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Measuring Segregation of the Poor in India[†]

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Abstract

In this paper a poverty segregation curve is proposed to measure regional inequality in the distribution of the poor. Axioms of relative income inequality are reformulated and interpreted in the context of the poverty segregation curve. A generalized version of the segregation curve is formalized for the first time Segregation analysis is applied to study regional concentration of the poor in India in the decade following economic reforms of the early 1990s. Using household survey data poverty levels are estimated in all 35 states and territories in India. Results indicate that there was a significant increase in the segregation of the poor in India; when poverty was measured both by income and non-income deprivation indices. Other measures such as the dissimilarity index, the Gini index and the square root index also confirm an increase in inequality in the distribution of the poor. The generalized segregation curve however shows that the decline in poverty more than compensated the rise in inequality in the distribution of the poor.

Key words: inequality, poverty, segregation, generalized Lorenz curve, regions, reforms, India
JEL classification: D63, I32, O15, O53, O57, R11

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Introduction

There is a large and diverse body of literature covering several aspects of poverty: definition, measurement, data availability, estimation methods, its causes and effects. However the question of how the poor are spatially distributed has received relatively less attention. The literature on poverty mapping has focused largely on estimating poverty at disaggregated geographic units by combining survey data on household characteristics with census data (Hentschel et al, 2000). Poverty mapping generates estimates of poverty for small geographic areas when micro level data is not available. It does not directly address the question of measuring inequality in the distribution of the poor. The purpose of this paper is to fill the gap in the literature on spatial distribution of the poor by addressing the following questions: How do we measure inequality in the distribution of the poor? Can we adopt techniques used in income inequality to measure poverty inequality? Are the poor in a country increasingly concentrated in some geographic areas or are they distributed uniformly across regions? How has the distribution of the poor evolved over a period of time?

Segregation of population groups has long been studied by sociologists in a variety of contexts. There is a large literature studying residential and school segregation in the United States by race and ethnicity.[1] Relatively, literature on segregation in economics is small; it has tended to focus on introducing new measures of segregation on the theoretical side and studying largely gender based occupational segregation, on the empirical side (Silber, 1989, Hutchens, 1991). However we are not aware of any study which has applied segregation analysis to measure spatial inequality in the distribution of the poor.

[1]For a literature review, see Krivo et al (2009) for racial segregation and Frankel and Volij (2011) for school segregation.

In this paper we propose a poverty segregation curve to measure regional segregation of the poor. The segregation curve is a visual aid to graphically compare the extent to which actual distribution of the poor deviates from the ideal situation when the poor are distributed proportionally among different regions. Measuring segregation of the poor is distinct from measuring segregation of population groups based on race (white and non-white residents) and gender (male and female workers) since unlike division of people along their intrinsic features, the division between the poor and non-poor is not strict. A person cannot change his racial status but she can switch from being poor to being not poor and vice versa. We discuss this ability to change group membership in the context of the Pigou-Dalton transfer principle satisfied by the segregation curve. We reformulate axioms of the Lorenz curve of income inequality and interpret them in the context of the poverty segregation curve.

A generalized Lorenz curve was proposed by Shorrocks (1983) to measure income inequality adjusted to income levels. We have not yet come across a generalized version of the segregation curve. In this paper we propose, for the first time, a generalized version of the segregation curve to measure segregation adjusted to poverty levels. The generalized Lorenz curve is derived, ceteris paribus, by assuming a social preference for a more equitable distribution and higher incomes. For the generalized poverty segregation curve, we translate this as a preference for a more equitable distribution of the poor and lower poverty rates.

The segregation analysis is applied to study changes in the distribution of the poor among regions in India. Since economic reforms of the early 1990s, average income in India has grown at 4 to 5 percent per year. However growth of income has been largely

uneven among populations in different regions. Rising regional disparity is one of the main reasons why poverty has not declined significantly in all regions, despite strong economic growth. There are currently, more than 400 million poor in India living on less than a dollar per day poverty line. Figure 1 shows poverty rates in 1994 and 2004.

Although poverty rates declined in most regions, it is not evident how the spatial distribution of poor changed during that time. Ongoing debates on poverty in India have largely focused on measurement differences, discrepancies in survey data and the choice of poverty lines. However we are not aware of any study so far, which systematically quantifies the concentration of the poor in India. We measure changes in the distribution of the poor in the decade following economic reforms (1994-2004). The poverty segregation curves imply that the distribution of the poor became more unequal between 1994 and 2004; though the generalized segregation curves indicate that the decline in poverty rates more than compensated the rise in inequality in the distribution of the poor.

The rise in segregation of the poor is confirmed by estimating different indices of segregation, namely, the dissimilarity index, the Gini index and the square root index. Further disaggregation of poverty within states reveals that the poor were more segregated within the urban sector compared to the rural sector. Segregation curves are also plotted by measuring deprivation in multi-dimensions, namely, as lack of primary education, lack of access to electricity for lighting and percent of wasted children. For each dimension, it is seen that segregation of the deprived population increased both in rural and urban sectors.

The remainder of the paper is organized as follows; in Section 2 we formalize the notion of a poverty segregation curve, and in Section 3 we specify properties satisfied by

the class of segregation measures which rank distributions in accordance to the segregation curve. Section 4 introduces the generalized segregation curve. Background on economic reforms in India is given in Section 5. Segregation analysis of regional poverty is detailed in Section 6 and conclusions in Section 7.

2. A Poverty Segregation Curve

The segregation curve has been long been used to measure inequality in the distribution of two population subgroups. It was first used by Duncan and Duncan (1955) to measure residential segregation between the white and the non-white population in the United States. Since then, the curve has been applied to measure segregation in different contexts. For instance, Moir and Selby-Smith (1979) used the segregation curve to compare distribution of female employees with total workforce. Hutchens (1991) used the curve to measure segregation of female employees compared to their male counterparts. Dygalo (2007) used it to measure distribution of old and not-so-old workers across occupations. In a recent paper on group-based inequality concepts, Reddy and Jaydev (2011) illustrate the extent of segregation by an illustrative example of a representational inequality Lorenz curve. Below we define a poverty segregation curve to measure segregation of the poor from the general population. [2]

[2] A distinction is sometimes made between the terms, segregation and concentration; the former is used to compare differences in the distribution of two mutually exclusive groups whereas the latter to compare the proportion of a particular group in the overall population (Lewis, 1996). However we do not make this distinction, following Moir and Selby-Smith (1979) and Jayadev and Reddy (2011) among others. Additionally the definition of segregation provided by the Oxford English Dictionary as "the separation of a portion of portions of a collective or complex unity from the rest; the isolation of particular constituents of a compound or mixture", suits our purpose.

Let a population of size N be divided into two groups $t = 1,2$, namely, the poor and the non-poor.[3] The population is distributed among R regions $i = 1,2...R$, $R \geq 2$. The set of all possible distributions for a fixed value of R is given by D_R, and the union set for different R values is given by $D = U_{R \in I} D_R$ where $I \geq 1$ is a set of positive integers. Distribution $X \in D_R$ is denoted by a $2xR$ matrix $\begin{bmatrix} x_{11} & x_{12} \cdots x_{1R} \\ x_1 & x_2 \quad x_R \end{bmatrix}$, where x_{ti} is the number of type t people in region i, $N_t(X) = \sum_{i=1}^{R} x_{1i}$ is the population of type t people in all regions combined; $x_i = \sum_{t=1}^{2} x_{ti}$ is the population in region i combined across all types and $N(X) = \sum_{t=1}^{2} \sum_{i=1}^{R} x_{ti}$ is the total population for all types in all regions combined. [4]

2.1 Definition:

A poverty segregation curve for $X \in D$, relates the cumulative proportion of the poor population $\sum_{i=1}^{m} \frac{x_{1i}}{N_1}$ as a function of the cumulative proportion of the total population $\sum_{i=1}^{m} \frac{x_i}{N}$ in m regions combined, when regions are ordered in increasing value of the poverty rate $\frac{x_{1i}}{x_i}$.

Figure 2 shows the poverty segregation curves for India. By definition, the curve is bounded in a unit square between (0, 0) and (1, 1), with positive slope and is convex in

[3] The poor can be defined as those with income less than benchmark poverty line income or by using non-income factors such as those who lack housing, health services, education or a combination of a multiple of dimensions. For our purpose any acceptable definition of the poverty line will suffice.

[4] To make the problem meaningful, there are non-zero numbers of poor in any distribution $N_1(X) > 0$. Additionally whenever the context of distribution X is implied, $N(X)$ is simply written as N.

shape.[5]There is no segregation when every region's share of the poor is equal to its share of the total population $\frac{x_{1i}}{N_1} = \frac{x_i}{N}$; which implies that each region's poverty ratio is exactly equal to the national poverty ratio, $\frac{x_{1i}}{x_i} = \frac{x_{1j}}{x_j} = \frac{N_1}{N}$ for all $i, j = 1,2,...R$. When there is no segregation, the segregation curve lies along the diagonal of the unit square. Conversely, if the poor and the non-poor are completely segregated then all the poor reside in one region, say j, $x_{1j} = x_j = N_1; x_{2j} = 0$ and all the non-poor in other regions $x_{1k} = 0; x_{2k} = x_2; \sum_{k=1}^{R-1} x_{2k} = N_2$ for all $k \neq j$ so that the segregation curve is L-shaped. In general, the more the regional distribution of the poor matches the distribution of the overall population, the closer the segregation curve will be to the diagonal line. Formally, the dominance relation between the segregation curves can be stated as follows.

2.2 Dominance Relation:

For any two distributions $X, Y \in D$, $(X \geq_P Y)$ i.e. X's poverty segregation curve '*dominates*' that of Y if and only if Y's curve lies at some point below and at no point above X's curve. The $\geq_P$relation is a strict partial ordering, similar to the Lorenz-dominance relation. For any distributions $X, Y, Z \in D$, $\geq_P$ is irreflexive$(not\ X \geq_P X)$, asymmetric$(X \geq_P Y\ implies\ not\ Y \geq_P X)$, transitive $(X \geq_P Y\ and\ Y \geq_P Z, implies\ X \geq_P Z)$ but not complete (there exist $X, Y \in D$, such that neither $X \geq_P Y$ nor $Y \geq_P X$) i.e. when two segregation curves intersect, $\geq_P$cannot rank order distributions. Thus non-intersecting segregation curves provide a ranking of distributions based on increasing level of segregation of the poor.

[5] Given the discrete number of regions, the segregation curve is piece-wise linear. Segregation curves are plotted by smoothly joining discrete data points and are compared only at those points for which data is available.

3. Axiomatic Properties

The Lorenz curve of income inequality is a relative inequality measure and satisfies basic axioms of symmetry, scale invariance (homogeneity and population principle) and the Pigou-Dalton transfer principle.[6] These properties were reformulated by Hutchens (1991, 2004) for the occupational segregation curve and by Alonso-Villar (2010) for the employment concentration curve. Below we formulate these axioms for the poverty segregation curve. In particular, we find that the principle of regressive transfer lends itself to different interpretation in the context of poverty segregation.

3.1 Symmetry in Regions

The property of symmetry treats individuals anonymously; income inequality remains unchanged when individuals trade places with each other. Similarly if one region trades places with another region, there is no change in poverty segregation. For any two distributions $X, Y \in D$, if Y is derived by permuting columns of X then $Y =_P X$.

3.2 Population Invariance

Relative inequality remains unaffected by a change in the size of income (homogeneity principle) or a change in the size of population (population principle) as long as the proportion of population receiving each income is fixed. Hence a proportional change in the number of poor and the number of non-poor in every region should not change the extent of segregation. For any two distributions $X, Y \in D$, if Y is derived from X such that $y_{ti} = w_t x_{ti}; w_t$ for $t = 1,2$ is a positive scalar such that $w_{1i} x_{1i} \leq (w_1 x_{1i} + w_2 x_{2i})$ for all $i = 1,2,...R$, then $Y =_P X$.

[6] See Lemma 2 in Foster (1985).

3.3 Pigou-Dalton Transfer Principle

The principle of transfer by Pigou (1912) and Dalton (1920) states that a regressive transfer of income from a poor person to anyone who is less poor increases inequality. In the context of poverty segregation, this property can be formulated as follows. Arrange all *R* regions in distribution $X \in D_R$ in an increasing order of their poverty ratio (x_{1i} / x_i). Distribution Y is derived from X by a regressive transfer of the poor, if $y_{ti} = x_{ti}$ for $t = 1,2$ in all $i \neq h, j$, $\alpha > 0$ and in regions $h, j (h \leq j - 1)$:

i) $y_{1h} = x_{1h} - \alpha$ and $y_{2h} = x_{2h} + \alpha$

ii) $y_{1j} = x_{1j} + \alpha$ and $y_{2j} = x_{2j} - \alpha$

If Y is derived from X by a regressive transfer of the poor then $Y >_P X$. In all regions except *h* and *j*, distribution *Y* has identical population shares as in distribution *X*. A regressive transfer of the poor results in an increase in the number of poor in a poorer region (j) and a decrease in the number of poor in a less poor region (h). Conversely a regressive transfer of poor results in an increase in the number of non-poor in a less poor region and a decrease in the number of non-poor in a poorer region. There are two ways which can bring about such a transfer.

A transfer of income is termed regressive when income is transferred from a poor to a less poor individual. Accordingly, a regressive transfer of poor can happen *between* regions i.e. by transferring (α) poor from a less poor region $[y_{1h} = x_{1h} - \alpha]$ to a poorer region $[y_{1j} = x_{1j} + \alpha]$ and transferring equal number of non-poor in a reverse direction, from a poorer region $[y_{2j} = x_{2j} - \alpha]$ to a less poor region$[y_{2h} = x_{2h} + \alpha]$. Note that we require the transfer of the poor *and* the non-poor to happen simultaneously in order to

ensure that population in both regions remains unchanged since we measure the number of poor as a fraction of the regions' total population. On the other hand, Hutchens (1991) who measures the number of women as a fraction of men employees in an occupation defines the transfer when women leave a male dominated occupation to join a female dominated occupation without requiring male employees to move in a reverse direction.[7]

Another way to interpret the above regressive transfer property is by affecting the transfer *within* regions i.e. (α) poor in a less poor region move out of poverty $[y_{1h} = x_{1h} - \alpha$ and $y_{2h} = x_{2h} + \alpha]$ and (α) non-poor in a poorer region move into poverty $[y_{1j} = x_{1j} + \alpha$ and $y_{2j} = x_{2j} - \alpha]$. This alternative way to characterize a regressive transfer is possible because unlike being a "female" or an "African American", being "poor" is not an intrinsic feature of an individual. It is possible that a person is poor in one distribution and not poor in another distribution. Though interchangeability of type is not unique to segregation of the poor (a person can be unemployed or employed, single or married; obese or healthy), as far as we know, its implications for interpreting the regressive transfer property have not been discussed in the literature so far.

3.4 Insensitivity to proportional division of a region

In addition to the properties of the Lorenz curve of income inequality, a segregation curve also satisfies another property of insensitivity to proportional divisions (Hutchens 2004). For any two distributions $X, Y \in D$, if Y is derived from X such that $y_{ti} = x_{ti}$ for $t = 1,2$ and for $i = 1,2,...R-1$, and $y_{ti} = (x_{tR} / M)$ for $t = 1,2$ and for $i = R,...R+M-1$, where M is a positive integer, then $Y =_P X$. The property states that everything else remaining same, if distribution Y is derived from distribution X by sub-

[7] Hutchens (1991) refers to the transfer property as the principle of movement between groups.

dividing a region (*R*) into additional *(M)* regions such that the population shares in these additional regions are exactly identical to those of the former region, then both distributions will have equal levels of segregation.

3.5 Segregation Curve Criterion

A poverty segregation index $PSI : D \to R^1$ provides a ranking of distributions $X, Y \in D$ consistent with the ranking provided by the poverty segregation curve when:

a. $Y >_P X$ implies $PSI(Y) > PSI(X)$

b. $Y =_P X$ implies $PSI(Y) = PSI(X)$

A poverty segregation index is consistent with the poverty segregation curve criterion if and only if it satisfies the properties of symmetry in regions, population invariance, Pigou-Dalton transfer and insensitivity to proportional division of a region. The literature has generated more than twenty different segregation indices (Frankel and Volij, 2011). We choose three indices closely related to the poverty segregation curve, namely, the Dissimilarity index, the Gini index, and the Square Root index and estimate them (in section 6.3) using data on India; detailed formulae for the indices are given in the appendix.

4. A Generalized Poverty Segregation Curve

Shorrocks (1983) first proposed a generalized Lorenz curve based on the notion that greater inequality can be compensated by higher average living standards. Despite its similarity to the Lorenz curve, the segregation curve has never been generalized and this is the first attempt to define it. The generalized Lorenz curve is derived by assuming a social preference for a more equitable distribution of income and higher income levels,

ceteris paribus. For the poverty segregation curve, we translate it as a preference for a more equitable distribution of the poor and lower poverty rates. A generalized Lorenz curve is constructed by scaling up the ordinary Lorenz curve by the mean income of the distribution. We define a generalized poverty segregation curve by scaling the poverty segregation curve by the mean of the *non-poor* population.

4. 1 Definition:

A generalized poverty segregation curve for distribution$X \in D$, relates the cumulative proportion of the poor population $\sum_{i=1}^{m} \frac{x_{1i}}{N_1}$ scaled by the *average non-poor ratio* $\frac{N_2}{N}$ as a function of the cumulative proportion of the total population $\sum_{i=1}^{m} \frac{x_i}{N}$ in m regions combined, when regions are ordered in increasing value of the headcount poverty ratio $\frac{x_{1i}}{x_i}$.

By definition, the curve is bounded between $(0,0)$ and $(0,1)$. If the segregation curve of distribution X is below that of Y and if the average poverty rate of X is higher than that of Y, then of course the generalized segregation curve of X will be below that of Y. However if distribution X's segregation curve intersects that of Y, and there is ambiguity between the ranking of the two distributions, but distribution X has substantially low poverty rate than that of Y, then the generalized segregation curve of X can be higher than that of Y. Thus, the generalized segregation curve helps rank a distribution with substantially lower poverty rates above a distribution with higher poverty levels, when ranking is not possible by ordinary segregation curves. In the

following sections we estimate the poverty segregation curve and its generalized version empirically, to measure inequality in the distribution of the poor in regions in India.

5. Application

5. 1 Background

Until the 1980's India's economic growth was extremely slow with the growth rate of per capita gross domestic product (GDP) barely exceeding 2 percent per year. In the 1980s the growth rate increased to more than 3 percent but as was evident later, the faster growth was unsustainable since it was fuelled by an increase in government spending and borrowing from abroad. By the end of the decade, the country faced a severe fiscal and balance of payments crisis which led to its adoption of broad ranging economic reforms in the early 1990s.[8] Overall the reforms systematically shifted the economy to a more open economy with greater reliance on market forces. The reforms were successful in accelerating economic growth. Per capita GDP grew on an average at 4 percent per year during the 1990s and by more than 5 percent per year since 2001.

There is growing evidence that economic disparity in India has increased since the economic reforms. There is considerable regional variation in terms of income levels and growth rates and most of the studies find no convergence among the different states in the country.[9] In 2004, per capita income in Bihar was as low as 6,000 Rupees whereas that in Chandigarh was as high as 60,000 Rupees. States that were initially poorer grew more slowly and were unable to keep pace with the rapid growth witnessed by the richer states (Deaton and Dreze, 2002). In terms of economic performance, Bihar, Madhya Pradesh,

[8] See Joshi and Little (1996) and Srinivasan and Tendulkar (2003)
[9] See Purfield (2006), for literature review on convergence of income in Indian states

Orissa, Rajasthan, and Uttar Pradesh are considered lagging behind; Andhra Pradesh, Assam, Karnataka, Kerala, Tamil Nadu, and West Bengal are intermediate; and finally Gujarat, Haryana, Punjab, and Maharashtra are the faster growing states. There is a general consensus that poverty in India declined since economic reforms.[10] However the ensuing debate about the extent, the rate at which poverty declined originates from differences in poverty estimates based on different methodological assumptions, poverty lines and adjustments made to survey data (See Deaton and Kozel 2005).

Few studies in the literature have analyzed spatial distribution of the poor in India. Jha and Sharma (2003) analyze distribution of rural poverty in India by tracking the rank mobility of regions over time. They find that there is remarkable stability in the rankings of regions by poverty and that these ranking have not changed significantly since economic reforms. Shah (2010) examines the spatial pattern of poverty in India to understand how multiple deprivation leads to reproduction of poverty traps in forest-based economies. Despite a large body of literature on regional disparity in income and poverty levels, we are not aware of any study so far, which systematically quantifies the segregation of the poor in India.

5. 2. Data:

Segregation of the poor is measured for all the regions in India, namely, 29 states and 6 union territories. [11] Poverty estimates for all states are calculated using household survey data from the National Sample Survey (NSS) Organization of the Ministry of Statistics and Program Implementation, Government of India. The NSS conducts large consumer expenditure surveys every five years, the latest survey being conducted in

[10] For instance see Ahluwalia (2002), Deaton and Dreze, (2002) and Datt and Ravallion (2011).
[11] States are typically larger in area than union territories. Unlike state legislatures, the union territories are governed directly by the appointees of the central government. Pondicherry is the only union territory with its own elected legislature.

2004-2005. We choose the 50th (1993-1994) and the 61st (2004-2005) survey rounds so that we are able to observe changes in the distribution of the poor in the decade following economic reforms of early 1990s.[12] Data on population levels in each state is obtained from the Census Bureau of India. [13] Poverty in each state is estimated using state-specific poverty lines specified by the Planning Commission of India's Expert Group on Estimation of Proportion and Number of Poor (1993). Poverty lines are based on monthly per capita expenditure and are adjusted for state level price differences.

6. Segregation of Poverty in India

6.1 Poverty Segregation Curve

By definition, the segregation curve is a straight line along the unit diagonal when each region's share of poor population is equal to its share of the total population. The further away the segregation curve is from the diagonal, the greater is the extent of segregation. Figure 2 shows the poverty segregation curves for 1994 and 2004. [14] The X-axis shows the cumulative proportion of population in each state, and the Y-axis shows the cumulative proportion of poor population in each state, when states are ranked in an increasing order of the poverty index. As seen in figure 2, segregation curve of 1994 largely dominates that of 2004, implying that regional segregation of the poor in India increased between 1994 and 2004.

Table 1 shows the regional share in the poor population in both the years. As seen in the table Bihar and Uttar Pradesh combined had more than 30 percent of the total poor

[12] The 51st round (1999-2000) was another large survey round conducted by the NSS. However we do not use data from the 51st round because poverty estimates from this round are not comparable with estimates from other rounds. The main reason for the non-comparability of the data was that the NSS changed the recall periods in the 51st round (See Dhongde, 2007 for details).
[13] The Census Bureau conducts population surveys every 10 years 2001, 1991, 1981 and so on; we use projections of populations for 1994 and 2004.
[14] Given the discrete number of regions, the segregation curve is piece-wise linear. Segregation curves are plotted by smoothly joining discrete data points and are compared only at those points for which data is available.

population and roughly 25 percent of the total population in the country. Between 1994 and 2004, although poverty rates declined in every state, some states saw an increase in their share of the poor population. By 2004, the poor were increasingly segregated in the relatively densely populated states of Bihar, Orissa, Madhya Pradesh, Maharashtra and Uttar Pradesh. Poverty levels in these states were higher than average national poverty levels. These states combined constitute roughly 50 percent of the total population; but their share in poor population increased from 58 percent in 1994 to 65 percent in 2004.Thus although poverty rates declined during the decade, the proportion of the poor increased significantly in high poverty regions and decreased significantly in low poverty regions.

6.2 Generalized Segregation Curve

There is an overall consensus that poverty rates declined significantly in the post reform period (Datt and Ravallion, 2011). Our estimates indicate that on an average, poverty at the national level declined from 36 percent in 1994 to 27 percent by 2004. Differences between segregation curves in Figure 2 are relatively small compared to reduction in state poverty rates during the decade.[15] In order to take into account the substantial decline in poverty levels by 2004, Figure 3 plots the generalized segregation curve. It is constructed by scaling the Y-axis of the segregation curve by the proportion of the non-poor population in the country. The percent of non-poor population increased from 64 percent in 1994 to 73 percent in 2004. This increase in the percent of non-poor population explains the reversal of ranking of the two curves. The generalized

[15] The ordinates of the segregation curves differ by less than a factor of 2 while poverty rates among states vary by a factor of 3 to 4.

segregation curve of 2004 dominates that of 1994 suggesting that the decline in poverty levels more than compensated for the rise in inequality in the distribution of the poor.

6.3 Indices of Poverty Segregation

The rise in segregation in 2004 is also evident from different segregation indices given in Table 2. The dissimilarity index gives the maximum vertical distance between the segregation curve and the equality line. It measures the proportion of the poor that will have to move from one region to another so that the distribution of the poor exactly matches the distribution of the total population and there is no segregation. Thus in 2004, 16 percent of the poor would have had to move between regions, compared to 11 percent in 1994, in order to attain perfect integration. The Gini index is equal to the area between the Lorenz curve and the equality line as a proportion of the total area under the equality line. All the three measures, the dissimilarity index, the Gini index and the square root index show that the segregation of the poor increased between 1994 and 2004.

6.4 Segregation of the Poor in Rural-Urban Sectors

The square root index is aggregative and additively decomposable (Hutchens 2004). Since NSS data is available separately for rural and urban sectors within each state, in this section we compute sector wide composition of segregation using the square root index. Table 3 shows the value of the total square root index is equal to the sum of values of the square root index for the rural and the urban sector. The urban sector accounted for more than 50 percent of the total segregation, though in India, the urban sector is relatively small and consists of about 30 percent of the total population. The rural-urban composition was about 40-60 percent in 2004.

The square root index is also additively decomposable. Total value of the square root index can be written as the sum of the weighted average values of the square root index within the rural and the urban sector and the value of the index between sectors. The between-sector inequality shows the value of the square root index if the poor and the non-poor within each sector were redistributed across regions such that the within-sector measure was zero. As seen from table 4, segregation values between the rural and the urban sector are strikingly low, and nearly close to zero. Low values for between sector segregation are observed in all three years. In fact proportional share of population between sectors was remarkably similar over the period of time. The rural sector had about 70% of the total population, and roughly about 70% of the poor and the non-poor population in 2004. Thus unlike the trend observed globally (Ravallion et. al. 2007), the poor in India have not urbanized at a faster pace than the population as a whole.

Total segregation was largely accounted for by segregation within each sector. In the rural sector, the value of the square root index remained close to 0.04 in both years. However segregation of the poor increased significantly within the urban sector. The square root index for the urban sector rose from 2.8 in 1994 to 4 percent in 2004. Thus all the measures indicate that there was a rise in segregation in the urban sector between 1994 and 2004.

6.5 Segregation of the Poor defined by multi-dimensional factors

So far in the application, we have defined the poor as those with income less than the benchmark income level. Thus defined, we find that the poor were increasingly concentrated in some regions in the country. There is a growing literature measuring poverty in a multi-dimensional manner (Alkire and Foster, 2011). As a test of robustness

of our results, we measure segregation of the poor, when the poor are defined by non-income variables such as those who lack education, adequate nutrition and are denied access to basic amenities.

The National Family Health Surveys (NFHS) collect data from nationally representative household surveys on population, health, and nutrition across all state in India. We use data from NFHS-1survey round (1992-1993) and the latest NFHS-3 survey round (2005-2006) and estimate segregation of poor households deprived on three different counts. A household is considered deprived of education if the head of the household does not have primary education. Similarly, a household is poor if it does not have permanent access to electricity for lighting. Finally, a household is deprived if 60% or more of its children in the age group 0-3 years are wasted i.e. due to inadequate food intake they are too thin for their height. We plot segregation curves for each dimension, based on the percent of deprived households in each state as calculated by Mishra and Ray (2011).

Figure 4 shows segregation curves separately for the rural and urban sectors. The top panel shows that between 1994 and 2004, segregation of the poor defined by education increased in the urban sector and less so in the rural sector. [16] However during the same period, segregation of the poor defined by access to electricity increased in both the rural and the urban sectors. As seen in the bottom panel, segregation of households with undernourished children also increased. Thus between 1994 and 2004, segregation of the poor increased both when the poor were defined using income and multiple non-income measures.

[16] Since the NFHS survey rounds (1992-1993 and 2005-2006) are very close to the survey rounds of NSS (1993-1994 and 2004-2005), we continue referring to the segregation curves by the same denomination as 1994 and 2004.

7. Conclusions

In this paper we measured spatial inequality in the distribution of the poor by introducing a poverty segregation curve. Axiomatic properties of the segregation curve were discussed in detail. Additionally a generalized segregation curve was introduced. Segregation analysis was applied to study disparity in poverty levels across regions in India. Since economic reforms of the early 1990s growth rate of the Indian economy picked up. Yet the progress in reducing poverty was largely uneven across regions. Our results indicated that the poor were increasingly segregated in the relatively densely populated states. More than 65 percent of the poor lived in these five regions (Bihar, Orissa, Madhya Pradesh, Maharashtra and Uttar Pradesh).Within regions, the poor were highly segregated in the urban sector and less so in the rural sector. Inequality in the distribution of the poor increased and this rise in segregation was robust to the definition of the poor by income and non-income measures. If this trend continues, significant percent of the poor population in India will be spatially isolated in a few regions. There is a growing concern that widening inequalities among regions may pose a serious threat to the political stability in India.

Economists have largely ignored this topic, choosing to focus on measurement and comparability of poverty estimates. Increasing segregation of the poor is a cause of concern not only because it exacerbates regional disparity in a country and can adversely impact its economic growth but also because segregation of the poor violates our notion of equality and fairness.

Appendix on Poverty Segregation Measures

1. Dissimilarity index

The dissimilarity index has been commonly used to measure of segregation between two population groups; for instance between white and non-whites (Duncan and Duncan, 1955). Moir and Selby- Smith (1979) modified the index to measure segregation of female employees compared to the total workforce.[17]

$$D = \frac{1}{2}\sum_{i=1}^{R}\left|\frac{x_i}{N} - \frac{x_{1i}}{N_1}\right|.$$

The dissimilarity index measures the proportion of the poor that will have to move from one region to another so that the distribution of the poor exactly matches the distribution of the total population and there is no segregation. Geometrically, it gives the maximum vertical distance between the segregation curve and the equality line. If there is perfect integration, the index is equal to zero; if there is perfect segregation it is equal to one. The index does not satisfy the transfer principle. So long as both regions have headcount ratio of poverty above or below the national average, an inter-regional regressive transfer of the poor does not bring about any change in the dissimilarity index.

2. The Gini index

The Gini index is commonly used to measure inequality of income among individuals. It is equal to the area between the Lorenz curve and the equality line as a proportion of the total area under the equality line.

$$G = \sum_{i=2}^{R} X_{i-1}Y_i - \sum_{i=2}^{R} X_i Y_{i-1}.$$

[17] See Lewis (1982) for the relation between the dissimilarity index and its modified version.

$X_k = \sum_{i=1}^{k} \frac{x_i}{N}$ and $X_{1k} = \sum_{i=1}^{k} \frac{x_{1i}}{N_1}$ are cumulative proportions of the population and the cumulative proportion of the poor for any $k = 1,2,..R$ regions respectively, when regions are arranged in an increasing order of the headcount ratio. The Gini index also takes values between 0 and 1, a value close to zero indicating less segregation and vice versa. It satisfies all three properties, namely, symmetry, scale invariance and the regressive transfer of poverty. But a main drawback of the Gini index is that it is not decomposable; nor is it additively separable.

3. The Square Root Index

Hutchens (2004) proposed the Square Root Index to measure segregation within groups. The index is calculated as $SR = 1 - \sum_{i=1}^{R} \sqrt{\frac{x_i}{N} . \frac{x_{1i}}{N_1}}$ and takes values between 0 and 1. In addition to the properties of symmetry, scale invariance and the regressive transfer of poverty, the square root index also satisfies the aggregative property and the additive decomposable property neither of which are satisfied by the dissimilarity index or the Gini index. Aggregative property implies that total segregation is a continuous and increasing function of segregation in sub-groups and the additive decomposable property implies this function is additive.

References

Ahluwalia M., (2002) “Economic reforms in India: A decade of gradualism”, *Journal of Economic Perspectives*, Vol. 16, No. 3, 67-88.

Alkire S. and J. Foster, (2011) “Understandings and misunderstandings of multidimensional poverty Measurement”, *Journal of Economic Inequality*, Vol. 9, No. 2, 289-314.

Alonso-Villar O., (2010) “Measuring concentration: Lorenz curves and their decompositions”, *Annals of Regional Sciences*, Vol. 47, 451-475.

Census Bureau of India http://www.censusindia.gov.in/default.aspx

Datt G. and M. Ravallion, (2011) "Has India's economic growth become more pro-poor in the wake of economic reforms?" *World Bank Economic Review*, Vol. 25, No. 2, 157-189.

Dalton H., (1920) “The Measurement of Inequality of Incomes”, *Economic Journal*, 30, 348-361.

Deaton A. and J. Dreze, (2002) “Poverty and inequality in India: A reexamination”, *Economic and Political Weekly*, September 7, 3729-3748

Deaton A. and V. Kozel, (2005) *Data and Dogma: The great Indian poverty debate*, MacMillian New Delhi.

Dhongde S., (2007) “Measuring the impact of growth and income distribution on poverty in India”, *Journal of Income Distribution*, Vol. 16, No. 2, 25-48

Duncan O.D. and B. Duncan, (1955) “A methodological analysis of segregation indices”, *American Sociological Review*, 20 (2), 210-217

Dygalo N., (2007) “On unemployment duration and narrowing job opportunity at older ages”, *Economics Bulletin*, Vol. 10, No. 21, 1-6

Foster J., (1985) “Inequality measurement”, in: P. Young (ed) Fair allocation, Proceedings of Simposia in Applied Mathematics, Vol 33, 31–68

Frankel D. and O. Volij, (2011) “Measuring school segregation”, *Journal of Economic Theory*, Vol. 146, No. 1, 1-38

Hentschel J., Lanjouw J., Lanjouw P., and J. Poggi (2000), "Combining census and survey data to trace the spatial dimensions of poverty: A case study of Eucador", *World Bank Economic Review*, Vol. 14, No. 1, 147-165.

Hutchens R., (1991) "Segregation curves, Lorenz curves and inequality in the distribution of people across occupations", *Mathematical Social Sciences*, Vol. 21, 31-51

Hutchens R., (2001) "Numerical measures of segregation: desirable properties and their implications" *Mathematical Social Sciences*, Vol. 42, 13-39

Hutchens R., (2004) "One measure of segregation", *International Economic Review*, 45 (2), 555-578

Jayadev A. and S. Reddy, (2011) "Inequalities between groups: theory and empirics", *World Development* Vol. 39, No. 2, pp. 159–173

Jha R. and A. Sharma, (2003) "Spatial distribution of rural poverty: last three quinquennial rounds of NSS", *Economic and Political Weekly*, pp. 4985-4993

Joshi V. and I.M.D. Little, (1996) *India's economic reforms 1991-2001*, Oxford University Press, New Delhi.

Krivo L., Peterson R. and D. Kuhl, (2009) "Segregation, Racial Structure, and Neighborhood Violent Crime", *American Journal of Sociology* Vol.114:1765–802.

Lewis D., (1996) "Occupational Crowding" *The Economic Record*, Vol. 72, No. 214, 107-117

Mishra A., and R. Ray, (2011) "Multi-Dimensional Deprivation in India during and after the Reforms: Do the Household Expenditure and the Family Health Surveys Present Consistent Evidence?" *Social Indicators Research*, Online First, 31 October 2011.

Moir H., and J. Selby-Smith, (1979) "Industrial segregation in the Australian labor market", *Journal of Industrial Relations*, Vol. 21, 281-291.

National Sample Survey Organization, India http://mospi.nic.in/cso_test1.htm.

Planning Commission of India http://planningcommission.nic.in/

Pigou, A., (1912) *Wealth and Welfare*, Macmillan, London.

Purfield C., (2006) “Mind the Gap: Is Economic Growth in India Leaving Some States Behind?” Working Paper No.06/103, International Monetary Fund, Washington, D.C.

Ravallion M., Chen S., and P. Sangraula, (2007) "New evidence on the urbanization of global poverty," *Population and Development Review*, The Population Council, Inc., 33(4), 667-701

Shah A., (2010) “Patterns of poverty in remote rural areas: a case study of a forest-based region in Southern Orissa in India”, Working Paper, Overseas Development Institute, London.

Shorrocks A., (1983) “Ranking income distributions”, *Economica*, New Series, 50 (197), 3-17.

Srinivasan T. and S. Tendulkar, (2003) *Reintegrating India with the World Economy*, Institute for International Economics, Washington, D.C.

Figure 1 Poverty Rates in India

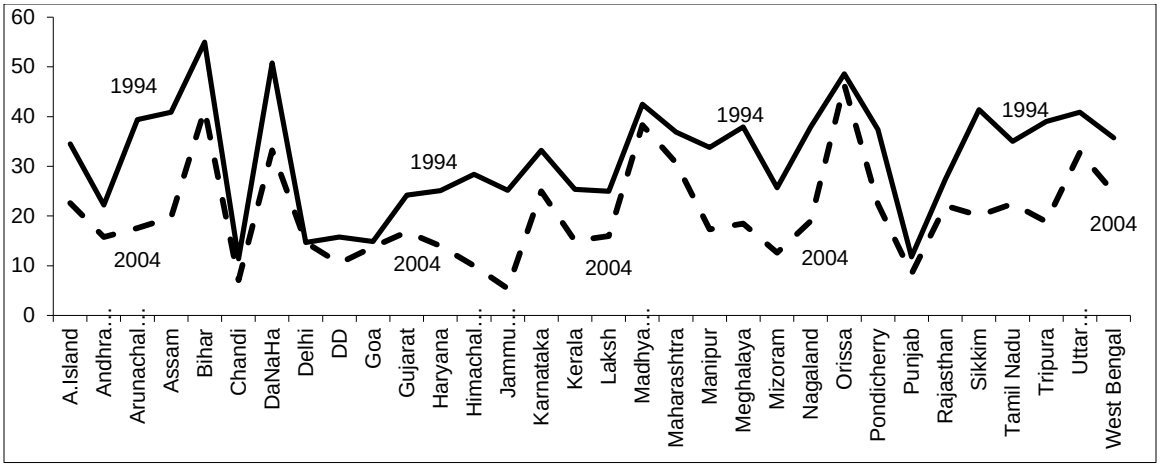


Figure 2 Segregation Curves of Poverty in India

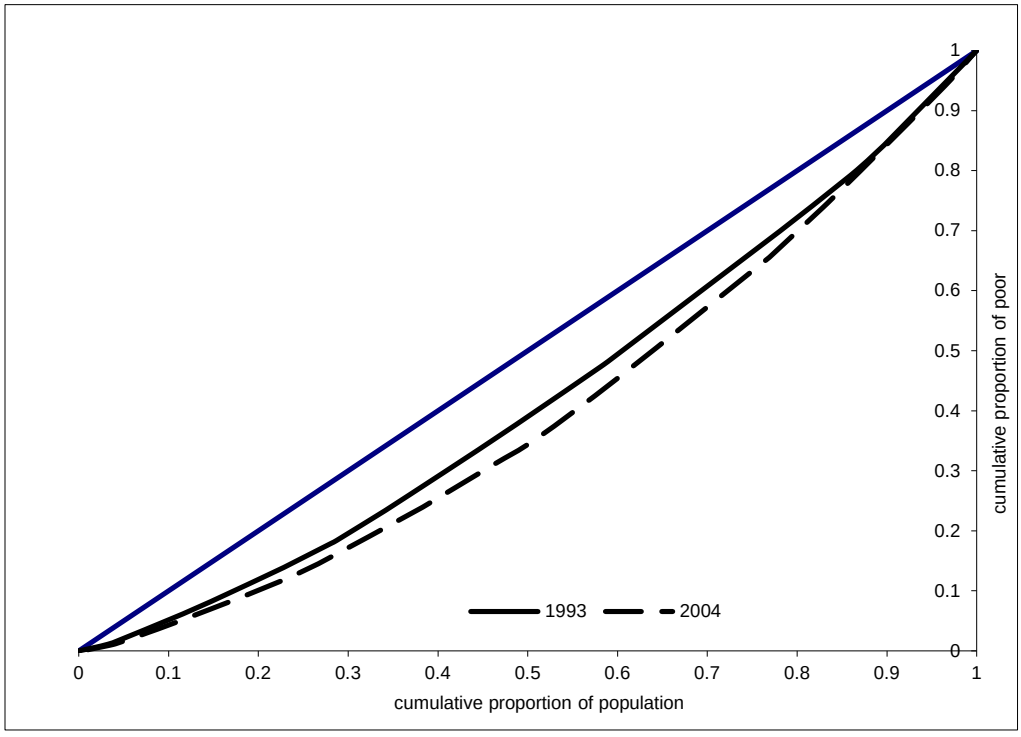


Figure 3 Generalized Segregation Curves of Poverty in India

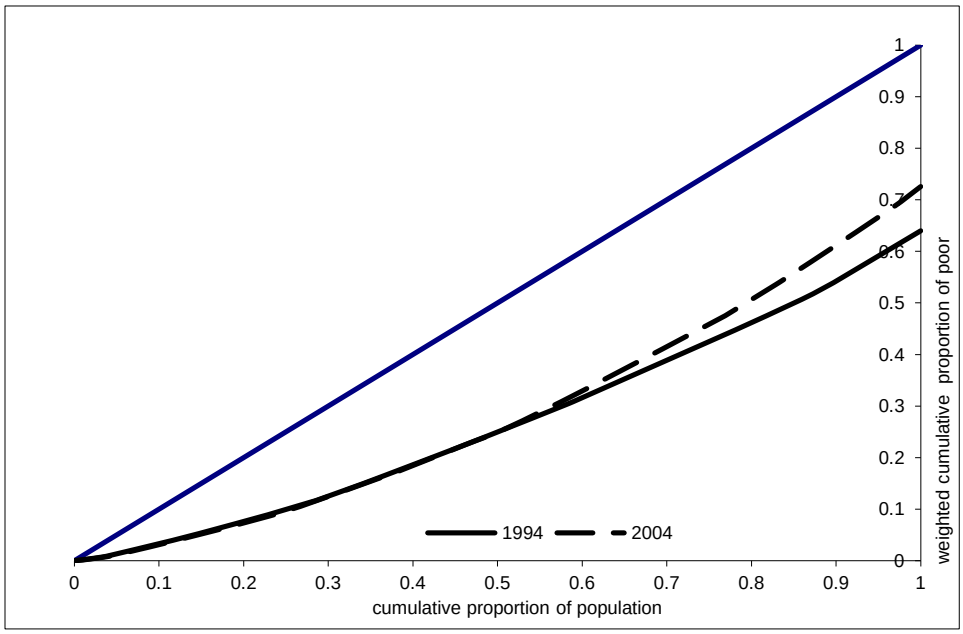
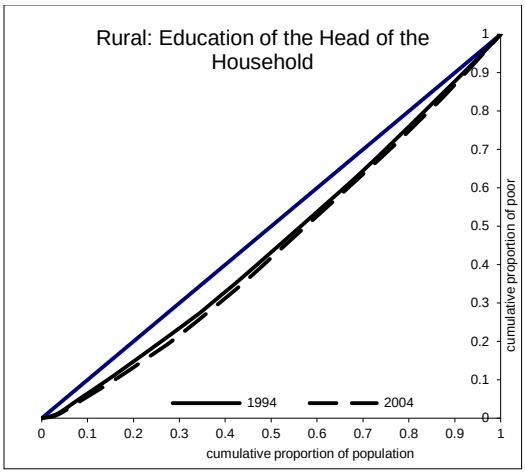
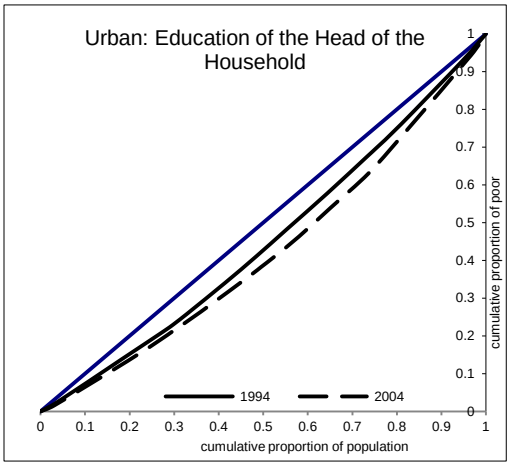
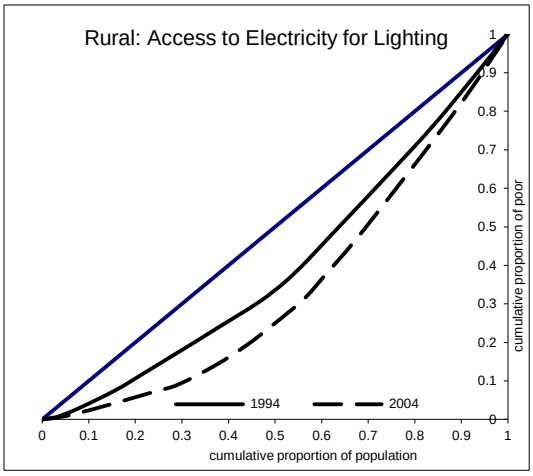
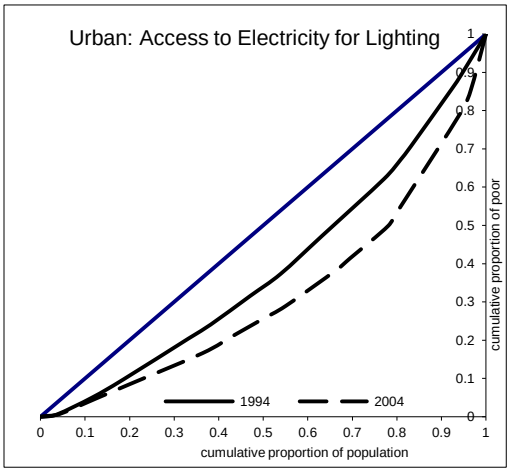


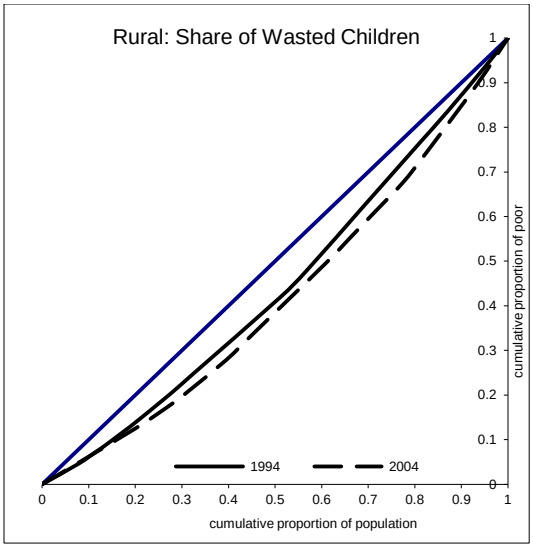
Figure 4 Segregation Curves for Multidimensional Poverty Measures











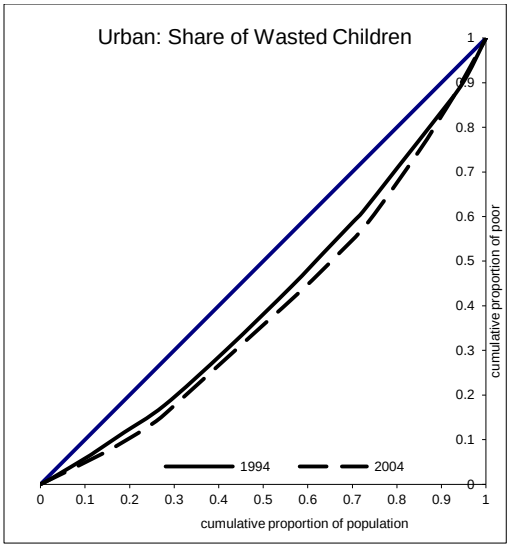


Table 1 Regional Share of the Poor

States and Union Territories	1994	2004
A & N Island	0.0	0.0
Andhra Pradesh	4.8	4.2
Arunachal Pradesh	0.1	0.1
Assam	3.0	1.8
Bihar	15.7	12.3
Chandigarh	0.0	0.0
Chattisgarh	N/A	3.0
Dadra & Nagar Haveli	0.0	0.0
Daman & Diu	0.0	0.0
Delhi	0.5	0.8
Goa	0.1	0.1
Gujarat	3.3	3.0
Haryana	1.4	1.1
Himachal Pradesh	0.5	0.2
Jammu & Kashmir	0.6	0.2
Jharkhand	N/A	3.9
Karnataka	4.9	4.6
Kerala	2.4	1.6
Lakshadweep	0.0	0.0
Madhya Pradesh	9.3	8.3
Maharashtra	9.6	10.5
Manipur	0.2	0.1
Meghalaya	0.2	0.1
Mizoram	0.1	0.0
Nagaland	0.2	0.1
Orissa	5.0	5.9
Pondicherry	0.1	0.1
Punjab	0.8	0.7
Rajasthan	4.0	4.5
Sikkim	0.1	0.0
Tamil Nadu	6.3	4.8
Tripura	0.4	0.2
Uttar Pradesh	18.6	19.5
Uttaranchal	N/A	1.2
West Bengal	7.9	6.9
Total	**100**	**100**

* The states of Chattisgarh, Jharkhand, and Uttaranchal were created in 2000 from parts of Bihar, Madhya Pradesh and Uttar Pradesh.
Source: Author's calculations

Table 2 Poverty Segregation Indices for Indian States

Measures of Segregation	1994	2004	Percent Change
Gini Index	16	21	+ 31.3
Dissimilarity Index	11	16	+ 45.5
Square Root Index	1.1	1.8	+ 63.6

Table 3 Extent of Rural-Urban Segregation as measured by Square Root Index

Year	Rural	Urban	Total
1994	0.7	2.9	3.6
2004	1.7	2.4	4.1

Table 4 Decomposition of Segregation as measured by Square Root Index

Year	Within Sectors		Weighted Average	Between	Total
	Rural	Urban	Within Sector	Sectors	
1994	3.7	2.8	3.4	0.2	3.6
2004	4.0	4.0	4.0	0.1	4.1