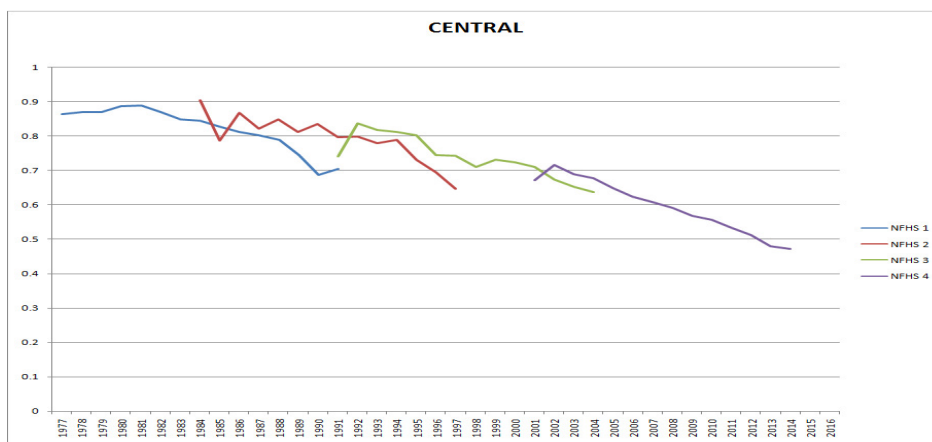
Figure 5.4: SPPRs from 4th to 5th birth of South Region

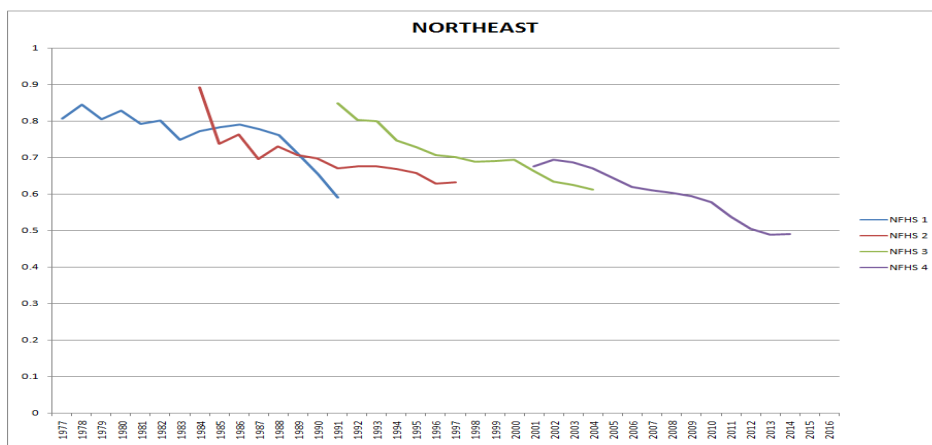**Figure 5.5: SPPRs from 4th to 5th birth of Central Region**

Figure 5.6: SPPRs from 4th to 5th birth of Northeast Region
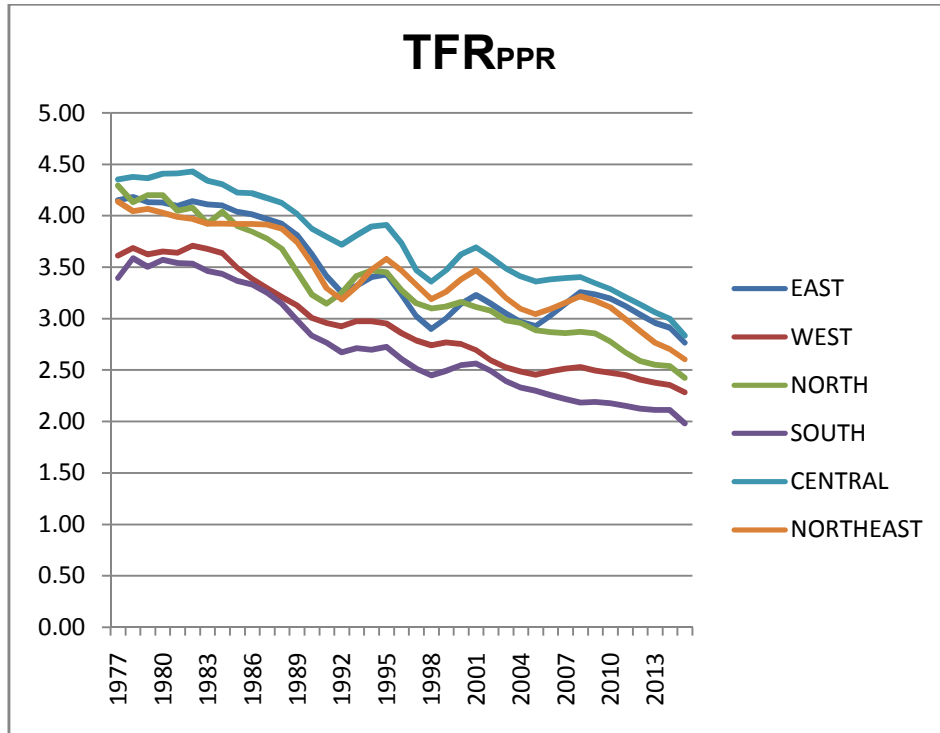**Figure 5: SPPRs from 4th to 5th birth (three-year moving average)**

Figure 6: Line graph of TFRPPR of regions of India from 1977 to 2015