THE INTERPLAY BETWEEN GROWTH AND DEVELOPMENT: EVIDENCE FROM INDIAN DISTRICTS

*Jyoti Prasad Mukhopadhyay and Nilanjan Banik**

In this paper we examine the nexus between growth and development using a recursive structural equation system which, to the best of our knowledge, has not been tried so far to examine such relationships in the Indian context. Another novel feature of our study is that we use district-level data to capture greater heterogeneity at a substate level. We use the growth rate of per capita income (PCI) as an indicator of economic growth, and the infant mortality rate (IMR) and literacy rate as the development outcomes. We find that IMR and literacy rate have a positive and statistically significant effect on the growth rate of PCI. Our results also show that the growth rate of PCI has a positive and statistically significant effect on IMR and the literacy rate. Further sensitivity analysis is performed to test the robustness of these findings.

JEL Classification: C31, R12.

Key words: Growth, development, structural equation system, seemingly unrelated regressions (SUR).

---

* Jyoti Prasad Mukhopadhyay (corresponding author), PhD scholar, Institute for Financial Management Research (IFMR), 24 Kothari Road, Chennai, India (e-mail: jyoti.mukhopadhyay@ifmr.ac.in); and Nilanjan Banik, Professor, Institute for Financial Management Research (IFMR), 24 Kothari Road, Chennai, India (e-mail: nil@ifmr.ac.in). A preliminary version of this paper was presented at the following conferences: 3rd International Conference on Applied Econometrics at IBS Hyderabad (2011), 48th Annual Conference of the Indian Econometric Society (TIES) in Puducherry (2012), BREAD-IGC-ISI Summer School in Development Economics at Indian Statistical Institute, New Delhi (2012), International Conference on "India's Development Strategy: Discourses on Past, Present and Future" at Jamia Millia Islamia, New Delhi (2013) and Annual conference 2013 of the Scottish Economic Society, Scotland, United Kingdom of Great Britain and Northern Ireland. We are grateful to the participants of these conferences for their helpful comments and discussions. We are also thankful to K.L. Krishna, Anurag Narayan Banerjee, Basudeb, Sharon Barnhardt and three anonymous referees for their valuable comments which helped us immensely in improving the earlier version of the paper. All remaining errors, if any, are our own.

I. INTRODUCTION

Growth and development are interdependent but there is a difference between them. While growth is a unidimensional concept measured purely on the basis of growth of per capita gross domestic product (GDP) or income, development is a multidimensional concept and refers to improvement in the quality of life of an average citizen of a country or region. The two-way causality between economic growth and human development is widely recognized in the literature on growth and development. In the Indian context, the impact of economic growth on development and vice-versa has been studied (Zaidi and Salam, 1998; Kurian, 2000; Dholakia, 2003; Ghosh, 2006) mostly using non-contemporaneous state-level data in a standard single-equation regression framework where growth is considered to be exogenous in analyzing its impact on development, and vice-versa. These studies typically regress future development outcomes (future growth figures) on past growth outcomes (past development outcomes) with appropriate time-lags. This is done to avoid the problem of endogeneity arising from reverse causality between growth and development. However, the reverse causality phenomenon in this context opens up the scope for building a structural equation model to analyse such relationships where both growth and development outcomes are considered to be endogenous. To the best of our knowledge, structural equation modelling to examine growth-development nexus has not been tried in the Indian context. This paper fills this void in the literature by building a recursive structural equation model where both growth of per capita income (PCI) and development outcomes are treated as endogenous variables.

In this paper we examine the two-way causality between growth of PCI, and development outcomes measured in terms of infant mortality rate (IMR), a proxy for health outcome, and literacy rate, as a proxy for education. Another value addition of this study is that we use district-level data to capture greater heterogeneity at a substate level. We argue in this paper that state-level data represents only an average level of outcomes and hence fails to capture both increasing divergence and spatial disparity at a substate level (district level).[1] Thus district-level data are expected to capture a more robust relationship between growth and development, in comparison to state-level data. We find that IMR and literacy rate positively affect the growth rate of PCI. Our results also show that the growth rate of PCI has a positive and statistically significant effect on IMR and the literacy rate. The rest of the paper is organized as follows. Section II discusses the growth-health-education triad based on the existing literature on the interdependence among economic

[1] Chaudhury and Gupta (2009) point out that “sub-state level estimates are extremely useful in identifying pockets of impoverishment or prosperity across the length and the breadth of the country. Even in a state like Gujarat with commendable growth performance in terms of level of living, poverty or inequality, we find districts like Dangs, which was among the most critically poor regions of India in 2004-05. Such incidents would have escaped our attention had we restricted ourselves to state-level averages only.”

growth, health and educational outcomes. Section III discusses the literature on the growth-development nexus specifically in the context of India. Section IV sets up the recursive structural equation system, and briefly discusses the methodology for identification, and estimation of the structural parameters. Section V describes the data sources. Section VI presents the empirical results, and section VII concludes.

II. THE ECONOMIC GROWTH-HEALTH-EDUCATION TRIAD: A BRIEF SURVEY OF LITERATURE

Economic growth generates the resources that are vital for improving health and educational outcomes. On the other hand, improvement in the quality of life augments labour productivity and hence economic growth. Growth causes a surge in PCI and thus paves the potential way for further development. Using cross-country data, studies find a positive association between PCI and life expectancy at birth (LEB) (Preston, 1975; Pritchett and Summers, 1996; Banik, 2009).[2] Using cross-sectional data at the country level (98 countries), Barro (1991) finds evidence of a positive association between the initial stock of human capital (measured by the school enrolment rate in 1960) and the real per capita GDP growth rate for the period 1960-1985. However, correlation analysis does not tell us anything about the direction of causation but only shows strong association (linear) between two variables. Studies (Behrman and Deolalikar, 1988; Duraisamy, 1998; 2001) that use micro-level (farm level or household level) data find convincing evidence of the direction of causation: from growth to development outcomes and vice-versa. For example, initially, using household-level data from Tamil Nadu, and later on using data from the Human Development Index (HDI) Survey conducted nationwide by the National Council for Applied Economic Research (NCAER)-HDI, Duraisamy (1998; 2001) finds that an increase in income or total consumption expenditure reduces morbidity.

According to modern growth theory (Romer 1990; Mankiw, Romer and Weil, 1992) human capital and health are two important determinants of economic growth in the long run. If citizens of an economy are healthy then they can work harder and assimilate knowledge more efficiently, which translates to higher productivity and growth (Grossman, 1972; Bloom and Canning, 2000). Using a country-level panel dataset, Barro (1997), and Barro and Sala-i-Martin (2004), examine the effect of health on the growth rate of real per capita GDP and find that LEB, as an index of health, has a positive and statistically significant impact on the annual growth rate of real per capita GDP. At a micro level, studies find that improved health and nutritional outcomes positively affect labour productivity, more so in case of

---

2 Preston (1975) covers three time periods – 1900s involving 10 countries, 1930s involving 38 countries, and 1960s involving 57 countries. The correlation coefficient between the logarithm of per capita national income and life expectancy was 0.885 during the 1930s, and 0.880 during the 1960s. Pritchett and Summers (1996) use data from more than 100 countries (184 countries in most regressions), and find a strong association between PCI and LEB.

poor households (Strauss, 1986; Deolalikar, 1988).[3] Modern growth theory (Romer, 1990; Mankiw, Romer and Weil, 1992) in which technological progress and long-run growth rate are endogenously determined broadened the concept of capital by incorporating human capital into the growth accounting equation. Thus, there is a close relationship between the stock of human capital and economic growth. In the Indian context, Trivedi (2002) finds that secondary school enrolment rate has a statistically significant effect on PCI in the long run. At a micro level, using data from rural households in Tamil Nadu and other parts of India, studies such as those by Kalirajan and Shand (1985), Rosenzweig (1995), and Foster and Rosenzweig (1995), show that education has a positive effect on agricultural productivity. Literate farmers are more adept at adopting modern technology.

Existing evidence also suggests interdependence of health and educational outcomes. Health can potentially affect educational outcomes in two ways. First, healthy children are less likely to miss schooldays. They also have better learning and cognitive abilities and hence they are expected to have better educational outcomes (higher school completion rates, higher average years of schooling, etc.). Schultz (1999) finds that better health positively affects efficiency of human capital formation at the household level in Africa. Others such as Bleakley (2003), and Miguel and Kremer (2004), find that targeted health improvement programmes such as deworming of children cause better educational outcomes (read, reduced absenteeism) in South America and Kenya, respectively. Second, increased longevity or a reduced morbidity rate can encourage individuals to invest more in human capital as healthy individuals are likely to realize higher returns from education (Kalemi-Ozcan, Ryder and Weil, 2000). Using data from 52 different countries, Bils and Klenow (2000) find that improved life expectancy positively affects investment in education. On the other hand, there is a growing body of literature on the causal relationship between education and health outcomes. Individuals with higher levels of schooling adopt better health behaviour and lifestyle practices, and hence experience better health outcomes. In an evaluation of primary school construction conducted by the Indonesian Government between 1973 and 1979, Breierova and Duflo (2004) find that households with higher mean years of education have a lower incidence of child mortality. By looking at schooling and adult mortality data from the United States of America between 1976 and 1996, Deaton and Paxson (2001) find a similar negative relation.

The literature on the growth-health-education triad is huge and still growing. The preceding paragraphs are in no way complete but present the crux of the whole story. From the discussion on the growth-health-education triad so far, it is evident that development should not be perceived merely as an end but also as an important means to augment

[3] Strauss (1986) uses household-level data from Sierra Leone, and Deolalikar (1988) uses International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) data from rural South India.

growth. This gives rise to the reverse causality between growth and development, which is the subject matter of this paper. Next we discuss very briefly studies that examine the growth-development nexus in the Indian context.

III. GROWTH AND DEVELOPMENT IN INDIA: THE EVIDENCE SO FAR

It is evident that the progress of India in terms of the income growth rate has been remarkable since post-1991 reforms. Since 1991, real GDP growth picked up to an average of around 6 per cent. There has been a further surge in income growth from 2003. Average growth was 8.8 per cent from 2003/04 to 2007/08, translating into per capita income growth of 7.3 per cent. More specifically, growth was 8.5 per cent in 2003/04, 7.5 per cent in 2004/05, 9.5 per cent in 2005/06, 9.7 per cent in 2006/07 and 9.0 per cent in 2007/08.[4] The reason for faster growth is attributed to broad-based economic reforms.[5] To make this growth process inclusive, Government started intervening in the market through various social welfare programs (e.g. Integrated Rural Development Program (IRDP), Swarnjayanti Gram Swarozgar Yojana (SGSY), Sarva Shiksha Abhiyan (SSA), Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), National Bank for Agriculture and Rural Development (NABARD)-led Self-Help Groups (SHG) based microfinance). So far so good. But what has happened to development? Studies looking at growth-development nexus in the Indian context can be divided into two groups. The first group of studies look at the growth-development nexus in a time series context, whereas, the latter group focuses on cross-sectional analysis and classifies districts and/or states into forward or backward groups of varied degree on the basis of some development indicators without quantifying the linkages between the growth and the development indicators over a period of time.

To examine growth-development nexus, Dholakia (2003) considers triennium average per capita state domestic product (SDP) as a measure of economic development, and HDI at the state level. Considering the time period between 1977 and 1997, he finds evidence of two-way causality between economic development and human development.[6] Similar

---

4 India, Ministry of Finance, *Economic Survey* (New Delhi, various years).

5 Economic reforms basically refer to liberalization of economic activities and encouraging globalization by bringing down tariffs. Other components of economic reforms, namely fiscal adjustments, macroeconomic stabilization, strengthening private property rights and exchange rate reform, also have an important bearing on income growth.

6 Dholakia (2003) considers a lag of eight years for examining the impact of human development on economic development. For examining the impact of economic development on human development he considers a lag of two years. The paper considers the Human Development Index, Human Poverty Index, inequality adjusted per capita consumption expenditure, literacy rate, intensity of formal education, expectation of life at the age of one year, and infant mortality rate, as the indicators of development.

studies such as Ghosh (2006),[7] and Roy and Bhattacharjee (2009), considering state-level data on HDI for the period between 1981 and 2001, find evidence of beta-convergence (States with lower HDI growing faster than those with higher HDI), and not sigma-convergence (cross-sectional dispersion of HDI in was non-decreasing). In a single equation framework, and using OLS as a method of estimation, Ghosh (2006) examines the effect of growth on development by regressing the development indicators at time, t, on average PCI value of the preceding five years (t-5). He finds that coefficient of PCI is positive and statistically significant. In a separate regression, he analyses the reverse causality running from human development to economic growth by regressing triennium average value of PCI on HDI indicators lagged by three years. He finds evidence of the positive and statistically significant effect of human development on economic growth. Kurian (2000) considers female literacy as an important "index of development" and he finds that Indian states belonging to the "forward group of states" such as Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, Punjab and Tamil Nadu, have female literacy above the national average female literacy rate.[8]

In a cross-sectional framework, Mehta (2003) finds that a given state may perform extremely well on all indicators but there may be districts within that state that are among the most deprived in the country, or a state may have very high levels of attainment on certain specific development indicator(s) but not on all of them.[9] The study by Debroy and Bhandari (2003) identifies the most backward districts benchmarking them on the attainment of Millennium Development Goals (MDGs) set by the United Nations Development Programme (UNDP) in terms of six measures of socioeconomic progress: poverty, hunger, literacy rates, immunization, IMR and gross elementary rates. According to this study, the worst performing districts are located in Bihar, Uttar Pradesh, Jharkhand, Orissa, Madhya Pradesh, Assam, Maharashtra, West Bengal and Chhattishgarh, with a few districts from Arunachal, Karnataka and Tamil Nadu thrown in.

From the discussion so far, it is evident that disparities are more pronounced at a substate (district level). However, the existing studies examining the growth-development nexus in India use state-level data, and also fail to capture the reverse causality between growth and development in a structural equation system. This paper fills this gap in the literature where we use district-level data and analyse the nexus between growth and development in a recursive structural equation framework.

---

7 Ghosh (2006) uses HDI, literacy rate, and expectation of life at birth, as development indicators.

8 Kurian (2000) on the basis of 1991 Census data of Government of India concludes that in addition to female literacy rate, the forward group of states has performed better in terms of other development indicators such as sex ratio (females per 1000 males) and level of infrastructure development. In fact, the "backward group of states" such as Assam, Bihar, Rajasthan, Uttar Pradesh and West Bengal, has fallen behind when measured in terms of these indicators.

9 Mehta (2003) finds that most of the severely deprived districts are located in Orissa, Bihar, Madhya Pradesh and Uttar Pradesh, which also rank high in terms of income poverty.

IV. EMPIRICAL MODEL AND ESTIMATION STRATEGY

As a measure of economic growth, we consider the compound annualized growth rate[10] of PCI between 2001 and 2005. We consider the infant mortality rate (IMR) and literacy rate as indicators of development. These chosen indicators also serve as a proxy measure of health outcome and the stock of human capital. The rationale behind considering these variables for our analysis is evident from the preceding review of literature. To examine the interaction between growth and development indicators we consider the following recursive structural equation model:

$$growth_i = \alpha_0 + \alpha_1 \, ln(PCI2001_i) + \alpha_2 \, ln(IMR2001_i) + \alpha_3 \, ln(literacy2001_i) + \varepsilon_{1i} \tag{1}$$

$$ln(IMR2007_i) = \beta_0 + \beta_1 \, growth_i + \beta_2 \, ln(literacy2001_i) + \beta_3 \, ln(hospitaldisp2001_i) + \varepsilon_{2i} \tag{2}$$

$$ln(literacy2011_i) + \gamma_0 + \gamma_1 \, growth_i + \gamma_2 \, ln(IMR2007_i) + \gamma_3 \, ln(schoolscoll2001_i) + \varepsilon_{3i} \tag{3}$$

where, subscript *i* stands for the i^{th} district, *growth* denotes the growth rate of PCI between 2001 and 2005; *PCI2001* denotes PCI in 2001; *IMR2001* and *IMR2007* denote IMR in 2001 and 2007, respectively; *literacy2001* and *literacy2011* denote the literacy rate in 2001 and 2011, respectively; *hospitaldisp2001* denotes the number of hospitals and dispensaries per one lakh[11] population in 2001, and *schoolcoll2001* denotes the number of schools and colleges, per one lakh population in 2001. Variables are measured in logarithmic (natural, base = e) terms because it is a standard practice especially for variables which are skewed in either direction (Flegg, 1982; Anand and Baernighausen, 2004).

In the above-specified system of equations, $growth_i$, $IMR2007_i$ and $literacy2011_i$ are the endogenous variables which enter recursively into the system of equations. All other variables are considered to be exogenous. The parameters of particular interest are the coefficients of the exogenous development indicators (α_2 and α_3) in Eq. (1); the coefficient of the endogenous growth variable (β_1) and the coefficient of the exogenous development indicator (β_2) in Eq.(2); and coefficients for the endogenous growth and development variables (γ_1 and γ_2) in Eq.(3).

Given Eqs. (1), (2) and (3), the next step is to identify and estimate the structural parameters α's, β's and γ's. Since the system is recursive or triangular, all the parameters are identified (Gujarati, 2004).[12] We have considered a very simple recursive model where variables affecting growth such as access to road, institution and governance, are not

[10] Annual compound growth rate is also used by Ghosh (2008).

[11] One lakh = 0.1 million.

[12] Gujarati (2004), pp. 764-766.

controlled for but these omitted variables can very well influence the endogenous variables namely, growth, IMR and literacy. As a result we conjecture that the errors are correlated across Eqs. (1), (2) and (3) (Maddala and Lahiri, 2009).[13] In other words we assume that the variance-covariance matrix of errors (∑) is not diagonal. Since the errors terms are correlated, Eqs. (1), (2) and (3) cannot be estimated using equation-by-equation ordinary least square (OLS). In this context OLS estimators are inconsistent. Hence we estimate the system of equations using two alternative methods to check for the robustness of our estimates and we also report OLS estimates for the sake of comparison.

In the first method, we estimate Eq. (1) using simple OLS as there is no endogeneity problem (all regressors are exogenous). Then we use the estimated value of *growth* from Eq. (1) as an instrument for *growth* in Eq. (2) and estimate it using simple OLS. This allows us to circumvent the problem of endogeneity due to non-zero covariance between *growth* and the error term (ε_2). Similarly, we estimate Eq. (3) by OLS and use estimated *growth* obtained from Eq. (1) and estimated *ln(IMR2007)* obtained from Eq.(2) as instruments for *growth* and *ln(IMR2007),* respectively. This method is in the spirit of two-stage least square (2SLS) and hence we report them under the heading 2SLS in table 2. The structural Eqs. (2) and (3) contain original values of *growth* and *ln(IMR2007)* and not their estimated values and hence we correct second-stage OLS standard errors following the procedure suggested by Greene (2011).[14]

However, this 2SLS method of estimating parameters fails to correct standard errors of estimators for cross-equation correlation among error terms. This motivates us to go for the second estimation method, namely seemingly the unrelated regression method (SUR) originally proposed by Zellner (1962). Hausman (1975) first observes that in a recursive or triangular system, the determinant of the Jacobian in the likelihood function is unity, and hence it vanishes such that the likelihood function becomes identical with that of SUR. Lahiri and Schmidt (1978) show that the SUR estimation method, which is actually a Feasible Generalized Least Square (FGLS) estimator, gives consistent estimates of the parameters in triangular models. Kmenta and Gilbert (1968) show, using Monte Carlo experiments, that the FGLS estimator has the same asymptotic properties as iterated FGLS (IFGLS) originally proposed by Zellner (1962) and they recommend use of FGLS in small samples as it is also computationally efficient. We report the parameter estimates obtained using SUR under the heading SUR[15] in table 2. We also test for correlation amongst error terms across equations, that is, whether variance-covariance matrix (∑) is diagonal using the test suggested by Breusch and Pagan (1980).

---

[13] Maddala and Lahiri (2009), p. 597.

[14] Greene (2011), chap. 8.

[15] The efficiency gain from SUR over OLS will depend on magnitude of the cross-equation correlations of the residuals and correlations among the covariates across different equations. The gains will be higher if the former is higher and it will be lesser if the latter is higher.

Finally, to check robustness of our results we perform sensitivity analysis as outlined in Levine and Renelt (1992). The idea is to see whether inclusion of additional explanatory variables affect the regression coefficients. The coefficient of a variable in the original model is considered to be robust if its sign and statistical significance do not change with inclusion of additional explanatory variables. The results are generated using the statistical software package Stata.

V. DATA DESCRIPTION

We use data on district-level PCI taken from India, Planning Commission (2010).[16] For Bihar and Orissa, we use PCI data for 2004/05 whenever data for 2005/06 are not available. PCI data for the years after 2005/06 are not available for all the districts which results in significant drop in the number of observations.[17] Also many of the districts are newly formed, and PCI data for them is not available for the earlier years.[18] Therefore, to maintain uniformity and to get a more robust result, we consider the time period 2001-2005 for PCI growth rate calculation. We consider a total of 281 districts across all the nine states where the Annual Health Survey (2010-11)[19] (AHS) was conducted, namely Assam, Bihar, Chhattishgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh and Uttarakhand. These nine states together account for 48 per cent of India's population and nearly 70 per cent of Infant deaths in India (India, Ministry of Health and Family Welfare, 2011). Data on literacy and IMR for 2001, proportion of main workers in the total workforce, proportion of households not having latrine facility, average distance from the nearest town, number of factories, hospitals and dispensaries, schools and colleges[20] are taken from Census 2001 and 2011 published by Office of the Registrar General of India, Government

---

[16] There are issues related to estimation of gross district domestic product (GDDP) and its comparability across districts of different states (Katyal, Sardana and Satyanarayana, 2001; Indira, Meenakshi and Vyasulu, 2002). Hence we verified the accuracy of the available GDDP estimates by summing over all the districts of a particular state for a particular year. The total figure thus obtained was very close (absolute magnitude of deviation was less than 1 per cent) to the estimate of state domestic product (SDP) given by the Central Statistical Organisation (CSO) for the particular state for that particular year at constant prices (1999/2000).

[17] India, Ministry of Home Affairs (2011). Planning Commission does not report data on district-level PCI data for the period after 2006/07.

[18] In 2000 there are 585 districts, and in 2011 there are 627 districts in India. Many of these districts are newly formed, and for some of them information about the income variable is not available. The case in point is Delhi. The Census 2001 contains information about many variables related to north, north-east, north-west, south, south-west, west, east, and central Delhi. However, during 2001, when it comes to PCI we find information only relating to Delhi as a whole, and not its constituent districts (India, Planning Commission, District of India – districts status. Available from http://districts.nic.in/dstats.aspx (accessed 2 April 2011)).

[19] See http://censusindia.gov.in/vital_statistics/AHSBulletins/ahs.html.

[20] Number of factories, hospitals and dispensaries, schools and colleges all are measured per one lakh population of the district.

of India. IMR figures for 2007 are taken from the Annual Health Survey 2010-11 Fact Sheets published by the Ministry of Health and Family Welfare (MOHFW), Government of India.[21]

VI. EMPIRICAL RESULTS

Estimation results

The descriptive statistics of the variables used in this study are reported in table 1. Table 1 shows that there is considerable heterogeneity (high standard deviation) across districts for most of the variables. For the sake of comparison we start our analysis by separately estimating Eqs. (1), (2) and (3) and summarize results under column 1 in table 2. Panels A, B and C correspond to estimation results of Eqs. (1), (2) and (3). First column of Panel A in table 2 shows that increased IMR has a negative effect on growth of PCI and it is statistically significant at 10 per cent level. We do not find any statistically significant effect of literacy on growth. There is also strong evidence of conditional divergence in growth rate of PCI as the coefficient of logarithmic PCI in 2001 is positive and highly statistically significant. But this finding is not robust as we will see later. Eq. (1) has no endogeneity problem[22] and hence no result is reported under the second column meant for 2SLS results. We report SUR estimation results in the third column. The third column of table 2 shows that increased IMR does negatively affect growth rate of PCI and it is statistically significant at 5 per cent level. The estimated coefficient of IMR implies that a 10 per cent decrease in IMR will increase the growth rate[23] of PCI by 0.12 percentage points. The coefficient of literacy also turns out to be statistically insignificant even in SUR results. Thus we find strong evidence of the positive effect of improved health outcome on growth although we do not find any statistically significant effect of the stock of human capital (read literacy rate) on growth. This is perhaps because the effect of literacy on growth happens only in the long run. Also, existing evidence suggests that the quality of human capital also matters for growth (Hanushek and Wobmann, 2007). In India studies have found that students are not learning enough in schools and hence the quality of education remains abysmally low (ASER Centre, 2013).

---

21 The reference period of IMR estimates published in the fact sheets is 2007-09 and hence we consider the published IMR figures as figures for 2007 in our analysis.

22 *IMR2001* and *literacy2001* are suspected to be endogenous in Eq. (1). Endogeneity tests using percentage of household having telephone connection and percentage of household having bathroom facility as instrumental variables, failed to reject the null hypothesis of no endogeneity (X^2 test statistic value is low).

23 Note: growth rate is measured in decimals.

Table 1. Summary statistics

Variable	Min	Max	Mean	Median	SD[a]	N
Growth rate of PCI (2001-2005)[b]	-0.12	0.18	0.03	0.03	0.033	282
Ln(PCI2001)	8.14	10.76	9.27	9.28	0.419	282
Ln(IMR2001)	3.00	4.98	4.20	4.21	0.297	253
Ln(IMR2007)	2.94	4.63	4.07	4.07	0.257	282
Ln(Literacy2001)	3.41	4.38	4.04	4.08	0.213	281
Ln(Literacy2011)	3.75	4.47	4.23	4.25	0.129	281
Ln(No. of hospitals and dispensaries)	2.89	4.69	3.76	3.74	0.349	281
Ln(No. of schools and colleges)	4.20	6.27	4.99	4.93	0.450	281
Ln(Prop.main workers)[b]	-11.22	-7.78	-9.91	-9.94	0.591	280
Ln(No. of factories)	3.55	6.06	4.76	4.77	0.418	281
Households without latrine facilities (%)	2.61	4.55	4.25	4.38	0.346	282
Ln(distance)	2.61	6.38	5.13	5.22	0.644	258

Source: Authors' own calculations.
Notes: [a] SD means standard deviation.
[b] Measured in decimals.

As regards Panel B, under OLS, we find that the growth of PCI improved IMR in 2007 as the sign of the estimated coefficient of growth was negative and it was statistically significant at the 1 per cent level. The same is true in the case of 2SLS and SUR results also. The estimated coefficient of the growth variable in SUR model implies that if growth rate increases by 1 percentage point then it leads to a reduction in IMR of approximately 3.22 per cent. Under OLS and SUR, we find that districts with higher literacy rates in 2001 experienced lower IMR in 2007 (the sign of the estimated coefficient of literacy in OLS and SUR was negative and statistically significant). A 1 per cent increase in the literacy rate leads to an approximately 0.24 per cent reduction in IMR. However, this is not true in the case of 2SLS. Our results also show that better access to health-care services measured in terms of number of hospitals and dispensaries per one lakh population has a favourable impact on health outcomes, that is, it reduces IMR. The coefficient of the number of hospitals and dispensaries per one lakh population measured in logarithmic terms is statistically significant at the 5 per cent level under SUR.

As regards Panel C, under both OLS and SUR, we find that the growth of PCI positively affects literacy rates. Districts that grew faster during 2001-2005 in terms of PCI also experienced higher literacy rates in 2011. The coefficient of PCI growth is positive and statistically significant at 10 per cent and 5 per cent levels in OLS and SUR, respectively. An increase in the growth rate by 1 percentage point causes the literacy rate to increase

Table 2. Estimation results

Covariates	Coefficient		
	(1) OLS	(2) 2SLS	(3) SUR
Panel A: Dependent variable: *PCI growth rate (2001-2005)*			
Ln(PCI2001)	0.017***		0.016***
	(0.005)		(0.005)
Ln(IMR2001)	-0.011*		-0.012**
	(0.006)		(0.006)
Ln(Literacy2001)	0.0008		0.012
	(0.009)		(0.009)
Constant	-0.087*		-0.113***
	(0.049)		(0.051)
N	253		253
R^2	0.09		0.08
F	7.68		11.36
Prob > F	0.000		0.000
Panel B: Dependent variable: *Ln(IMR2007)*			
Growth rate of PCI (2001-2005)	-3.079***	-8.182***	-3.227***
	(0.593)	(3.150)	(0.549)
Ln(Literacy2001)	-0.123*	-0.012	-0.240***
	(0.067)	(0.109)	(0.079)
Ln(No. of hospitals and dispensaries)	-0.104*	-0.096	-0.106**
	(0.062)	(0.099)	(0.050)
Constant	5.051***	4.730	5.537***
	(0.301)	(0.514)	(0.282)
N	253	253	253
R^2	0.18	-	0.17
F	11.35	4.81	25.47
Prob > F	0.000	0.002	0.000

Table 2 ***(continued)***

Covariates	Coefficient		
	(1) OLS	**(2) 2SLS**	**(3) SUR**
Panel C: Dependent variable: *Ln(literacy2011)*			
Growth rate of PCI (2001-2005)	0.571*	-8.724	0.801***
	(0.315)	(9.063)	(0.307)
Ln(IMR2007)	-0.106***	-1.528*	-0.177***
	(0.027)	(0.835)	(0.032)
Ln(No. of schools and colleges)	0.021	0.006	0.016
	(0.021)	(0.007)	(0.018)
Constant	4.537***	10.681	4.842***
	(0.164)	(3.733)	(0.166)
N	253	253	253
R^2	0.09	-	0.07
F	13.90	-	20.50
Prob > F	0.000	0.003	0.000

Source: Authors' own calculations.

Notes: For OLS, robust standard errors are in parentheses.
* Significant at 10% level, ** significant at 5% level, *** significant at 1% level.

by 0.8 per cent. 2SLS results, however, do not show such a positive relationship. Panel C results also show that improved health outcomes measured by reduced IMR (2007) lead to improved educational outcomes measured by increased literacy rates (2011). The coefficient of IMR (2007) is negative and statistically significant at 1 per cent, 10 per cent and 1 per cent levels under OLS, 2SLS and SUR, respectively. The estimated coefficient of IMR under SUR implies that a reduction in IMR by 1 per cent increases the literacy rate by approximately 0.18 per cent. We do not find any statistically significant impact of access to educational institutions on literacy rate across all the three estimation techniques. This result is counterintuitive. We argue that building schools and other educational institutions is not enough unless it is ensured that students do attend and learn in schools and teachers also do justice to teaching. However, as mentioned earlier students do not necessarily learn the basic skills of reading, writing and counting or arithmetic in schools (ASER Centre, 2013).

Finally, we test correlations amongst the errors across Eqs. (1), (2) and (3), namely, whether the variance-covariance matrix ($\sum$) is diagonal using the test suggested by Breusch and Pagan (1980). Based on this test we could reject the null of zero correlations amongst errors at the 5 per cent level of significance (X^2 = 8.93, p-value = 0.030). This justifies the estimation of the system of equations using SUR.

Sensitivity analysis

We re-estimate the system of equations using SUR with additional control variables and report the results in table 3. In Eq. (1), we include the proportion of main workers (as a proxy for the size of the workforce)[24] and number of factories measured in logarithmic terms (as a proxy for the level of industrialization) as additional control variables. Eq. (2) and Eq. (3) are re-estimated with proportion of households without latrine facility (as a proxy for health practices and awareness at the household level) and average distance of the villages from the nearest town (as a proxy for accessibility to educational institutions in town) as additional control variables.

We refer to the original regression as the base regression, and the model with newly added explanatory variables for sensitivity analysis as the augmented regression. Since actual magnitudes are of little interest, we report only the sign and statistical significance of the re-estimated coefficients in table 3. In Eq. (1), the coefficient of logarithmic PCI in 2001 is not robust across base and augmented regression. However, the relation between IMR and growth rate is robust across both base and augmented regression. The sign of the coefficients of additional control variables in the augmented version of Eq. (1) are as expected and are statistically significant. As regards Eq. (2), we find that the relation between the growth rate of PCI and IMR (2007) is robust and so is the relation between literacy rate and IMR. The relation between number of hospitals and dispensaries per one lakh population and IMR turns out to be fragile. The additional control variable, the proportion of households without latrine facilities, has the expected sign but it is not statistically significant. In the case of Eq. (3), we find that the positive relation between the growth rate of PCI and literacy rate (2011) is robust across both base and augmented specifications. Health outcome measured by IMR also has a positive and statistically significant effect on literacy rate and this relation is robust as the sign and significance of the coefficient of IMR are not affected by the addition of new explanatory variables. The additional control variable, log of distance from the nearest town, has the expected sign and it is statistically significant. We again perform the Breusch and Pagan (1980) test of independence of error terms across equations. The null hypothesis of zero correlations amongst errors across equations is rejected at the 10 per cent level of significance (x^2 = 6.90, p-value = 0.075).

[24] Main workers are those who had worked most of the time during the reference period (i.e. 6 months or more). This is a crude proxy for the size of the workforce because many workers especially in rural areas work as marginal workers (not working most of the time during the reference period).

Table 3. Sensitivity analysis summary

Covariates	Base SUR regression		Augmented SUR regression		Conclusion
	Sign	Significant	Sign	Significant	
Panel A: Dependent variable: *PCI growth rate (2001-2005)*					
Ln(PCI2001)	+	Yes	+	No	Fragile
Ln(IMR2001)	-	Yes	-	Yes	Robust
Ln(Literacy2001)	+	No	+	No	Robust
Additional control variables					
Ln[Prop. main workers)]			+	Yes*	
Ln(No. of factories)			+	Yes	
N	253			231	
Panel B: Dependent variable: *Ln(IMR2007)*					
Growth rate of PCI (2001-2005)	-	Yes	-	Yes	Robust
Ln(Literacy2001)	-	Yes	-	Yes	Robust
Ln(No. of hospitals and dispensaries)	-	Yes	-	No	Robust
Additional control variable					
Households without latrine facilities (%)			+	No	
N	253			231	
Panel C: Dependent variable: *Ln(Literacy2011)*					
Growth rate of PCI (2001-2005)	+	Yes	+	Yes	Robust
Ln(IMR2007)	-	Yes	-	Yes	Robust
Ln(No. of schools and colleges)	+	No	+	No	Fragile
Additional control variable					
Ln(distance)			-	Yes	
N	253			231	

Source: Authors' own calculations.

Notes: Augmented SUR regressions are jointly significant (Prob > F = 0.000).
The base regression is the same as the regression model reported in table 1.
The last column indicates the robustness or fragility of estimated coefficients which are significant in the base regression.
The coefficient of a variable of interest is considered to be robust if its sign and significance do not change across all augmented regressions.
* Significant at 10% level.

VII. CONCLUSIONS

In contrast to the conventional approach of investigating separately the effect of growth on development and the effect of development on growth, this study examines the interdependent nature of growth and development using a recursive or triangular structural equation system. By allowing cross-equation error terms to be correlated, we estimate the system using SUR. Our results show that health outcomes measured by IMR do affect the growth rate of PCI positively, and this relationship is robust. Inclusion of additional control variables does not change our results. Our finding is similar to that of Barro (1997). We also find the growth of PCI improves literacy rates and helps to reduce IMR. These relationships are also statistically significant, and robust after the addition of other control variables. This finding is similar to the empirical conclusions of Pritchett and Summers (1996). Thus one clear conclusion that emerges from this study is that economic growth plays a significant role in improving health and educational outcomes. Thus broad-based economic reforms that aim to augment the growth rate of an economy will also yield better development outcomes. Likewise, improved development outcomes will help to sustain economic reforms, and hence contribute to economic growth in the long run. For example, during the 1960s and the 1970s, Brazil witnessed higher growth but as the distribution of income, along with other indicators of the quality of life, such as health and education, were neglected, policymakers eventually had to follow a populist policy in fear of losing power in parliament. Since policies for broad-based development took a back seat, the larger “have not” group was neglected, and the ruling parties in Brazil were repeatedly thrown out of power. This has put a halt to Brazil’s reform programmes and prevented them from achieving higher growth rates in the 1980s.

One limitation of this study is that it does not control for state-specific fixed effects. Depending on the availability of data on PCI and other development indicators for the later years (2006 onwards) at the district level, further studies can be done to account for state-level fixed effects because state policies also play an important role in determining growth and development outcomes.

REFERENCES

Anand, S., and T. Baernighausen (2004). Human resources and health outcomes: cross-country econometric study. *The Lancet,* vol. 364, No. 9445, pp. 1603-1609.

ASER Centre (2013). *Annual Status of Education Report (Rural) 2012.* New Delhi. Available from http://img.asercentre.org/docs/Publications/ASER%20Reports/ASER_2012/fullaser2012report.pdf.

Banik, N. (2009). Trade and social development: the case of Asia. Asia-Pacific Research and Training Network on Trade Working Paper, No. 68. Bangkok: ESCAP.

Barro, R.J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics,* vol. 106, No. 2, pp. 407-443.

__________ (1997). *Determinants of Economic Growth: A Cross-country Empirical Study.* Cambridge, Massachusetts: MIT Press.

Barro, R., and X. Sala-i Martin (2004). *Economic Growth*. New Delhi: Prentice-Hall of India.

Behrman, J.R., and A.B. Deolalikar (1988). Health and nutrition. In *Handbook of Development Economics,* vol. 1, H. Chenery and T. Srinivasanothers, eds. Amsterdam: Elsevier.

Bils, M., and P. Klenow (2000). Does schooling cause growth? *American Economic Review,* vol. 90, No. 5, pp. 1160-1183.

Bleakley, H. (2003). Disease and development: evidence from the American South. *Journal of the European Economic Association,* vol. 1, No. 2-3, pp. 376-386.

Bloom, D., and D. Canning (2000). The health and wealth of nations. *Science,* vol. 287, pp. 1207-1209.

Breierova, L., and E. Duflo (2004). The impact of education on fertility and child mortality: do father's really matter less than mothers? Working Paper, No. 10513. Cambridge, Massachusetts: National Bureau of Economic Research.

Breusch, T., and A. Pagan (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The Review of Economic Studies,* vol. 47, No. 1, pp. 239-253.

Chaudhury, S., and N.Gupta (2009). Levels of living and poverty patterns: a district-wise analysis for India. *Economic and Political Weekly*, vol. 44, No. 9, pp. 94-110.

Deaton, A.S., and C. Paxson (2001). Mortality, education, income, and inequality among American cohorts. In *Themes in the Economics of Aging,* David A. Wise, ed. Illinois: University of Chicago Press.

Debroy, B., and L. Bhandari (2003). *District-Level Deprivation in the New Millennium.* New Delhi, India: Konark Publishers and Rajiv Gandhi Institute for Contemporary Studies.

Deolalikar, A. (1988). Nutrition and labour productivity in agriculture: estimates for rural south india. *Review of Economics and Statistics,* vol. 70, No. 3, pp. 406-413.

Dholakia, R. (2003). Regional disparity in economic and human development in India. *Economic and Political Weekly,* vol. 38, No. 39, pp. 4166-4172.

Duraisamy, P. (1998). Morbidity in Tamilnadu: levels, differentials and determinants. *Economic and Political Weekly,* vol. 33, No. 17, pp. 982-990.

__________ P. (2001). Health status and curative healthcare in rural India. Working Paper Series, No. 78. New Delhi: National Council of Applied Economic Research.

Flegg, A.T. (1982). Inequality of income, illiteracy and medical care as determinants of infant mortality in underdeveloped countries. *Population Studies,* vol. 36, pp. 441-458.

Foster, A., and M. Rosenzweig (1995). Learning by doing and learning from others: human capital and technical change in agriculture. *Journal of Political Economy,* vol. 103, No. 6, pp. 1176-1209.

Ghosh, M. (2006). Economic growth and human development in Indian states. *Economic and Political Weekly,* vol. 41, No. 30, pp. 3321-3329.

__________ (2008). Economic reforms, growth and regional divergence in India. *Margin*: *The Journal of Applied Economic Research,* vol. 2, pp. 265-285.

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy,* vol. 80, No. 2, pp. 223-255.

Greene, W.H. (2011). *Econometric Analysis.* 7th ed. New Jersey: Prentice Hall.

Gujarati, D. (2004). *Introduction to Econometrics.* New Delhi, India: Tata McGrawHill Publishing.

Hanushek, E.A., and L. Wobmann (2007). *Education Quality and Economic Growth.* Washington, D.C.: World Bank.

Hausman, J. (1975). An instrumental variable approach to full-information estimators for linear and certain nonlinear econometric models. *Econometrica*, vol. 43, No. 4, pp. 727-738.

India, Ministry of Finance (various issues). *Economic Survey*. New Delhi.

India, Ministry of Health and Family Welfare (MOHFW) (2011). Family welfare statistics in India. New Delhi: Statistics Division.

India, Ministry of Home Affairs (2011). Annual health survey bulletin 2010-11. Delhi: Office of the Registrar General & Census Commissioner.

India, Planning Commission (2010). District of India – districts status. Available from http://districts.nic.in/dstats.aspx. Accessed 2 April 2011.

Indira, A., R. Meenakshi, and V. Vyasulu (2002). Estimation of district income and poverty in Indian states. *Economic and Political Weekly,* vol. 37, No. 22, pp. 2171-2177.

Kalemli-Ozcan, S., H.E. Ryder, and D.N. Weil (2000). Mortality decline, human capital investment, and economic growth. *Journal of Development Economics,* vol. 62, No. 1, pp. 1-23.

Kaliranjan, K., and R. Shand (1985). Types of education and agricultural productivity: a quantitative analysis of Tamilnadu rice farming. *Journal of Development Studies,* vol. 21, No. 2, pp. 232-243.

Katyal, R., M. Sardana, and J. Satyanarayana (2001). Estimates of district domestic product. Human Development Resource Centre Discussion Paper, No. 2. New Delhi: United Nations Development Programme.

Kmenta, J., and R. Gilbert (1968). Small sample properties of alternative estimators of seemingly unrelated regressions. *Journal of the American Statistical Association*, vol. 63, No. 324, pp. 1180-1200.

Kurian, N.J. (2000). Widening regional disparities in India: some indicators. *Economic and Political Weekly,* vol. 35, No. 7, pp. 538-550.

Lahiri, K., and P. Schmidt (1978). On the estimation of triangular structural systems. *Econometrica,* vol. 46, No. 5, pp. 1217-1221.

Levine, R., and D. Renelt (1992). A sensitivity analysis of cross-country growth regressions. *American Economic Review,* vol. 82, No. 4, pp. 942-963.

Maddala, G., and K. Lahiri (2009). *Introduction to Econometrics*. India: Wiley.

Mankiw, N.G., D. Romer, and D.N. Weil (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics,* vol. 107, No. 2, pp. 407-437.

Mehta, A. (2003). Multidimensional poverty in India: district level estimates. CPRC-IIPA Working Paper, No. 9. Manchester, United Kingdom: Chronic Poverty Research Centre, Department for International Development.

Miguel, E., and M. Kremer (2004). Worms: identifying impacts on education and health in the presence of treatment externalities. *Econometrica*, vol. 72, No. 1, pp. 159-217.

Preston, S. (1975). The changing relation between mortality and level of economic development. *Population Studies,* vol. 29, No. 2, pp. 231-248.

Pritchett, L., and L.H. Summers (1996). Wealthier is healthier. *The Journal of Human Resources,* vol. 31, No. 4, pp. 841-868.

Romer, P. (1990). Endogenous technological change. *Journal of Political Economy,* vol. 98, No. 5, pp. 71-102.

Rosenzweig, M. (1995). Why are there returns in schooling? *American Economic Review,* vol. 85, No. 2, pp. 153-158.

Roy, H., and K. Bhattacharjee (2009). Convergence of human development across Indian states. IGIDR proceedings PP-062-22 presented at the Quantitative Approaches to Public Policy – Conference in Honour of Professor T. Krishna Kumar held in conjunction with the Fourth Annual International Conference on Public Policy and Management Indian Institute of Management Bangalore (IIMB), Banalore, 9-12 August. Accessed 12 May 2011.

Schultz, T. (1999). Health and schooling investment in Africa. *Journal of Economic Perspective,* vol. 13, No. 3, pp. 67-88.

Strauss, J. (1986). Does better nutrition raise farm productivity? *Journal of Political Economy,* vol. 94, No. 2, pp. 297-320.

Trivedi, K. (2002). Educational human capital and levels of income: evidence from states in India, 1965-92. Department of Economics Discussion Paper, No. 97. Oxford, United Kingdom: University of Oxford.

Zaidi, N.A., and M.A. Salam (1998). Human development in India: an interstate comparison. *Indian Journal of Economics,* vol. 78, No. 311, pp. 447-460.

Zellner, A. (1962). An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias. *Journal of the American Statistical Association,* vol. 57, No. 298, pp. 348-368.