Spending to Save?
State Health Expenditure and Infant Mortality in India

Sonia Bhalotra[♣]

Department of Economics & CMPO, University of Bristol

Abstract

This paper analyses the effects of state health expenditure on infant mortality in India, using individual data on about 120000 rural births that occurred during 1970-1998 across the fifteen major Indian states. The main finding is that health expenditure has a significant mortality-reducing effect, with a lag of three years. The long run elasticity is -0.19. The paper underlines the importance, in studying this relationship, of controlling for confounding effects of unobservable time-varying factors, and of allowing for lagged effects.

Address for correspondence: Sonia Bhalotra, Department of Economics, University of Bristol, 8 Woodland Road, Bristol BS8 1TN. Email: s.bhalotra@bristol.ac.uk.

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1. Introduction

Motivation and Context

In poor countries, 30% of deaths are amongst children, compared with less than 1% in rich countries (Cutler et al. 2005, p.15). As a result, variation in life expectancy in developing countries is created mainly by variation in childhood mortality. The main causes of childhood death are poor maternal health and infectious diseases, and most of these deaths are avoidable (e.g., Jones et al. 2003, Black et al. 2003). It is estimated that, in 1995, more than nine million children under the age of five died avoidable deaths (Filmer and Pritchett 1999).

Analyses of the historical decline in childhood mortality rates in today's industrialised countries suggest that important drivers of this decline were improved nutrition, public health, and medical technological progress (see Fogel 2004, Cutler and Miller 2005, Cutler et al. 2005, Deaton 2005). While improved nutrition tends to be associated with income growth, improvements in education, water and sanitation, immunization and targeted programmes against diseases like malaria and diarrhoea tend to be associated with growth in public expenditure. Medical progress may, in principle, diffuse across geographic boundaries with no tight connection to incomes and public expenditure. Secular tendencies in income, public expenditure and technology may be difficult to disentangle. Yet it is relevant for policy design to ask what the impact is of small changes in, for example, public health expenditure, controlling for growth in income and technology. This is the aim of this paper.

The analysis is conducted for India, which accounts for one in six of the world's people, one in four of under-5 deaths, and one in three of the world's poor. The health outcome that is analysed is infant mortality, which is death in the first year of life. In the sample period (1970-98), almost one in ten children died in infancy, accounting for 77% of under-5 deaths. There is considerable temporal and spatial variation in mortality rates in India, and this study investigates the extent to which variation in health expenditure can explain this. Like the United States, India has a federal political structure. Health is a "state subject", which means that the level and allocation of health expenditure are decided at the state level, although the central government makes transfers to states that are tied to public health programmes. The states differ markedly in other relevant dimensions, including political institutions, ethnic composition and climate.

Related Literature

The available literature on the effects of public health expenditure on mortality (or other indicators of health) is surprisingly limited. Paxson and Schady (2005) show that infant mortality spiked (it was 2.5 percentage points higher) during the Peruvian financial crisis, coincident with a 30% fall in per capita GDP between 1987 and 1990. They show that public health expenditure fell by 58% in this period, its budget-share falling from 4.3 to 3%. They conclude that this, together with a decline in private health expenditure, is a likely explanation of the rise in infant mortality in this period. While this analysis of trends broken by a big exogenous shock is persuasive, it is difficult to generalise from. In particular, changes in health expenditure might impact mortality only when they are very large.

In an influential study, Filmer and Pritchett (1999) investigate this relationship using cross-sectional data on 98 developing countries in 1992/3. They conclude that health expenditure has a very small and statistically insignificant effect on infant and under-5 mortality. They find that 95% of the variation in mortality across countries is explained by income per capita, income inequality, female education, ethnic fractionalisation, and whether the country is more than 90% Muslim, each of these variables showing a significant impact. This is an important study with striking results. But the results are not incontrovertible. Indeed, using cross-sectional data for 22 developing countries in 1985, Anand and Ravallion (1993) find that health expenditure raises life expectancy and that, conditional upon this, income has no effect. Similarly, using data for 50 developing and transition countries observed in 1994, Gupta, Verhoeven and Tiongson (1999) find that health expenditure reduces childhood mortality rates. Non-robustness may be expected for at least two reasons. First, as the authors recognise, the data on both mortality rates and public health expenditure are unlikely to be comparable across countries. Second, these studies suffer the problems common to cross-country regressions, most eminently, unobserved heterogeneity that might be correlated with the variable of interest (e.g., Temple 1999, Durlauf et al. 2005).

A recent World Bank report includes an analysis of infant mortality and health expenditure using a panel of data for the Indian states during 1980-99 (World Bank

2004: pp.45-50). This study finds no effect of health expenditure on mortality rates once state fixed effects and a linear time trend are included in the model. I find a similar (preliminary) result below. The World Bank study further investigates the relationship for a reduced sample of four years and fourteen states (N=56) for which information on female literacy is available. For this sample, an interaction term between health expenditure and state income is included and the results suggest a negative effect of health expenditure but only in the poorer states. I am unable to replicate this result on my larger data sample. However, as the following discussion shows, there are differences in the sample period but also in data structure, data sources and estimator.

Outline and Contributions

This paper uses individual mortality data that I derive from a national household survey, organise by birth-cohort, and merge with a twenty-nine year panel of state-level data on health expenditure and income. The survey has a rich set of individual-level covariates of mortality that I condition upon. The individual data are "nested" in a state-year panel, the risk of death in the first year after birth being matched to state health expenditure (and income) in the state and year of birth. The panel aspect of these sub-national data offers some clear advantages relative to previous cross-sectional or time-series analyses, as well as relative to analyses of cross-country panels.

An important advantage is that it permits controls for time-varying unobservables. If, for example, health expenditure were correlated with health technology, then the effects of (unobserved) variation in health technology would tend to load on to the expenditure effect. This would create a bias in the expenditure effect which may be positive or negative, depending upon the correlation between expenditure and technology. This bias can be avoided by including time dummies in a panel data setting to the extent that trends in unobservables like technology are common across the regions. Although this is not an innocuous assumption when the regions are countries,[1] it is relatively plausible for states within a country. This

[1] Temple (1999), for example, shows that countries have different rates of technical progress in growth regressions, casting doubt that technology is a public good. This said, diffusion of health technology across countries may occur more effectively than diffusion of production technology.

assumption is made even more plausible by further including state-specific trends in the model.

Since health expenditure varies across state-year, we cannot, of course, include state-year dummies that would control comprehensively for state-specific health shocks. As a result, health expenditure is potentially endogenous in the equation for infant mortality. Consider, for example, that a particular state suffers an epidemic, a flood or a famine, the effects of which persist for two years. Suppose that, in this time, more infants die, and the state raises health expenditure. This will show as a (spurious) positive relationship between infant mortality and health expenditure. Ideally, I would have state-year data on all such shocks and control for them. In the absence of such data, I allow several (four) lags of health expenditure. With an appropriately flexible lag structure, I would hope to avoid contemporaneous correlation of mortality and health expenditure induced by state-specific shocks. Lags are also useful to explore because health expenditure might take more than a year to take effect on the field. I am not aware of previous research that has investigated lagged effects, and this may explain some of the previous findings of small or insignificant effects.

The rest of this paper is organised as follows. Section 2 describes the data and Section 3 presents relevant descriptive statistics. An empirical model is set out in Section 4 and results are discussed in Section 5. Section 6 discusses the results, and Section 7 concludes.

2. The Data

The micro-data are derived from the second round of the National Family Health Survey of India (NFHS-2)[2]. This contains complete fertility histories for ever-married women aged 15-49 in 1998-99, including the time and incidence of child deaths. I use these to construct individual-level indicators of infant mortality.[3] The children in the sample are born in 1961-1999. This paper isolates rural births since both poverty and mortality are concentrated in rural areas.

As the data are retrospective, they are wedge-shaped, there being fewer observations for children born earlier in time. Moreover, the thinning of the data does

[2] For details on sampling strategy and context, see IIPS and ORC Macro (2000).

[3] I also did the analysis for under-5 mortality. As the broad conclusions of this study are not different, these results are not discussed.

not occur randomly, but is a function of maternal age at birth. In particular, births recorded in the 1960s will have been, selectively, to young mothers. Births that occurred in the 1960s to older women will not be recorded in the data if these women are, in 1998/9, older than 49 years. In contrast, in and around 1998/9, births in the sample will be fairly representative of births across the maternal age range 15-49. Towards addressing this problem, I drop children born in the 1960s, and I condition upon maternal age at birth.

Another issue that arises with retrospective data is that the mother is interviewed in a particular state at the time of the survey but it is possible that she was in a different location at the birth of the index child. This problem is addressed by making use of a question in the survey that asks the mother how long she has lived in her current location. The analysis is then restricted to births that occurred in the mother's current location. After applying this restriction, I retain 85.1% of births. With this restriction in place, I can be confident that I am relating mortality risk in the first year of life for every child to health expenditure in the state in which the child was born.

The conventional definition of infant death is death before the first birthday of the child. To allow for age-heaping at six-monthly intervals, evident in these data, I define this indicator to include the 12th month. The main results are not sensitive to this difference, but I retain the inclusive definition since this increases the ratio of ones to zeroes in the dependent variable.

The micro-data are merged with a panel of data on health expenditure and other relevant statistics for the 15 Indian states.[4] The merge is done by state and time, where calendar time in the panel is matched to the year of birth of the child in the micro-data (henceforth *t*). So for children born in year *t* in state *s* and exposed to the risk of infant death in *t*, I have matched information on health expenditure in state *s* and year *t*. To ensure that every child is allowed full exposure to the risk of infant

[4] The state time series for net domestic product, population and the consumer price index are from a database assembled by Ozler, Datt and Ravallion (1996) and extended by Besley and Burgess (2004), who were kind enough to supply me with their database. The health expenditure series were kindly given to me by Juan Pedro Schmid, who gathered them from Reserve Bank of India publications. Juan made the series consistent before and after 1985, the year in which the published categorisation of health expenditure was changed. Before 1985, state health expenditure included expenditure on medical and public health, family planning and water supply and sanitation. From 1985 onwards, family planning and water-sanitation expenditures appear separately in the accounts and need to be added in.

mortality, I exclude births that occur in the 12 months preceding the survey. The estimation sample contains about 120000 children of more than 37000 mothers born in 1970-1998 across the 15 major Indian states.

State health expenditure includes expenditure from state revenue (85%) and central government health allocations to the state (15%). I use actual as opposed to budgeted (planned) revenue expenditure (even if this makes it more likely that health expenditure is endogenous). State health spending covers rural and urban public health services; medical education, training and research; general administration; water supply and sanitation; and family welfare. The central government funds tend to finance public health and family welfare programmes. The expenditure series is cast in per capita terms, using state-level time-series of population. It is further deflated by the state-year value of the consumer price index for agricultural workers.

Public health expenditure in India was 1.3% of GDP in 1990, and this had declined to 0.9% in 1999 (NRHM 2005). India devotes a smaller share of its income to health spending than, for example, Bangladesh (1.4%) or Sri Lanka (1.8%) (see World Bank 2004, p. 29; these are figures for the year 2000), and it spends a disproportionate part of its health budget on (curative) hospital services which are less pro-poor than (preventive) public health expenditures (Peters et al. 2002).

3. Descriptive Statistics

For the descriptive analysis, the individual data on mortality are aggregated up to the state-year level using sample weights; state is the state of birth and year is year of birth of the child.[5]

Growth rates of the main variables by state are in Table 1, and Figures 1-4 are lowess plots of state-specific trends in these variables. The average incidence of infant mortality in India over this period is 9.34%. It declined at an average linear rate of 3.2% p.a.[6] Figure 1 shows that there is considerable state variation in both its level and trend. Health expenditure per capita in India has increased in real terms at an average linear rate of 6.6% p.a. In this same period, the average growth rate of state income was just under 3% p.a. The share of health expenditure in state income, accordingly, increased at about 3.6% p.a. Figures 2 and 3 show that the rate of

[5] The Figures and Table 1 use all-India data on mortality rather rural data. There is no qualitative change if I instead use only rural data on mortality.

[6] It is estimated that, by 2000, infant mortality in India had fallen to 6.8% (UNDP 2003).

increase in health expenditure and its share in income has slowed in recent years, even as the increase in state income has accelerated (Figure 4). These figures also show that, like mortality, health expenditure and income vary substantially across the Indian states in both level and trend.

Figures 5-8 draw non-parametric state-specific relationships between these variables. Figure 5 shows that the "raw" relationship between mortality and health expenditure is generally negative, as one might expect. Figure 6 plots these data again, after removing state-specific trends. What is striking is that, in the de-trended data, there is little evidence that increases in health expenditure are systematically associated with decreases in mortality. The relationships between infant mortality and state income are presented in Figures 7 and 8, in a similar format. Again, what is a clearly negative relation in the raw data, becomes much less clear after de-trending. Comparing Figures 6 and 8, more of the states exhibit a negative relationship of mortality with income than of mortality with health expenditure.

The rest of this paper explores whether these simple associations in the data persist after conditioning upon other covariates, and after allowing for lagged effects.

4. The Empirical Model

The baseline model is

$$(1)\ M^{*}_{ifst} = \alpha_0 + \alpha_s + \alpha_t + \mu_s t + \beta \ln H_{st} + \gamma \ln Y_{st} + \lambda_k X_{kifst} + \varepsilon_{ifst}$$

Subscripts s and t indicate state and year and i and f indicate the individual child and mother (or family) respectively. The individual data are "nested" in a state panel. M^* is a latent variable measuring the probability of infant death. It equals one if the child dies before the age of one, and zero otherwise. H is per capita real health expenditure, Y is per capita real net domestic product, X is a vector of k variables observed at the child or mother level. These are child gender, a dummy for birth-month of the child, age of mother at birth of the child, dummies for levels of education of each of mother and father, and indicators for ethnicity and religion of the household. Summary statistics of all variables in the model are in Appendix Table 1. State and year fixed effects are denoted α_s and α_t respectively, and $\mu_s t$ denotes state-specific trends. The elasticity of central interest is β. To avoid clutter, I do not display lags or non-linear terms in (1), but these are investigated and discussed in the Results section.

The state effects, $\alpha_{s,}$ control for all forms of time-invariant unobserved heterogeneity specific to a state. In this context, this is likely to include sluggish political institutions, cultural attitudes, geography, and initial conditions, including the initial level of mortality in the state. They will also pick up any persistent differences across the states in accounting conventions. The time dummies, $\alpha_{t,,}$ will capture all time-varying unobservables that are common across the states, including any common technology and income trends. The fact that time dummies permit a completely flexible form for time effects means that they will also capture common shocks such as famines, floods or epidemics.[7] The state-specific trends are included to capture unobservable time-varying variables that are specific to states, for example, fertility, or state-specific components of health technology.

Identification of β and γ relies upon there being independent fluctuations in health expenditure and income across the states.[8] The relatively long time dimension of the data makes it more likely that such "within-group" variation exists, and the analysis below investigates and confirms this.

I estimate (1) using the linear probability model (LPM), because this is more convenient when the model includes fixed effects, and because it is difficult to interpret non-linear effects in non-linear models like the probit and logit (see Ai and Norton 2003). I nevertheless compare the LPM with probit estimates and confirm that the results are similar. All standard errors reported in this paper are robust and clustered by state. These adjustments allow for conditional heteroskedasticity and for conditional autocorrelation within states (see Bertrand et al 2004, Cameron and Trivedi 2005, p.788, Donald and Lang 2001).

A strong advantage of the pooled model over state-specific (time-series) models is that it permits controls for common trends. Also, there is not enough data to obtain robust estimates of state-specific models. However, to gain at least an

[7] The mortality data, when aggregated up to a time series, show a large dip in 1973 for which there is no evident explanation. The time dummy for 1973 picks this up. To allow for inter-state variation in the "1973 effect", I also estimated the equations starting in 1974, and confirmed that the broad conclusions of this analysis are unchanged.

[8] In a model that also includes state-specific trends, it relies upon there being within-state variation around a linear trend.

indicative sense of the state-specific relationships, I also estimate the following simple linear model for each state:

$$(2)\ M^{*}_{ift} = \phi_0 + \eta t + \chi\, lnH_t + \nu\, lnY_t + \mu_k X_{kift} + \varepsilon_{ift}$$

5. Results

In this section, *health expenditure* refers to the logarithm of real per capita state health expenditure and *income* refers to the logarithm of real per capita net domestic product of the state.

Preliminary Results: State-Specific Estimates

Let us first consider the results of estimating equation (2) for every state: see Appendix Table 2. A static linear specification is used for parsimony. A negative effect of health expenditure appears in only three of fifteen states (Assam, Maharashtra, West Bengal) and a negative effect of income in only one (Bihar). The last row of the Table shows, nevertheless, that estimating this simple specification on the pooled state data gives a significant negative effect of income, but not of health spending. The second panel of the same Table shows estimates of (2) obtained after dropping the state-specific trend (t). Now health expenditure has a mortality-reducing effect in five states, Karnataka, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. These five states do not form a natural group in terms of being, for example, more poor, or in having more liberal governments. Income is now significantly negative in three states: Bihar, Madhya Pradesh and Rajasthan. These three states do have in common that they are all poor and have high levels of infant mortality.

As discussed in the preceding section, an important advantage of estimating models that pool the state series is that this allows us to factor out common trends.[9] This is especially important when analysing an outcome like mortality, given the evidence that trends in technology have contributed substantially to declines in mortality (e.g. Deaton 2005). The rest of this section therefore discusses results of estimating (versions of) equation (1).

[9] The models I estimate would be panel data models if I aggregated the binary dependent variable, infant mortality, to create a state-year aggregate rate. Instead, I use the individual data. As the individuals are nested in state-year cells, and health expenditure and income are measured at the state-year level, the estimated models share many of the advantages of panel data models. In particular, I can include year dummies to capture common trends.

Estimates on Pooled Data: Static Models

Table 2 reports estimates of the risk of infant mortality using, alternatively, a (log) linear and quadratic specification of state health expenditure. Every equation in this Table includes state income and the range of individual and household specific variables listed in the preceding section. To allow the reader to observe and assess the degree to which unobserved trended variables can confound the estimates of interest, for each specification, I report results before and after conditioning, successively, on time dummies and state-specific trends.

Here is what I find. When health expenditure is entered linearly and there are no time effects in the model, it exhibits an elasticity (at the mean) of -0.31, which is statistically significant (column 1). However, once time dummies are included, the effect of health expenditure is insignificant and close to zero (columns 2, 3). This is similar to the state-specific results plotted in Figures 5 and 6.

Allowing a quadratic specification of expenditure, I find evidence of significant nonlinearity (columns 4, 5). Mortality risk is hump-shaped in health expenditure, the relation being positive at low levels of expenditure and then turning negative.[10] In column 4, which excludes time dummies, the turning point occurs at about the third percentile of the sample distribution of health expenditure. In other words, the relationship is negative for most of the range of the data. The elasticity at the mean level of expenditure is a significant -0.45. However, once time dummies are included in the model, the effect of health expenditure on mortality is driven towards zero, even if it remains statistically significant (column 5). When state-specific trends are included, even significance is lost (column 6). In both cases (columns 5-6), the turning point is at the mean, very close to the median of the distribution.

The third panel in Table 2 (columns 7-9) reports results of using a quadratic in the logarithm of the share of health expenditure in state income. As we might expect, these results are essentially similar to those that obtain when I use a quadratic in

[10] A possible explanation of this finding, namely that health expenditure lowers mortality only when it is relatively high is that, at low levels of expenditure, most of it goes to politically prioritised areas such as preventive care in urban areas, while bigger budgets have room for allocations to lower-priority areas such as preventive care, water supply or sanitation, that are more likely to impact mortality. However, not too much is read into the curvature of this relationship because, conditional on time-effects, there appears to be no significant relationship between mortality and health expenditure in any of the specifications in Table 1. Note also that, column 9 suggests a U-shape rather a hump-shape. But, again, the relationship is statistically insignificant.

health expenditure, and so they are not discussed. I also investigated a specification in which I interacted health expenditure and income, following the results of the previous Indian study (World Bank 2004, pp. 45-50). The interaction term was negative but insignificant; these results are not displayed.

Overall, Table 2 shows that, if we neglect to control for unobserved time-variation, it appears that state health expenditure has a significant mortality-reducing effect, with an elasticity at the mean of -0.45. However, once we control for time-varying unobservables, deviations in health expenditure are not associated with deviations in mortality. In the preferred specification (column 6, or column 9), the elasticity of mortality with respect to health expenditure is effectively zero.

Notice that Table 2 shows a significant mortality-reducing effect of *income* in the first and third column of each panel. Although the income effect vanishes upon including time dummies (as did the health expenditure effect), it re-establishes itself upon inclusion of state-specific trends (which health expenditure did not).[11] In the preferred specification, which includes time dummies and state-specific trends, income is significant, and the elasticity at the mean is -0.26 (column 6).

Dropping income does not alter the result that health expenditure has no direct effect on mortality (see Appendix Table 3). This Table presents estimates of the equations in Table 2 when not only income but also the other conditioning variables (X) are dropped. I dropped X and income in sequence, and found that each change had only a minor effect. In sum, health expenditure appears to have no effect on mortality, once common time-varying unobservables are removed, and this result is not sensitive to controlling for other influences, not even of income.

Might these conclusions be sensitive to the choice of estimator? It appears not. Probit estimates of the main equations from Table 2 are compared with LPM estimates in Appendix Table 4. I also compare results with and without adjusting the standard errors (see Appendix Table 5). There is a substantial increase in standard errors in moving from column 2 to 3, or 5 to 6. The results show that allowing for clustering within states can influence inference and does influence significance of the income effect. However, health expenditure is insignificant even before clustering is allowed.

[11] This result is consistent with the state-specific trends capturing omitted variables that are positively correlated with mortality and negatively correlated with income, for example, fertility.

Each of the sets of state dummies, year dummies and state-specific trends is jointly significant at the 1% level in every specification in which they appear. I find that the restriction that the time dummies can be replaced by a linear trend is not satisfied by the data. Both, inclusion of time dummies rather than a linear trend, and inclusion of state-trends in the model have an impact on estimates of the key parameter.

Distributed Lag Models Estimated on the Pooled Data

As discussed in section 1, state-specific health shocks can raise both infant mortality and health expenditure, as a result of which the estimated coefficient on health expenditure will tend to carry a positive bias. This might be dominating any true negative effect in the results we have seen so far. I therefore investigate a distributed lag model: see Table 3. Now every column includes state and time dummies, and I display results with and without inclusion of state-specific trends.

The first panel (columns 1-2) shows the results from a model which includes current income, current health expenditure, and four lags of each. The income variables are jointly significant at the 5% level, while the health expenditure variables achieve joint significance at only the 13% level. Neither income nor health expenditure has a significant long run impact in column 1, which excludes state-specific trends. Conditional upon state-trends, there is a significant long-run impact of income, but health expenditure continues to have no significant impact. The same specification was estimated without controls for individual and household heterogeneity (X) and, in this case, the third lag of health expenditure was significant at 1% in column 2 (results available upon request).

For this reason, in the second panel of Table 3, I report estimates of a model that includes the third lag of each variable, and the fourth lag of income- in other words, a model that retains the significant terms from a fourth-order lag specification, absent the Xs. Now, conditional upon state-trends and Xs, the third lag of health expenditure has a highly significant impact. A 10% increase in health expenditure in period (t-3) results in a drop in the risk of infant mortality in period t of 0.002 probability points (or 1.9% at the sample mean). The long run elasticity is -0.19, which is significant in column 4. Notice that the long run elasticity with respect to income is -0.30, which is about 30% bigger.

The results for income are roughly in line with the results in Table 2 (column 6). However, Tables 2 and 3 offer rather different results concerning the effects of health expenditure. In sum, we need to allow a three-year lag, and we need to condition upon state-specific trends, and only then does what would appear to be a robust and significant impact of health expenditure emerge. A likely explanation of this is that health expenditure is endogenous in a model of infant mortality, and that this endogeneity is being addressed by factoring out state-specific trends, and by lagging the health expenditure variable.

6. Discussion

The analysis in this paper shows that failing to allow for lagged effects and/or to factor out the effects of time-varying unobservables can result in an under-estimation of the beneficial effects of health expenditure. Using a fairly flexible specification, this paper finds that increases in state health expenditure have a significant negative impact on the risk of infant mortality in India. However, the effect is not large. This is especially disappointing as, at high levels of infant mortality (9.3% in the sample period) and with most infant deaths being avoidable (see section 1), there would seem to be considerable scope for public health spending to save young lives. This section considers why the effects might be small and, accordingly, how state spending can be made more effective.

First, infant mortality is concentrated amongst poor households (e.g. Wagstaff 2000), and health expenditure in India is, mostly, non-progressive (Peters et al. 2002, World Bank 2004: chapter 2). Health expenditure can be made more progressive by shifting allocations in favour of public health, water and family welfare programmes in rural areas and, within rural areas, by improving access for politically and socially disadvantaged groups. Even relatively progressive elements of health expenditure, such as piped water provision, may produce only limited benefits for the poor if maternal education or other inputs are complements to piped water in the production of child health (e.g., Jalan and Ravallion 2003). Small effects of state health expenditure are then consistent with low levels of education and awareness, and with income poverty amongst the households where deaths are most likely. In sum, it may be possible to improve health with no increase in health expenditure, simply by re-allocating existing expenditures from, say, curative to preventive care, or by ensuring that people utilise available services effectively by, for example, educating mothers or disseminating public health information within communities.

Second, there are governance and delivery problems which break the causal chain running from health expenditure to improved health (see Filmer, Hammer and Pritchett 2000). For instance, Rajkumar and Swaroop (2002) find that in countries with better governance, health outcomes are more responsive to changes in health expenditure. Developing countries have particularly weak institutions. This includes bad roads that impede delivery of medical supplies or travel to medical centres, and vulnerability of local institutions to corruption or to political capture. Governance and delivery problems in India appear to be more severe in the poorer states, where infant mortality is concentrated. There is evidence from the poor states of high rates of absenteeism of doctors and paramedics, poor availability of drugs and other medical supplies, and crumbling infrastructure in state-funded health centres (Public Affairs Centre 2002). For example, 43% of primary health care workers in the country as a whole are absent from their place of work, this figure being 58% in the poor state of Bihar (World Bank 2004, p.31). There is increasing awareness of the importance of effective public service delivery over and above public expenditure (e.g. World Development Report 2003), and of the political economy issues that this involves (see Besley 2006). More effective spending in India will, amongst other things, require improving accountability amongst employees in the public health sector, while at the same time improving their working conditions. It is especially likely in the health sector that seeing results would inspire greater commitment, it being more difficult for workers to appear on the job when supplies do not appear, and a culture of indifference is allowed to develop. Also pertinent is recent research on incentives in public sector organisations where workers are motivated not just by profits but by the "greater good" that they are doing. This emphasises the importance of aligning the mission incentives of principals and agents (see Besley and Ghatak 2006).[12]

A recent initiative of the central government of India, the National Rural Health Mission, 2005-2012, holds promise. Public spending on health over this period

[12] Public health expenditure also appears to have small if any effects on health in richer countries. In this case, crowding-out of private expenditures is a more likely explanation than in poor countries, but it is likely that elements of the preceding discussion apply in this case as well. In particular, there are not dissimilar issues of the allocation of health expenditure across categories and people, and of the problems of incentives, competition and quality that surround the effective supply of local public goods.

is expected to rise to "2-3%" of GDP (see NRHM 2005). More importantly, it aims to undertake "architectural correction" of the health system, promoting policies that strengthen public health management and service delivery in the country. Key components of the plan include institution of a female health activist in each village, creation of a village health plan by the village-government (Panchayat), with decentralisation expected to improve accountability of personnel to the community, integration of nutrition, saniation, hygiene and safe drinking water with other components of the health plan at the district level, and a focus on improving access to primary healthcare, especially for poor women and children. The analysis in this paper needs to be repeated six years from now!

7. Conclusions

Infant mortality is regarded as a sensitive indicator of the availability, utilisation and effectiveness of healthcare, and it is commonly used for monitoring and designing population and health programmes (The Tribune, 2002). The main finding of this study is that, although state health expenditure has no contemporaneous effect on infant mortality, it has a significant effect with a three-year lag. These findings are consistent with endogeneity of health expenditure. The long run impact is not large. A 10% increase in health expenditure, holding constant state income, is estimated to reduce infant mortality by 0.002 percentage points, which is 1.9% of the sample mean. State income also has a significant impact, which is about 30% larger. These results obtain after controlling for individual covariates such as gender, birth-month and parental education, for time-invariant heterogeneity across states, and for time-varying unobservables across and within states.

Important questions for future research include the following. To what extent do political differences across the states and temporal variation associated with electoral cycles determine the effectiveness of health expenditure? Is it the case that public health spending has large effects on infant mortality that are being swamped by its aggregation with state expenditure on other items like medical training? Or is even public health spending not very effective on account of delivery or uptake problems? Answers to these questions would provide further insight into the mechanisms that link health expenditure to infant mortality.

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Table 1: Average annual linear rate of growth of main variables, 1970-98
All figures are in percentages

State	**Infant mort.**	**Health exp.**	**Health share**	**Income**
Andhra	-2.59	7.45	3.70	3.75
Assam	-1.55	7.37	4.86	2.52
Bihar	-2.24	7.27	5.63	1.63
Gujarat	-3.28	6.09	2.67	3.54
Haryana	-1.15	6.30	3.29	3.00
Karnataka	-3.26	6.84	3.64	3.21
Kerala	-7.83	5.47	2.51	2.96
Madhya	-2.91	7.22	4.17	3.04
Maharashtra	-3.63	6.28	1.95	4.33
Orissa	-2.71	6.61	3.51	3.10
Punjab	-0.10	5.98	3.17	2.81
Rajasthan	-2.36	7.12	4.89	2.23
Tamil Nadu	-4.14	6.58	2.16	4.17
Uttar Pradesh	-4.14	7.04	5.13	1.91
West Bengal	-5.27	5.63	3.00	2.63
India	-3.15	6.58	3.57	2.99
s.d.	1.82	0.64	1.12	0.76

Notes: Growth rates are obtained by regression of the logarithm of the variable on a linear trend. The standard deviation of growth rates across states is denoted s.d.

Table 2: Alternative Specifications of Health Expenditure- Static Models

	Linear expenditure			**Quadratic in expenditure**			**Quadratic in expenditure share**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Health expenditure	**-0.029**	0.003	0.002	**0.375**	**0.475****	0.004			
	[2.05]	[0.28]	[0.18]	**[4.28]**	**[6.48]**	[0.02]			
Square of health expenditure				**-0.013**	**-0.015****	-0.000			
				[4.34]	**[7.17]**	[0.01]			
Share of health exp in income							**0.440**	**0.531****	-0.101
							[2.42]	**[4.22]**	[0.73]
Square of share of health expenditure							**-0.015**	**-0.016****	0.003
							[2.45]	**[4.30]**	[0.73]
Income	**-0.031**	-0.009	**-0.024**	**-0.023**	-0.007	**-0.024**	**-0.063**	-0.014	***-0.023***
	[2.89]	[0.31]	**[1.96]**	**[3.33]**	[0.34]	**[1.96]**	**[11.54]**	[0.54]	***[1.65]***
State dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year dummies	×	✓	✓	×	✓	✓	×	✓	✓
State-specific trends	×	×	✓	×	×	✓	×	×	✓
Coefficient at min health exp				0.023	0.0628	0.004	0.031	0.095	-0.019
Coefficient at mean health exp				-0.042	-0.0062	0.004	-0.037	0.024	-0.006
Coefficient at max health exp				-0.072	-0.0467	0.004	-0.074	-0.017	-0.002
Elasticity of health expend at mean	**-0.31**	0.032	0.021	**-0.45**	**-0.065**	0.043	**-0.40**	**0.25**	-0.064
Elasticity of income at mean	**-0.33**	-0.097	**-0.26**	**-0.25**	-0.075	**-0.26**	**-0.68**	-0.15	**-0.25**
Observations	121966	121966	121966	121966	121966	121966	121966	121966	121966

Notes: These are coefficients from a linear probability model; significant coefficients are in bold. Since the dependent variable, infant mortality, is binary, the coefficients denote changes in the probability of infant mortality. Elasticities are calculated by dividing the predicted change in probability by the sample mean of infant mortality [0.0933]. Absolute t-statistics are in parentheses. In every column, each of the included sets of state dummies, year dummies and state-specific trends are jointly significant at the 1% level. Every equation also includes the following variables: child gender, dummy for birth-month, age of mother at birth of child, dummies for levels of education of each of mother and father and indicators for ethnicity and religion of household.

Table 3: Distributed Lag Specification

	Unrestricted fourth-order		Restricted to significant terms	
	(1)	(2)	(3)	(4)
	No state-trends	**Add state-trends**	**No state-trends**	**Add state-trends**
Health expenditure	0.004	0.004		
	[0.35]	[0.38]		
Lag-1 health expenditure	0.008	0.005		
	[0.89]	[0.45]		
Lag-2 health expenditure	0.004	-0.002		
	[0.30]	[0.14]		
Lag-3 health expenditure	-0.007	-0.014	-0.008	**-0.018***
	[0.61]	[1.45]	[0.81]	**[2.53]**
Lag-4 health expenditure	-0.007	-0.01		
	[0.71]	[1.12]		
Income	-0.009	-0.015		
	[0.45]	[0.93]		
Lag-1 income	0.012	0.01		
	[0.70]	[0.64]		
Lag-2 income	0.005	0.001		
	[0.30]	[0.09]		
Lag-3 income	**-0.066****	**-0.068****	**-0.058***	**-0.065****
	[4.86]	**[4.56]**	**[2.61]**	**[4.66]**
Lag-4 income	**0.050****	**0.033****	**0.054****	**0.037****
	[3.58]	**[3.04]**	**[3.42]**	**[3.47]**
State dummies	✓	✓	✓	✓
Year dummies	✓	✓	✓	✓
State-specific trends	×	✓	×	✓
F-test of joint significance of health variables	0.125	0.04	n.a.	n.a.
F-test of joint significance of income variables	0.002	0.006	0.001	0.001
Long run health expenditure elasticity [t-stat]	0.03 [0.14]	-0.18 [1.16]	-0.09 [0.81]	**-0.19 [2.53]**
Long run income elasticity [t-stat]	-0.10 [0.24]	*-0.41 [1.74]*	-0.05 [0.16]	**-0.30 [3.08]**
Observations	114296	114296	118269	118269

Notes: See Notes to Table 2. For the F-tests, I report p-values.

Appendix Table 1: Summary Statistics of Variables in the Analysis

Variable	Mean	Std. Dev.	Min
infant mortality	0.093	0.291	0.000
log p.c. real health expenditure	16.042	0.691	13.740
log share of health expenditure in state income	15.905	0.670	13.626
log p.c real net state domestic product	0.136	0.352	-0.731
Child gender			
Male	0.521		
Female	0.479		
Child birth-month			
January	0.068		
February	0.065		
March	0.082		
April	0.079		
May	0.078		
June	0.085		
July	0.087		
August	0.106		
September	0.091		
October	0.095		
November	0.088		
December	0.076		
Mother's age at birth of index child			
9-15	0.036		
16-18	0.158		
19-24	0.468		
25-30	0.249		
31-49	0.090		
Mother's education			
None	0.733		
Incomplete primary	0.086		
Primary	0.060		
Incompete secondary	0.084		
Secondary or higher	0.037		
Father's education			
None	0.399		
Incomplete primary	0.122		
Primary	0.099		
Incompete secondary	0.202		
Secondary	0.093		
higher than secondary	0.085		
Ethnicity			
Higher castes	0.331		
Scheduled caste	0.207		
Scheduled tribe	0.121		
Other backward caste	0.341		
Ethnicity missing	0.013		
Religion			
Hindu	0.844		
Muslim	0.113		
Christian	0.013		
Other religion	0.006		

Notes: Standard deviations, minimum and maximum values are not provided for indicator variables. The category that is excluded from the regression is italicised.

Appendix Table 2: State-Specific Estimates Using Current Health Expenditure

	Panel A: Include Trend			Panel B: No Trend		N
	health exp	**Income**	**trend**	**health exp**	**income**	
Andhra Pradesh	-0.032	-0.030	0.001	-0.025	-0.017	6025
	[1.2]	[0.59]	[0.31]	[1.53]	[0.62]	
Assam	***-0.028***	-0.019	***0.002***	-0.017	0.017	6246
	[1.63]	[0.36]	***[1.88]***	[1.04]	[0.35]	
Bihar	0.017	**-0.072**	***-0.001***	-0.002	**-0.065**	15978
	[1.23]	**[2.45]**	***[1.65]***	[0.3]	**[2.23]**	
Gujarat	0.002	-0.013	-0.002	-0.016	-0.037	5296
	[0.07]	[0.31]	[0.9]	[0.79]	[1.22]	
Haryana	-0.004	-0.023	-0.001	-0.007	-0.039	4969
	[0.18]	[0.3]	[0.23]	[0.38]	[1.19]	
Karnataka	-0.030	0.096	-0.004	**-0.054**	0.037	6338
	[1.06]	[1.45]	[1.29]	**[2.34]**	[0.84]	
Kerala	0.004	0.022	-0.002	-0.017	-0.013	2920
	[0.16]	[0.51]	[1.3]	[0.74]	[0.41]	
Madhya	-0.001	-0.058	-0.002	-0.009	**-0.091**	13445
	[0.08]	[1.26]	[0.94]	[0.62]	**[3.04]**	
Maharashtra	**-0.062**	-0.047	0.003	**-0.052**	-0.002	4660
	[2.82]	[0.81]	[0.83]	**[2.86]**	[0.1]	
Orissa	-0.010	-0.009	-0.002	-0.031	-0.026	7679
	[0.33]	[0.2]	[1.14]	[1.38]	[0.66]	
Punjab	-0.030	-0.011	0.001	-0.026	0.001	3939
	[0.88]	[0.14]	[0.2]	[0.97]	[0.03]	
Rajasthan	0.000	-0.055	-0.001	-0.016	**-0.057**	13685
	[0.01]	[1.96]	[0.51]	[1.28]	**[2.04]**	
Tamil Nadu	-0.025	0.043	-0.004	***-0.051***	-0.006	4679
	[0.81]	[0.81]	[1.32]	***[1.95]***	[0.18]	
Uttar Pradesh	-0.028	0.077	**-0.005**	**-0.067**	-0.010	20975
	[1.5]	[1.24]	**[4.85]**	**[3.81]**	[0.17]	
West Bengal	**-0.113**	0.007	0.001	**-0.101**	0.032	5132
	[2.93]	[0.11]	[0.63]	**[3.19]**	[0.59]	
India	0.004	**-0.032**		0.002	-0.011	195365
	[0.47]	**[2.46]**		[0.21]	[0.42]	

Notes: These are coefficients from a linear probability model in which a binary indicator for mortality is regressed upon state health expenditure and state income. Absolute robust t-statistics are in parentheses. Significant coefficients are in bold. Panel A shows results from a model that also includes a trend, the analogue of the model that includes state-specific trends when the data are pooled, as in Tables 2-3. The trend is not significant in most states. Panel B shows results obtained after dropping the trend. To obtain the all-India coefficients, I condition upon state dummies and time dummies and, in parallel with the state-specific results, include state-specific trends in Panel A but not in Panel B. There are no other control variables (X) in these models.

Appendix Table 3: Alternative Specifications of Health Expenditure
Income and Other Conditioning Variables Are Dropped

	Linear expenditure			Quadratic in expenditure			Quadratic in exp share		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Health expenditure	**-0.041**	0.002	-0.005	**0.387**	**0.513**	0.065			
	[5.96]	[0.13]	[0.48]	**[5.49]**	**[5.99]**	[0.33]			
Square of health expenditure				**-0.014**	**-0.016**	-0.002			
				[5.92]	**[6.75]**	[0.36]			
Share of health exp in income							0.285	**0.565**	-0.027
							[1.25]	**[3.55]**	[0.22]
Square of share of health exp							-0.011	**-0.017**	0.001
							[1.43]	**[3.42]**	[0.26]
State dummies	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year dummies	×	✓	✓	×	✓	✓	×	✓	✓
State-specific trends	×	×	✓	×	×	✓	×	×	✓
Observations	121966	121966	121966	121966	121966	121966	121966	121966	121966

Notes: See Notes to Table 2. These equations include only the variables displayed in the Table, namely, a measure of health expenditure and some combination of state dummies, year dummies and state-specific trends.

Appendix Table 4: Alternative Estimators

	Linear probability model	**Probit marginal effects**
	(1)	(2)
Health expenditure	-0.000	0.002
	[0.03]	[0.14]
Income	**-0.027**	**-0.029**
	[2.26]	[2.09]

Notes: N=121966. Both columns contain state and year dummies and state-specific trends. Compare with Table 2 and see Notes to Table 2.

Appendix Table 5: Standard Error Adjustments

	No state-specific trends			**Include state-specific trends**		
	none	**robust**	**cluster**	**none**	**robust**	**cluster**
	(1)	(2)	(3)	(4)	(5)	(6)
Health expenditure	0.009	0.009	0.009	0.002	0.002	0.002
	[1.16]	[1.16]	[0.80]	[0.19]	[0.20]	[0.14]
Income	**-0.021**	**-0.021**	-0.021	**-0.029**	**-0.029**	**-0.029**
	[2.22]	[2.22]	[0.88]	[2.17]	[2.17]	[2.09]

Notes: N=121966. Absolute t-statistics are in parentheses. Every column contains state and year dummies. Compare with Table 2 and see Notes to Table 2

Figure 1

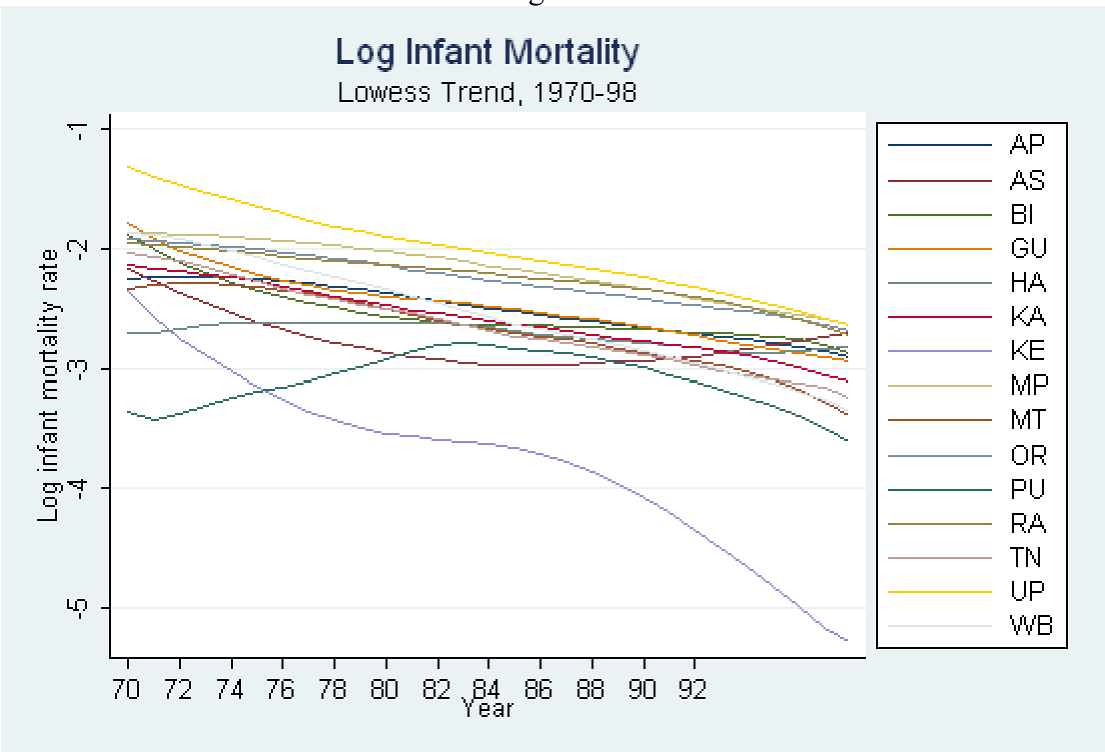

Figure 2

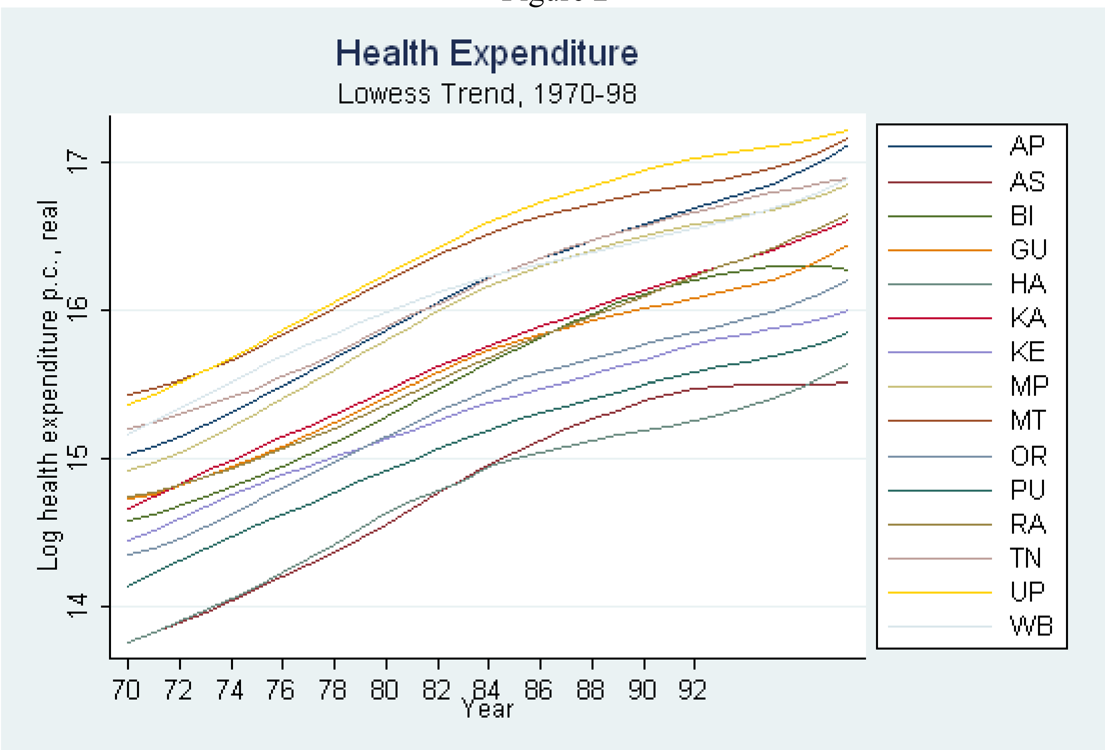

Figure 3

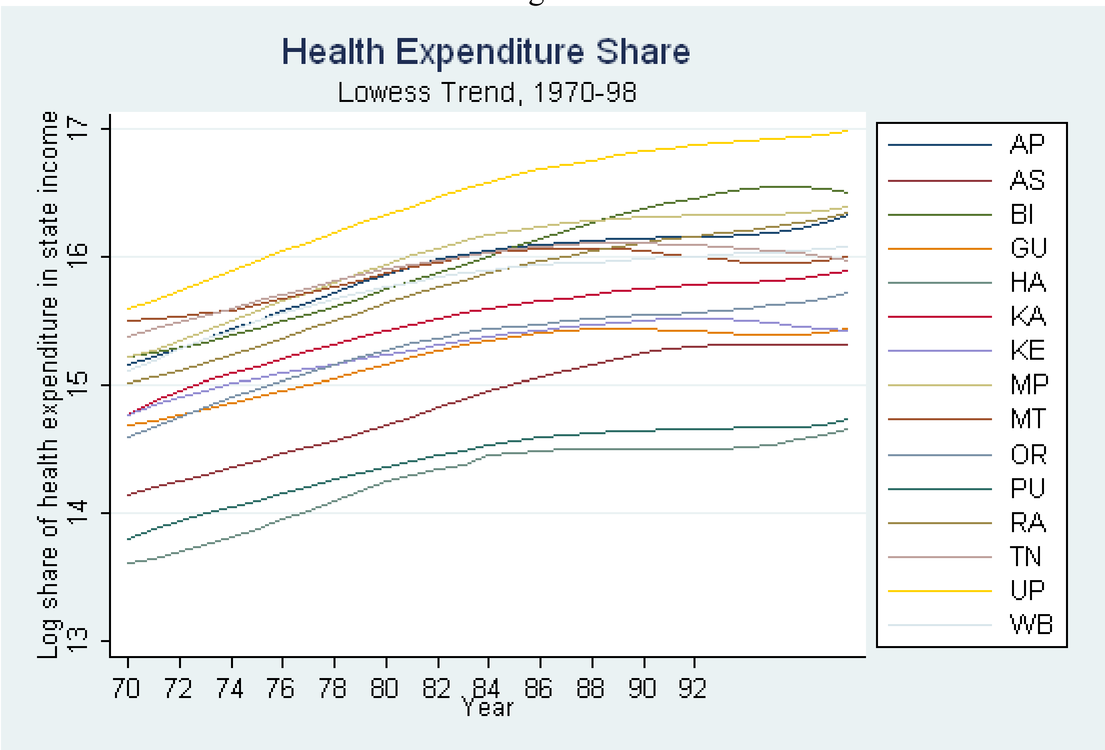

Figure 4

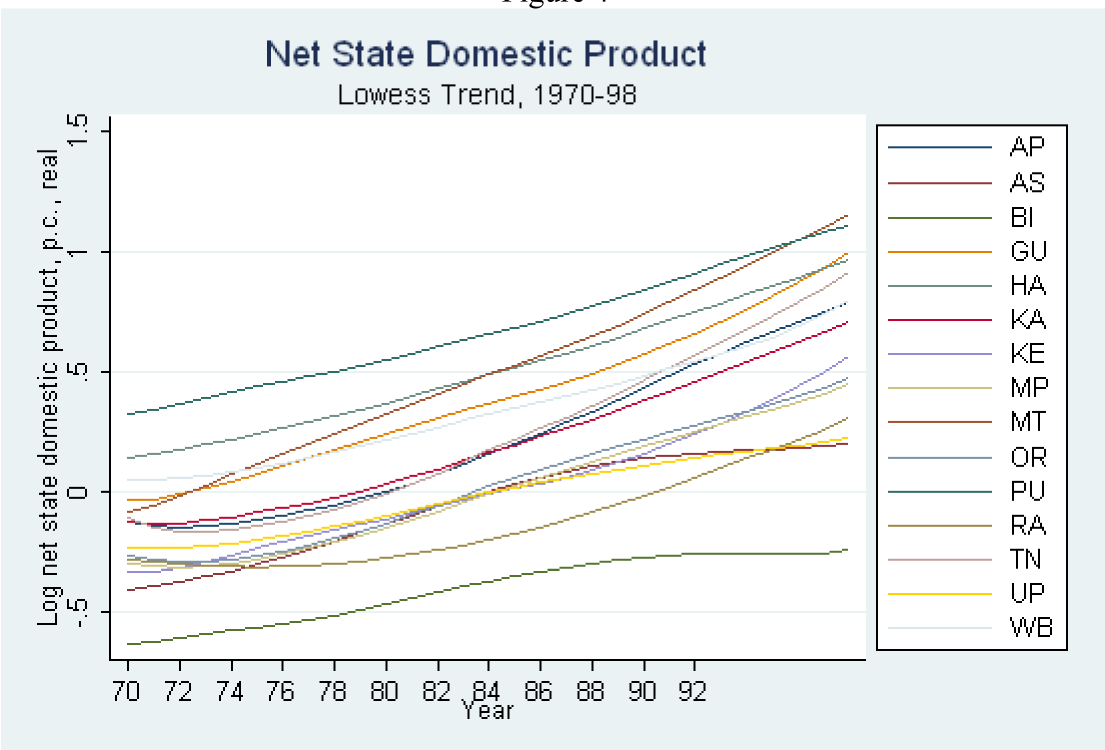

Figure 5

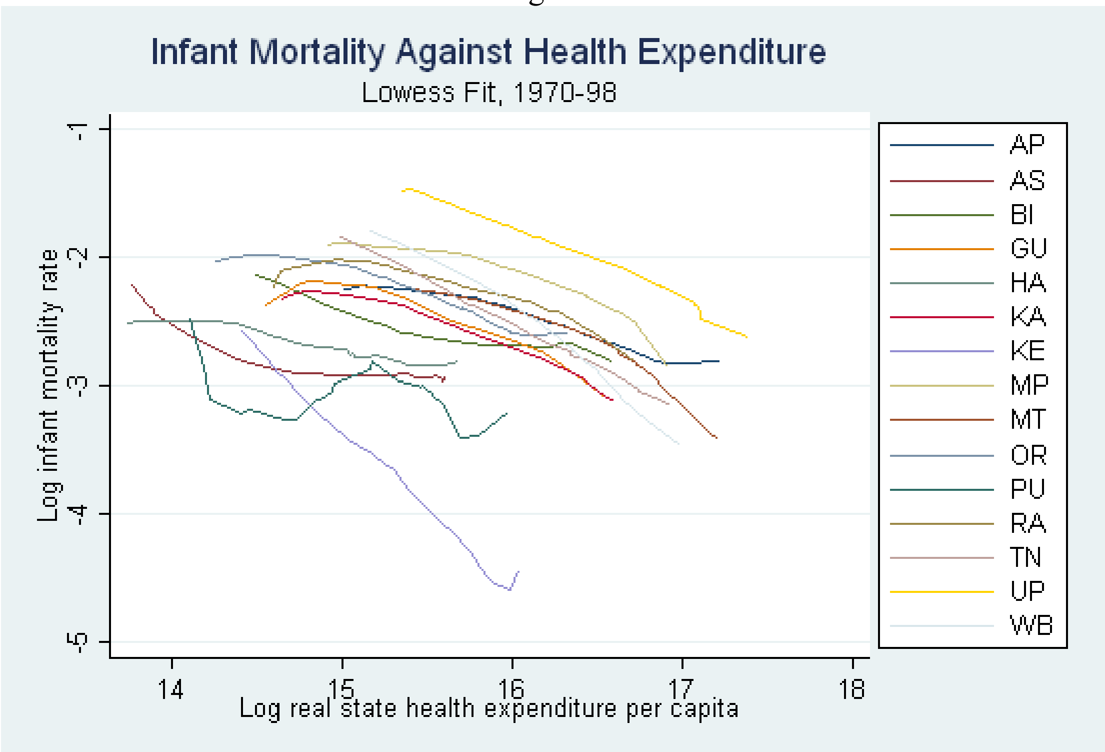

Figure 6

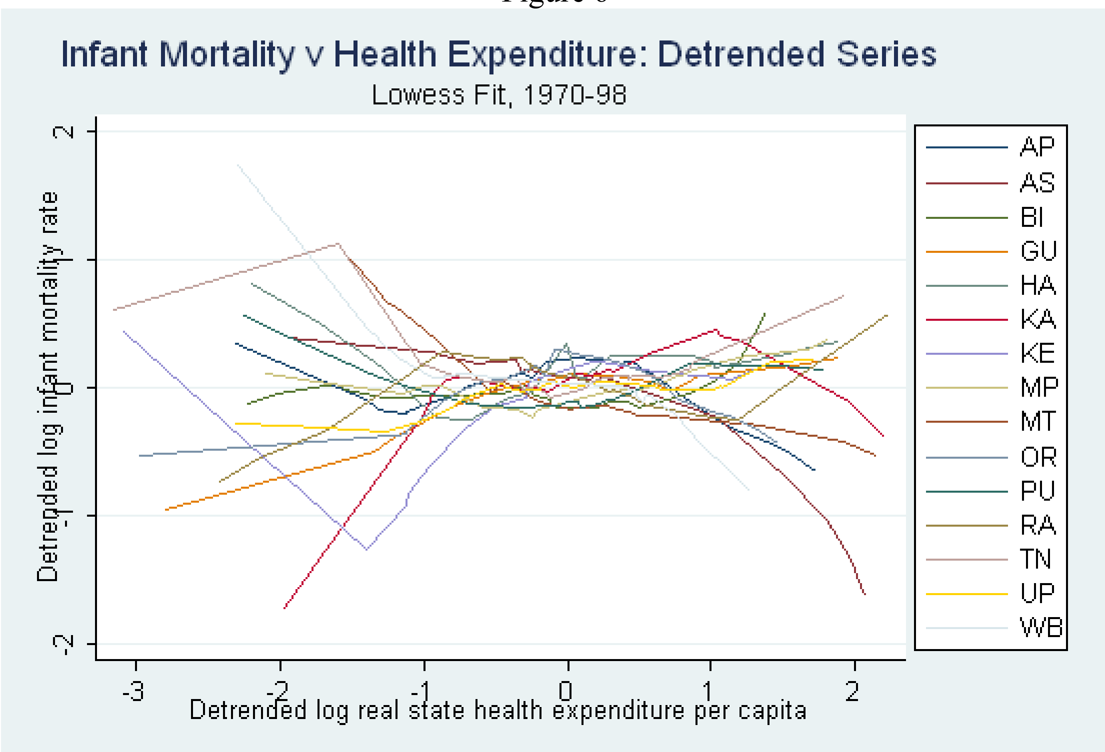

Figure 7

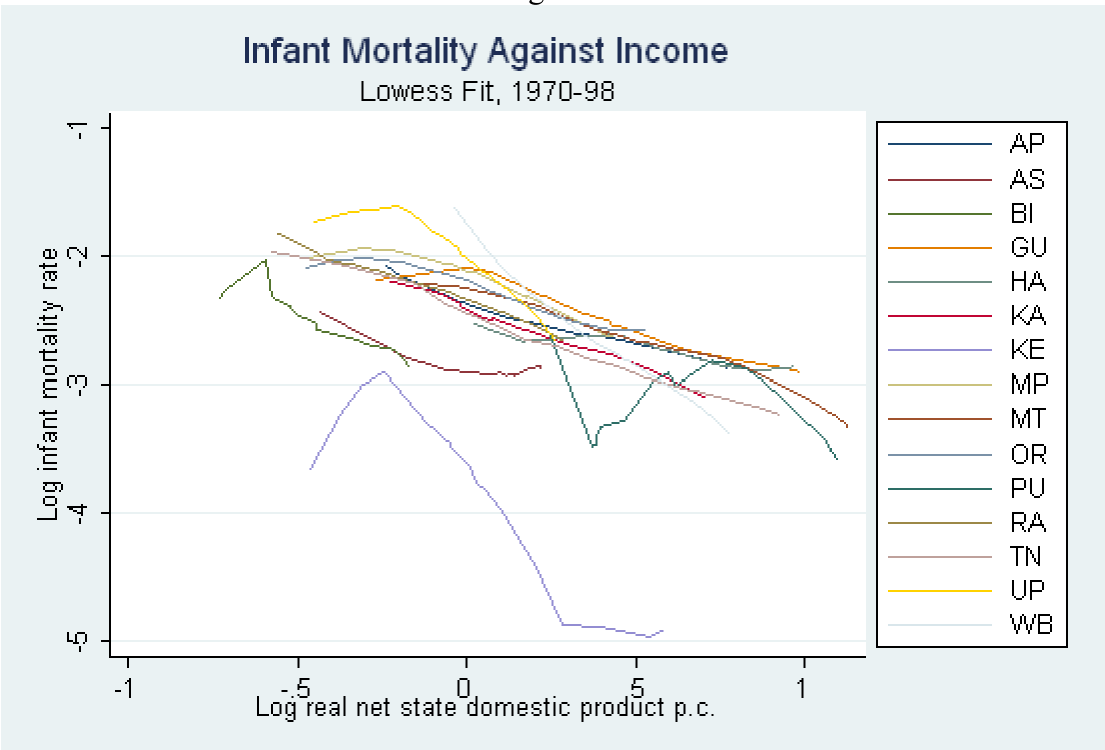

Figure 8