REGIONAL HETEROGENEITY AND FERTILITY BEHAVIOUR IN INDIA*

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November 1998

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* Presented at a Seminar, Fertility Transition in South India in a Comparative Perspective, as Background paper, held at the Centre for Development Studies (CDS), 6-8 April, 1998. This seminar was organised by the authors of this paper with financial assistance from CDS, French Institute of Pondicherry, Indo-French Exchange Programme and The Wellcome Trust, United Kingdom. Comments from the participants as well as the referee of this working paper series are greatly appreciated.

ABSTRACT

This paper examines regional heterogeneity both from statistical and cartographic perspectives, using factor analysis of non-demographic data, models of fertility determinants and district-wise mapping to test out the presence of regional clustering. Regional analysis reveals that economic, social and health indicators display spatial patterns as strong as fertility rates. All recent models of fertility incorporate a significant geographical component (using dummy regional variables or auto-correlation measurements). The map of fertility decline spreading along culturally and spatially contiguous regions also suggests that diffusion mechanisms may play an independent role in the spread of new reproductive behaviour (small family norm). Though diffusion per se, no real explanation for the fast decline of fertility in Southern or Coastal India (what would then be the cause of diffusion in the first place?), it would definitely be important to understand how these mechanisms are facilitated by social and cultural homogeneity or by regional policies.

JEL Classification: J 11, J 13, I12, I 28

Key Words : Fertility, South India, diffusion, heterogeneity, family planning, reproductive behaviour, coastal India, infant mortality.

Introduction

This paper aims at bringing to the fore some questions central to the South Indian experience in fertility transition. First, we should ask ourselves whether boundaries as we know them are just administrative contours or whether statistical characteristics do mark off South India (and other regions) from the rest of the country. To this purpose, we will use two basic devices: statistics and maps. Statistics will help us determine if fertility trends constitute an isolate feature or rather an essential component of a more complex South Indian pattern. Maps will illustrate more graphically the regions we are talking about and point to a geographical patterning of fertility decline in India which is probably less simple than the common North/South divide. We will also examine different statistical models of fertility determinants to see what they tell us about the relative role of social, economic or other components of fertility decrease. We will end this paper with a discussion of the insights of a regional approach to fertility decline and some suggestions for future research.

1. A Global View of Regional Partitioning

Our first approach will be strictly non geographical. The question is simple: if we did not know about India's geographical and cultural patterning, would we still be able to recognize the main features of regional heterogeneity by examining the available statistics? Or to put it in a different and more provocative way, could it be that the stress on regional differences is a sheer geographical artefact relying on spatial projections of localities on a two-dimension map and that geographical regularities have nothing to teach us?

To approach these issues, we compiled a database on Indian regions using some of the more meaningful social, demographic, cultural and economic indicators that could be identified. We realized very soon that collecting the necessary data at the district level was an impossible task. The contents of information available at the district level would not take us very far, as very little data apart from Census and agricultural data, can be gathered below the State level. This in itself is an indication of the limited capacities we have to understand or monitor economic and social development at micro-regional levels, and this remains true of demographic statistics, even though some of them are now available at a somewhat more detailed scale than other indicators.

A few words about the database: we have tried to bring together data from a large number of sources in order to cover several aspects of social and economic diversity such as data on maternal and child health, women's position in society, fertility trends and family planning, other social development indicators (mainly education), global economic indicators such as infrastructure, State expenditures or agricultural and industrial production levels, as well poverty or household consumption indicators. We use various statistical publications such as the UNFPA and CMIE year books. Demographic indicators are mainly taken from the NFHS and from the SRS series. This quest resulted in a first set of 80 variables, from which we then excluded variables which turned out to be too highly correlated. Around 55 variables were finally retained, which we will use to explore India's regional diversity (see Table 1 for description of the variables).

The methodology is straightforward for we are not trying to model anything at this stage (better models are presented further below), but rather to capture the main dimensions of India's regional diversity. We have therefore used a factor analysis, opting for the principal component method. The object of this commonly used technique is to summarize a set of variables by identifying "components" (or "factors") by combining individual inter-correlated variables. Principal components or factors are vectors formed by linear combination of original variables with maximum variance[1] . Variables are first scaled to have equal, standard deviation before the calculation is undertaken.

The first factor analysis is based on a large set of economic or infrastructure data. Using 21 variables, the factor analysis yields at least four highly significant components. The weight of each component can be assessed from "eigenvalues" shown in Table 2. A factor associated with the eigenvalue 1 accounts for as much variance in the data set as would one single variable, on average. As it appears, the first factor has a very high eigenvalue of more than 8, and accounts indeed for 40% of the total variance of the 21 variables. This represents an extremely powerful contribution. The contributions of the other factors decrease fast, but the next three are still significant (see Table 2).

As could be expected, Factor 1 (hereafter e1) will be an economic index encompassing almost all economic variables. Most prominent among indicators of economic development are the following variables which are strongly positively associated with e1:

National State domestic product
Index of infrastructure
Consumption of power per capita

1. For a description of factor analysis applied to demography, see Halli and Rao (1992)

Tractors per hectare
Agricultural yield (Kg/ha)
Household consumption (rural areas)
Workforce share in the tertiary sector.
Telecommunications lines per capita
Fertilizer consumption (Kg/ha)
Pucca houses (urban areas)

The same factor is also negatively correlated with high poverty levels and low bank density.

The following factors 2 and 3 (respectively e2 and e3) are also interesting though their interpretation is not as obvious as for factor 1. Factor 2 is composed mainly of the share of tertiary workforce, the telecommunication lines per capita, the sex ratio (F/M) of workers, urbanization and industrial sector. It is negatively associated with different indicators of agricultural development (irrigation, tractors, yield) and proportion of houses with no toilet facilities. This factor underlines clearly the demarcation between regions according to the prevalent urban- or agriculture-based orientations of development.

Factor 3 is positively linked to specifically industrial and urban development (along with drinking water facilities), but also with high poverty level, low banking infrastructure and especially low expenditures level per capita for both urban and rural areas. This factor plays a minor role in distinguishing between States, except for the case of Himachal Pradesh, and will no longer be used in our analysis.

Figures 1 and 2 help us to visualize the respective positions of the different States. Note that the variance of each factor is not standardized to one, but on the contrary is exactly proportional to the part of the total variance explained. This accounts for the fact that the first horizontal axis (first factor) is usually much larger than the vertical axis (second factor).

On Figure 1, twelve States are represented according to the first two factorial dimensions: on the right side, richer States like Punjab or Haryana and other regions such as Maharashtra and Gujarat are opposed to poorer States shown on the left side. Vertically, there is a marked opposition between agro-based regional economies of the Punjab, Haryana as well as the poorest Hindi belt States and Orissa on one hand, and States where urban industries and services play a major role such as Maharashtra, Gujarat and most South Indian States.

This diagram suggests a few comments. These two dimensions of economic development are rather well known and determine what might be called the Indian development triangle with three vertices. The first pole comprises the two States where the strongest global economic development is observed and where agriculture is a dynamic sector (viz. Punjab and Haryana). A second angle corresponds to medium-rank States such as Maharashtra where the bulk of the economy is mostly urban-based or non-agricultural. The third focus is around the North Indian States from Rajasthan to Orissa, which are both agro-oriented and under-developed.

As can be seen on these graphs, the geographical configuration of these States is more or less preserved on the graph. Contiguous States usually have close values on both factors and the regional patterning is visible: most notably for our purpose, the South Indian States are in a somewhat similar position, and appear quite distinct from Bimaru States (Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh) and from the Punjab-Haryana cluster.

We will now repeat the same exercises with social and health data. We have selected a set of rather disparate variables to cover some important components of what is usually subsumed under the label of social development: literacy and education, infant and child mortality. Other health-related variables are also used including maternal and child health data from the NFHS, medical and paramedical personnel per inhabitant, regional expenditures on health and family planning. Other variables correspond to several gender-specific aspects of social development, i.e. female age at marriage, overall sex ratio as well as sex ratio among workers and among the literate population. We have of course excluded all variables related directly or indirectly to fertility levels as these will be examined later on.

The factor analysis proves more powerful with these social and health characteristics than in our previous analysis of regional economic profiles. A single factor (sh1) accounts for more than half of the total variance of the 17 variables selected. This means that most health and social characteristics tend to move in the same direction, along a one-dimension scale of depicting social development. The most significant components of this factor are the following input variables:

Literacy rates

Female literacy

School enrolment

Deliveries assisted by professionals in a health facility

Low child and infant mortality rates

Antenatal care

Kerala is distinctly ahead from other States, with the four large northern States along with Orissa and Assam trailing behind. But it is also worth stressing in this respect that almost all the 17 original variables describing maternal and child health and women's status are actually related to this first factor (hereafter sh1). The only three variables that apparently bear no relationship to global health improvement are breast feeding, ORS treatment for diarrhoea, and sex ratio of the working population.

The second factor (sh2) is of lesser statistical weight. It highlights the peculiar position of States in the South with high female sex ratios, longer breast feeding, as well good delivery facilities, as opposed to States in the north-west displaying higher public health expenses and better medical infrastructures.

Figure 2 summarizes the results and once again points to a very clear regional pattern. On the top of the graph, the four southern States are close to each other, even when their respective sanitary and social development levels are heterogeneous. At the bottom of the figure, Punjab, Haryana and Himachal Pradesh constitute a separate cluster. Maharashtra and Gujarat appear also to lie very close to each other.

These results can also fit in a triangle. South India emerges as a distinct pattern of social and sanitary development relying more on women's involvement and position in society and less on government expenditures as in the north-western States. The less developed States of northern and central India represent the last angle of the triangle where health and social development indicators are at their lowest. A simple way to interpret these results would probably be to stress the existence of two distinct paths to social progress in India exemplified by Kerala on one hand, and the Punjab on the other hand. In Kerala as in other southern States, social development seems rather to come from the bottom up, because of the role played by the gender dimension and other individual variables, whereas in the Punjab or Himachal Pradesh government involvement (i.e. the impact of provisions from the top) appears much more important in shaping social progress.

2. Fertility and Regional Profiles

We will now examine the fertility differentials among States in the light of the most important factors identified above. Fertility will be measured here in two different ways though differences are admittedly rather limited. We may either use the Total Fertility Rate (tfr) from the NFHS, or perform a factorial analysis on the 11 fertility-related variables at our disposal (birth and fertility rates and various family planning indicators). Not surprisingly, this last factor analysis yields a very strong principal component (hereafter f1) accounting for almost two-thirds of the variance linking low fertility indicators with high levels of contraceptive protection among couples. We may use either the fertility rates or high fertility factor f1[2].

Our comments on the resulting 8 graphs will be brief and we will concentrate on the response of the fertility factor f1 to regional characteristics. The statistical analysis is not developed due to the sample limitations. The first two economic dimensions that resulted from our factor analysis are correlated with low fertility. The first factor which we translated as the index of global economic development (e1) is negatively linked to fertility, but the statistical correlation is rather weak (especially in view of the small number of regional units used). However, an important feature of the figure displayed is probably the emergence of what seems to be two different patterns of development-fertility linkage. A first pattern is typified by Haryana and the Punjab where the

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2 It might appear surprising to use a composite indicator such as fl when direct measures of fertility are available. However, individual indicators such as NFHS fertility rates or SRS birth rates are not strictly equivalent, pointing to the possibility of measurement errors. The correlation matrix for 22 States shows that SRS- and NFHS- derived indicators are not identical: correlation coefficients (r) are often lesser than 0.9 and it is difficult at this point to identify the best set of estimates. On the contrary, the result of the factor analysis tends to smooth out discrepancies between various sources.

effects of rapid economic progress on fertility appear to be both slow and limited. Another pattern emerges from South Indian States with faster fertility decline for a similar improvement in the global development level. This reflects the well-known absence of strong link between economic variables and birth rates in South India.

The existence of these two different paths to low fertility is one of the reasons for the poor statistical correlation. Had we been able to divide regional units in two separate sets (with the Northwest on one hand and South and coastal States on the other), the strength of the statistical relationship between fertility and economic development would have been greatly enhanced. The size of our sample clearly prevents us from doing this.

What is interesting in figure 5 is the fact that the link between economic orientation (e2) and fertility decline is much more apparent here than in the previous figure. This economic dimension related to the share of industrial and urban development (vs. agriculture intensification, etc.) has a visible depressing impact on fertility levels with a significantly stronger correlation coefficient. And there appears to be less "outliers", except for the Punjab. The two figures therefore stress the importance of "deconstructing" economic growth as a plural phenomenon encompassing distinct waves of social and economic changes. Indian regions follow different paths to economic progress and the relation to fertility decline is far from mechanical. What is usually seen as the core components of economic advance (i.e. domestic product, infrastructure, mechanization of agriculture, etc.) may turn out to be less effective in lowering birth rates than the economic orientation away from the primary sector.

Coming now to social and health dimensions, Figure 7 summarizes the powerful relationship that links fertility behaviour with social development. The global index of social and health conditions (f1) has a very strong, negative impact on fertility levels, even if this impact tends to dwindle when fertility reaches below-replacement level like in Kerala. Most variables (such as literacy rates, maternal and child health indicators, women's position in society, etc.) are now almost treated as "intermediary variables" of fertility and the result in itself is hardly surprising. But it is once again visible on the graph that north-western States follow a slightly distinctive pattern as if the response of fertility to social improvements was delayed or reduced by other intervening characteristics.

The second factor sh2 which contrasts two alternative sources for social development displays no monotonous linear relationship with fertility indicators. However, the bell-shaped Figure 9 helps to assess the relative impact of these two divergent dimensions of social and sanitary development (government intervention vs. people's participation): both types have a marked negative effect on fertility though the impact is more pronounced for the South Indian pattern.

We will come to some more significant statistical results that confirm most of these conclusions, but it is important to stress that all our figures have reinforced our geographical perception of regional configuration. States appear on most graphs as regional clusters, something that would definitely be less visible if we had been able to plot the same variables and factors for some three hundred Indian districts. We can therefore distinguish at least four groups: southern States, north-western States (Punjab, Haryana, HP), Maharashtra and Gujarat, and large northern Indian States (Bimaru States). The cluster of eastern States (West Bengal, Orissa, Assam) also displays also common features although these States (especially West Bengal) are often close to national average values.

3. Modelling Fertility Differentials

Before moving to a more graphic examination of geographical patterning, let us have a look at more sophisticated models of fertility analysis. With the availability of census-based fertility data at the district level in 1981, fertility modelling is now much more attractive than those based on State averages. Though district-level variables used are still limited in number and variety[3], they offer a much stronger basis for statistical modelling. Moreover, State-level analyses tend to conceal the great deal of heterogeneity that exists within large regional units. For instance, the examination of fertility estimates indicates that in 1991, ther were very strong inter-district disparities in several States such as Karnataka, Maharashtra, Rajasthan, West Bengal or Madhya Pradesh.[4] Here, instead of adding yet another model to the statistical literature, we have opted for the comparison of three models which have recently been proposed by demographers (Bhat 1996, Murthi et al. 1995, Malhotra et al. 1995)

Before closer examination, let us list some of the features common to these models. As previously said, they use district data and rely therefore on around 300 observations (districts from smaller States are often excluded for want of adequate data). These models, however, often make use of a small number of independent variables (between 10 and 20, excluding regional dummy variables), a majority of which are derived from the Census. Some economic, social and demographic aspects are not covered at all at the district level.

Authors rarely use the same variables, but we have grouped them in a single category whenever they described similar phenomena. For

3 Variables incorporated in district analyses are sometimes State regional averages.

4. Fertility variations among taluks within a single State or a single district can also be considered.

instance, female literacy rates computed from 1981 or 1991 data, or with respect to total population or population below 7, are clubbed together under the "female literacy" label. Variables are then grouped together within 7 (somewhat arbitrary) broad categories: economic development, social structure, women's status, health infrastructure, ideational dimension (a category found in only one of the models), spatial autocorrelation (missing from one model), and regional dummy variables. Compared to our State-based analysis, variables are much more diverse and would have required more than two factor analyses. At the same time, they are much less precise in terms of economic development levels and health practices.

The strength and direction of the statistical association with fertility are summarized with the help of arrow symbols which make it easy to compare coefficients across different models. At the bottom of the table, the model characteristics are also given, but of course, a more detailed inter-model comparison would call for a more detailed description of both the variables and the statistical results.

The first observation about these models is that all of them account for at least 75% of the variance of fertility. At the same time, the statistical links between individual variables and fertility indicators usually tally across models although the strength of the correlation may vary. This allows for some generalization on fertility determinants. The main points are the following:

Economic development has little measurable impact on fertility. Variables describing agricultural modernization or other forms of development do have some influence, but statistical coefficients are never highly significant in every model in which they are used. For instance, agricultural productivity or banking infrastructure displays a significant influence in only one model. It is even more puzzling to realize that some other crucial variables such as poverty level, urbanization or share of agriculture appear to be unrelated to fertility decline at the district level.*

Among the few social structure variables at our disposal, the prevalence of joint family and the proportion of Muslims are significantly associated with high fertility. The impact of Dalit and tribal shares in the district population is somewhat ambiguous as it is not confirmed in all the models. Variables depicting women's status and autonomy are systematically related to fertility decline with the exception of the female exogamy variable. These variables actually emerge as the most important determinants of fertility reduction. Similarly, data on child mortality and other health indicators display a strong statistical relationship with fertility levels. This is consistent with our previous observation on the role of social factors at the State level, even though the variables available at the district level are of lesser quality.

Bhat's model has tried to confront fertility decline with a set of variables describing various forms of exposure to new ideas. [5] His model does confirm the role of most variables selected though some of the most significant such media and cinema exposure is measured only at the State level. The ideational framework emphasizes the role played by communication among the population as the crucial element explaining the propagation of new ideas and practices. Though it is still difficult to gather data to capture the phenomena involved in such diffusion processes, this attempt points to one of the most promising avenues for future data collection.

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5. See Cleland and Wilson (1987).

* As a reviewer rightly pointed out, cross-sectional analysis may be insufficient to capture the relationship between socio-economic variables and fertility as it exists in different stages of development.

The last two categories of variables pertain to the geographical patterning of fertility in India. Two models have incorporated the effect of spatial autocorrelation. The presence of spatial autocorrelation in these models indicates that contiguity between districts (measured here by way of a simple dichotomous variable) has a statistical impact on the dependant variable and in each model, it emerges as an essential dimension of fertility variation. In other words, after controlling for other variables describing economic or social characteristics, the geographical location of districts vis-à-vis each other is still very much significant.

A less sophisticated method to highlight the geographical aspect of fertility variations in India is the use of regional dummies, all of them proving statistically meaningful in spite of all the other variables inserted in the models. The regional identity of South India as a whole, or of individual States such Kerala or Tamil Nadu, is preserved in all models examined.

These two attempts to test out the regional dimension of fertility determinants in India might lead to different observations: one may firstly conclude that there are limitations in the database and that some regional characteristics of central importance to fertility are missing; alternatively, one may contemplate the possibility of distinct geographical processes at work that may not be captured by conventional statistical analysis.

4. Mapping Fertility Differentials

The available mapping of fertility[6] available for the period following Independence is of uncertain quality for it relies on distributions based on age groups with unstable behaviour. It will be noted, however, that the regions with low fertility in 1951 and 1961 appear to be

6. See Anderson (1974). The likely increase in fertility levels between the 1950s and the 1960s is of course an additional problem for comparing maps over the last five censuses.

distributed, according to analyses by Anderson, along the Bay of Bengal, from the Thanjavur region to coastal Andhra and Orissa, with another pocket located in the Garhwal region (Uttarkhand). Conversely, the areas with the highest recorded fertility values are more scattered, covering the Punjab, the valley of the Brahmaputra in Assam and a few isolated areas of Bihar and Madhya Pradesh. This map of pre-transitional fertility is difficult to interpret because the data are both inconsistent and incomplete. The spatial structuration of fertility is very fragmented because the distribution of values is segmented around different characteristic regions such as the Punjab, Assam or the Tamil country. Regional demographic identities seem to take precedence over a global spatial principle. Nevertheless, some geographical orientations in fertility appear to foresee features illustrated by recent maps, the broad North-South opposition, for instance.

Ever since the 1960s, the geographical pattern of fertility in India has become more and more contrasted. Whereas the range of fertility levels used to be from 1 to 1.4, it now extends from 1 to 3.[7] A major effect of fertility decline has been to increase heterogeneity within India as can be seen on the maps prepared from 1981 and 1991 estimates. These maps (maps I and II) employ the total fertility rates per district as estimated by Bhat (1996); we have held to one homogeneous source so as to limit the discrepancies which could result from different methods of evaluation.[8]

The maps present a coherent and regular picture of the distribution of Indian fertility, with regional variations which are sufficiently pronounced to enable a detailed geographical interpretation. Since the

7 For older periods, see various estimates in Visaria and Visaria (1982: 509) and Srinivasan (1995: 67-94).

8 See Bhat (1996) for description of the estimation procedure.

late 1970s (map I), average fertility has fallen below 3.5 children per woman in several areas. The first of these Malthusian pockets is of course centred on Kerala, or more precisely around the former regions of Travancore and Cochin, which recorded the lowest values in the country. Other adjoining districts also reached this low level of fertility, namely the historic centre of Tamil country (Coimbatore, Madurai, Thanjavur) and the nearly continuous coastal strip of the Konkan extending from northern Kerala, by way of Goa, to Mumbai. The adjacent regions, forming a large crown bordering the coast from Gujarat to Andhra Pradesh and southern Bengal, clearly seem to have entered into this declining evolution, though less sharply. Other areas of decline are also perceptible, notably in the Punjab, Himachal Pradesh and Manipur. Mumbai and several other urban centres appear to be strongly affected by the decline such as Chandigarh, Pune, Chennai (Madras) and Calcutta, often with an effect on their rural hinterlands.

This profile has become remarkably pronounced in a period of ten years (map II). Fertility in 1991, at less than 2.5 children per woman, henceforth entered the final phase of its transition in the southernmost tip of the subcontinent. The decrease in fertility was particularly spectacular in Kerala and Tamil Nadu, even if some small regions, for instance Malabar, remained slightly behind. The same holds for the districts of Goa, Bangalore and the Karnataka coast. Elsewhere in India, equally low fertility levels are scarcely to be found, except in some metropolitan agglomerations such as Chandigarh, Mumbai and Calcutta. In these areas, the decline in fertility, following the example of the experience in European or Asian countries, must not be long in reaching a lower limit of about 1.5 children per woman.

The general downturn in fertility in the regions identified ten years earlier also increased, to the extent of covering nearly all of coastal and southern India with fertility levels of less than 3.5 children. In the interior of coastal States such as Maharashtra and West Bengal, districts with highly variable fertility levels nevertheless coexist. The decline also continued in the pocket of the Northwest, centred on Chandigarh and rural pockets in the Punjab, without having registered as great an impact in the Hindi-speaking areas of Haryana and Uttar Pradesh. The very rapid urbanization of Delhi and its region appears, moreover, to have only a modest effect on demographic behaviour. It is, however, true that the capital is next to the zone which shows the greatest resistance to the diffusion of new attitudes and reproductive practices, about which a few words should be said.

This region, which in a way constitutes the core of the traditional demographic system, characterized above all by high fertility and a vigourous patriarchy, has grown smaller in the interval of two censuses, but conserves a strong spatial cohesion within the Bimaru zone. It includes the western fringe of Uttar Pradesh, a rather prosperous agricultural region bathed by the Ganga and the Yamuna (Doab), then extends south toward Rajasthan and above all toward Madhya Pradesh, of which it forms notably the northern border (Chambal Valley, Bundelkhand and Baghelkhand), stretching toward Bihar. This region occupies a central position in the Hindi-speaking zone of the Ganga basin, which includes Haryana and Uttar Pradesh, as well as by extension Rajasthan, Madhya Pradesh and Bihar, the regional or local languages of which (Rajasthani, Bhojpuri, Urdu, etc.) are very close to Hindi. It is particularly characterized by its pronounced economic under-development, the importance of Brahmans and the marginalization of women, both in terms of education and employment [9] But on other planes, it is far from being completely homogeneous, in particular as concerns social composition

9 For detailed descriptions, see the recent work by Jeffery 1997 and Dreze 1996. See also Sathia 1991.

(number of Muslims, tribals), density and urbanization or landscape (plains, hills, forests).

5. A Spatial Interpretation of Fertility

Some specifically spatial dimensions of demographic change, which we are about to examine, scarcely emerge from statistical analyses. In fact, the dispersion of fertility in India, as interpreted by means of these two maps, presents a sufficiently manifest geographical regularity to now provide a few main principles. Thus, if one does not take into consideration the demographic geography of the States in the Northeast, which is, moreover, not well known, the strong contiguity of demographic change reflects an image of Indian fertility as successive crowns centred around the Gangetic region, which has the highest fertility. The distance from this centre is, moreover, the first key to interpreting the diffusion, originating on the periphery, of the decline in fertility. We thus propose, on the basis of these maps, to substitute for the classic North-South dichotomy, popularized in particular by Dyson and Moore (1983), a more complex spatial structuration, defined by an almost concentric (centrifugal) distribution of fertility around a central locus at the junction of Hindi-language States.[10] Although the most distant regions, in this case the southern promontory of India, are indeed those in which the reduction of fertility has been the greatest, the principle of gradation is also applicable to the nearest peripheral areas such as the mountainous regions of Himachal Pradesh and Uttar Pradesh (Garhwal). The movement in the last twenty years of the "front line," which delineates the belt of high fertility areas, serves to accentuate this crown-shaped organization of Indian space, but also the progressive isolation of the regions most favouring rising birth rates which had earlier formed a

10 See Guilmoto (1997)

much more extensive space, including even border countries such as Nepal, Pakistan and Bangladesh.[11]

A second key to the interpretation of our maps relates to what we shall call the "littoral effect," that is to say, the particularly rapid rate which characterizes the transition in the coastal areas, perhaps with the exclusion of Orissa. The coastal regions are, in fact, those where exchanges with the rest of the world, notably as a result of colonization, were most intense.[12] Their population also often distinguishes itself from the inland areas (earlier conversions to Christianity and Islamization, castes of fishermen, etc.), and improvement in education has been much more rapid there. It could seem difficult to distinguish the littoral effect from the centripetal gradient mentioned above, insofar as these two principles of spatial organization appear to describe the same degree of proximity to or distance from the core. However, it will be noted that classic examples of diffusion refer more often to concentric outward diffusion rather than centripetal change originating from a periphery.

A third rule, independent of the two first principles, follows from the focal role which falls to a large number of metropolises in the diffusion of new reproductive behaviour, in particular agglomerations with a high industrial concentration. We have already mentioned the effect pertaining to Calcutta, Chennai and Chandigarh. But a closer reading also brings out the influence of Bhubaneshwar in Orissa, Bangalore in Karnataka, Nagpur in Vidarbha (Maharashtra), Rourkela and the other industrial towns of Chota Nagpur, Patna in Bihar, Lucknow and Kanpur in Uttar Pradesh, etc. If it is once again a question of a gradient effect, this principle obviously also holds on a smaller scale, for the influence of towns is rapidly diluted as soon as one moves away

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11. For a broader geographical analysis of some of these issues, see Aggarwal (1994).
12. On the specific identity of coastal India, see Sopher (1980: 316-319)

from them.[13] Moreover, it remains to explain why the effect of certain metropolises sometimes appears to be imperceptible or very weak in the interior of regions with a high fertility (around Delhi or Jaipur), or regions with a low fertility (around Kochi or Coimbatore).

Alongside these general guiding principles, certain regional particularisms are still perceptible. It is thus no longer a question of a transverse gradient, but of a structuration in more homogeneous sub-regions which are clearly distinguished from neighbouring areas. The pioneering and atypical role of the Punjab has already been noted in the fertility decline in North India. Similarly, an apparently rapid decrease was recorded in Telengana (Andhra Pradesh), Goa and Saurashtra (Gujarat). Conversely, pockets of high fertility subsist in more extensive areas where changes were, on the contrary, very rapid. This is notably the case over an area of the western part of the Deccan plateau, along a band extending northward to Maharashtra (Marathawada) as far as Karnataka (Hyderabad Karnatak), and closely corresponding to the implantation's of the Muslim sultanates until the eighteenth century. Similarly, the peripheral tribal areas of Madhya Pradesh (Chhatisgarh, Gondwana, the Bhil country) report a singularly high fertility rate. One may think to discern the effect of sociological profiles of a type favouring high birth rates (presence of tribals or Muslims), or of a Malthusian type (Christian and Sikh presence) in the determination of these regional disparities. But the effects of these factors on fertility are not unequivocal, as indicated by the statistical analyses (see above) based on less impressionist examinations of the Indian demographic landscape.

This last observation will call to mind that, as concerns the limitations of our interpretation based solely on cartographic

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13 This " urban effect" would also probably appear more clearly on the micro-regional scale.

representations, compared with the contribution of statistical models, the spatial configuration of fertility does not of itself enable one to confirm the connection between demographic behaviour and the other social, cultural and economic dimensions of the Indian landscape. One must, also be able to evaluate the specific effect of the spatial configuration on the relationships between variables. The only tools presently available for this undertaking concern the measure of spatial autocorrelation which evaluates the role of contiguity of spatial units in the correlation of statistical residues. The two statistical models examined previously which have integrated this spatial dimension have clearly underscored the intensity of this spatial autocorrelation and our cartographic examination confirms this aspect, for the very high level of covariation between border districts is evident.

This spatial correlation is, however, manifested in a more complex manner than by the effect of spatial proximity alone. In effect, the sociocultural boundaries (population, linguistic group, historic substratum) create very abrupt points of continuity, as, for example, going from coastal Andhra (Godavari delta) to the Bastar region (Madhya Pradesh); or, without leaving the State of Gujarat, going from the town of Vadodara (Baroda) to Panch Mahals district. These stages indicate the presence of invisible boundaries, as for instance that of tribal India in the examples which we have mentioned. Conversely, numerous identified areas, which consequently correspond to demographic territories having a distinct identity, span several States, sometimes crossing over well-established social, cultural or topographical borders. The central region of high fertility is a prime illustration of this. One may take as an additional example the most advanced centre of fertility decline in India, on either side of the Western Ghats. The homogeneity of this area respective of fertility, with henceforth less than two children per woman, would lead one to overlook the linguistic heterogeneity

(Tamil-Malayalam) and the natural border of the Ghats.[14] As regards the neighbouring regions such as the rest of Tamil Nadu or southern Karnataka, the discontinuity of fertility values is pronounced.

The cartographic study therefore makes it possible to identify certain less known boundaries which divide Indian space in the interior. Insofar as the decline in fertility is indicative of the penetration of a new system of norms, and more particularly of new parameters in the equation which links individual and familial reproductive behaviour with social and economic contexts, the uneven penetration in India of Malthusian behaviour illustrates the new social differentiation which modernity could introduce, above and beyond the better known differences in terms of social classes or of type of residence (urban/rural). It would subsequently be appropriate to relate this map to that of other dimensions of social change (electoral behaviour, penetration of wage-earning and market economy, etc.).

6. On Spatial and other Interpretations of Fertility Decline

From a more theoretical point of view, the geographic approach brings with it a few additional interpretative points important in the classic analysis of fertility decline in India. As we have seen, models based on district data emphasize the importance of social variables as against less important economic characteristics, with a sizeable "residual" spatial dimension. And the profile of States derived from our factor analysis suggests that the response of fertility to social and economic development may also exhibit dissimilar regional patterns. The strong geographic coherence which emerges from the cartographic examination seems to confirm the independent role played by the spatial mechanisms characteristic of the process of diffusion.

14 Except for parts of Malabar where Muslim presence tends to increase average fertility levels.

The transition of fertility may in fact have followed a course typical of the diffusion of innovations along the channels of social change, relying thus heavily on social and cultural contiguities in order to spread.[15] Government intervention, whether a question of diffusion of contraceptive products or, in a more nonmaterial manner, that of a new system of norms giving greater importance to the quality of children (health, education) over their quantity, has consequently received responses which are highly variable from region to region.

However, the success of the diffusion framework to describe fertility decline results partly from the failure of other theories, especially the demand theory of fertility initiated by the new home economics (Becker, Easterlin) .[16] As seen previously, economic variables per se play but a minor role as long they do not incorporate important features of local social institutions that mediate economic behaviour (social structure, patriarchy, etc.) Similarly, the conclusion of the large Princeton study of fertility decline in Europe has stressed the absence of clear social and economic determinants accounting for the respective onset and intensity of regional demographic change. In comparison, the diffusionist explanation is a very simple framework in which adoption of contraception is a mainly technological matter. Because it places emphasis mostly on the quality and the quantity of communication and uses culture as a fixed background, this theory has been criticized by some anthropologists for its inherent reductionism.[17] It would definitely be dangerous to rely only on diffusion theory to account for all the local and structural dynamics which lay behind changes in reproductive behaviour in India.

15 For a classic survey of diffusion mechanisms, see Retherford and Palmore, 1983.

16 On the recent debate on cultural and economic determinants of fertility, see Cleland and Wilson (1987), Friedlander *et al.* (1991), Pollack and Watkins (1993), Montgomery and Casterline (1993).

17. Greenhalgh (1996, 7)

This geographical presentation of the unequal progress in the decline of fertility in the interior space of the country therefore reinforces the interest in the study of the mechanisms of diffusion at work in the redrawing of the demographic map of India. Previous theoretical work on diffusion[18] has stressed some regularities of diffusion mechanisms with respect to time and space: the S-shaped curve of the cumulative number of adopters, the two components of diffusion (external and internal influences), the hierarchical effect (diffusion from larger to smaller centres), and the neighbourhood effect (diffusion as an inverse function of distance). Some of these traits can be identified from our analysis, but this would require more systematic investigation for different reasons. First of all, fertility decline does not correspond to a binary variable as adoption of the small family norm is a continuous process, not a discrete one. Yet, most diffusion literature is concerned with binary change (like the adoption of a specific product). Moreover, many diffusion models do not take into account the specific impact of social and spatial segmentation; within Indian regions, the low intensity of communication and exchange between social groups or between subregions is probably a strong impediment to the spread of innovations. Some other questions remain in abeyance to which our analysis cannot respond. Notably, one does not know the precise locus of the demographic innovation because numerous scales of interpretation exist regarding changes in reproductive behaviour: women, households, communities (local or caste), or social groups. Our level of analysis so far (that of the district) obviously remains too global to test precise hypotheses. Our analysis remains confined to an approach which is too global to be able to identify the relays and channels characteristic of the diffusion of new familial representations and contraceptive techniques. With the help of a more detailed micro-

18. See for example Rogers (1995) or Mahajan and Peterson (1985).

regional cartography, one should be able to bring to light the respective roles of institutional intervention (family care and planning centre) or of communication infrastructures (road network, cinemas, etc.), in the dynamics of the demographic landscape.

The cartographic scale employed for this article nevertheless makes it possible to shed light on a few fundamental features of the new spatial dynamics in India which call into question classical models of fertility geography. The segmentation in autonomous enclaves, a legacy of the historic morphology of Indian space, seems to gradually subside. The different forms of modernization which can be selectively supported by regional identities (political, social, cultural, etc.) as the example of Kerala call to mind, impose new principles of organization, and the mechanisms of exchange and munication at the centre of the diffusion process have precisely substituted more ample and constantly shifting boundaries for the strong historical disparities. And Indian space has henceforth changed from a mosaic to a crown-shaped structure which seems to be principally oriented around the hard core of traditional India, where fertility has scarcely declined. In such a structure the least customary feature is indubitably the peripheral (exogenous?) origin of innovation and the centripetal progression of birth control, which starts from the coastal fringes of Indian space and moves toward the centre of the Gangetic valley. Contrary to the centrifugal action of propagation which gains ground starting from the origin, the process of diffusion from the periphery toward a centre of resistance is more similar to a gradual encircling of a central region which appears to be besieged by modernity.

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Appendices

Table 1: Input variables used for factor analysis

	Variable description	reference year	publication
v1	Total population (million)	1996	
v2	% Illiterate (f 6+)	1992-93	NFHS
v3	% Attending school (f 6-14)		NFHS
v4	% Of households with drinking water from pump/pipe		NFHS
v5	T of households with no toilet facility		NFHS
v6	Percent of women age 20-24 married before age 18		NFHS
v7	Crude birth rate		NFHS
v8	Total fertility rate		NFHS
v9	Percent of women using any contraceptive method		NFHS
v10	Percent of women using any sterilization method		NFHS
v11	Unmet need for family planning		NFHS
v12	Infant mortality rate		NFHS
v13	Under-five mortality		NFHS
v14	Mothers receiving antenatal care		NFHS
v15	Mothers receiving two doses of tetanus toxoid vaccine		NFHS
v16	Births delivered in a health facility		NFHS
v17	Deliveries assisted by health professional		NFHS
v18	Children who received either ors of rhs for diarrhoea		NFHS
v19	Fully immunized (age 12-23 months)		NFHS
v20	Exclusively breast feeding (age 0-3 months)		NFHS
v21	Receiving breast milk and solid/mushy food (age 6-9 months)		NFHS
v22	Percent of living children under four years of age/under-weight		NFHS
v23	Stunted		NFHS
v24	Wasted		NFHS
v25	Disaggregated human devlt index for India		UNFPA

v26	Gender-related health index		UNFPA
v27	Reproductive health index		UNFPA
v28	F/m ratio	1991	UNFPA
v29	Urbanisation	1991	UNFPA
v30	Population in urban areas and slums	1991	UNFPA
v31	Estimated slum population		UNFPA
v32	Crude birth rate (three-year moving averages)	1982	UNFPA
v33	Crude birth rate (three-year moving averages)	1987	UNFPA
v34	Crude birth rate (three-year moving averages)	1992	UNFPA
v35	Crude birth rate (rural)	1992	UNFPA
v36	Crude birth rate (urban)	1992	UNFPA
v37	Couples effectively protected	1972	UNFPA
v38	Couples effectively protected	1982	UNFPA
v39	Couples effectively protected	1992	UNFPA
v40	Infant mortality rate (rural)	1994	UNFPA
v41	Infant mortality rate (urban)	1994	UNFPA
v42	Health manpower/population (rural)	1991-2	UNFPA
v43	Paramedical manpower/population	1991-2	UNFPA
v44	Bed per 10,000 population in public hospitals	1991	UNFPA
v45	Access to safe drinking water (rural)	1991*	UNFPA
v46	Access to safe drinking water (urban)	1991*	UNFPA
v47	Access to safe drinking water (total)	1991*	UNFPA
v48	Per capita public health care expenditure: medical & public health	1990-1	UNFPA
v49	Per capita public health care expenditure: family welfare	1990-1	UNFPA
v50	Crude literacy rate (persons)	1991	UNFPA
v51	Crude literacy rate : f/m ratio*	1991	UNFPA
v52	Crude literacy rate : scheduled castes	1991	UNFPA
v53	Crude literacy rate : scheduled tribes	1991	UNFPA

v54	Age specific (6-10y) enrolment ratio at primary level	1993	UNFPA
v55	Enrolment in class v as of class i enrolment	1993	UNFPA
v56	Per capita net State domestic product	1991	UNFPA
v57	Sectoral share in net State domestic product, primary	1990-3	UNFPA
v58	Sectoral share in net State domestic product, secondary	1990-3	UNFPA
v59	Sectoral share in net State domestic product, tertiary	1990-3	UNFPA
v60	% Of population below poverty line	1987-8	UNFPA
v61	Work participation rate, main workers f/m ratio	1991	UNFPA
v62	Sectoral employment, main workers, primary	1991	UNFPA
v63	Sectoral employment, main workers, secondary	1991	UNFPA
v64	Sectoral employment, main workers, tertiary	1991	UNFPA
v65	% Of households occupying pucca houses, (rural)	1991	UNFPA
v66	% Of households occupying semi-pucca houses (rural)	1991	UNFPA
v67	% Distribution of households occupying pucca houses, (urban)	1991	UNFPA
v68	% Of households occupying semi-pucca houses (urban)	1991	UNFPA
v69	Rural expenditures per capita	1988-89	CMIE
v70	Urban expenditures per capita	1988-89	CMIE
v71	Relative infrastructure index	1993-94	CMIE
v72	Telecom lines per 10000	1993-94	CMIE
v73	Consumption of power per capita	1994	CMIE
v74	Average size of holding	1990-91	CMIE
v75	% Net irrigated areas	1992-93	CMIE
v76	Fertilizer consumption (kg/ha)	1995-96	CMIE
v77	Tractors (per lakh ha)	1992-93	CMIE
v78	Yield (kg/ha)	1994-95	CMIE
v79	Population per bank	1996	CMIE
v80	NSDP per capita (rs)	1994-95	CMIE

Table 2: Factor analysis of economic variables

* economic and amenities data
(obs=15)
(principal components; 5 components retained)

Component	Eigenvalue	Difference	Proportion	Cumulative
1	**8.41951**	4.32651	**0.4009**	0.4009
2	**4.09300**	1.23763	**0.1949**	0.5958
3	**2.85537**	0.74050	**0.1360**	0.7318
4	2.11487	1.01207	0.1007	0.8325
5	1.10280	0.20857	0.0525	0.8850
6	0.89423	0.33000	0.0426	0.9276

Table 3: Factor analysis of health and social variables

* health and sociodemographic data
(obs=16)
(principal components; 5 components retained)

Component	Eigenvalue	Difference	Proportion	Cumulative
1	**12.37036**	9.76091	**0.5378**	0.5378
2	**2.60945**	0.86717	**0.1135**	0.6513
3	1.74228	0.21507	0.0758	0.7270
4	1.52721	0.28550	0.0664	0.7934
5	1.24171	0.11250	0.0540	0.8474
6	1.12921	0.42849	0.0491	0.8965

Table 4: Models of fertility at the district level

Authors / Explanatory variables	Bhat	Murthi *et al.*	Malhotra *et al.*
economic development			
Rice cultivation	•	•	0
Share of agriculture	0	•	•
Poverty level	•	0	•
Agricultural laborers	↑	•	•
Child labour	**↑**	•	•
Agricultural productivity	•	•	**↓**
Landless peasants	•	•	⬇
Development index	↓	•	•
Banks	**↓**	•	•
Urbanization	•	0	•
social structure			
Male literacy	•	0	⬇
Joint family	⬆	•	•
Muslims	⬆	•	**↑**
Dalits	**↑**	0	0
Tribal	•	⬇	0
Women's status			
Female mortality ratio	•	•	↑
Female participation rate	**↓**	⬇	⬇
Female exogamy	•	•	0
Female literacy	⬇	⬇	**↓**
Female mean age at marriage	**↓**	•	•
Sex ratio (F/M)	⬇	•	•
Sanitary infrastructure			
Male infantile mortality	⬆	•	⬆
Below 5 mortality	⬆	•	•
Family planning dynamics	0	•	•
Unmet FP need	**↑**	•	•
Medical staff density	•	0	0
ideational dimension			
Media exposure	⬇	•	•
Cinema	**↓**	•	•
Transport and communication	0	•	•
Density	**↓**	•	•
Spatial auto-correlation			
Spatial autocorrelation index	•	⬆	⬆
Regional dummy variables			
Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan	**↑**	•	•
West	•	**↓**	•
East	•	•	**↓**
South	•	**↓**	**↓**
Kerala	**↓**	•	•
Tamil Nadu	⬇	•	•
Model characteristics			
N (number of districts)	326	296	358
Reference year	1991	1981	1981
Maximum adjustment or R^2	0.90	0.89	0.74
Method used	Least squares	Likelihood	Likelihood

- Arrows symbolize the existence or direction (positive or negative) of measured correlation coefficients. When authors have used a set of different indicators for the same dimension or different models, the arrow represents the average value of the t ratios:

⬆ if t>3 ; **↑** if 3>t>2 ; ↑ if 2>t>1,5 (↑ for *positive* correlation, ↓ for negative correlation) ;
0 for non significant correlation coefficient; • for variables not included in the model.

- For the detailed definition of variables used, see Bhat (1996), Murthi *et al.* (1995) et Malhotra *et al.* (1995).

Figure 1: The first two economic components

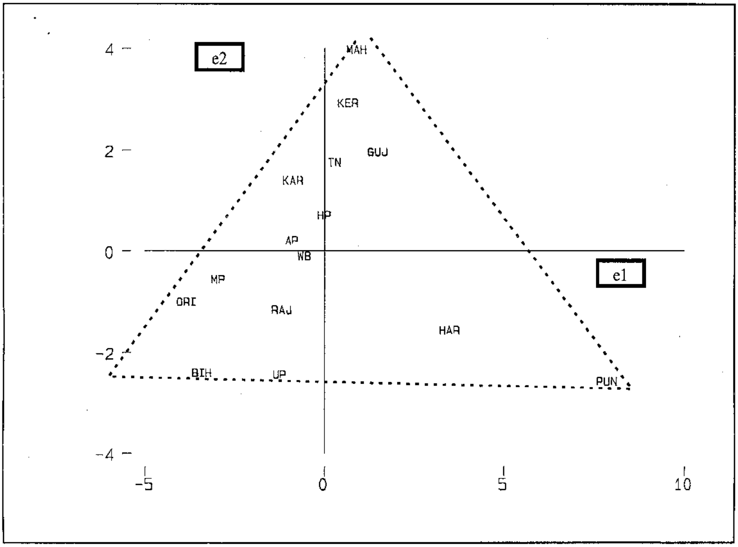
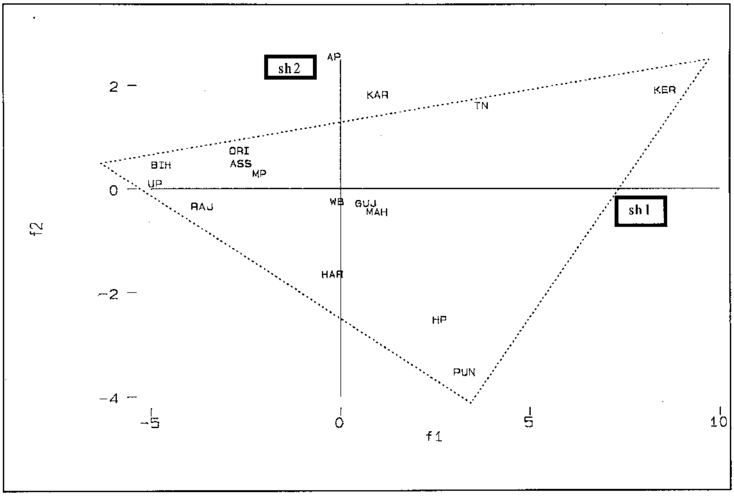
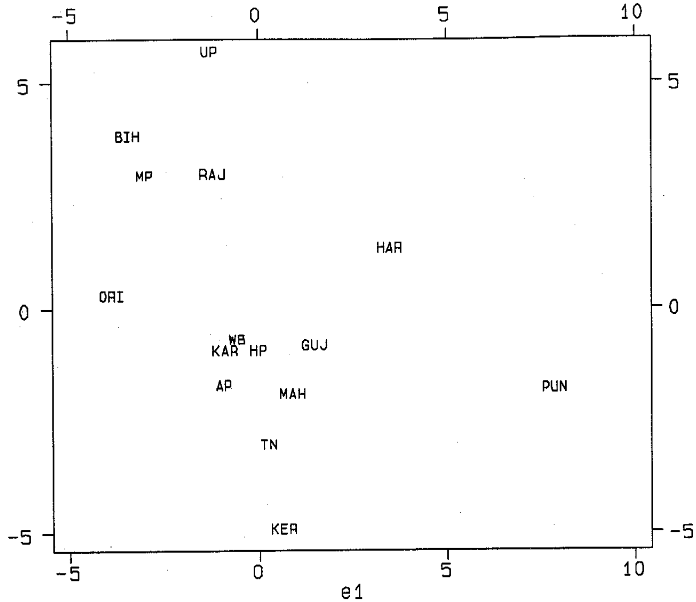
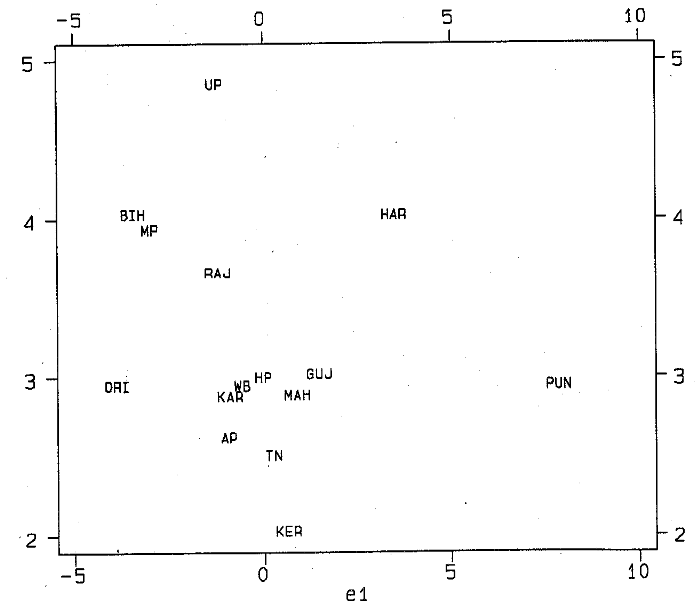


Figure 2: The first two social and health components

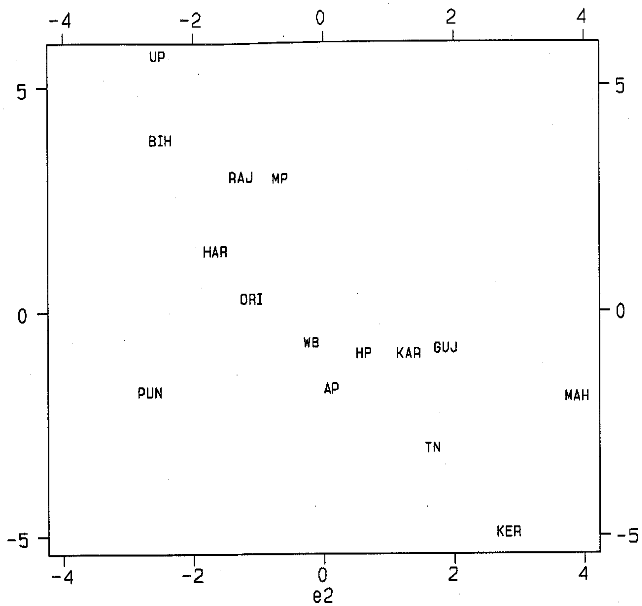


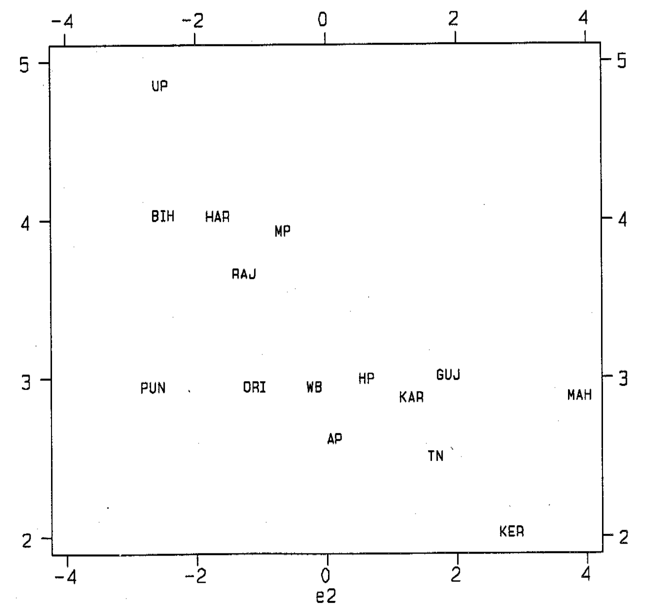
Figures 3 and 4: **Fertility indicators and the first economic component**



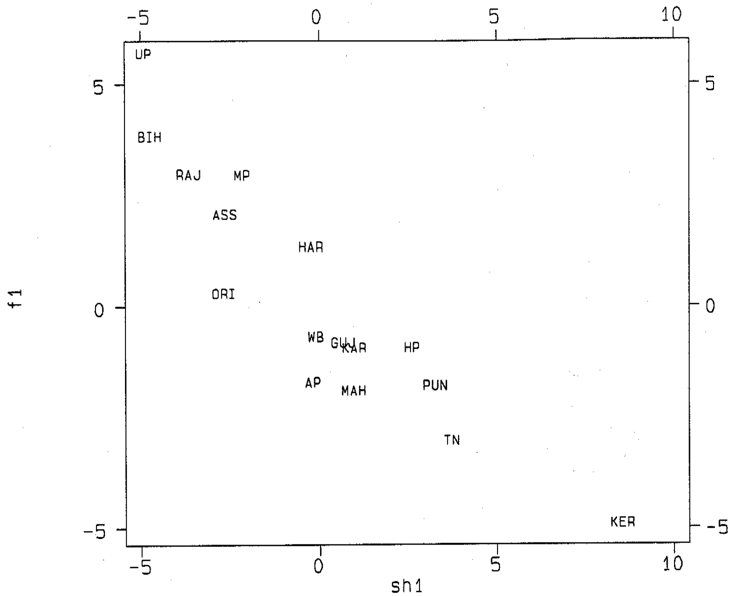


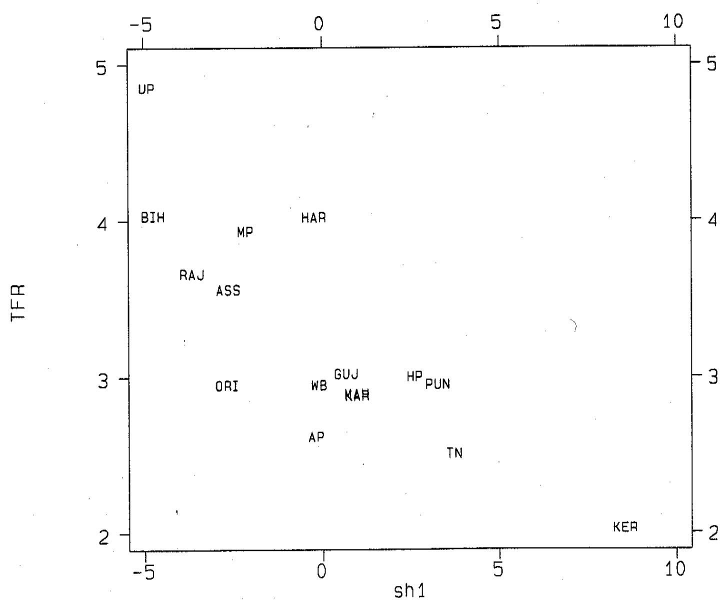
Figures 5 and 6: **Fertility indicators and the second economic component**



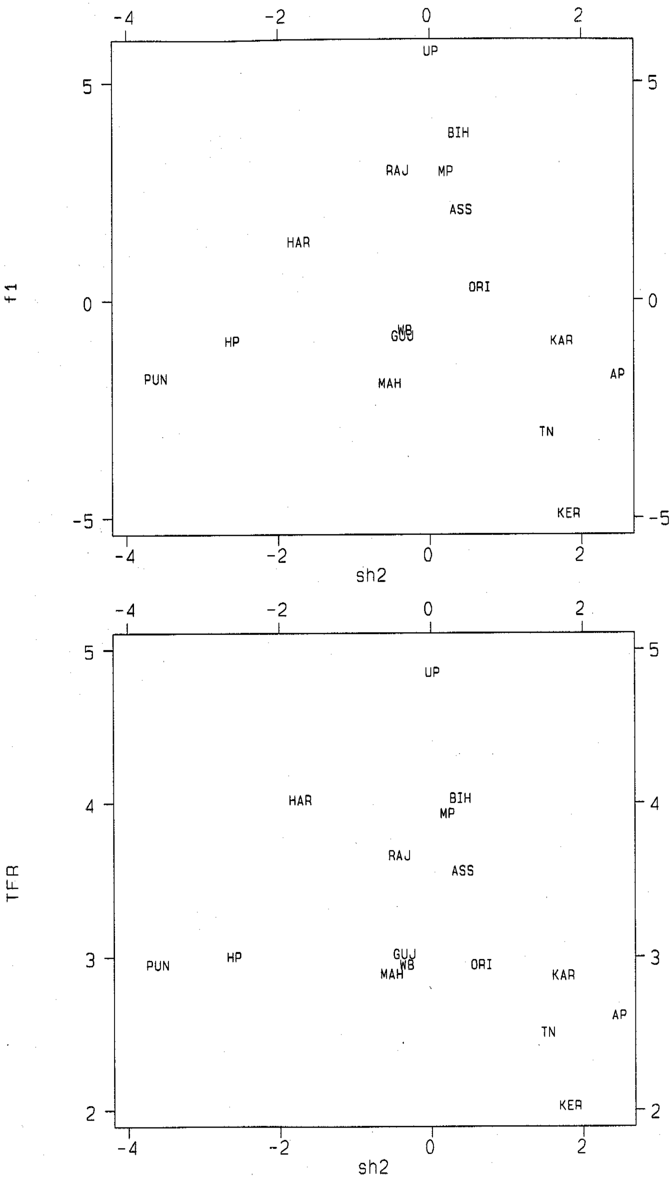


Figures 7 and 8: **Fertility indicators and the first social and health component**

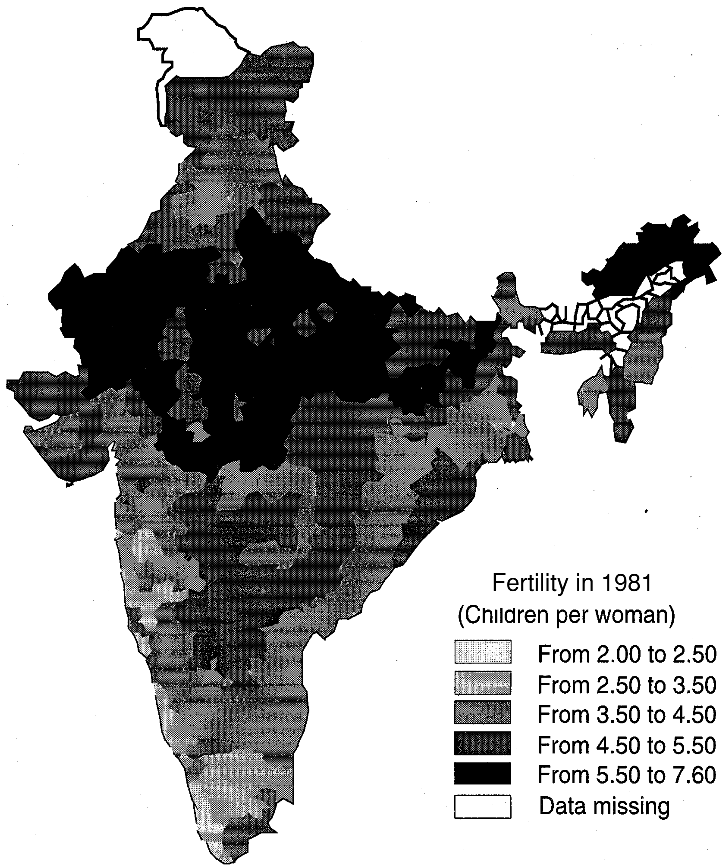




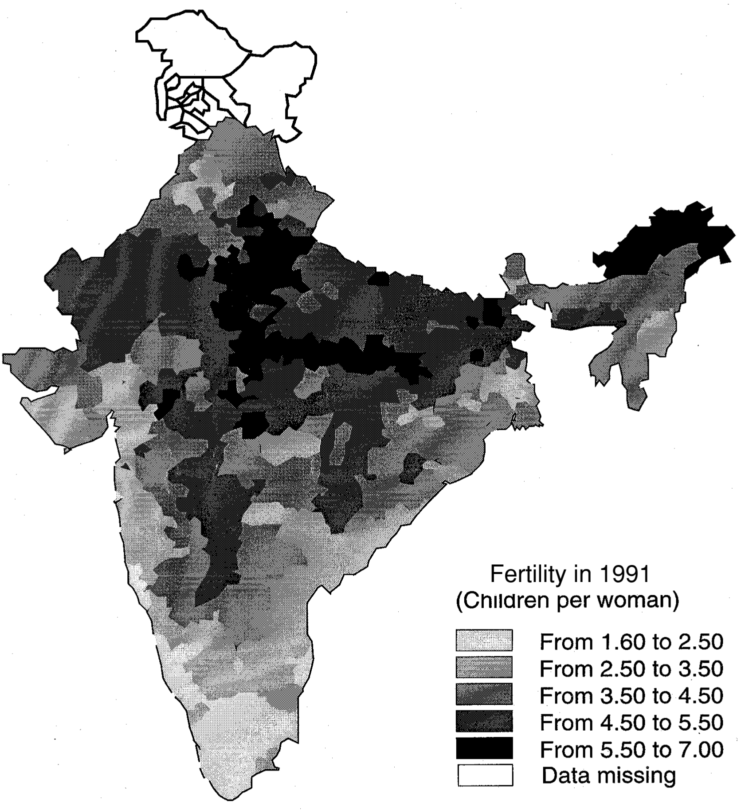
Figures 9 and 10: **Fertility indicators and the second social and health component**



MAP I


Fertility in 1981
(Children per woman)
From 2.00 to 2.50
From 2.50 to 3.50
From 3.50 to 4.50
From 4.50 to 5.50
From 5.50 to 7.60
Data missing

MAP II


Fertility in 1991
(Children per woman)
From 1.60 to 2.50
From 2.50 to 3.50
From 3.50 to 4.50
From 4.50 to 5.50
From 5.50 to 7.00
Data missing

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