Interlink between human capital and income in Indian States: An empirical investigation for the period 1998–2019

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Economic openness undoubtedly has income-increasing effects across all economies, but it has led to increasing inequality within and across countries. India and its states are no exceptions in this regard. There have been many endogenous factors that justify the increasing growth trends in gross and per capita incomes in the postopenness phase. Human capital formation through spending on health and education heads has been one such endogenous factor. The present study aims to investigate the role of education and health expenditure on income in India's sixteen major states/union territories (UTs) for the 1998–2019 period. By Johansen cointegration analysis, it is found that there is a long-run association among education expenditure, health expenditure and income in fourteen states: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, National Capital Territory (NCT) Delhi, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. From vector error correction mechanism (VECM) estimation, the long-run causal relation jointly from education and health expenditure to income has been found in Assam, Bihar, Haryana, Maharashtra, NCT Delhi, and Rajasthan. Employing the Granger causality test in a vector autoregressive (VAR) setup, mixed results were found for both unidirectional and bidirectional causality.

Keywords:
education,
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Introduction

The neoclassical growth model, introduced by Solow (1956), was a strong theory of economic growth that came after the Keynesian line of the Harrod-Domar model and stated that the effect of savings on growth should be temporary, while the latter model proposed that there should be a perpetual growth effect. According to the phase diagram, the growth rate of income moves to zero at the steady state. The reason behind this was the effect of the diminishing marginal productivity of physical capital. In addition to this growth effect, the assumption of diminishing productivity led to the prediction of cross-country convergence in the future. In the 1980s, the empirical data showed that developed countries were able to widen the gap of income growth with the relatively weaker countries in the world, which disproved the neoclassical growth theory's prediction of cross-country convergence. In that context, the theories of the endogenous growth model were developed, and the endogenous factors were knowledge creation, research and development, human capital formation through health and education expenditures, the role of public institutions, etc. The effects of these factors were to generate perpetual growth rates of per capita income over the long run.

There has been a list of studies in the field of endogenous growth across different countries, such as the studies by Levine–Renelt (1992), Mincer (1996), Benhabib–Spiegel (1994), Pritchett (1997), Mehrara–Musai (2013), Teixeira (2014), Das–Mukherjee (2019), Das (2020), and Das–Chatterjee (2020). The present study is an attempt to focus on the role of human capital in the income growth of the Indian states.

Generally, it is argued that higher human capital causes more economic growth. Here, we are concerned with two sources of accumulation of human capital: (i) expenditure on education and (ii) expenditure on health. Lucas Jr. (1988) argues that the accumulation of human capital is responsible for sustained growth and that education is the main channel through which human capital accumulates. Romer (1986, 1990) shows that human capital, which generates innovations, stimulates growth. As is well documented in the literature, education also causes spillover effects, increases the adaptation speed of entrepreneurs to disequilibrium, and boosts research productivity.

Furthermore, there are possible feedback effects from economic growth to human capital. It is argued that economic growth could lead to human capital accumulation (Mincer 1996). Therefore, the causal chain between economic growth and education implied by the existing macroeconomic paradigms seems relatively ambiguous.

Therefore, the dynamic causal relationships in the Granger sense remain uncertain. There is mixed evidence in the empirical literature regarding the relation between education and economic growth. Benhabib–Spiegel (1994), Pritchett (1997) report a fragile correlation between growth and education. Levine–Renelt (1992) show that education does not have a significant impact in many of the growth regressions they have estimated. Bils–Klenow (2000) find weak causality from education to growth; thus, the statistical significance of education in growth regressions may arise from omitted variables. Therefore, cross-sectional studies seem to yield mixed results. Dessus–Herrera (1999) argues that the findings of Benhabib–Spiegel (1994) and Pritchett (1997) may be due to specification bias. Dessus–Herrera' (1999) panel data results suggest that as the education quantity increases, the quality of the education decreases. This may be the reason why enormous educational investments in developing countries fail to generate higher growth.

This study contributes to the research on economic growth, that is, human capital, and how it fosters economic growth according to the research of Lucas Jr. (1988); Barro (1991); Mankiw et al. (1992). The chapter's main contribution to the literature is that it analyzes the cointegration and Granger causal relationship among government expenditure on education (GEE) and government expenditure on health (GEH), which are the variables of interest, and economic growth, proxied as net state value added (NSVA), for sixteen major states of India during the period from 1998–1999 to 2018–2019.

Literature review

Many theoretical and empirical studies available in the literature have been undertaken to establish the relation between human capital investment and economic growth. The prominent among them are reviewed below.

Becker (1964) focused on the presupposition of general-purpose and firm-specific human capital and developed an economic approach to human capital. Lucas Jr. (1988) appraised the prospects of the neoclassical theory of growth and developed a model emphasizing specialized human capital accumulation through learning-by-doing. Mankiw et al. (1992) argue that the Solow model is consistent with international evidence if one acknowledges the importance of human capital as well as physical capital. Barro (1991) showed that the growth rate of real per capita gross domestic product (GDP) is positively related to initial human capital and negatively related to the initial level of real per capita GDP. Benhabib–Spiegel (1994) found that human capital insignificantly affects per capita growth rates but affects the growth of total factor productivity. Mincer (1996) makes clear the process of growth not merely as a cause by human capital but also as an effect of developments generated by economic growth. Gemmel (2009) finds evidence contrary to that of Romer (1990), who argued that across a large group of developed and developing countries, human capital affects economic growth significantly. It is also well known that richer countries spend more on education (Armellini–Basu 2010, Blankeau et al. 2007). A study by Khembo–Tchereni (2013) probes whether education and health positively affect GDP per capita. They suggested making quality education accessible and recommended this idea to policy-makers. A similar result was presented by Qadri–

Waheed (2011) utilizing a health-adjusted education indicator and found that economic growth was highly affected by this indicator.

Considering the long-run relationship between human capital and economic growth, Haldar (2009) concluded that human capital affects the economy both in the long run and in the short run. The same result was found by Muktadir-Al-Mukit (2012) in Bangladesh. The cointegration test is confirmed by Sharma–Sahni (2015) and shows that there is a long-term relationship and two-way causality between human capital investment (education & health investment) and economic growth. According to Basu–Bhattari (2009), public spending on education has favorable effects on growth. Using the autoregressive distributed lag technique for cointegration, Adu–Denkyirah (2017) demonstrate that both primary and secondary education have beneficial effects on economic growth. Hatam et al. (2016) discovered a strong and positive relationship between health expenditures and economic growth. Recent research on India's states by Hussain–Das (2023) used a panel study and demonstrated that human capital and incomes have a permanent relationship and that human capital has an immediate influence on the state income of India. Education and health are the primary sources of human capital and lead to intellectual capital, which contributes to a rise in the national income of the economy (Hussain et al. 2022).

Heshmati (2001) found a unidirectional causality from health care expenditure to income. However, Al-Yousif (2008) found bidirectional causality between education and economic growth. Rahman (2011) shows the existence of bidirectional causality for education expenditure and GDP, and unidirectional causality is obtained from health expenditure to GDP. Similarly, the study by Mehrara–Musai (2013) shows the causality from economic growth to education in developing countries. In a similar study, Sghari–Hammami (2013) discovered bidirectional causality between per capita health expenditures and GDP per capita. Using data from 16 Indian states between 1990-1991 and 2010-2011, Mohapatra (2017) established a causal relationship from public health expenditures to economic growth in the long run. The study by Chandra (2010) shows that causality runs from education spending to economic growth in India. Similarly, Chakraborty–Krishnankutty (2012) found that expenditures on education positively and significantly influenced the economic growth of Indian states. A positive significant result of the association between secondary education and economic growth was supported by Khattak–Khan (2012). Kouton (2018) and Osiobe (2020) exposed the relationship between education and economic growth and concluded that government spending on education has a positive impact on GDP. Using data from 1951 to 2015 for India, Jariwala (2017) found a long-term relation between education and GDP. According to the findings of Nasrin (2021), economic growth is positively related to overall health expenditures in all Asian countries. On a panel basis, the findings of Ozyilmaz et al. (2022) show a bidirectional causality relationship between health expenditures and growth in the economy.

Rationale, objective and hypotesis of the study

As evident from the review of the literature, many studies have been conducted at the global and national levels. However, a few studies have been conducted on India, but not a single study shows the relationship between human capital and economic growth in states/UTs of India. Thus, the present study aims to visualize the interconnection between human capital (education expenditure and health expenditure) and state income of sixteen major states/UTs of India during the period of 1998–1999 to 2018–2019. The choice of the study period is based upon the availability of data. The states are Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal and Delhi.

The present research study aims to test the empirical relation between human capital (as proxied by government expenditure on the heads of education and health) and the income of the major states and union territories (UTs) of India for the period 1998–1999 to 2018–2019.

The present study is based on the following hypothesis: "Human capital investment has significant long-term and short-term impacts on the income of the major states in India."

Theoretical model, variable description and data source

Under the neoclassical growth model, the effect of savings on economic growth was short-lived; according to the phase diagram, it moved to zero at the steady state. The reason behind this was the working of the diminishing marginal productivity of physical capital. In addition, the diminishing productivity assumption led to the prediction of cross-country convergence in the long run. In the 1980s, the empirical data showed that developed countries had been able to widen the gap of income growth with the relatively weaker countries in the world, which disproved the neoclassical growth theory's prediction of cross-country convergence. The theories of the endogenous growth model developed in that context, and the endogenous factors are knowledge creation, research and development, human capital formation through health and education expenditures, institutions, etc. The effects of these factors were to generate perpetual growth rates of per capita income over longer periods of time. The present study agrees with Lucas's (1988) theory where human capital (education and health) becomes the endogenous component of growth. In the Appendix, the theoretical model of Lucas is explained briefly.

Human capital is measured by GEE and GEH, and the Income level is measured by NSVA. Thus, the present study has three key variables: GEE, GEH and NSVA.

The center allocates grants to several leaders of the states, and the total funds then become the income of the states. Using other sources of income, the states add the total income (their own and from the center's shares) and allocate it among several heads, including education and health. The GEE and GEH are computed using the data availabilities on the shares of GEE and GEH and NSVA.

Under GEE, expenditure on education as well as expenditure on sports, art and culture is also included (Reserve Bank of India [RBI] statement 26). Some noteworthy researchers found evidence that education or expenditures on education can be interpreted as investments in human capital and have a direct or indirect positive effect on economic growth. These studies include Barro (1991), Gemmell (1996), Musila–Belassi (2004) and Al-Yousif (2008).

GEH includes expenditures on medical care, public health and family welfare (RBI statement 27). Public spending on health contributes to human capital (Gupta et al. 2002) and thus improves economic growth by reducing inequality and poverty (Gupta et al. 1998). Benefits derived from health care financing include that people are healthier and have less difficulty performing physical and mental tasks (Doryan 2001, Bidani–Ravallion 1997). As a result, these advantages boost labor productivity and sustain economic growth (Razmi et al. 2012).

Here, both GEE and GEH are based on revised budget estimates, and the actual value of expenditures is calculated from the ratio to their respective aggregate expenditure (revenue and capital expenditure). The data used in the study are secondary and were collected from annual publications of the RBI [1].

Methodology

We can now connect the theoretical model with the empirical model. The human capital of any state at time t, HC_t, is generated by the two sources of funding, education ($GEE\ or\ E_t$) and health ($GEH\ or\ H_t$). That means,

$$HC_t = E_t + H_t \tag{1}$$

The progress of E_t is viewed by the following autoregressive process:

$$E_t = a_1 E_{t-1} + a_2 E_{t-2} + \ldots\ldots + a_{21} E_{t-21} + U_t \tag{2}$$

where 21 is the total time point for the duration 1998–1999 to 2018–2019.

Similarly, for the head of health, the data generation process follows the following expression:

$$H_t = b_1 H_{t-1} + b_2 H_{t-2} + \ldots\ldots + b_{21} H_{t-21} + V_t \tag{3}$$

where a_i and $b_i < 1$ to maintain the stability of the data series.

Thus, the expression for HC_t is

$$HC_t = (a_1+b_1)\ HC_{t-1} + (a_2+b_2)\ HC_{t-2} + \ldots. + (a_{21}+b_{21})\ HC_{t-21} + (U_t+V_t) \tag{4}$$

Or,

$$HC_t = h_1\ HC_{t-1} + h_2\ HC_{t-2} + \ldots. + h_{21}\ HC_{t-21} + W_t \tag{5}$$

Here, $h_i < 1$ for stability of the HC_t series, and W_t follows ordinary least squares (OLS) properties.

Similarly, the incomes of the states will follow the expression as

$$Y_t = c_1 Y_{t-1} + c_2 Y_{t-2} + \ldots\ldots + c_{21} Y_{t-21} + \eta_t \tag{6}$$

Here, $c_i < 1$ for stability of the Y_t series.

To obtain long-run relations between human capital, HC_t and income, Y_t of any representative state in India, the following model is to be estimated:

$$Y_t = \alpha_t + \beta_t\, HC_t + \varepsilon_t \tag{7}$$

Here, β_t can be separated into the coefficients of E_t and H_t. The corresponding estimated values of the parameters with their acceptable statistical properties will justify the accepted equilibrium relation for the long run between income and human capital formation in the states.

Given the nature of the problem and the quantity of data, this study forms an econometric perspective starting with the stationarity of the data by using the natural log of the series. This study employs the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests to check the stationarity of the series and the Johansen cointegration test to check the long-run relationship among the variables. Then, the vector error correction model is estimated. Finally, the VAR Granger causality test is applied to investigate the causality among GEE, GEH and NSVA.

Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) test

The augmented Dickey–Fuller (ADF, 1979) test is preferred, as most studies have adopted it to examine the unit root in time series data. The common models for the purpose of testing the null Hypothesis H_0: $\delta = 0$ is

$$\Delta Z_t = \alpha + \delta Z_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta Z_{t-i} + u_t \tag{8}$$

where Z_t is any time series variable, income, education expenditure or health expenditure; u_t is a white noise error term. If the absolute computed value of the tau statistics (τ) is greater than the ADF or Mackinnon critical values, we reject the null hypothesis that H_0: $\delta = 0$ and conclude that the time series is stationary. The structure for the Phillips–Perron (1988) test, allowing for less stringent assumptions about the distribution of error terms, is

$$\Delta Z_t = \alpha + \delta Z_{t-1} + u_t \tag{9}$$

The decision to reject the null hypothesis is the same as in the ADF test discussed above.

Cointegration test

In this section, Johansen's ML approach of the cointegration test is used to study the long-run relationships. The equation is illustrated as follows:

$$\Delta Z_t = m + \pi Z_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta Z_{t-i} + v_t \tag{10}$$

where ΔZ_t= the 3*1 vector, i.e., $(\Delta Z_{1t} = \Delta \ln NSVA\ , \Delta Z_{2t} = \Delta \ln GEE\ , \Delta Z_{3t} = \Delta ln\ GEH)'$, m= 3*1 vector of intercept, $\pi = -(I - \sum_{i=1}^{p} A_i)$, $\pi_i = -\sum_{j=i+1}^{p} A_i$, A = coefficient matrix and I = identity matrix, p = lag length, v_t = 3*1 vector of residual term. If all variables are I(1), then variables ΔZ_{t-i} are stationary. The likelihood ratio test statistic, the trace test (λ_{trace}), is

$$\lambda_{\text{trace}}\,(r) = -\,T\sum_{i=r+1}^{k}\ln(1-\hat{\lambda}_i) \tag{11}$$

where $\hat{\lambda}_i$ = estimated values of the characteristic root (i.e., Eigenvalue) obtained from the estimated π matrix and T = the number of usable observations. The rejection of the null hypothesis indicates the existence of at most r cointegrating vectors.

Vector error correction mechanism (VECM)

However, when the variables are nonstationary but cointegrated, the VECM is used. Of course, in the short run, there may be disequilibrium. The purpose of the VECM is to indicate the speed of adjustment from the short-run disequilibrium to the long-run equilibrium state. The VECM is specified as

$$\Delta\ln NSVA_t = a_1 + \sum_{i=1}^{p} b_i\Delta\ln NSVA_{t-i} + \sum_{i=1}^{p} c_i\Delta ln\,GEE_{t-i} + \sum_{i=1}^{p} d_i\Delta ln\,GEH_{t-i} + \lambda_1\hat{\varepsilon}_{t-1} + \varepsilon_t \tag{12}$$

The error term ε_t is the white noise error term; $\hat{\varepsilon}_{t-1}$ is the one-period lagged value of the error term from the cointegrating regression of $lnNSVA_t$ on $\ln GEE_t$ and $lnGEH_t$. Additionally, $\hat{\varepsilon}_{t-1}$ is called the error correction term (ECT). λ = The coefficient of ECT is the feedback effect, adjustment effect, or error correction coefficient and shows how much of the disequilibrium is being corrected. However, equilibrium will be restored in the long run if and only if $\lambda < 0$.

Granger causality in VAR

Granger (1969) provides a formal test to examine the direction of causality between the variables. The Granger causality test can be performed easily using the VAR model as follows:

$$\Delta\text{lnNSVA}_t = a_1 + \sum_{i=1}^{p} b_i\Delta\text{lnNSVA}_{t-i} + \sum_{i=1}^{p} c_i\Delta\text{lnGEE}_{t-i} + \sum_{i=1}^{p} d_i\Delta\text{lnGEH}_{t-i} + \varepsilon_{1t} \tag{13}$$

$$\Delta\text{lnGEE}_t = a_2 + \sum_{i=1}^{p} g_i\Delta\text{lnNSVA}_{t-i} + \sum_{i=1}^{p} h_i\Delta\text{lnGEE}_{t-i} + \sum_{i=1}^{p} q_i\Delta\text{lnGEH}_{t-i} + \varepsilon_{2t} \tag{14}$$

$$\Delta lnGEH_t = a_3 + \sum_{i=1}^{p} l_i\Delta lnNSVA_{t-i} + \sum_{i=1}^{p} r_i\Delta\text{lnGEE}_{t-i} + \sum_{i=1}^{p} s_i\Delta\text{lnGEH}_{t-i} + \varepsilon_{3t} \tag{15}$$

Here, the Granger causality test is based on testing the joint significance of the lags of each variable in the system, apart from its own lags. The null hypotheses are H_{01}: $c_i = d_i = 0$ [GEE and GEH do not Granger cause NSVA]; H_{02}: $g_i = q_i = 0$ [NSVA and GEH do not Granger cause GEE] and H_{03}: $l_i = r_i = 0$ [NSVA and GEE do not Granger cause GEH].

Empirical results and discussion

Representation of data and the correlation coefficient of variables

By observing the Figure A1 in the Appendix, it is easy to identify that GEE and health increased over time (1998–1999 to 2018–2019) across the major 16 states and UT of India. At the same time, the NSVA also increased during this period. The upward sloping trend of these three variables may have a positive and significant correlation among them. The correlation coefficients between NSVA and GEE and between NSVA and GEH are shown in Table 1.

Table 1

Correlation Coefficient between NSVA, GEE and GEH during 1998–1999 to 2018–2019

States/UTs	r 1	Prob	r 2	Prob
Andhra Pradesh	0.8984	0.0000	0.9305	0.0000
Assam	0.9664	0.0000	0.9354	0.0000
Karnataka	0.9431	0.0000	0.9860	0.0000
Madhya Pradesh	0.9669	0.0000	0.9738	0.0000
Bihar	0.9709	0.0000	0.9487	0.0000
Gujarat	0.9721	0.0000	0.9846	0.0000
Haryana	0.9705	0.0000	0.9767	0.0000
Kerala	0.9938	0.0000	0.9886	0.0000
Maharashtra	0.9669	0.0000	0.9738	0.0000
Orissa	0.9808	0.0000	0.9226	0.0000
Punjab	0.9419	0.0000	0.9346	0.0000
Rajasthan	0.9741	0.0000	0.9738	0.0000
Tamil Nadu	0.9827	0.0000	0.9842	0.0000
Uttar Pradesh	0.9653	0.0000	0.9853	0.0000
West Bengal	0.9566	0.0000	0.9760	0.0000
NCT Delhi	0.9891	0.0000	0.9880	0.0000

Note: 'r1' and 'r2' denote the Karl Pearson correlation coefficient values between NSVA and GEE and between NSVA and GEH, respectively.

From Table 1, it is observed that the correlation coefficients between NSVA and GEE and between NSVA and GEH are highly positive and significant for all the states/UTs under the study. This implies that government expenditures on education and health are highly and positively correlated with the income of the states/UTs.

Here, it should be noted that the correlation coefficient only shows the degree of association between variables. It does not show the cause-and-effect relationships among the variables. In the following sections, we used time series econometric methods to investigate their interrelationships for the long run and short run.

Unit root test results

Since estimation from nonstationary time series variables may lead to spurious relations, it is the first step to check the stationarity of the variables. For the unit root test for stationarity, ADF and PP tests are conducted for ln(NSVA), ln(GEE) and ln(GEH). The ADF and PP test results for the first/second difference of the natural log series for all states/UTs under study are provided in Table 2. Here, the null hypothesis, H_0 = Series, has a unit root.

Table 2

Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) test results

States/UTs	Test	lnNSVA	Prob	lnGEE	Prob	lnGEH	Prob	Remarks
Andhra Pradesh	ADF	–3.533	0.0185	–4.864	0.0012	–4.463	0.0027	I(1)
	PP	–3.506	0.0195	–4.861	0.0012	–4.463	0.0027	I(1)
Assam	ADF	–3.708	0.0129	–5.811	0.0002	–4.303	0.0037	I(1)
	PP	–3.736	0.0122	–5.817	0.0002	–4.303	0.0037	I(1)
Bihar	ADF	–2.983	0.0581	–5.886	0.0002	–4.855	0.0022	I(1)
	PP	–3.938	0.0080	–9.845	0.0000	–11.857	0.0000	I(1)
Gujarat	ADF	–3.431	0.0227	–4.498	0.0025	–4.995	0.0009	I(1)
	PP	–3.477	0.0207	–4.499	0.0025	–4.987	0.0009	I(1)
Haryana	ADF	–4.611	0.0022	–7.019	0.0000	–5.002	0.0011	I(2)
	PP	–4.755	0.0016	–13.815	0.0000	–18.822	0.0000	I(2)
Karnataka	ADF	–7.345	0.0000	–4.640	0.0019	–3.246	0.0329	I(1)
	PP	–3.065	0.0467	–4.637	0.0019	–3.218	0.0348	I(1)
Kerala	ADF	–5.987	0.0001	–5.947	0.0002	–5.848	0.0002	I(2)
	PP	–6.251	0.0001	–14.647	0.0000	–12.013	0.0000	I(2)
Madhya Pradesh	ADF	–3.973	0.0074	–6.350	0.0001	–7.294	0.0000	I(1)
	PP	–4.042	0.0065	–6.793	0.0000	–7.716	0.0000	I(1)
Maharashtra	ADF	–4.809	0.0016	–5.049	0.0010	–4.627	0.0023	I(2)
	PP	–8.819	0.0000	–7.957	0.0000	–17.406	0.0000	I(2)
NCT Delhi	ADF	–3.443	0.0249	–5.143	0.0007	–6.475	0.0000	I(1)
	PP	–3.746	0.0440	–7.357	0.0000	–11.598	0.0000	I(1)
Odisha	ADF	–4.914	0.0013	–4.738	0.0017	–5.111	0.0012	I(2)
	PP	–9.371	0.0000	–4.900	0.0012	–15.585	0.0000	I(2)
Punjab	ADF	–3.778	0.0117	–5.763	0.0003	–6.256	0.0001	I(2)
	PP	–3.756	0.0123	–19.203	0.0000	–16.014	0.0000	I(2)
Rajasthan	ADF	–4.258	0.0041	–4.425	0.0029	–4.900	0.0088	I(1)
	PP	–4.269	0.0040	–4.490	0.0025	–5.375	0.0004	I(1)
Tamil Nadu	ADF	–4.238	0.0046	–4.837	0.0015	–5.159	0.0008	I(2)
	PP	–4.341	0.0037	–9.101	0.0000	–15.073	0.0000	I(2)
Uttar Pradesh	ADF	–5.065	0.0009	–5.375	0.0005	–7.621	0.0000	I(2)
	PP	–5.142	0.0007	–8.662	0.0000	–20.507	0.0000	I(2)
West Bengal	ADF	–7.695	0.0000	–8.307	0.0000	–7.720	0.0000	I(2)
	PP	–7.695	0.0000	–11.947	0.0000	–18.926	0.0000	I(2)

Note: I(1) and I(2) imply that the series are stationary at the first and second difference orders, respectively.

The null hypothesis of nonstationarity under both the ADF and PP tests is not rejectable in the level value of all the variables for all the states/UTs. This implies that the series belonging to ln(NSVA), ln(GEE) and ln(GEH) are not stationary in level value. They become stationary after taking either the first difference, I(1), or the second difference, I(2), of the series. The variables are I(1) in eight states/UT- Andhra Pradesh, Assam, Bihar, Gujarat, Karnataka, Madhya Pradesh, NCT Delhi and Rajasthan. The remaining eight states have no unit root in the second difference, i.e., the series are I(2): Haryana, Kerala, Maharashtra, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal.

Cointegration test results

Johansen's cointegration technique is used on the above sixteen states/UT to examine the long-run relationship among ln(NSVA), ln(GEE), and ln(GEH). The study used trace statistics (λ_{trace}), and the results are given in Table 3.

Table 3

Johansen's cointegration test results

States/UTs	Hypothesized No of CE(s)	Lag	Trace statistics	Prob	Remarks
Andhra Pradesh	None *	2	31.0604	0.0356	Cointegrated
	At most 1		7.79020	0.4881	
	At most 2		0.14530	0.7031	
Assam	None *	1	30.7186	0.0391	Cointegrated
	At most 1		10.82696	0.2446	
	At most 2		1.390388	0.19202	
Bihar	None *	2	34.27088	0.0143	Cointegrated
	At most 1		11.00537	0.2112	
	At most 2		0.000812	0.9784	
Gujarat	None *	2	61.58081	0.0000	Cointegrated
	At most 1		11.47502	0.1839	
	At most 2		2.509114	0.1132	
Haryana	None *	1	33.31846	0.0189	Cointegrated
	At most 1 *		16.38292	0.0367	
	At most 2		1.646857	0.1994	
Karnataka	None *	2	33.77207	0.0165	Cointegrated
	At most 1		13.01266	0.1144	
	At most 2		2.53674	0.1112	
Kerala	None *	1	44.42255	0.0005	Cointegrated
	At most 1*		23.53826	0.0025	
	At most 2*		8.464225	0.0036	
Madhya Pradesh	None *	1	39.03679	0.0033	Cointegrated
	At most 1		10.60073	0.2373	
	At most 2		0.009518	0.9220	

(Table continues on the next page.)

(Continued.)

States/UTs	Hypothesized No of CE(s)	Lag	Trace statistics	Prob	Remarks
Maharashtra	None *	1	31.63846	0.0303	Cointegrated
	At most 1*		17.1437	0.0280	
	At most 2*		5.63873	0.0176	
NCT Delhi	None *	1	38.0776	0.0045	Cointegrated
	At most 1 *		17.7182	0.0228	
	At most 2		3.26191	0.0709	
Odisha	None	1	27.3688	0.0929	Not Cointegrated
	At most 1		11.9390	0.1599	
	At most 2		3.61559	0.0572	
Punjab	None *	1	34.11329	0.0150	Cointegrated
	At most 1		10.60226	0.2372	
	At most 2*		4.570604	0.0325	
Rajasthan	None *	1	38.73771	0.0036	Cointegrated
	At most 1 *		17.11848	0.0282	
	At most 2		0.751677	0.3859	
Tamil Nadu	None *	2	42.90093	0.0009	Cointegrated
	At most 1*		15.93818	0.0429	
	At most 2		0.748588	0.3869	
Uttar Pradesh	None *	1	35.36131	0.0103	Cointegrated
	At most 1 *		17.71177	0.0228	
	At most 2		5.537263	0.0186	
West Bengal	None	1	26.7662	0.1075	Not Cointegrated
	At most 1		10.83887	0.2216	
	At most 2*		4.342682	0.0372	

Note: * denotes rejection of the hypothesis at the 0.05 level; the lag order selected by the decision from AIC (Akaike Information Criterion) as the result is presented in Appendix, Table A1.

From Table 3, it is observed that the null hypothesis of 'no cointegration' is rejected in fourteen states/UT. The variables ln(GEE), ln(GEH) and ln(NSVA) are cointegrated. This implies that there is a long-run stable relationship among public expenditure on education, public expenditure on health and the income of the states/UT. These fourteen states/UTs are Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, NCT Delhi, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

Education fosters abilities that increase productivity. This suggests that improvements in income are the result of higher productivity brought about by educational spending (Lucas Jr. 1988, Romer 1990, Barro 2001). Similarly, investing in health that generates capital spurs economic growth (Mushkin 1962, Barro 1996, Erdil–Yetkiner 2004). In contrast, an increase in income may lead to an increase in expenditures on education and health. This relation follows Wagner's law, emphasizing that government spending is an endogenous factor that is driven by the increase in national income (Wagner 1958).

The variables are not cointegrated (no long-term relationship) for Odisha and West Bengal. The reason may be the presence of a structural break point of the variables. The possible reason may be that, from 2007–2008, there was an increasing fluctuation in expenditure for education in Odisha due to loans and advances for education provided by the Education Department. Similarly, with enhanced autonomy in selecting spending priorities during the 14th Finance Commission period, West Bengal emerged as the state with a growth in both health expenditure and education expenditure. The study thus has attempted to find the presence of structural b breaks in the two series only.

To find the structural break point, the study used the Zivot–Andrews (1992) unit root test method and found the structural break point for ln NSVA in 2014–2015 for both Odisha and West Bengal. For lnGEE and lnGEH, the break year is 2009–2010 in West Bengal. In Odisha, the structural break year for ln GEE is 2007–2008. The results of the unit root test with break points for the two states are given in Table A2 in the Appendix.

In addition, the study has reexamined cointegration relations among the three noted variables for the two states using Gregory-Hansen's residual method. The results are again given in the Appendix (refer to Table A4), where a stable cointegrating relation is observed only for Odisha but not for West Bengal.

Vector error correction model (VECM) estimation

In addition to the long-run stable relationships among GEE, GEH and NSVA, there may exist short-run diversification from the long-run equilibrium position. The study proceeds to estimate VECM to examine the short-run dynamics for these fourteen cointegrating states/UT, where the negative and significant coefficient of the ECT implies that if there exists any short-run disequilibrium from the long-run equilibrium relation, the error is corrected over time and the long-run stable relationship is restored. It also implies the speed of convergence toward a permanent relationship and can be represented as a long-run causal relationship from the independent variable to the dependent variable. The present study shows the estimated coefficient of ECT for the above fourteen cointegrating states/UT in Table 4.

In Table 4, the short-run adjustment coefficient of ECT appears to be negative and significant in Assam, Bihar, Haryana, Maharashtra, NCT Delhi, and Rajasthan. This implies that government expenditures on both education and health jointly cause state income in these six states/UTs in the long run. The empirical results support the endogenous growth theory that emphasizes that the sustained increase in income is due to human capital formation via expenditures on the education and health sectors.

The rate of convergence is highest for Haryana (43.6 percent annually), followed by Maharashtra (29.3 percent annually), Rajasthan (28.2 percent annually), Bihar (25.1 percent annually), NCT Delhi (19.7 percent annually) and Assam (18.9 percent annually).

Table 4

Estimated coefficient of ECT for the vector error correction model

States/UTs	Dependent variable: ln NSVA		
	Coefficient of ECT	Prob	Remarks
Andhra Pradesh	0.0104	0.2134	No long-run causality
Assam	–0.1892	0.0353	ln GEE, ln GEH → ln NSVA
Bihar	–0.2518	0.0425	ln GEE, ln GEH → ln NSVA
Gujarat	0.0120	0.3392	No long-run causality
Haryana	–0.4364	0.0073	ln GEE, ln GEH → ln NSVA
Karnataka	0.2944	0.0861	No long-run causality
Kerala	–0.3385	0.1145	No long-run causality
Madhya Pradesh	0.1584	0.0091	No long-run causality
Maharashtra	–0.2937	0.0616	ln GEE, ln GEH → ln NSVA
NCT Delhi	–0.1979	0.0309	ln GEE, ln GEH → ln NSVA
Punjab	–0.0669	0.7039	No long-run causality
Rajasthan	–0.2823	0.0005	ln GEE, ln GEH → ln NSVA
Tamil Nadu	–0.3689	0.2814	No long-run causality
Uttar Pradesh	–0.1098	0.4021	No long-run causality

Note: '→' implies direction of long-run causality from independent variables to dependent variable.

The study found no long-run causal relationship from education and health expenditure to income in eight states: Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Punjab, Tamil Nadu and Uttar Pradesh. There may exist a long-run relationship in the reverse direction. However, for Odisha, after obtaining the significant long-run relation, the study carries out the VECM test, and the estimated equation is as follows:

VECM for Odisha

$$\text{dlnNSVA} = 0.03277\,\varepsilon_{t-1} + 0.0371\,\text{dlnNSVA}_{t-1} + 0.0411\,\text{dlnGEE}_{t-1} - 0.116{*}\text{dlnGEH}_{t-1} + 0.122$$

Prob: (0.7815) (0.9022) (0.7067) (0.1162) (0.0054).

The results show that the errors are not corrected for Odisha.

Results of Granger causality in VAR

Despite long-run causality, there may exist a short-run causal relationship among public expenditure on education, public expenditure on health and income of states/UT. To check the short-run causality among them, Granger causality in the VAR model is conducted. The test results are presented in Table 5.

As can be inferred from the above results (Table 5), there are mixed results regarding the direction of causality among education expenditure, health expenditure and income of states/UTs.

Table 5

Results of the VAR Granger causality test for the sample from 1998–1999 to 2018–2019 by states/UT

States/UTs	Dependent variable	Chi-square value	DF	Prob	Remarks
Andhra Pradesh	Δ ln NSVA	1.3045	4	0.8606	GEH caused by NSVA and GEE
	Δ ln GEE	2.0293	4	0.7304	
	Δ ln GEH	10.703	4	**0.0301**	
Assam	Δ ln NSVA	0.4354	2	0.8044	GEH caused by NSVA and GEE
	Δ ln GEE	1.5995	2	0.4494	
	Δ ln GEH	5.5938	2	**0.0610**	
Bihar	Δ ln NSVA	2.0447	4	0.7275	No short-run causality
	Δ ln GEE	3.1430	4	0.5342	
	Δ ln GEH	3.6812	4	0.4509	
Gujarat	Δ ln NSVA	4.5076	4	0.3416	No short-run causality
	Δ ln GEE	1.6032	4	0.8082	
	Δ ln GEH	2.0203	4	0.7320	
Haryana	ΔΔ ln NSVA	1.0189	2	0.6008	GEE caused by NSVA and GEH GEH caused by NSVA and GEE
	ΔΔ ln GEE	8.8026	2	**0.0123**	
	ΔΔ ln GEH	5.3222	2	**0.0699**	
Karnataka	Δ ln NSVA	8.8207	4	**0.0657**	Intercausality among all
	Δ ln GEE	12.283	4	**0.0154**	
	Δ ln GEH	17.648	4	**0.0014**	
Kerala	ΔΔ ln NSVA	2.3030	2	0.3162	No short-run causality
	ΔΔ ln GEE	0.2304	2	0.8912	
	ΔΔ ln GEH	2.2450	2	0.3255	
Madhya Pradesh	Δ ln NSVA	1.5380	2	0.4635	No short-run causality
	Δ ln GEE	0.8142	2	0.6656	
	Δ ln GEH	0.8320	2	0.6597	
Maharashtra	ΔΔ ln NSVA	15.875	2	**0.0004**	NSVA caused by GEE and GEH
	ΔΔ ln GEE	4.1779	2	0.1238	
	ΔΔ ln GEH	0.3817	2	0.8262	
NCT Delhi	Δ ln NSVA	1.9803	2	0.3715	No short-run causality
	Δ ln GEE	1.0916	2	0.5794	
	Δ ln GEH	0.6779	2	0.7125	
Odisha	ΔΔ ln NSVA	5.6812	2	**0.0584**	NSVA caused by GEE and GEH
	ΔΔ ln GEE	1.6038	2	0.4485	
	ΔΔ ln GEH	0.6669	2	0.7165	
Punjab	ΔΔ ln NSVA	0.1451	2	0.9300	No short-run causality
	ΔΔ ln GEE	0.4750	2	0.7886	
	ΔΔ ln GEH	0.5142	2	0.7733	
Rajasthan	Δ ln NSVA	0.8198	2	0.6637	No short-run causality
	Δ ln GEE	1.2092	2	0.5463	
	Δ ln GEH	0.4375	2	0.8035	
Tamil Nadu	ΔΔ ln NSVA	3.4160	4	0.4908	No short-run causality
	ΔΔ ln GEE	4.4050	4	0.3540	
	ΔΔ ln GEH	1.3530	4	0.8523	
Uttar Pradesh	ΔΔ ln NSVA	3.4096	4	0.4918	No short-run causality
	ΔΔ ln GEE	0.6432	4	0.9581	
	ΔΔ ln GEH	0.8497	4	0.9317	
West Bengal	ΔΔ ln NSVA	6.0222	2	**0.0492**	NSVA caused by GEE and GEH
	ΔΔ ln GEE	0.9716	2	0.6152	
	ΔΔ ln GEH	0.0304	2	0.9849	

Note: Lag order selected by AIC (Akaike Information Criterion) during the course of estimation. 'DF' represents degrees of freedom.

A significant indication of a unidirectional causal relationship runs jointly from education spending and health expenditure to income in three states: Maharashtra, Odisha and West Bengal. This denotes that both education and health expenditure jointly affect income, but the converse is not valid.

In contrast, the unidirectional causality runs jointly from state income and education expenditure to health expenditure in two states: Andhra Pradesh and Assam.

In Haryana, the results show that there are two-way intercausal relationships among the variables in the short run. First, income and health spending jointly cause education expenditure; second, income and education expenditure jointly cause health expenditure.

Similarly, in Karnataka, there is three-way intercausality in the short run. Income is immediately affected by both the education and health expenditures of the government; at the same time, income aggravates the education expenditure and health expenditure of the government in the short run.

Finally, the study finds no causal relationship among education expenditure, health expenditure and income in the short run across nine states/UTs, namely, Bihar, Gujarat, Kerala, Madhya Pradesh, NCT Delhi, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh.

The above results might be associated with different policies taken by the central and state governments in India. However, the real issue lies within the availabilities of the related policies in India and its states in some phased manners. We could have used education and health policy regimes as the sources of discussion to support our results. However, this is again impossible, as India's running education policy is more than 60 years old as it was established in 1968. The new policy will be applicable in 2023 and onward. Regarding health, the first national health policy was in 1983, then in 2017, but the implementation of the latter started two years after our study period was over. The states in India usually follow the central policies in education and health.

The robustness of the above results was checked through diagnostic checking in terms of the histogram-normality test, where the value of the Jarque-Bera (JB) statistic and its corresponding probabilities are considered. The results are given in Table A5 in the Appendix. It is found that the states having significant causal interplays generally satisfy the JB test. Hence, we can consider the above results to be robust.

Conclusions, limitations and future research agenda

Since the economic reforms of the early 1990s, the Indian economy has witnessed a rapid rise in economic growth and, simultaneously, an increase in economic efficiency. The objective of this study is to provide empirical evidence to show the relationship between human capital formation as the result of public expenditures on education and health and state income after globalization for sixteen Indian major states from 1998–1999 to 2018–2019. In this regard, the study applied a cointegration technique to show long-run associations; the VECM was estimated to examine short-run dynamics and long-run direction causality, and finally, the Granger causality test was applied to examine the direction of short-run causality among education, health and income.

The empirical results show that except for Odisha and West Bengal, there is a long-run association among these three variables in fourteen states: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, NCT Delhi, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. The long-run causal relation jointly from education and health expenditure to income has been found in Assam, Bihar, Haryana, Maharashtra, NCT Delhi, and Rajasthan.

Despite long-run causality, there exists a short-run one-way causal relationship jointly from education and health expenditure to income in three states: Maharashtra, Odisha and West Bengal. Unidirectional causality runs jointly from state income and education expenditure to health expenditure in two states: Andhra Pradesh and Assam. Finally, in Haryana and Karnataka, there exists two-way and three-way causality, respectively.

Although the study has obtained some interesting results on the impacts of education and health expenditures on the incomes of the states and their long-run relationships, it has some limitations on the grounds that it did not consider the growth analysis with respect to GEE and GEH. Furthermore, it did not consider any control variables to study the said relationships. The study preserves them as the future research agenda.

Disclosure

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Appendix

Theoretical Model

The simplest production function that presents the endogenous growth model is Y = AK. Here, 'A' stands for various endogenous factors. The Lucas model of growth incorporates human capital in the production system in addition to physical capital to justify endogenous technological progress, and this is one way of explaining 'A'.

Suppose the capitals are K (physical capital) and H (human capital), with labor being constant under normalization conditions. The production function becomes

$$Y = f(K, H)$$

Where the production function has standard neoclassical properties with CRS but there are no diminishing returns to scale in K and H.

In intensive form, the production function becomes
$y = aY = f(aK, aH)$, where 'a' is the scale change

$$\text{Assuming } a = \frac{1}{K}$$

$$Y/K = f(1, \frac{H}{K}),$$

$$Y = K.\ f(1, \frac{H}{K})$$

$$\text{or } Y = K.\ f(\frac{H}{K})$$

where $f' = \frac{df}{d(\frac{H}{K})} > 0$. This means that more human capital per physical capital leads to more output.

Output (Y) can be used on a one-for-one basis for consumption, physical capital formation and human capital formation, such as investment in the education, training and health sectors.

Suppose both forms of capital depreciate at rates δ and μ. Further assume that population (L) is constant. This means that an increase in H leads to an increase in human capital without being exploited by L.

Now suppose Rk and Rh are the rental prices per unit of physical capital and human capital. Having a competitive structure in both capital markets, the long-run profit by the firms using these two types of capital will be zero. This means that the marginal productivity of K and H will be equal to Rk and Rh.

We have our production function-

$$Y = K.\ f(\frac{H}{K})$$

$$MP_K = f(\frac{H}{K}) - K.\ f'(\frac{H}{K}).\ (-\frac{H}{K^2})$$

$$\text{or } MP_K = f(\frac{H}{K}) - (\frac{H}{K}).\ f'(\frac{H}{K}) = Rk$$

$$\text{Again, } MP_H = \frac{K.f'(\frac{H}{K}).1}{K} = Rh$$

$$\text{or } MP_H = f'(\frac{H}{K}) = Rh$$

After deducting the depreciation rates from the rental prices of each of the capitals, we obtain net rental prices. These prices are (Rk – δ) and (Rh - μ). Hence, the above two marginal conditions will be rewritten as

$$MP_K = \mathrm{f}(\tfrac{H}{K}) - (\tfrac{H}{K}).\ \mathrm{f}'\,(\tfrac{H}{K}) = \mathrm{Rk} - \delta$$

$$\text{and } MP_H = \mathrm{f}'\,(\tfrac{H}{K}) = \mathrm{Rh} - \mu$$

These two net rental prices will ultimately be equal to the market rate of interest (r). This means that Rk = Rh = r, which leads to

$$MP_K = \mathrm{f}(\tfrac{H}{K}) - (\tfrac{H}{K}).\ \mathrm{f}'\,(\tfrac{H}{K}) = \mathrm{r} - \delta$$

and $MP_H = \mathrm{f}'\,(\tfrac{H}{K}) = \mathrm{r} - \mu$

which means $MP_K = MP_H = \mathrm{r}$

$$\mathrm{f}(\tfrac{H}{K}) - (\tfrac{H}{K}).\ \mathrm{f}'\,(\tfrac{H}{K}) + \delta = \mathrm{r}$$

$$\text{and } \mathrm{f}'\,(\tfrac{H}{K}) + \mu = \mathrm{r}$$

$$\text{or } \mathrm{f}(\tfrac{H}{K}) - (\tfrac{H}{K}).\ \mathrm{f}'\,(\tfrac{H}{K}) + \delta = \mathrm{f}'\,(\tfrac{H}{K}) + \mu$$

$$\text{or } \mathrm{f}(\tfrac{H}{K}) - (\tfrac{H}{K}).\ \mathrm{f}'\,(\tfrac{H}{K}) - \mathrm{f}'\,(\tfrac{H}{K}) = \mu - \delta$$

$$\text{or } \mathrm{f}(\tfrac{H}{K}) - [1 + (\tfrac{H}{K})].\ \mathrm{f}'\,(\tfrac{H}{K}) = \mu - \delta$$

The left-hand side is monotonically increasing in $\frac{H}{K}$, which means that there exists a unique and constant value of $\frac{H}{K}$.

If we define A = $\mathrm{f}(\frac{H}{K})$ [so $\mathrm{f}'\,(\frac{H}{K})\,\frac{\mathrm{dA}}{\mathrm{d}(\frac{H}{K})} = 0$ and then $\mathrm{f}(\frac{H}{K}) = \mu - \delta =$ constant], then the production function given in Equation (1) will look like-

$$\mathrm{Y} = \mathrm{K}.\ \mathrm{A} = \mathrm{AK}$$

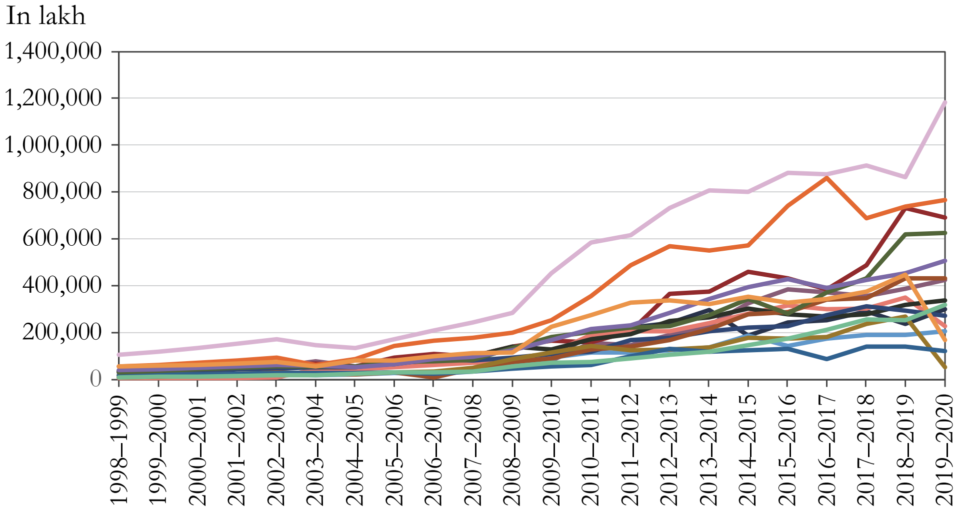
This means that the model with two types of capital (K & H) is essentially the same as the AK model. which means that MP_K is not diminishing and is guarded by the human capital term, H.

Hence, the presence of human capital in the production system makes the productivity of K constant and allows the growth rate of income, K and C to be nonzero in the long run. Converting into per capita terms, as L is constant, there will be no change in the growth rates of the per capita variables as well. The ultimate rate of growth of all the variables is at the rate at which the $\frac{H}{K}$ (per unit human capital to physical capital) is growing.

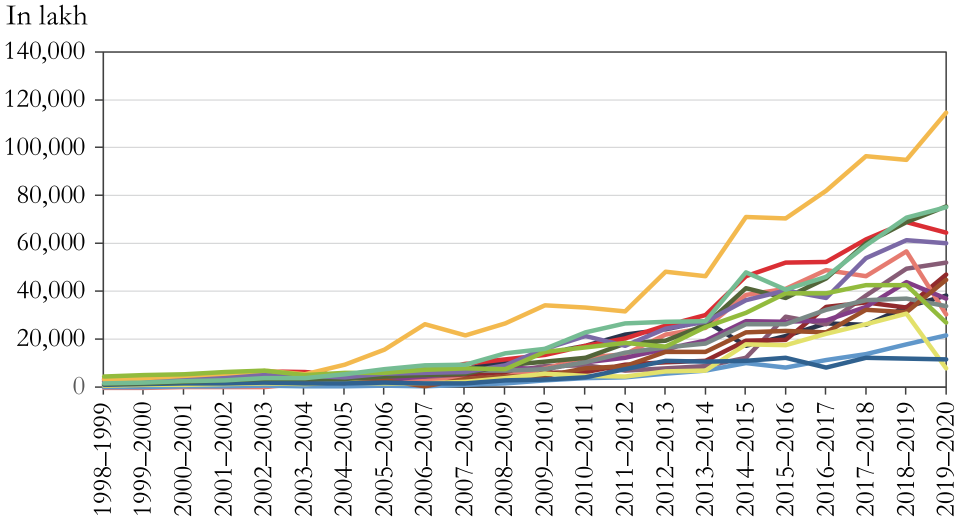
Figure A1

Trends of GEE, GEH and NSVA

GEE



GEH



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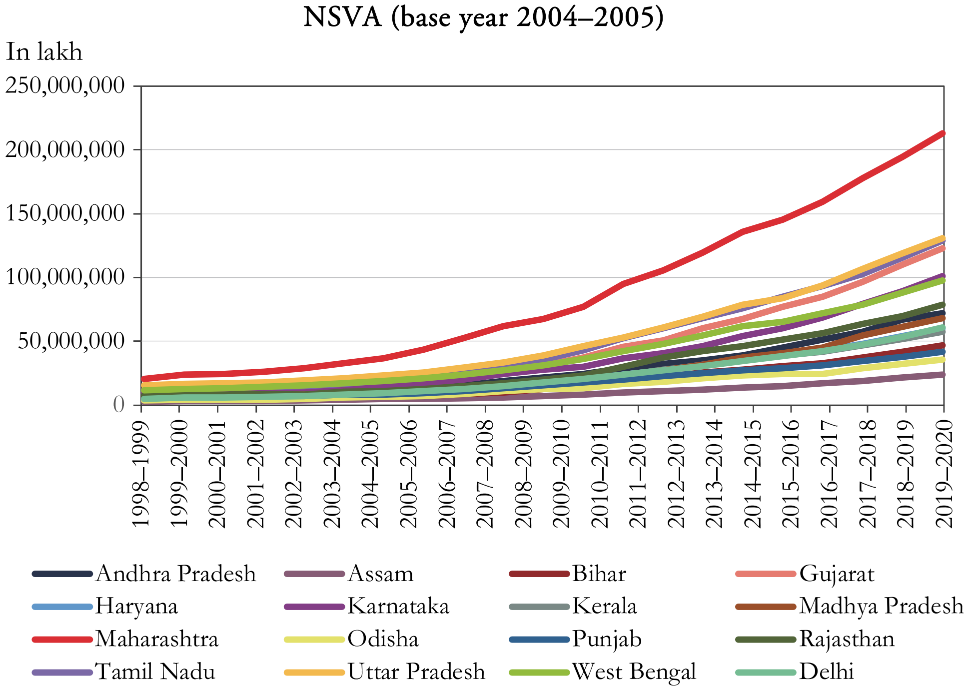


Table A1

Lag order selection by Akaike Information Criterion (AIC)

States/UT	AIC		
	lag 0	lag 1	lag 2
Andhra Pradesh	0.7116	–4.5941	–5.1592*
Assam	1.7222	–4.6935*	–4.5735
Bihar	1.6939	–2.3665	–2.7285*
Gujarat	2.6912	–3.6029	–4.1745*
Haryana	–5.9246	–6.1526*	–6.1378
Karnataka	1.0508	–6.5955	–7.3495*
Kerala	–8.1758	–8.3286*	–8.0062
Madhya Pradesh	–1.6561*	–1.3039	–1.4178
Maharashtra	–6.1182*	–6.0582	–6.0101
NCT Delhi	–6.4664	–6.8111*	–6.6992
Odisha	–3.4753	–3.5267*	–2.8561
Punjab	–6.2829	–6.6161*	–6.2995
Rajasthan	–4.7695*	–3.9952	–3.9608
Tamil Nadu	0.2137	–5.7554	–6.7593*
Uttar Pradesh	–4.5139	–4.5504*	–4.1896
West Bengal	–5.7888	–5.8038*	–5.3562

Note: * implies the lag order selection by the decision from AIC. We proceed with ‘lag 0’ as ‘lag 1’ in the estimation.

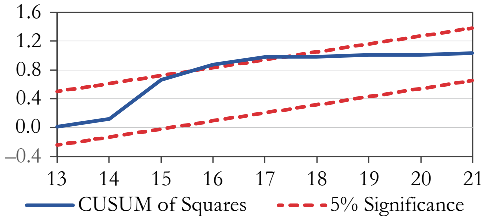
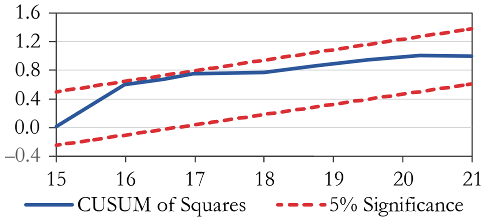
Table A2

Zivot-Andrews Unit Root Test Results for Odisha and West Bengal

States	Null Hypothesis: Variable has a unit root with a structural break			
	Variable	Break Year	t-Statistic	Prob
Odisha	ln NSVA	2014–2015	–2.95374	0.0134
	ln GEE	2007–2008	–4.52082	0.0078
	ln GEH	2012–2013	–1.41475	0.7510
West Bengal	ln NSVA	2014–2015	–3.50217	0.0073
	ln GEE	2009–2010	–4.56979	0.0000
	ln GEH	2009–2010	–4.28009	0.0021

Table A3

Coefficient of dummy variable and the stability check of the model for Odisha and West Bengal

$\text{lnNSVA}_t = \beta_1 + \beta_2 \text{ lnGEE}_t + \beta_3 \text{ lnGEH}_t + \beta_4 D_t + \beta_5 D_t{*}lnGEE_t + \beta_6 D_t{*}lnGEH_t + \text{u}$			
States	Coefficient of dummy, β_5	Prob	CUSUM of Square Test
Odisha	9.632444	0.0885	
West Bengal	–2.354446	0.5006	

Note: D_t is the dummy variable. The models are stable, but the coefficients are insignificant for both of these states.

Table A4

Gregory-Hansen cointegration test for Odisha and West Bengal

States	Dependent variable	ADF value of residual	Prob
Odisha	ln NSVA	–3.24009	**0.0333**
	ln GEE	–2.74057	0.0858
	ln GEH	–1.33352	0.5930
West Bengal	ln NSVA	–2.6932	0.0926
	ln GEE	–1.92847	0.3135
	ln GEH	–1.82226	0.3596

Figure A2

Inverse Root of AR Characteristic Polynomial

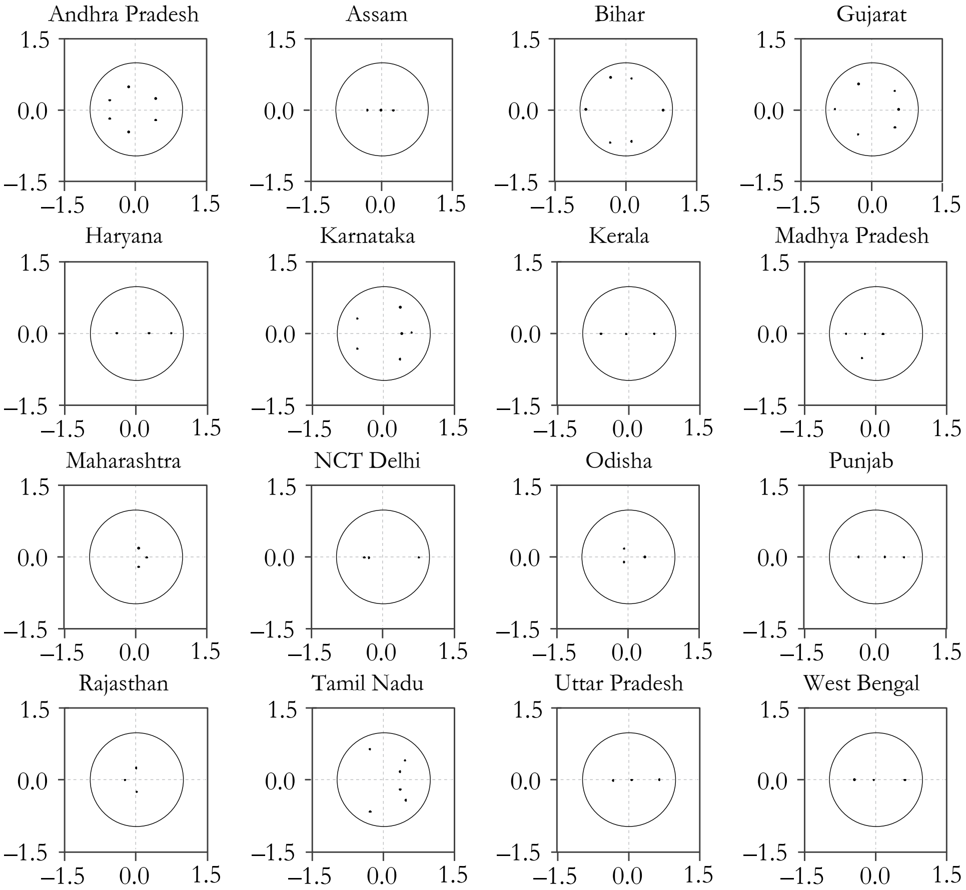


Table A5

Histogram-Normality Test

Country	Dependent variable	JB statistics	Prob	Remarks
Andhra Pradesh	Δ ln NSVA	1.1138	0.5729	Not satisfied
	Δ ln GEE	3.7614	0.1524	Not satisfied
	Δ ln GEH	32.753	**0.0000**	Histogram-Normality Test satisfied
Assam	Δ ln NSVA	2.8084	0.2460	Not satisfied
	Δ ln GEE	2.1681	0.3382	Not satisfied
	Δ ln GEH	6.6041	**0.0549**	Histogram-Normality Test satisfied
Bihar	Δ ln NSVA	0.0902	0.9412	Not satisfied
	Δ ln GEE	1.4714	0.4791	Not satisfied
	Δ ln GEH	0.8592	0.6507	Not satisfied
Gujarat	Δ ln NSVA	6.5971	**0.0508**	Histogram-Normality Test satisfied
	Δ ln GEE	0.3472	0.8402	Not satisfied
	Δ ln GEH	3.9085	0.1416	Not satisfied
Haryana	ΔΔ ln NSVA	0.4346	0.8046	Not satisfied
	ΔΔ ln GEE	7.5099	**0.0449**	Histogram-Normality Test satisfied
	ΔΔ ln GEH	8.3561	**0.0478**	Histogram-Normality Test satisfied
Karnataka	Δ ln NSVA	8.3926	**0.0317**	Histogram-Normality Test satisfied
	Δ ln GEE	7.5951	**0.0402**	Histogram-Normality Test satisfied
	Δ ln GEH	6.9334	**0.0506**	Histogram-Normality Test satisfied
Kerala	ΔΔ ln NSVA	0.5607	0.7555	Not satisfied
	ΔΔ ln GEE	1.0314	0.5970	Not satisfied
	ΔΔ ln GEH	0.2842	0.8675	Not satisfied
Madhya Pradesh	Δ ln NSVA	0.8696	0.6473	Not satisfied
	Δ ln GEE	3.7807	0.1510	Not satisfied
	Δ ln GEH	5.3735	**0.0681**	Histogram-Normality Test satisfied
Maharashtra	ΔΔ ln NSVA	6.8299	**0.0501**	Histogram-Normality Test satisfied
	ΔΔ ln GEE	0.2551	0.8802	Not satisfied
	ΔΔ ln GEH	0.5035	0.7773	Not satisfied
NCT Delhi	Δ ln NSVA	0.7565	0.6849	Not satisfied
	Δ ln GEE	0.8146	0.6654	Not satisfied
	Δ ln GEH	0.1368	0.9338	Not satisfied
Odisha	ΔΔ ln NSVA	7.7026	**0.0437**	Histogram-Normality Test satisfied
	ΔΔ ln GEE	1.5334	0.4645	Not satisfied
	ΔΔ ln GEH	0.7796	0.6771	Not satisfied
Punjab	ΔΔ ln NSVA	0.4191	0.8109	Not satisfied
	ΔΔ ln GEE	1.5166	0.4684	Not satisfied
	ΔΔ ln GEH	0.0449	0.9777	Not satisfied
Rajasthan	Δ ln NSVA	2.3037	0.3160	Not satisfied
	Δ ln GEE	0.6136	0.7357	Not satisfied
	Δ ln GEH	1.1355	0.5667	Not satisfied
Tamil Nadu	ΔΔ ln NSVA	2.5291	0.3032	Not satisfied
	ΔΔ ln GEE	1.2233	0.5424	Not satisfied
	ΔΔ ln GEH	3.5958	0.1656	Not satisfied
Uttar Pradesh	ΔΔ ln NSVA	0.2711	0.8732	Not satisfied
	ΔΔ ln GEE	0.7564	0.6850	Not satisfied
	ΔΔ ln GEH	0.1949	0.9071	Not satisfied
West Bengal	ΔΔ ln NSVA	6.7572	**0.0501**	Histogram-Normality Test satisfied
	ΔΔ ln GEE	0.3352	0.8456	Not satisfied
	ΔΔ ln GEH	0.7698	0.6805	Not satisfied

Table A6

Model Estimation with Dummy Variable

$$\text{lnNSVA}_t = \beta_1 + \beta_2 \text{ lnGEE}_t + \beta_3 \text{ lnGEH}_t + \beta_4 D_t + \beta_5 D_t * lnGEE_t + \beta_6 D_t * lnGEH_t + \text{u}_t$$

States/UT	β_2	Prob	β_3	Prob	β_4	Prob	β_5	Prob	β_6	Prob
Andhra Pradesh	0.5839	0.2345	0.3756	0.4491	5.2477	0.4403	–0.786	0.3543	0.4481	0.5341
Assam	0.2980	0.5246	0.1625	0.6559	–1.936	0.4738	0.1460	0.7571	0.0659	0.8578
Bihar	1.1663	0.0005	–0.348	0.1928	4.1846	0.1999	–0.826	0.0462	0.6566	0.0372
Gujarat	0.2417	0.2597	0.3967	0.0104	–0.705	**0.0175**	0.7133	**0.0118**	0.3244	**0.0118**
Haryana	0.8603	0.0057	–0.080	0.7735	5.9559	0.6892	–0.925	0.6082	0.5841	0.4859
Karnataka	1.3873	0.0000	–0.602	0.0075	10.331	**0.0029**	–2.125	**0.0000**	1.6485	**0.0000**
Kerala	0.9716	0.0074	0.0015	0.9957	–0.290	0.8630	0.1120	0.6892	–0.107	0.5566
Madhya Pradesh	0.0772	0.3818	–0.127	0.2822	0.9766	0.3088	–0.172	0.4751	0.1240	0.5592
Maharashtra	0.1125	0.2597	–0.058	0.5700	3.0715	0.8565	–0.232	0.8485	0.0085	0.9689
NCT Delhi	–0.036	0.5872	0.0634	0.3164	0.3622	0.0855	0.0055	0.9490	–0.040	0.6732
Punjab	0.2150	0.2057	–0.163	0.2666	1.1791	0.4479	0.1782	0.7109	–0.350	0.5550
Rajasthan	–0.191	0.3365	0.0524	0.7922	–1.148	0.4774	0.2810	0.2722	–0.227	0.1674
Tamil Nadu	0.2291	0.1792	–0.056	0.5712	3.9082	0.6570	–0.380	0.6445	0.0959	0.6738
Uttar Pradesh	0.0184	0.7567	–0.008	0.8745	–0.113	0.8921	0.0679	0.5812	–0.058	0.4225

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