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MODELLING OF INDIAN NUPTIALITY*

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SUMMARY. The three parameter model curve of Professor Coale has been fitted to the nuptiality schedules separately for males and females. State level data have been taken from the Census of India, 1971. It has been noted that Coale's method of fitting cannot be applied to Indian nuptiality data. An alternative method based on computer search out has been evolved and found satisfactory for most of the states of India.

Some preliminary analysis has also been made for exploration of the behavioral patterns of Indian nuptiality. The results of the analysis indicate that there is substantial variation in the nuptiality patterns between the two sexes. The age at entry into the marriage market (a_0) is correlated with SMAM and the proportions single in the age group 20–25 for males and 15–20 for females. The tempo parameter K is found to be uncorrelated with various indices of nuptiality for males. For females, however, the correlations between K and SMAM and K and C are both significant.

1. INTRODUCTION

Nuptiality has been known to be one of the important components of population growth in the developing as well as in the developed countries. Mathematical demography has been enriched substantially by encompassing nuptiality in its domain of study. Modelling of nuptiality has gained momentum in the field of analytical demography. Understanding of fertility process of a population vis-a-vis its nuptiality behaviour has been made comparatively easy due to the brilliant work in the field of nuptiality by Coale (1971) and Coale and McNeil (1972).

Though important contributions have been made by scholars in the modelling of nuptiality in different regions not much work has been done in this field with Indian nuptiality. Admitting data limitations in India, an investigation in this area seems to be rewarding. An attempt has, therefore, been made in this paper to analyse the Indian nuptiality by applying the model curve of Coale.

The marriage model developed by Coale (1971) relates observed distributions of first marriage frequencies to a standard schedule. The standard is based on the recorded distribution of first marriage frequencies in Sweden

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(1865–69). It has been shown that by adjusting the origin, the vertical scale and the horizontal scale of an observed distribution, it can be made to conform closely to the Swedish standard. Subsequently Coale and McNeil (1972) discovered that the standard schedule can be closely fitted by the convolution of a normal distribution and two or three exponential distributions. The marriage model is represented by

$$g_s(x) = \cdot 1946 \exp[-\cdot 174(x-6\cdot 06)-\exp\{-\cdot 2881(x-6\cdot 06)\}]$$

$g_s(x)$ is the probability density function of age at first marriage (among those who ever marry) in the standard population so that a proportion $g_s(x)dx$ of those who eventually marry do so in the age interval $(x, x+dx)$.

Let $f(a)$ represent the frequency of first marriages at exact age a in the given population, so that a proportion $f(a)da$ of the cohort marries in the age interval $(a, a+da)$. Let $g(a)$ be the probability density function of age at first marriage (among those who marry) in the given population.

$f(a) = Cg(a)$, where C is the proportion of the cohort ultimately marrying

$G_s(x) = \int_{-\infty}^{x} g_s(x)dx$ = standard proportion ever married at age x.

$G(a)$ = proportion ever married at age a in the given population.

We have the following relations

$$g(a) = \frac{1}{K} g_s\left(\frac{a-a_0}{K}\right)$$

$$G(a) = CG_s\left(\frac{a-a_0}{K}\right), \quad x = \frac{a-a_0}{K}$$

where a = age in the given population,

x = age in the standard scale,

a_0 = age at which a consequential number of marriages occur,

K = rate at which first marriage occurs relative to the standard.

This discovery is of paramount importance firstly because the three parameters a_0, K, C offer another means of summarising the different nuptiality schedules and secondly because each of the three parameters has a unique substantive interpretation.

An attempt has been made to disaggregate the census based singulate mean age at marriage (SMAM : Hajnal, 1953) into their a_0 and K components and to examine the interstate variations in SMAM in the light of variations

in the parameters a_0, K. A preliminary exploration of the relationship between the different parameters and two more indices of nuptiality have also been made in this paper.

2. Data source and method of analysis

The marital status distributions for different states of India by age and sex have been taken from the census of India (1971). The proportion single by five year age groups for males and females have been considered for the analysis of this paper. The basic data have been presented in Table 1.

TABLE 1 : PROPORTIONS SINGLE BY STATES—INDIA, 1971.

Male

state	age group							
	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50
Andhra Pradesh	.9824	.8038	.5045	.1396	.0409	.0207	.0151	.0117
Arunachal Pradesh	.9810	.9047	.6306	.3627	.1762	.0909	.0600	.0506
Assam	.9993	.9067	.7143	.3262	.1157	.0438	.0286	.0190
Bihar	.9314	.8560	.2898	.0985	.0410	.0270	.0210	.0183
Gujarat	.9828	.8622	.4468	.1387	.0527	.0306	.0251	.0210
Haryana	.9604	.7421	.3345	.1189	.0585	.0466	.0467	.0413
Himachal Pradesh	.9854	.8946	.5503	.1827	.0744	.0502	.0477	.0415
Jammu & Kashmir	.9897	.8902	.5529	.2335	.0978	.0577	.0447	.0356
Kerala	.9908	.9037	.8253	.3930	.1455	.0576	.0374	.0286
Madhya Pradesh	.8908	.6140	.2723	.0924	.0440	.0316	.0282	.0231
Maharashtra	.9890	.9145	.5849	.1925	.0578	.0323	.0214	.0179
Manipur	.9903	.9710	.7379	.4004	.1038	.0670	.0220	.0137
Meghalaya	.9978	.9455	.6833	.3169	.1203	.0699	.0431	.0357
Mysore	.9924	.9537	.7179	.2815	.0818	.0336	.0269	.0194
Nagaland	.9996	.9703	.7870	.4951	.1949	.0966	.0526	.0344
Orissa	.9948	.9033	.4880	.1250	.0337	.0142	.0112	.0093
Punjab	.9959	.9313	.5678	.2291	.1018	.0817	.0729	.0723
Rajasthan	.8962	.6685	.2950	.1062	.0553	.0386	.0375	.0363
Sikkim	.9928	.9131	.5959	.5038	.2295	.1174	.1089	.1087
Tamil Nadu	.9991	.9882	.7936	.3161	.0950	.0414	.0244	.0190
Tripura	.9976	.9558	.6903	.3968	.0871	.0273	.0173	.0112
U.P.	.8853	.6179	.2940	.1297	.0746	.0597	.0501	.0485
West Bengal	.9808	.9184	.6271	.2744	.1018	.0509	.0322	.0263

TABLE 1 (*Continued*): PROPORTIONS SINGLE BY STATES—INDIA, 1971.

Female

state	age group						
	10–15	15–20	20–25	25–30	30–35	35–40	40–45
Andhra Pradesh	.8759	.3156	.0448	.0107	.0060	.0030	.0033
Arunachal Pradesh	.9486	.6366	.2117	.0810	.0485	.0295	.0265
Assam	.9950	.5590	.1451	.0359	.0152	.0093	.0077
Bihar	.7857	.2307	.0356	.0104	.0047	.0040	.0026
Gujarat	.9640	.6013	.1015	.0185	.0079	.0053	.0041
Haryana	.8746	.3886	.0566	.0065	.0029	.0011	.0010
Himachal Pradesh	.9486	.4894	.0855	.0204	.0084	.0054	.0054
Jammu & Kashmir	.9529	.4968	.0903	.0168	.0071	.0046	.0044
Kerala	.9945	.8097	.3274	.0936	.0527	.0374	.0350
Madhya Pradesh	.7453	.2122	.0332	.0089	.0045	.0040	.0034
Maharashtra	.9309	.4582	.0992	.0234	.0109	.0066	.0061
Manipur	.9865	.7878	.4326	.2040	.0505	.0378	.0228
Meghalaya	.9796	.6863	.2545	.0890	.0360	.0235	.0196
Mysore	.9326	.4965	.1131	.0256	.0131	.0092	.0078
Nagaland	.9984	.8044	.5304	.2287	.1126	.0662	.0388
Orissa	.9026	.4249	.0610	.0174	.0089	.0054	.0041
Punjab	.9887	.7760	.2201	.0264	.0058	.0039	.0032
Rajasthan	.7494	.2407	.0255	.0048	.0026	.0016	.0015
Sikkim	.9910	.7594	.4258	.1044	.0333	.0622	.0286
Tamil Nadu	.9944	.7269	.1696	.0271	.0115	.0067	.0061
Tripura	.9634	.5325	.1399	.0266	.0099	.0041	.0028
U.P.	.7770	.2603	.0383	.0108	.0056	.0047	.0037
West Bengal	.9467	.4656	.1233	.0524	.0191	.0134	.0073

An examination of the above table reveals that there is substantial variation in the age specific proportions single by states for both sexes. To explore the behavioral patterns and their variations for different populations underlying the variations in nuptiality it is proposed to fit the model curve of Coale to the nuptiality data of India. The limitations of the investigations of such

behavioral model of first marriage in terms of the three parameters a_0, K and C are however to be noted. In this connection we may quote Coale (1977):

> Further research on the regularity of first marriage distributions and on the basis of that regularity has served to show that reality is more complex than the simple model Mc-Neil and I constructed. The good fit in the French survey of the predicted distribution of the intervals between meeting and marrying was at least partly fortuitous and may not be replicated in other surveys.

Theoretically Coale's method is applicable to a cohort schedule of nuptiality but we have considered cross sectional data and assumed that they will represent approximately the cohort nuptiality experience of the population. Coale has suggested a method of fitting the three parameter curve to observed proportion single in five year age groups. To be brief, the method is based on three sets of ratios R_1, R_2, R_3 [where R_i = ratio of proportions ever married in two successive five year age groups ($i = 1, 2, 3$)] and interpolating with the observed ratios (R_1, R_2) or (R_2, R_3) from the standard table to locate (a_0, K). Though the method is very elegant and operationally simple to apply, during the course of the investigation with Indian nuptiality by states it has been noted that the method recommended by Coale cannot be applied to as many as half of the states of India for both males and females.

It appears, tables of R_1, R_2, R_3 for various other combinations of (a_0, K) are necessary. Perfect fit is rare and by trial and error an alternative method based on computer search out is evolved. It has been observed that this alternative method gives a reasonably good fit to the Indian nuptiality schedules as judged by some heuristic criterion. The method has been described in the following paragraph. To save space and time the results of the analysis by Coale's method have not been presented in this paper.

We estimate C from an inspection of the observed schedule of percentage single. As there is more or less universal marriage, particularly for Indian females, and as no significant variation in the observed proportions ultimately marrying in different states is noted, it is expected that the value of C thus obtained will be sufficiently accurate.

For different combinations of (a_0, K) (with a_0 at intervals of ·1 year and K at intervals of ·01 year) the proportions single in 5-year age groups are estimated (See Coale, 1971, p. 209). A computer programme for such estimation is written. A heuristic criterion is adopted for the best possible choice of (a_0, K). By computer search out the combination (a_0, K) for which

$T = \sum_a |S(a) - \hat{S}(a)|$, the sum of absolute deviations, becomes minimum is taken as the best possible choice. Here $S(a)$ and $\hat{S}(a)$ are the observed and the expected proportions single in the 5-year age groups $(a, a+5)$. It should be noted that even with this search out procedure there is no unique method of estimation of parameters of the model. One might argue that alternative criteria, such as the sum of squared deviations $\sum_a [S(a) - \hat{S}(a)]^2$ or the proportionate error $\frac{\sum_a |[S(a) - \hat{S}(a)]|}{\sum_a S(a)}$, might be selected for minimisation. We however, believe that the estimates obtained by using different criteria will not differ substantially from those obtained here. The program has been checked to the extent possible and has been found to cope with all possible combinations of parameters (a_0, K) introduced into it. The values of a_0, K, C and T are shown in Table 2 below. The singulate mean ages at marriage as calculated from the model curve (SMAM (C)) along with those obtained from the observed schedules of proportions single (SMAM) are also shown in the same table.

3. Results and discussion

From a study of Table 2 the following observations can be recorded :

(1) The age at entry into the marriage market (a_0) varies substantially over the states for both males and females. The range of variation for males is however larger than the range of variation for females. For males, U.P. has as low a figure as 9·8 against 18·6 for Tamil Nadu. For females, Rajasthan exhibits the lowest figure of 8·8 as against 14·6 for Nagaland.

(2) The tempo of marriage (K) varies substantially over different states for both males and females. Whereas the range of variation is from ·56 (Orissa) to 1·00 (Sikkim) for males it is from ·40 (Gujarat) to ·80 (Sikkim) for females.

(3) As marriage is more or less universal, the variation of C is not substantial for any sex over the states.

(4) It appears there is no clear relationship between the age at entry into the marriage market (a_0) and the tempo of marriage (K). This is contrary to the experience of other regions (Smith, 1978) and might be partly due to more or less universal marriage, low age at entry into the marriage

TABLE 2: INDICATORS OF NUPTIALITY BY STATES: INDIA, 1971

Male

state	indicators					T	T'
	a_0	K	O	SMAM(C)	SMAM		
Andhra Pradesh	16.5	.58	.989	23.1	22.7	.0857	.0542
Arunachal Pradesh	14.0	1.00	.958	26.4	26.3	.0876	.0423
Assam	16.7	.80	.983	25.8	25.6	.0478	.0225
Bihar	11.1	.79	.982	20.1	19.8	.0719	.0356
Gujarat	14.1	.71	.980	22.2	22.2	.0679	.0452
Haryana	12.6	.71	.959	20.7	20.5	.0682	.0307
Himachal Pradesh	16.8	.58	.960	23.4	23.1	.0994	.0584
Jammu & Kashmir	14.7	.80	.966	23.8	23.6	.0637	.0359
Kerala	18.4	.74	.973	26.8	26.8	.0209	.0089
Madhya Pradesh	10.2	.84	.977	19.7	19.2	.1010	.0527
Maharashtra	16.6	.64	.983	23.9	23.6	.0857	.0490
Manipur	16.8	.83	.988	26.2	26.2	.1141	.0615
Meghalaya	16.1	.83	.969	25.5	25.3	.0483	.0233
Mysore	17.7	.67	.982	25.3	25.1	.0705	.0346
Nagaland	16.8	.92	.970	27.2	27.5	.0069	.0394
Orissa	16.5	.56	.991	22.9	22.8	.0674	.0435
Punjab	15.9	.67	.928	23.5	23.3	.0506	.0276
Rajasthan	11.3	.76	.964	19.9	19.5	.1182	.0588
Sikkim	13.3	1.00	.905	24.7	25.1	.2409	.0746
Tamil Nadu	18.6	.63	.983	26.0	26.0	.0222	.0101
Tripura	17.0	.74	.989	25.4	25.2	.0719	.0353
U.P.	9.8	.87	.952	19.7	19.3	.0860	.0430
West Bengal	15.5	.82	.970	24.7	24.4	.0748	.0389

market and low mean age at marriage for the Indian population. It is interesting to note that whereas the predominantly Hindi speaking states of India—Rajasthan, Bihar, UP and MP—exhibiting very early marriage also exhibit very low age at entry into the marriage market, the states showing relatively late marriage—Kerala, Tamil Nadu and the hilly states of Eastern India—also exhibit very high age at entry into the marriage market. Such a pattern is not, however, discernible with the tempo parameter K.

TABLE 2 (*Continued*): INDICATORS OF NUPTIALITY BY STATES: INDIA, 1971

Female

state	indicators					T	T'
	a_0	K	C	SMAM(C)	SMAM		
Andhra Pradesh	10.6	.61	.997	16.3	16.2	.0323	.0258
Arunachal Pradesh	12.2	.63	.970	19.4	19.5	.0612	.0325
Assam	12.4	.54	.994	18.5	18.7	.0165	.0075
Bihar	9.6	.50	.997	15.3	15.3	.0138	.0130
Gujarat	14.0	.40	.997	18.5	18.4	.0452	.0260
Haryana	9.9	.61	.999	16.8	16.6	.0829	.0623
Himachal Pradesh	12.8	.44	.995	17.8	17.8	.0430	.0279
Jammu & Kashmir	12.8	.44	.996	17.8	17.8	.0395	.0263
Kerala	13.9	.63	.970	21.1	21.0	.0254	.0114
Madhya Pradesh	9.2	.51	.998	15.0	15.0	.0162	.0162
Maharashtra	11.6	.53	.996	17.6	17.5	.0350	.0232
Manipur	13.4	.80	.987	22.5	22.4	.1320	.0545
Meghalaya	12.3	.68	.983	20.0	20.0	.0158	.0079
Mysore	12.1	.51	.993	17.9	17.8	.0468	.0298
Nagaland	14.6	.80	.971	23.7	23.7	.0706	.0300
Orissa	12.3	.44	.996	17.3	17.3	.0191	.0131
Punjab	14.5	.50	.998	20.2	20.1	.0279	.0139
Rajasthan	8.8	.57	.999	15.3	15.1	.0414	.0406
Sikkim	12.2	.80	.980	21.3	21.5	.1613	.0707
Tamil Nadu	14.5	.45	.995	19.6	19.5	.0167	.0087
Tripura	11.9	.57	.998	18.4	18.3	.0170	.0102
U.P.	9.0	.58	.997	15.6	15.4	.0369	.0398
West Bengal	11.2	.58	.994	17.8	17.4	.0228	.0143

(5) The SMAM values obtained from the observed schedules of proportions single closely agree with the corresponding values obtained from the model curve for all the states for both males and females. The close agreement between the two sets of SMAM may indirectly validate the suitability of the model to some extent.

(6) As judged by the heuristic criterion the fit is satisfactory for majority of the states for both males and females assuming a cut off point to be ·10

or 10% for the measure T. It may however, appear that a cut off point of ·10 for T is rather large and such a large value may actually indicate a poor fit. To probe further, an alternative statistic $T' = \sum_a |S(a) - \hat{S}(a)| / \sum_a S(a)$ has also been presented in Table 2. If we now set a threshold range for T' as ·05 to ·06 (proportionate error between 5 to 6 percent) indicating a reasonably good fit, we arrive at more or less the same over all conclusion, namely Coale's model gives a satisfactory representation of Indian nuptiality.

To understand the nuptiality variations in terms of the parameters of the model curve we have made some preliminary analysis by calculating the correlation matrix of the parameters of the model curve. Two more indices namely SMAM and the proportions single at ages 15–20 for females and 20–25 for males are also considered in this correlation analysis. Only such correlations assumed to be meaningful in theoretical sense have been considered for this analysis. The results are presented in Table 3 below.

TABLE 3: CORRELATION MATRIX OF THE INDICATORS OF NUPTIALITY

Male

	p.c. single in 20–24	SMAM	a_0	K	C
p.c. single in 20–24		.990*	.896*	.041	.224
SMAM			.871*	.100	.228
a_0				−.393	.318
K					−.220

Female

	p.c. single in 15–20	SMAM	a_0	K	C
p.c. single in 15–20		.973*	.892*	.495	−.702*
SMAM			.820*	.634*	−.754*
a_0				.070	−.458
K					−.693*

* significant at 1% level.

We can briefly summarise the results of the preliminary analysis presented in Table 3 as follows :

(1) For both males and females SMAM is highly correlated with a_0 the correlation coefficient being significant at 1% level :

(2) The tempo parameter K is not correlated with any of the nuptiality indices for males. For females, however, K is correlated significantly with SMAM and C,

(3) Proportions single in the early ages namely 15–20 for females and 20–25 for males are highly correlated with SMAM and a_0.

(4) For males the parameter C shows no significant correlation with the other indices of nuptiality. For females, however, the correlations with p.c. single in 15–20, SMAM and K are found to be statistically significant.

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