
Infant Mortality in India: District-Level Variations and Correlations

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Abstract

This paper examines the correlates of infant mortality in India using district-level data from the 1991 and 2001 Census of India. While infant mortality rates have dropped across districts over this ten year period, there still remains a lot of heterogeneity across districts and hence across the states. Using a panel dataset of 666 districts, the analysis seeks to determine which of socio and or economic factors play an important role in reducing infant mortality rates. In our empirical work, the explanatory variables used are male and female literacy, male and female labor force participation, the level of poverty, urbanization and other socio-economic variables. We use quantile regression analysis to determine which of these factors impact infant mortality. Quantile regression is preferred over OLS because it allows us to estimate models for the conditional median function, and the full range of other conditional quintile functions and therefore provides a more complete statistical analysis of the stochastic relationship among random variables. The analysis brings out the powerful influence of women's characteristics on infant mortality, especially literacy and labor force participation. Increases in both of these variables significantly reduce child mortality at the district level. Improvements in male laborers in non-agricultural work and reductions in poverty also reduce child mortality, but their quantitative impact is weak in comparison. Further the non-parametric analysis reinforces the results found in the parametric section. They indicate that the action or the impact of the covariates is strongest in the districts which lie in the center of the conditional distribution, rather than those at the extreme. This analysis allows us to determine in which districts the impact of additional target policies would yield the greatest reduction in infant mortality.

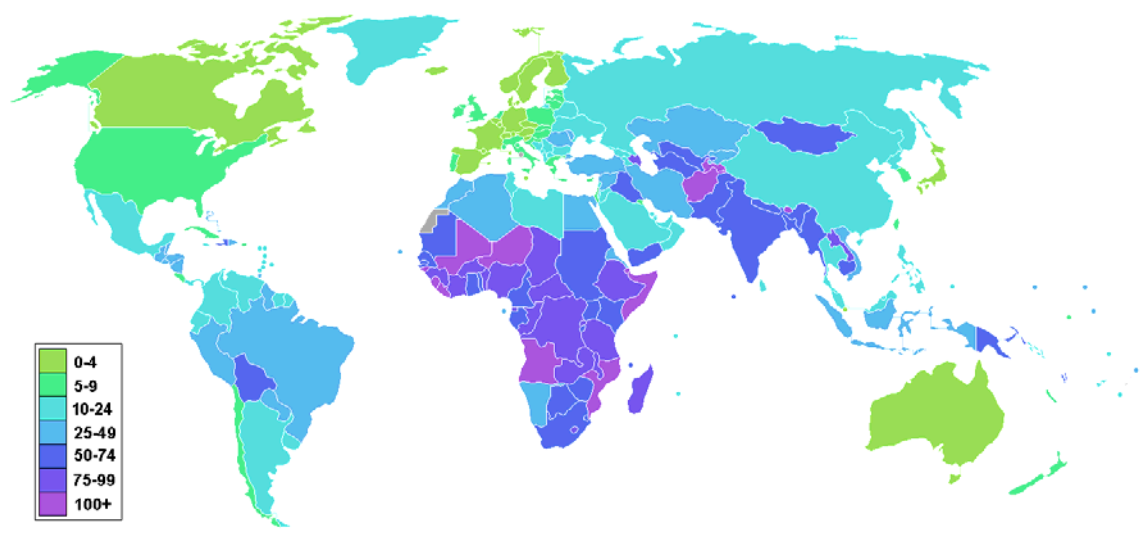
Key words: mortality, female literacy, work participation rate, demographic change, quantile regression and nonparametric methods.

JEL Classification: C23, J13, I12

Introduction

Children are important assets of a nation, therefore reduction in infant and child mortality is likely the most important objective of the Millennium Development Goals (MDG). Infant and child mortality rates reflect a country's level of socio-economic development and quality of life and are used for monitoring and evaluating population, health programs and policies. It is an outcome rather than a cause and hence directly measures results of the distribution and use of resources (Haines, 1995). The world map below (Figure 1) shows the level of Infant Mortality Rate (IMR) across various countries in 2006. While countries like Australia and Canada have IMRs well below 10 per 1,000 live births, most of the African countries are struggling with mortality level over 50 and in some cases 100 deaths per 1,000 live births. India lies in the range of 50-74 infant deaths per 1,000 live births. According to the United Nations estimates, 10 million infant deaths occur annually in the world. India accounts for a quarter of those. Thus any study of Indian infant mortality has global significance.

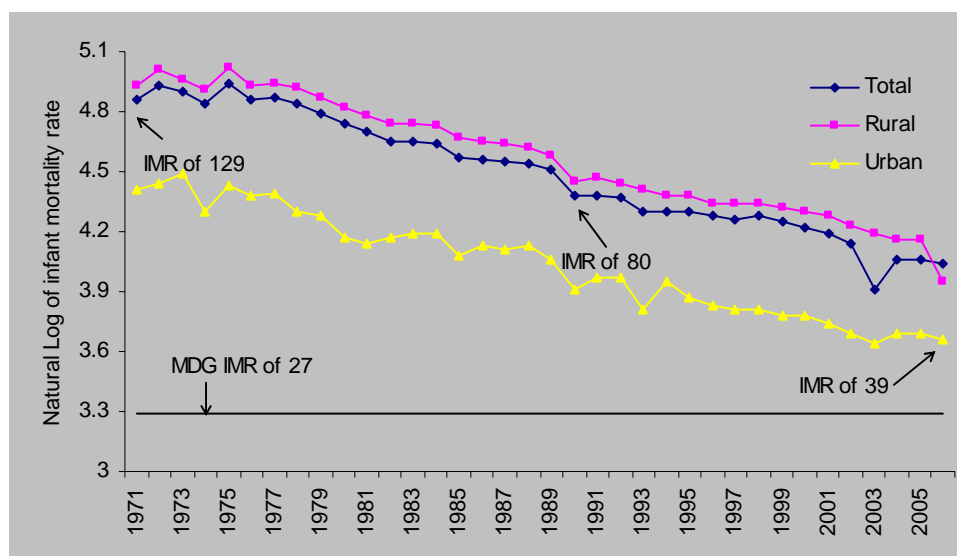
Figure 1: Infant Mortality Rate World Map, 2006



Source: CIA Factbook, 2006

India has experienced an impressive decline in infant mortality since the 1970s. From 130-140 deaths per 1,000 live births in the early 1970's, mortality levels have declined to as low as 60 deaths per 1,000 live births in 2000. This represents an annual rate of decline of around 2.6 percent. (Figure 2). However the absolute levels of infant and child mortality are still too high (about 68 infant and 95 child deaths per 1,000 live births in 1998- 99).

Figure 2: Infant Mortality rate, by residence 1971-2006

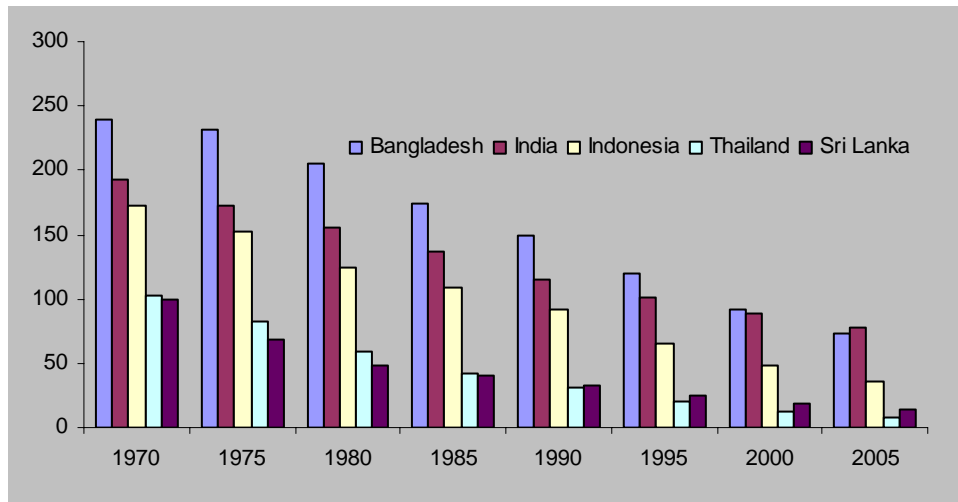


Source: Compendium of India's Fertility and Mortality Indicators 1971-1997, Registrar General & Family Welfare Program in India 2001, Department of family Welfare, Ministry of Health and Family Welfare, Govt. of India

According to the Registrar General of India, the IMR for the country as a whole is 57 infant deaths for every 1000 live births in the year 2006. The National Population Policy 2000 aims at achieving IMR of 30 by the year 2010 (Government of India, 2000). The MDG is to reduce infant and child mortality by two-thirds between 1990 and 2015. In the case of India this would imply a reduction of the IMR to 27 and of the under-five mortality rate to 32 by 2015 (World Bank, 2004). Figure 2 also shows that IMR has declined both in the urban and rural areas. The latest data from the sample registration system shows that the infant mortality rates for the urban and rural regions are 40 and 64, respectively, for every 1000 live births in the year 2004 (Government of India, 2006).

While there has been a significant decline in IMR in India over the last three decades, its performance with respect to other countries in Southeast Asia is not that impressive. Countries such as Indonesia, Sri Lanka, and Bangladesh have managed to reduce their IMR levels by between 3-5% annually. Figure 3 shows Child mortality rates for selected Asian countries over the period 1970–2005. As is seen in the figure, countries like Thailand and Sri Lanka have had stellar performance.

Figure 3: Mortality Rate Under-5 (per 1,000), 1970-2005, selected countries in Asia



Source: World Development Indicators, World Bank

Using a sample of 666 districts from the 1991 and 2001 census, this paper attempts to study the relevant relationships of demographic and socio-economic variables with IMR. The choices of independent variables are partly guided by previous literature on IMR and partly by the availability of data. Special attention has been paid to female literacy, female labor force participation rates, urbanization and some socio-economic variables. The prime intention of this analysis is to see which variables, economics or social, have a greater impact in reducing infant mortality levels and in which quintiles the impact is the strongest.

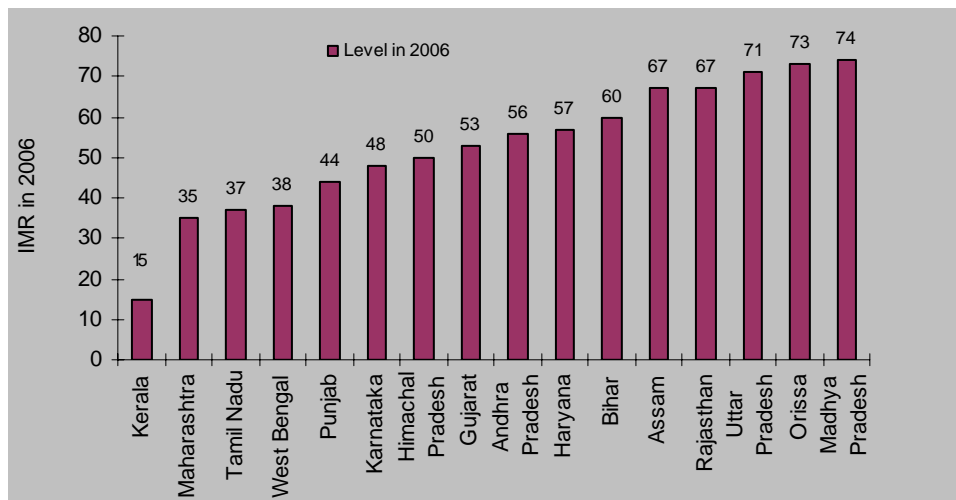
Cross-State Variation

India is demographically a very diverse country. India is administratively divided into 28 states and 7 union territories. The states are further divided into 593 districts for political and judicial purposes. There are variations in basic demographic indicators not only across states but districts also. At one end of the spectrum, Kerala has demographic features which are similar to those of middle income countries like Bulgaria, Russia and Ukraine: life expectancy at birth is 72 years, infant mortality rate is 12 per thousand live births, total fertility rate is 1.8 births per women and ratio of females to males in the population is well above unity (1.04). At the other end we have the large North Indian states which find themselves in the same league as some of the least developed countries for the same indicators. In Uttar Pradesh, infant mortality rate is 72, life expectancy at birth is 61, total fertility rate is 5.1 and female-male ratio is (0.8), lower than that of any country in

the world (Murthy et al., 1995). In the state of Arunachal Pradesh, there exist a districts such as East Kameng which has an IMR of 158, as well as districts like East Siang where the IMR is only 64.

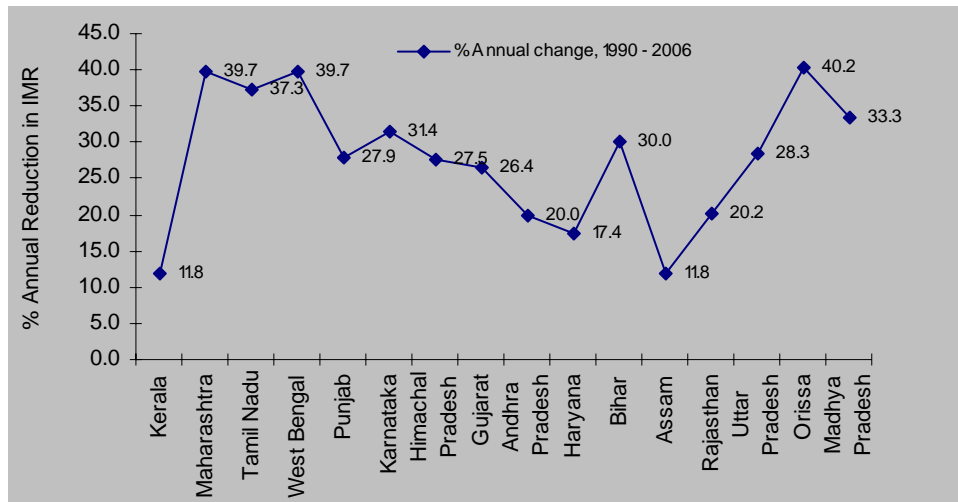
Due to wide inter-state and intra-state variations, it is therefore almost meaningless to talk about an average infant mortality rate for India. Figure 4 shows IMR across selected states in India. As far as the performance of individual states goes in terms of reducing their IMRs, the results are intriguing (Refer to Figure 5). Kerala was the slowest; it reduced its infant mortality at an annual rate of 12% between 1990 and 2006. On the other hand Bihar and U.P. which had the highest level of infant mortality achieved significant reductions (almost 30%) during the same period. States like Andhra Pradesh and Karnataka which are usually perceived to be good human development performers had the highest rate of decline in the above mentioned periods. Rajasthan, U.P., M.P. Bihar and Orissa are the high mortality states. These states also have high fertility and population growth rates. This implies that by the year 2015 a majority of India’s population will be concentrated in these states. Thus if the MDG of 27 is to be achieved, these states will have to work even harder to reduce their IMRs to lower levels.

Figure 4: Infant Mortality Rates across Indian states, 1990 - 2006



Source: Indiatat.com

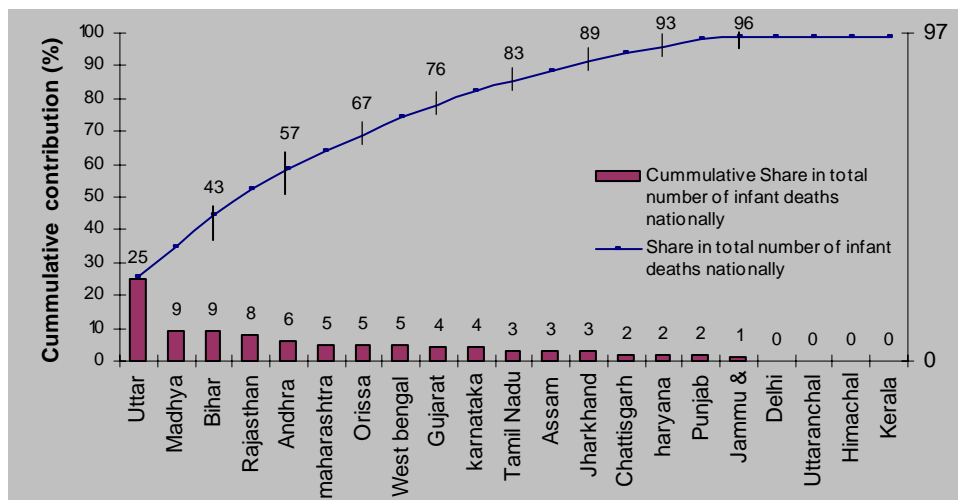
Figure 5: Percentage Annual reduction in Infant Mortality Rates across Indian states, 1990 - 2006



Source: Indiatstat.com

Due to heterogeneity, a look at the contribution of individual states to the number of infant deaths nationally is important from a policy perspective. In order to achieve the MDGs it is critical to target populous states with high IMRs. Figure 6 below shows the individual as well as the cumulative contribution of the 21 larger states to the total number of infant deaths nationally in 2000. About a quarter of the deaths occurred in the state of Uttar Pradesh.¹ The four largest states of Uttar Pradesh, Madhya Pradesh, Bihar and Rajasthan account for a little more than half of the nation's infant deaths.

Figure 6: Contribution of the 21 larger states to national infant deaths, 2000



¹ According to the 2001 census, Uttar Pradesh accounts for 16 % of India's population.

Objective

India is not only described by heterogeneity across states but also from large demographic variations within states (across districts). While a number of studies have looked at the correlates of infant mortality, most of them have exclusively concerned themselves with estimating the mean effect on infant mortality of variables such as mother's education, child's sex, urbanization level and birth order etc. Such estimates miss an important point for policy makers: exogenous variables and policy interventions may affect infant mortality differentially at different points in the conditional distribution. For example, while the effect of electrification may not influence infant mortality "on average", it might play an important role in the case of infants at the bottom of the conditional mortality distribution (i.e. infants at highest risk of mortality).

A study done by The World Bank (2004) analyzed the National Family Health Survey (NFHS-2) data and found that infant deaths in India were heavily concentrated in a relatively small number of districts and villages. During the period 1994 – 99, 20% of the villages and 22.5% of the districts accounted for half of all infant deaths in the country. Since the survey covered only a fraction of the villages in the country and the sample of households from each village was small, one could infer that these numbers are suggestive of patterns at the district level. It would be thus worthwhile to explore the data at the district level and identify factors most correlated with IMR.

This paper seeks to address this shortcoming in the existing literature. Using a unique dataset (at the district level) from India, estimate quantile regressions to analyze the affect of demographic, socio-economic and other correlates on infant mortality rates at different points of the conditional distribution of infant mortality. This technique will allow us to answer not only the question, "can policy influence infant mortality rate?" but more importantly, the question, "for whom do policy interventions matter the most?"

The unit of analysis is the district level for two reasons. First most of the studies on IMR have been done using data at the state level. To the best of my knowledge, no previous study has used the 2001 census data at the district level data to answer the above question. Second, using panel

data at the district level (compared to state level) gives me larger number of observations and more variation in the covariates. It also gives me the ability to control for state*year fixed effects. This study will be unique because it will be the first study to analyze the 1991 and 2001 census data for Infant Mortality at the district level. The Study will make use of quintile regressions and some basic non-parametric techniques to see whether it is mostly the economic factors or the social ones that play an important role in bringing down mortality levels at the district level.

Issues and Hypotheses

Vast bodies of empirical study have focused on analyzing the determinants of infant mortality in India, and elsewhere in the world. Household incomes, female education, access to health services and immunizations have been the key determinants of infant mortality. This indicates that public policies which promote access to schools, better health facilities and encourage economic growth can help reduce infant mortality. Other environmental factors like electricity, access to safe water and sanitation and use of cooking fuels all have been found to have important health implications on infants. A recent World Bank study on the role of public policy and service delivery to help India achieve its MDGs found a strong association between infant mortality and various other factors like government health spending, access to roads, supply of electricity and immunization.

There are multiple factors that go into determining whether a young infant will survive in his/her early years. During pregnancy and after, external factors like the family, the situation and practices of the household, the norms of the community can influence both the mother and the infant. A brief explanation of how the individual, family, community and services might affect infant mortality is explained in Table 1.1 below.

Table 1.1 Effect of individual, family, community and services on infant mortality

Health Outcome	Individual Woman/Mother	Household	Community	Service Provision
Lower child Mortality; Healthier babies and young children	Education (esp. post-primary) Nutrition (during pregnancy and breastfeeding) Age at first birth and spacing between births Hygiene practice (esp. hand washing)	Income and Wealth Intra-household dynamics Water (piped into households) Cooking fuels Hygiene practice Use of insecticide nets (malaria)	Environmental health practices (water, sanitation, solid waste) Beliefs and practices (e.g. at birth) Women's self help group	Basic health/nutrition services in village/outreach to households Access to health facilities for emergency obstetric and sick child care

Source: World Bank (2007)

This section is an attempt to take cues from various studies and hypothesis made to the extent that these help in understanding the resultant IMRs. Surveying the diverse connections emphasized in the literature to explain India's high IMRs would help create a framework for my analysis in the subsequent sections.

Mother's Education: Basic female education is considered as one of the most powerful factors that influence infant mortality and fertility. Education of the mother has often been treated as a proxy for socio-economic status. Caldwell has argued that it has a more direct effect on child mortality through improved child-care. Mothers who are more educated tend to get married upon adulthood, this in turn delays child bearing. An educated mother is likely to be more knowledgeable about nutrition, health care and hygiene of the infant (for example washing and feeding practice, taking better care of the sick child, immunization etc). This aspect of maternal education is particularly significant since large parts of rural India still practice childcare which is deficient in nature. For example, it is still quite common in villages to cut the umbilical cord with unsterilized sickles, keep the cooked food uncovered and exposed, leave the child immunized or follow orthodox methods to cure common childhood diseases like tetanus and diarrhea. If the mother is educated she can take advantage of public health services and request other members of the family to tend to the child's need. There can also be an effect due to income levels as more educated mothers are likely to have higher income. In Asia, the mortality among children of uneducated Nepalese women is almost 15 times greater than it is among those of Malaysian women with seven more years of schooling."² Caldwell (1979) examines education as a factor in mortality decline using the Nigerian data. He stresses on the role of parental education, particularly, that of the mother, in reducing infant and child mortality. He argues that a well educated mother can change the range of feeding and child care practices without imposing significant extra cost on the household, she is more capable of handling the modern world and that the education of women greatly changes the traditional balance of familial relationships with profound effects on child care. Thus, a priori, holding other factors constant, one would expect the

² John C. Caldwell, 'Cultural and Social Factors Influencing Mortality Levels in Developing Countries', *Annals of the American Academy of Political and Social Sciences*, Vol. 510, *World Population: Approaching the Year 2000* (1990), pp. 44-59.

sign of the female education coefficient to be negative in a regression of IMR on various covariates.

Female Labor Force Participation: The status of a woman in society can be measured by her ability to participate in economically gainful work outside the household. Gainful employment outside the house not only gives the women increased bargaining power within the household (Blumberg, 1991), it also increases the potential economic “worth” of female children due to higher discounted parental value for them. Various studies in the literature have reiterated the connection between female work participation and female worth (See for example Dasgupta et al. (2003), Miller (1981, 82), Rosenzweig and Shultz (1982), Sen (1987) Desai and Jain (1994), Murthy et. al (1995))

Work status of the mother can have a two way affect on mortality. The need to work outside the house, may affect child survival rates simply by preventing the mother from caring for the infant. The dual burden of employment and household work can reduce the time available for childcare activities. This could lead to substantial effect through a lack of feeding, especially breast feeding early in life. On the other hand, working outside the home leads to higher family income and gives the mother a modern outlook, both of which could increase the probability of survival. Kishor and Parasuraman (1998) using data from the 1992-93 National Family Health Survey, found that mother’s income translates into greater control over the expending of resources, increased exposure and access to relevant information about childbearing and childrearing practices, and an enhanced ability to engage the world outside the home to better meet the nutritive, medical and survival needs of infants. Their study showed that mothers who are employed have a 10 percent higher infant-mortality rate and a 36 percent higher child mortality rate than mothers who are not employed. The study also found that male mortality increases more than female mortality if mothers work. In the case of a girl child higher levels of female labor force participation may increase the importance attached to the survival of the girl child.

In India, female work outside the house is largely influenced by local customs and traditions. Female Work Participation Rate (FWPR) is generally higher in the southern states than in the northern states. Miller (1982) found a clear relationship between female labor-force participation

rates and regional pattern of female seclusion. Female seclusion was especially prevalent in the northern and north-western parts of the country. As a result female did little rural work. On the other hand women in the south were found to be very active as workers. Some studies also attribute the differential participation in economic activities between women in the northern and southern states to the type of production in that region (See Bardhan (1974, 1982, 1988), Gupta and Attari (1994), Miller (1981), Rosenzweig and Schultz (1982)). According to Boserup (1970)), seclusion of women will be found in areas where plough agriculture is practiced. Dry-field system of cultivation does not require much female labor. Thus wheat cultivation which is more prevalent in the north and requires less tedious but more physical power is primarily dominated by males. On the other hand, wet rice cultivation (staple for southern and eastern parts of the country); involve a lot of female intensive labor.

Other Influences: Apart from the educational and economic impact discussed earlier, several other variables' impact on mortality can be investigated using the district-level data on India.

To begin with it is worth investigating whether infant mortality rates vary across social groups Scheduled Castes (SCs) and Scheduled Tribes (STs) are Indian population groupings that are explicitly recognized by the Constitution of India as previously "depressed". According to the 2001 Census, SCs/STs together comprise over 24% of India's population, with SC at over 16% and ST above 8%. The proportion of SC/STs in the population of India has steadily risen since independence in 1947. Scheduled Caste/Scheduled Tribe along with the female-headed households is among the poorest in the country. The vulnerability of SC/ST households to acute poverty is evident in the arrangements for job reservations made for these groups in India. Other Backward Class households are also relatively poor compared to forward class households in most states. While one would argue that given their scarcity of resources on account of poverty, probability of male and female infant deaths could be expected to be greater in these households that might be just one side of the coin. Studies done by Liddle and Joshi (1986), Basu (1990), Miller (1981) have found that SC/ST households have a higher value for female children than their non-SC/ST counterparts. This is because originally bride price was more prevalent among lower castes and tribes. This would give less reasons of discrimination between male and female children.

Another issue of interest is whether urbanization plays an important role in influencing mortality levels. Greater urbanization should lead to lower mortality levels. Finally, the relationship between poverty and mortality is worth noticing. Does poverty have a strong effect on mortality rates after controlling for the other explanatory variables?

Methodology and Empirical Model

Due to wide inter-state variations in fertility levels it would be more meaningful to investigate the effect of income and other interventions on infant mortality rates at different quantiles of the conditional distribution of IMR. In this study I estimate regression equations at different points of the dependent variable's conditional distribution using the quantile regression technique. This technique was initially developed as a "robust" regression technique that would allow for estimation where the usual assumption of normality of the error term might not be strictly satisfied (Koenker and Bassett, 1978). This technique is commonly used to understand the relationship between the dependent and independent variables over the entire distribution of the dependent variable and not just at the conditional mean.

The following **basic model** will be used for the analysis:

$$\mathbf{IMR}_{it} = \alpha + \mathbf{X}_{it}\beta + \mathbf{D}_i\gamma + \mathbf{e}_{it}, \quad \text{where } i=1 \text{ to } n, t=2 \text{ time periods, 1991 and 2001}$$

\mathbf{IMR}_{it} - is the Infant Mortality Rate in district i for time 1991 and 2001 respectively

\mathbf{X}_{it} - is the vector of demographic, socio-economic and health care, exogenous variables like female literacy, poverty, urbanization, etc.

\mathbf{D}_i - is a vector of dummies ($n=332$ for districts, $n= 16$ for states)

\mathbf{e}_i - is independent and identically distributed error term for each district.

Factors associated with IMR i.e. variables comprising the X matrix, may be broadly grouped into three categories: the population's socio-cultural characteristics, availability and opportunities of female employment, material prosperity and economic development of a region. I begin to analyze IMR by first doing a simple Ordinary Least Square (OLS) regression. I then add some district/state dummies to capture the heterogeneity that might have not been addressed by the covariates. The use of Simultaneous Quintile Regressions helps me analyze the affect of the

covariates at various points of the IMR's distribution. I finally use some simple non-parametrics and compare my results from the parametric analysis.

Data Source

The analysis uses a sample of 666 districts for the years, 1991 and 2001. This represents 71 percent of the 938 districts from 17 states in India. The Census of India³ is the primary source of data for population related variables such as male and female work participation, literacy, place or residency and the scheduled caste and tribes. Mortality is measured by IMR, which represents the number of deaths before the first birthday for every 1,000 live births. With respect to the exogenous variables, the indicator of female (male) literacy is the crude female (male) literacy rate, defined as the proportion of literate females (males) above the age of six in the total population⁴. Female labor force participation is defined as the percentage of female "main workers" in the total female population above the age of 15 years⁵. A similar definition is followed for male work participation rate. In addition, I also include two other variables related to work. One is the percentage of agricultural workers among all female workers. And the second is the percentage of non agricultural workers among all male workers. To relate to the composition of the population, two variables which measure the proportion of scheduled castes and scheduled tribes in the population are included. Urbanization is measured by the percentage of total population living in urban areas⁶.

It is difficult to obtain reliable district level data on income and poverty in India as there is no nationwide comparable source for such data. The National Sample Survey⁷ is the largest nationwide survey on per capita household expenditure levels and over the years, the NSS unit data has

³ The Census is conducted by the Government of India and is the largest source of data on population characteristics. Data is available at the state, district and at the village level for rural and urban areas.

⁴ Literacy is defined in the Census of India as the ability to both read and write with understanding in any language for a person aged 7 years and above.

⁵ Female work participation rate is the ratio of female "main workers" (women engaged in economically productive work for at least six months) to the total female population. Household duties were not counted as economically productive work.

⁶ According to the 1991 and 2001 Census, "urban areas" were all statutory places with a municipality, corporation, cantonment board or notified town area committee, etc, and a place satisfying the following three criteria's: A population of over 5,000; those with at least 75 percent of the male labor force in the non-agricultural sector and those with a population density greater than 1,000 per square mile.

⁷ The National Sample Survey is conducted by the NSSO. Data on per capita consumption expenditure is collected quinquennially at the household level, using stratified random sampling.

been used to calculate estimates of district level income and poverty. Due to inherent lacunae in such calculations⁸, this paper uses data on poverty from Amaresh Dubey's calculations in Debroy and Bhandari (2003)⁹. The reference years for the poverty variables are 1993-94 for the 91 census and 1999-00 for the 2001 census. Although I do acknowledge that the reference years are not exact and there might be some limitations of using this data for the analysis, to my knowledge it is the best possible information on poverty at the district level.

While a comprehensive set of explanatory variables affecting IMR across districts of India is desirable, I am bound in my selection of variables by the limitation of the data set. A gamut of factors such as income levels, wage rates, medical facilities, which could potentially be good indicators for understanding IMR are simply not available at the district level. This definitely puts a limitation on my analysis and on the interpretation of my results.

Table 1.2 and 1.3 give the definitions and summarizes the means and the coefficient of variation of all the variables used for 666 districts in India. Note in Table 1.3 while the total number of observations for the panel data set should be 1,186 (593 districts for each year), I have data only 666 districts over the two years. This discrepancy in observations is due to the creation of new districts after the 1991 census. The new states (districts) created after the 1991 census have data only for the 2001 census. In some other cases, the data was simply missing or did not exist for the two time periods.

⁸ The NSS data is based on households and then aggregated at the state level. Strictly, the data is not collected at the district level and is not a census but a large survey.

⁹ For the purpose of identifying poor persons, a poverty line specified by the Planning Commission, Government of India in 1979 at 1973-74 prices was used. This poverty line is the cost of a bundle of commodities (share of expenditure on food items is over 80 percent and the remaining for other essential items such as clothing etc) that could provide a little over 2400 kilo calories to an average Indian living in the rural areas. For the urban areas, the commodity bundle used was similar, except that the average food energy requirements were fewer than 2100 kilo calories on the average. The cost of these bundles was worked out to be Rs 49.09 per person per day for the rural population. For the urban population it was Rs 56.64. The National Sample Survey Organization through periodic representative surveys from roughly 120,000 households collects information on household expenditure. The information on expenditure is collected at prevailing market prices. Consequently the Poverty Line has to be updated for price changes and this is done using the State and Sector specific price deflator.

Table 1.2: Definition of District Level Variables used in the analysis, India 1991 & 2001

Name used	Name of Variable	Definition
IMR	Infant Mortality Rate	The probability of dying before the first birthday
MWPR	Male Work Participation Rate	Male workers among the male population above 15 years
FWPR	Female Work Participation Rate	Female workers among female population above 15 years
MALE_LIT_AB_6	Male Literacy above the age of 6	Percentage of male literates above the age of 6
FEM_LIT_AB_6	Female Literacy above the age of 6	Percentage of female literates above the age of 6
AGR_WRK_IN_POP	Agricultural workers in the population	Percentage of agriculture workers in population
PER_FEM_AG_LAB	Percentage of female workers who are agricultural laborers	Percentage of agricultural workers among all female workers
PER_MALE_NON_AG_LAB	Percentage of male workers who are non agricultural laborers	Percentage of non agricultural workers among all male workers
POVERTY	Poverty	Headcount of poor (1993-94 values used for the 1991 census and 1999-00 used for 2001 census)
PER_SC	Percentage of SC	Percentage of Scheduled caste in the population
PER_ST	Percentage of ST	Percentage of Scheduled tribe in the population
PER_LIT	Percentage of literates	Percentage of literates in the population
PER_URBAN	Percentage of Urban population	Percentage of urban population among total population

Table 1.3: Descriptive Statistics of District Level Variables, India 1991 & 2001

VARIABLE	OBS	MEAN	STD. DEVIATION	MAX	MIN
Infant Mortality Rate	666	75.64	24.75	22	166
Male Worker Participation Rate	666	51.57	5.75	22.98	99.52
Female Worker Participation Rate	666	24.91	12.56	1.75	89.42
Male Literacy	666	68.67	13.64	26.29	97.46
Female Literacy	666	43.89	18.32	7.68	94.35
Percentage of Female Agricultural Laborers	666	39.59	18.57	0.14	79.85
Percentage of Male Non-Agricultural Laborers	666	40.13	18.18	9.54	99.89
Poverty	666	25.76	16.22	1.75	83.76
Percentage of Scheduled Caste	666	16.89	7.10	1.44	51.76
Percentage of Scheduled Tribe	666	7.86	13.45	0	86.85
Percentage of Urbanization	666	23.50	16.77	2.74	100
Year Dummy	666	0.5	0.5	0	1

Source: Calculated from the 1991 and 2001 census data by the author.

Results and Discussion

Ordinary Least Squares Regression

Table 1.4 below shows the results of the OLS regression of IMR on a set of explanatory variables.¹⁰ These results not only tell us the signs and statistical significance of different coefficients but they also make it possible to assess the quantitative effects of different variables on IMR. In arriving at the estimates in Table 1.4, I began with a fairly general specification (1) and went on to add a quadratic term (3) and also a log-log specification (5). With respect to IMR, the following observations are particularly noteworthy.

Female work participation rate: Higher female work participation reduces the extent of IMR and this effect is statistically significant. This result is in accordance to earlier study. The sign on the coefficient in all the 5 specifications (Table 1.4) is negative and significant at the 5% level. A mother who works outside the house has greater resources, better access and information to health care facilities and hence can take better care of the child, implying lower mortality rates in the household. A 1% increase in the female work participation rate decreases IMR by 6% (refer to specification 5). However one must be careful when examining the effect of female work participation rate on infant mortality. It is important to control for both economic and social disadvantages that motivates the women to seek gainful employment outside the household. So for example the level of poverty might be an important factor that determines the female's participation rate, and hence its effect on mortality rate.

Female Literacy: Female literacy has a negative and statistically significant effect on infant mortality. A 1% increase in female literacy leads to 23 % drop in IMRs on average (specification 5). These results further enforce the claims made in the existing literature, that there indeed is a strong association between female's education and infant mortality rates.

Percentage of female agricultural workers: Apart from the role of female work participation rate in reducing IMRs, percentage of women as agricultural laborers also seem to have a significant (at 5%) and negative influence of IMR. On average a 1 % increase in female agricultural laborers decreases IMRs by almost 2 %. The percentage of males working in non-agricultural areas has a

¹⁰ For a detailed description of the variables refer to the Data section.

significant (at 5%) and negative effect on IMR. A 1% increase in the percentage of male non agricultural workers decreases IMRs by almost 29%. This is a strong affect on IMR. More males working outside the agricultural sector could imply various possibilities, for one it could mean more work available for females in the agricultural sector. It could also lead to migration to urban areas, higher income and access to better services and resources. All these could indirectly play a role in reducing IMRs.

Poverty (as measured by the headcount ratio): Was found to be significant (at 5%) and positively associated with IMR. Higher levels of poverty are associated with higher levels of infant mortality. A 1% increase in the poverty level increases IMR by 4% on average. Poor people are less informed about health care issues, have fewer resources and access to medical facilities and are not able to take proper care of their child, resulting in higher mortality rates on average.

Scheduled Caste & Scheduled tribes: A higher proportion of Scheduled caste and Scheduled tribe in the population increases the extent of infant mortality. Increasing the percentage of scheduled class and scheduled tribes in the population increases IMRs by 13% and 3% on average respectively. The coefficients on both the variables are significant

Other variables: Contrary to other studies I found the effect of urbanization on IMR positive but significant. The sign could be reversed due to various other factors that might influence IMR in urban areas. These omitted factors might cause urbanization to have a positive influence on IMR. Male literacy was not found to be significant and that could be due to the strong correlation between male and female literacy.

Table 1.4: Results from the OLS Estimation of IMR, 666 Districts

	(1)	(2)	(3)	(4)	(5)
	IMR	IMR	IMR	LIMR	LIMR
Male Worker Participation Rate	0.137 (0.94)				
Female Worker Participation Rate	-0.236 (-2.28)*	-0.200 (-2.30)*	-0.184 (-2.09)*	-0.003 (-2.83)*	
Male Literacy above age 6	0.313 (1.52)	0.253 (1.35)	0.192 (1.04)	0.006 (2.51)	
Female literacy above age 6	-0.545	-0.492	-0.478	-0.009	

	(-3.25)**	(-3.23)**	(-3.20)*	(-4.74)**	
Percentage of female Agricultural laborers	-0.339 (-6.16)**	-0.338 (-6.11)**	0.148 (0.82)	-0.004 (-5.50)**	
Percentage of male Non-agricultural laborers	-0.663 (-6.13)**	-0.679 (-6.45)**	-0.645 (-6.08)**	-0.009 (-6.48)**	
Poverty	0.296 (4.10)**	0.291 (4.05)**	0.293 (4.12)**	0.003 (3.68)**	
Percentage of Scheduled Caste	0.437 (3.82)**	0.445 (3.89)**	0.402 (3.52)**	0.007 (4.95)**	
Percentage of Scheduled Tribe	0.408 (4.83)**	0.408 (4.80)**	0.372 (4.39)**	0.006 (5.51)**	
Percentage of Urbanization	0.294 (3.93)**	0.311 (4.64)**	0.314 (4.91)**	0.004 (4.36)**	
Square of percentage of female Agricultural workers			-0.006 (-2.74)*		
Log of Female Work Participation Rate					-0.059 (-3.06)**
Log of Female Literacy above age 6					-0.230 (-6.00)**
Log of Percentage of Female Agricultural laborers					-0.038 (-2.58)*
Log of Percentage of Male Non-agricultural laborers					-0.296 (-5.97)**
Log of Poverty levels					0.041 (3.01)
Log of Percentage of Scheduled Caste					0.136 (6.09)**
Log of Percentage of Scheduled Tribe					0.036 (5.85)**
Log of Percentage of Urbanization					0.075 (3.26)**
Year Dummy	2.505 (1.74)	2.450 (1.71)	2.658 (1.84)	0.088 (4.28)**	0.120 (4.92)**
Constant	90.443 (6.73)**	98.698 (10.56)**	93.746 (9.82)**	4.477 (40.55)**	5.707 (33.46)**
Observations	666	666	666	666	666
R-Squared	0.44	0.44	0.45	0.48	0.41
Absolute value of t statistics in parentheses					
* Significant at 5%; ** significant at 1%					

Source: Author's calculations

I also test the hypothesis, that for given values of explanatory variables included in the analysis, child mortality is higher in areas of higher gender inequality. Areas with high levels of gender inequality tend to suppress the role of women in society, this could lead to higher infant mortality rates (as the health of the child depends a lot on the women). In order to conduct this test, I used the juvenile sex ratio (number of females, per 1,000 males in the age group 0-10 years) as my exogenous variable in the equation of infant mortality. The validity of this procedure is based on the implicit assumption that juvenile sex ratio is not affected by IMR. Juvenile sex ratio here serves as a proxy for gender inequality. I found that holding other factors constant, child mortality is lower in district with a higher juvenile sex ratio, the effect was statistically significant¹¹. This supports the hypothesis that in districts with lower gender inequality, infant mortality rates are higher.

Fixed Effects

Due to diversity of cultural norms in India, each state is strikingly different from the other. It has its own norms and cultures which might influence and govern the attitudes towards female children, female work participation rates and other factors important to IMR. I tried to capture these unknown and unquantifiable unique factors by introducing state and district dummies respectively. While there is no denying that there might exist vast cultural, socio-economic differences within a state (especially the larger ones), I will assume that they are acting as rough cultural boundaries capturing mostly non quantifiable factors. Thus the state dummy would attempt to capture any state specific impact that might not have been captured by the existing variables in use. With the introduction of these state dummies most of the significant variables were rendered insignificant. With reference to table 1.5 below, specification 1 shows the simple OLS regression results. In Specification 2, the states dummies have been introduced. Female literacy and percentage of male non-agricultural laborers were the only two significant variables. The state dummies were found to be jointly significant¹². This indicates that there exists some heterogeneity across states which might affect IMR and is not being captured by these existing covariant. Specification 3 is with just the district dummies. These again were found to be jointly

¹¹ The coefficient on juvenile sex ratio is -0.06, with a t-ratio of -3.79.

¹² The F statistics was F(16,640) with Probability>F = 0.000

significant¹³. Finally in specification 4 I introduced state*time interaction terms which were found to be jointly significant, indicating that there are some time varying state effects affecting IMR and that is introducing heterogeneity across states.

Table 1.5: Results from the OLS Estimation of IMR with state and district dummies, 666 Districts

	(1)	(2)	(3)	(4)
	IMR	IMR	IMR	IMR
State Dummies	NO	YES	NO	NO
District Dummies	NO	NO	YES	NO
State*Time Interaction	NO	NO	NO	YES
Female Worker Participation Rate	-0.163 (-2.04)*	-0.154 (0.19)	0.449 (3.07)*	-0.102 (-1.25)*
Female literacy above age 6	-0.320 (-3.99)**	-0.401 (-4.98)**	-0.471 (-3.15)**	-0.309 (-3.14)**
Percentage of female Agricultural laborers	-0.353 (-6.69)**	-0.007 (-0.14)	-0.318 (-2.12)	0.009 (0.18)
Percentage of male Non-agricultural laborers	-0.680 (-6.42)**	-0.212 (-2.30)**	-0.138 (0.72)	-0.311 (-3.41)**
Poverty	0.302 (4.18)**	0.067 (1.17)	0.054 (0.34)	0.014 (1.35)
Percentage of Scheduled Caste	0.445 (3.87)**	0.148 (1.15)	1.302 (1.73)	0.106 (0.86)
Percentage of Scheduled Tribe	0.387 (4.44)**	0.092 (1.41)	-0.069 (-0.15)	0.110 (1.76)
Percentage of Urbanization	0.307 (4.51)**	0.064 (0.88)	0.044 (-0.20)	0.075 (1.05)
Year Dummy	2.604 (1.86)	0.855 (0.49)	-3.667 (-1.27)	7.540 (1.69)
Constant	108.11 (19.13)**	73.88 (11.66)**	17.06 (1.04)	74.47 (11.29)**
Observations	666	666	666	666
R-Squared	0.44	0.62	0.74	0.66
Absolute value of t statistics in parentheses				
* Significant at 5%; ** significant at 1%				

Source: Author's calculations

¹³ The F statistics was F(331, 325) with Probability>F = 0.000

Simultaneous Quantile Regression

In the previous section I estimated regression equations at the average (i.e. at the conditional mean level of infant mortality rate). However for any policy to be effective, it would make more sense to evaluate the effect of the above mentioned covariates at different levels of the infant mortality distribution. Policy makers could be more effective in terms of total lives saved if they allocated spending to the places where it would be most effective) In this section I estimate the reduced-form IMR equations at different points of its conditional distribution, using the quantile regression technique ((Koenkar and Hallock, 2001). This also helps me address the issue of heterogeneity in my district level data. The word “quantile” refers to one of the class of values of a variate that divides the total frequency of a sample or population into a given number of equal proportions¹⁴. So for example the median is the 50th quantile (percentile) and divides the population (sample) into two halves: one would have values greater than the median and the other half lesser than the median. The OLS estimator minimizes the sum of least squares and estimates a conditional mean function. In contrast, the method of quantile regression is based on minimizing the sum of asymmetrically weighted absolute residuals and provides estimates for the conditional median function, and the full range of other conditional quantile functions. Because of the potential non-independence of the error term, the errors in the decile may be heteroscedastic and the quantile regression variances may be biased. To resolve this problem, bootstrap estimates of the asymptotic variances of the quantile coefficients are calculated with 100 repetitions and are used in the reported asymptotic t-ratios. This method provides a greater insight into the various quantiles of the distribution of the IMR, which is not possible with the OLS alone. Figure 7 shows the distributional graph of IMR¹⁵.

Figure 7: The Distribution of Infant Mortality Rate, 1991 and 2001

¹⁴ Source: Dictionary.com

¹⁵ Source: Census of India, 1991 and 2001

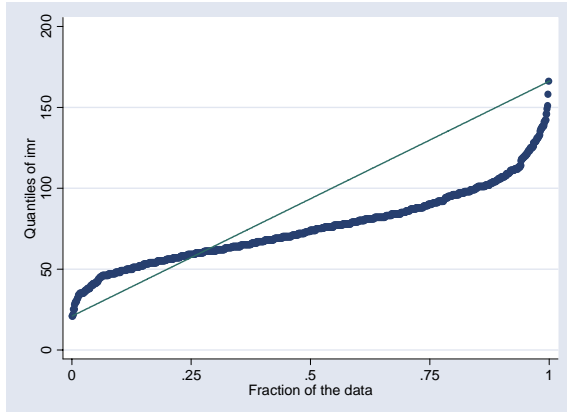


Table 1.6 below shows the simultaneous quantile regression results for each selected quantiles. ‘For comparison purposes I also report the OLS estimates. To capture any possible time affect, I introduced a time variable:

T = 0 if year is 1991
 = 1 if year is 2001

The quantile regression results suggest important differences at different points of the distribution. The effect of Female work participation rate is highest (in magnitude) and significant in the lowest 10% of the IMRs conditional distribution. As the distribution of IMR improves the affect is still significant but lesser. This indicates that increasing female work participation rate in districts with worst IMRs will be less effective than doing so in districts which are comparatively better off. Female literacy rates on the other hand had a strong and increasing negative affect on IMR as the quantiles increase. So for the districts which lie in the middle and the higher quantiles providing one more year of education to a female had a much stronger impact on reducing IMRs than for the lowest 10 percent of the districts. The affect of the percentage of female in agricultural labor was similar to that of female literacy in terms of reducing IMRs. The higher the quantiles the stronger was the negative affect. The districts in the 50th and 75th quintile showed a stronger impact of female workers in agriculture on IMR.

Poverty, percentage SC and percentage ST all had a significant and positive affect on IMR. These increased with each quantile. Thus increasing poverty in districts which were already worst off to begin with, had a greater negative effect on increasing IMR compared to those that fell in the lowest 10% of the IMR distribution. Percent of urbanization was effective only in the higher levels of the distribution, though the impact on IMR was still positive.

The results of the 50th quantile looks similar to the results obtained from the OLS estimation. Female work participation, female literacy, female participation as an agricultural laborer, greater male movement to non agricultural work all help in reducing IMRs and do so more in districts which are worst off in terms of IMRs. On the other hand, poverty and percentage of SC/ST all associate positively with higher IMRs. These results do point out to an encouraging conclusion: Socio economic variables though important have a lesser impact on IMRs compared to economic variables. This might have significant policy implications in terms of targeting specific districts to reduce IMRs.

Table 1.6: Results from the Simultaneous Quantile Regression and OLS

Independent Variable	Quantiles										OLS	
	0.10		0.25		0.50		0.75		0.90		Coeff.	T-ratio
	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio	Coeff.	T-ratio		
Female work participation rate	-0.22	-2.20	-0.26	-2.55	-0.18	-2.23	-0.15	-2.00	-0.13	-1.14	-0.16	-2.04
Female literacy above the age of 6	-0.28	-3.65	-0.35	-2.96	-0.41	-4.73	-0.37	-3.60	-0.39	-3.12	-0.31	-3.97
Percentage of female agricultural workers	-0.17	-3.98	-0.32	-6.70	-0.40	-10.02	-0.45	5.85	-0.31	-4.23	-0.35	-6.69
Percentage of male non-agricultural workers	-0.29	-2.48	-0.41	-3.95	-0.59	-5.32	-0.77	-6.34	-0.58	-4.41	-0.68	-6.42
Poverty	0.18	3.10	0.25	4.10	0.33	4.74	0.26	2.83	0.45	3.51	0.30	4.18
Percentage of scheduled caste	0.36	3.16	0.42	3.95	0.45	4.27	0.39	2.19	0.48	2.21	0.44	3.87
Percentage of scheduled tribe	0.27	3.46	0.31	5.09	0.34	4.56	0.44	3.32	0.50	2.30	0.38	4.44
Percentage of urbanization	0.04	0.60	0.15	2.68	0.26	4.25	0.38	4.80	0.35	3.74	0.30	4.51
Year	10.84	12.97	9.85	4.97	5.69	3.55	-0.005	-0.00	-15.39	-3.43	2.60	1.86
Constant	72.12	12.97	89.78	12.64	108.72	18.09	129.80	17.80	132.86	18.8	108.11	19.13
N	666										666	
R-Squared	0.27		0.27		0.29		0.29		0.29		0.44	

Note: Asymptotic t-ratios are shown above (heteroscedasticity robust for OLS; bootstrapped for quantiles). Figures in bold indicate statistic significant of the estimated coefficient at the 10% or lower level.

Source: Author's own calculations

Non Parametric Analysis

In the last section I discussed the results of quantile regression analysis which happens to be a more specific form of non-parametric. It takes into consideration heterogeneity but only across

low and high mortality districts. Non-parametric analysis is a more general form with no restrictions on the above. Let's consider a simple equation like $y_i = \alpha + \beta x_i + u_i$, parametric methods specify a form of $m(x_i)$. But typically the exact functional form connecting $m(x_i)$ with x is not known. If we force a linear or a quadratic function it may affect the accuracy of estimation of $m(x_i)$, hence we deploy the nonparametric method of estimation of the unknown function.

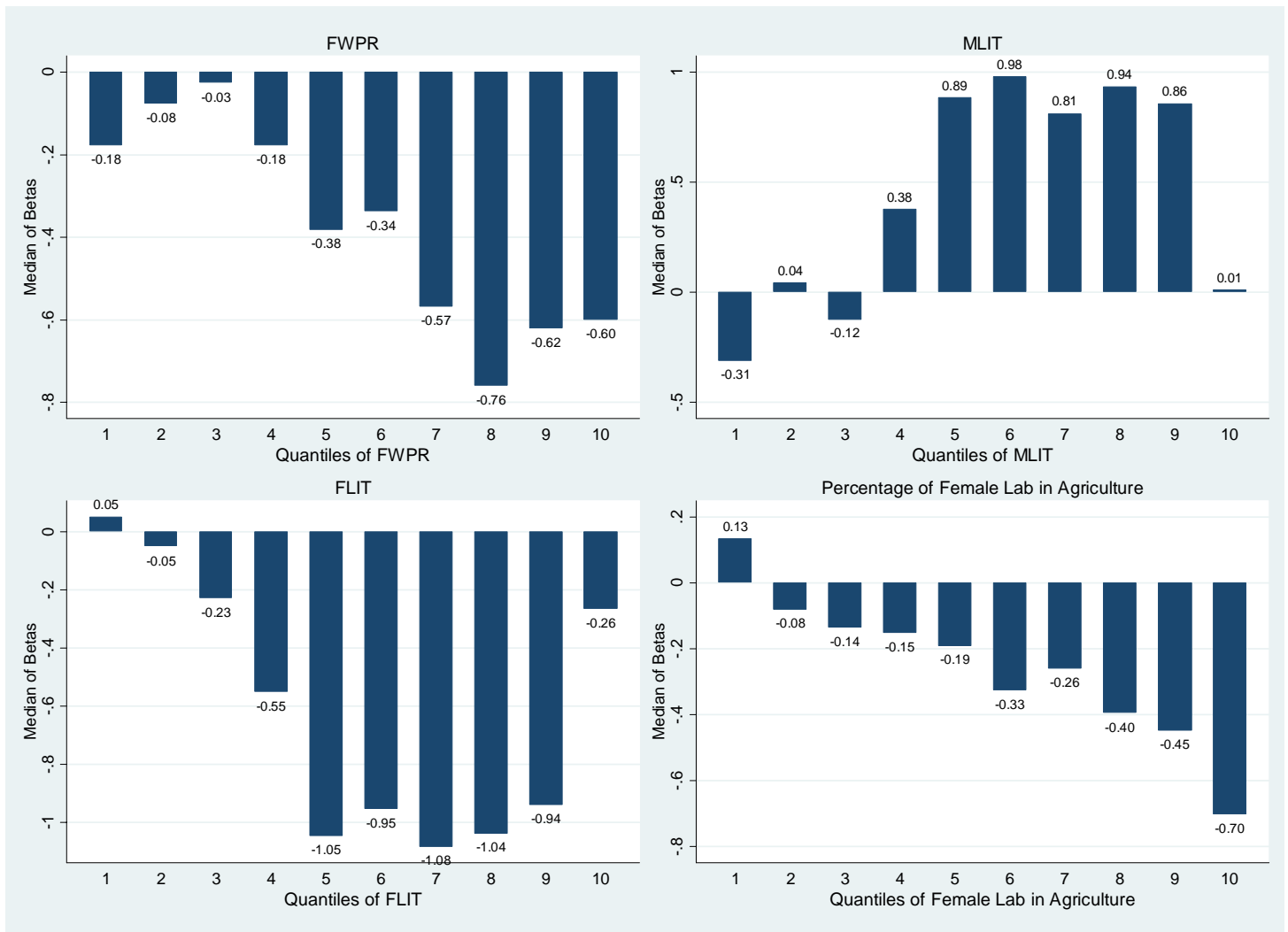
In this paper I have used the method of local linear regression estimator. It minimizes the following function: $\sum_i (y_i - m - (x_i - x)\beta)^2 K[(x_i - x)/h]$, $i=1$ to n , with respect to m and β . The estimated is found by performing a weighted least squares regression of y_i against $z_i = (1, (x_i - x))$ with weights $K_i^{1/2}$. Thus the local linear approximation fits a straight line. The advantage of using local linear estimation is that it can be analyzed with standard regression techniques. It also has the same first-order statistical properties irrespective of whether the x_i is stochastic or non stochastic. Pagan and Ullah (1999).

In order to obtain the β for each of the covariates, a non parametric regression was run of IMR on the relevant covariates. This produced 666 β s for each covariate. The median value of the β s was then taken over the respective quantiles of the covariates. The graphs (Figures 8.1 and 8.2) below show the quantiles of each covariate (X-axis) plotted against the median of the β s (Y-axis).

In the case of female work participation rate, as the participation rate increases, IMR drops by a greater level. This is expected; working mothers have better resources and are more informed regarding the care and upbringing of the child. So as the percentage of women working outside the house increases, infant mortality rates in those districts should fall. Thus in districts where work participation rate is higher its impact on reducing IMR is stronger.

According to the non-parametric estimates male literacy does not seem to have the desired affect on IMR. Only in districts where the levels of literacy are low, the affect is negative and significant. At higher quintiles of literacy the sign changes to positive (contrary to expectations). Educating more males in a district increases infant mortality rates in most of the quintiles. Once again as discussed earlier, this opposite affect could be due to the high correlation between male and female literacy. The introduction of both in the analysis could reduce the significance and the magnitude of the affect of male literacy on IMR.

Figure 8.1: Median of Betas over the quantiles of the covariates



Source: Author's calculations

Female literacy on the other hand has a strong and negative affect on IMR across almost all quintiles. With an increase in female literacy levels, reductions in IMRs are much higher and stronger. Educating more females leads to significant reductions in IMRs across those districts. The impact is strongest in the middle quintiles. By the time you reach the worst quintile the impact is still negative but weaker.

Again higher the percentage of female laborers in agriculture, higher is their affect on reducing IMR. Districts with low percentage of female agricultural laborers are faced with lower reduction in IMR. As discussed this could be because the mother who do not work are less aware of medical

care facilities, have access to fewer resources and probably have less income to take better care of the child. On average the affect of female laborers in agriculture on IMR is negative.

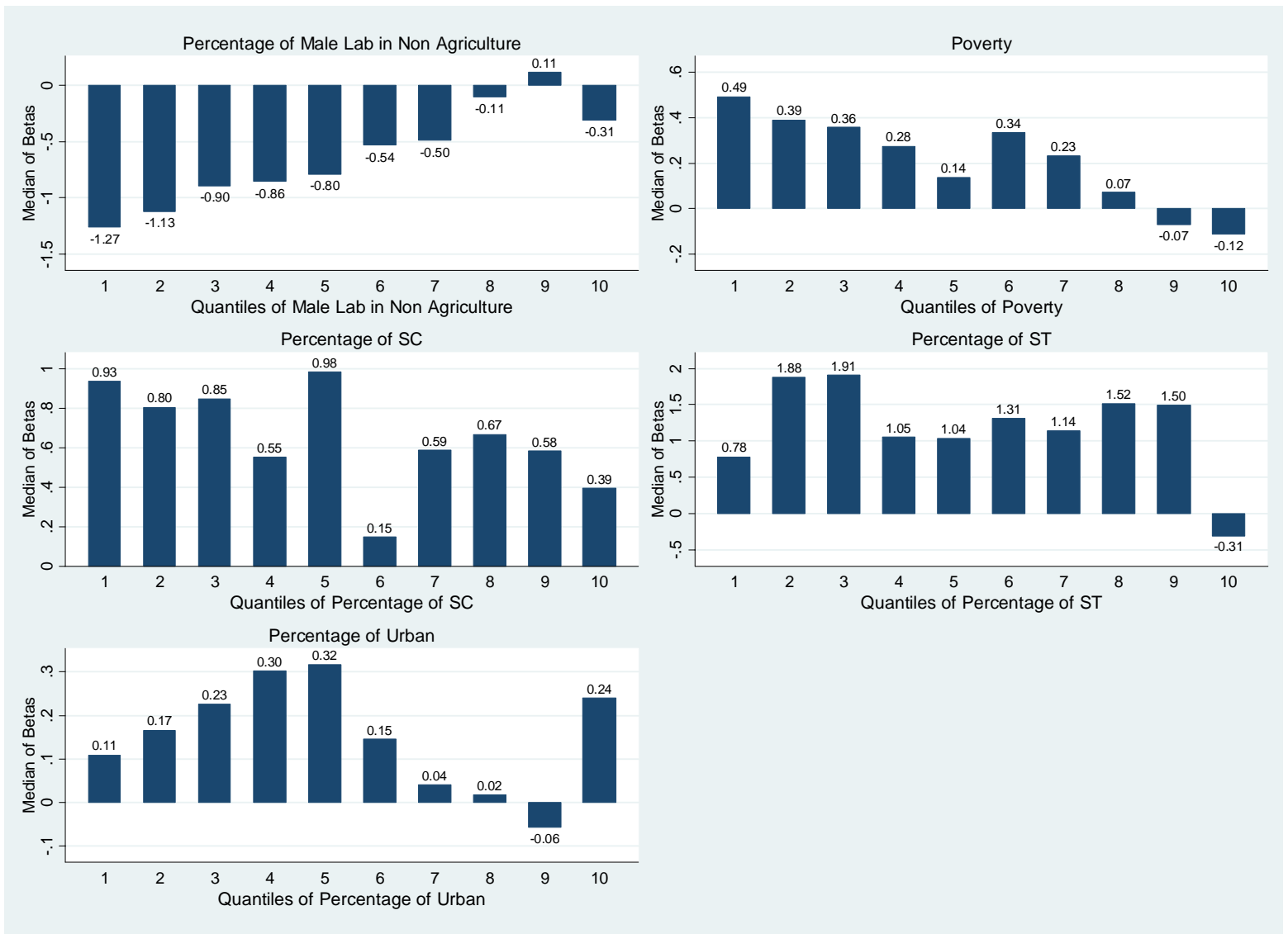
While the affect of the percentage of male laborers in non agricultural work on IMR is negative, surprisingly it is strongest in the lower quintiles (Refer to Figure 8.2). One would expect that increasing the percentage of male laborers in non-agricultural work would reduce IMR to a larger extent but my results show that the impact is strongest in districts with the lowest percentage of male workers.

Poverty does not seem to have the desired results. According to the graph below, lower levels of poverty increase IMR. This is not in accordance with the parametric results. The impact should have been negative in the lower quintiles. Though the graph does show that the in the lower quintiles the impact is the strongest, it is in the opposite direction.

With regards to the SC, ST population, the impact on IMR is positive in all the quintiles. This is in agreement with the parametric results. As the percentage of SC/STs are increased in the population, infant mortality increases.

Increasing the percent of urban population should have a negative affect on IMR, however both my parametric and non-parametric results show a positive effect on IMR. Though the impact is small it becomes stronger with subsequent quintiles. While theoretically one would believe the urbanization leads to lower IMR, this data suggests otherwise. One of the reasons for this could be that there are a lot other factors in the urban areas which might influence IMR and have not been captured here in this analysis. Maybe there is greater poverty in urban areas or parents spend less time on child care etc. A lot of unexplained and omitted factors might be the cause of this positive association between IMR and urbanization.

Figure 8.2: Median of Betas over the quantiles of the covariates



Source: Author's calculations

The above non-parametric analysis lends support to my parametric results. Economic variables like female work participation rate, female literacy and the percentage of female laborers in agriculture all had a strong and negative impact on IMR. The affect was stronger in districts were IMRs was higher. Some of the male variables and urbanization has a strong affect though in the opposite direction.

Conclusion

Based on all the empirical analysis above, the results can be summarized as follows:

First, female work participation rate, female literacy and the percentage of female laborers in agricultural work seemed to have the strongest affect on IMR. Improving the quality of female human capitals does seem to have a significant and positive affect on reducing IMRs.

Second, male variables like male literacy do play a small but not a very significant role in reducing infant mortality. The increase in percentage of male workers outside of agriculture does seem to indirectly reduce IMRs through factors discussed earlier.

Third, other economic and cultural factors like poverty, percentage of SC/STs surely contribute to reducing infant mortality. Thus any improvements in these variables will have direct or indirect affects on the child.

Finally, the impact of the covariates discussed above is strongest in districts with high levels of IMRs. So from a policy perspective programs and aid should be devised keeping in mind the districts which fall in the middle of the IMR distribution and not at the extremes.

The findings of this study clearly demonstrate the role of woman's agency and empowerment in reducing infant mortality. Furthermore the quintile analysis helps us identify that the results are strongest in districts with high IMRs. This is helpful in targeting policies in the districts that lie in the middle of the distribution and not the extremes. Economic variables like work participation rate, poverty played an important role in reducing IMRs. The results of this paper are similar to those found by Murthy et. al. (1995). In this paper I have attempted to analyze the district level IMRs in India using the 1991 and 2001 Census data. High IMRs across districts of India is an issue of concern. This paper serves the task of comprehensively discussing the issues in the recent Indian context. Using parametric and non-parametric techniques various important factors have been identified which could be targeted to improve the Infant mortality rates across districts and help in achieving the Millennium Development Goals of target IMR of 27.

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