JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

CAUSAL RELATIONSHIP BETWEEN ECONOMIC GROWTH AND SOCIO-ECONOMIC & ENVIRONMENTAL VARIABLES IN INDIA: A TIME SERIES ANALYSIS

Samridhi Narula,
Student, M.A. Econometrics, University of Madras,
Chennai, Tamil Nadu-600005
Mob: 8279803297, 8193973780
Email: samridhinarula99@gmail.com

Abstract : This study makes a modest attempt to examine the causal relationships between economic growth and socio-economic and environmental factors for India over the period 1991-2018. The data is collected from World Development Indicators maintained by the World Bank. The study uses correlation analysis, logarithmic regression and VAR model along with Granger Causality test, Impulse response function and Variance decomposition functions to determine the inter-dependencies among the 5 variables viz GDP, unemployment rate, CO2 emissions, school enrollment ratio and life expectancy at birth. There have been numerous studies on GDP and its possible determinants. However, there are very few studies for India individually which includes varied kinds of variables and the inter-dependencies among them. The reason for the selection of these variables is that previous literature suggests possible causal relationships among the variables considered. The study attempts to answer some the following questions: Which indicators have a significant impact on GDP? Is the relationship causal? Can we forecast GDP based on these relationships? Is there an impact of social indicators on GDP? Does Environmental degradation impact GDP? If yes, then how? Can these relationships help in policy making? This study can be useful for other researchers and analysts attempting to discover relationships among Economic Growth, Unemployment rate, CO2 emissions, school enrollment rate and life expectancy at birth. This study can also be used for policy making by the government to determine if increased expenditures on health or education will increase the nation's growth. The study revealed a strong correlation among the variables. Most variables exhibit unidirectional relationship. Only school enrollment and life expectancy displayed a bi-directional causal relationship over the period. In the long run, there is an impact among the variables of the model.

Key words: **Causal, economic growth, correlation, regression, VAR, GDP, unemployment, CO2 emissions, school enrollment, life expectancy at birth.**

I. INTRODUCTION

1.1 ECONOMIC GROWTH- AN OVERVIEW

Simon Kuznets. According to him "Modern economic growth reflects a continuing capacity to supply a growing population with an increased volume of commodities and services per capita." In a more economic sense, economic growth can be defined as an increase in the value of goods and services produced in an economy over a period of time. This is usually in terms of % increase in GDP or Gross Domestic Product. It is one of the main measures of measuring the performance of a nation.

1.2 Distinction between Economic Growth and Development

However, a distinction between economic growth and development is needed. Growth includes the value of only those goods and services which can be measured in monetary terms. Non-monetary activities like environmental damage or quality of life are not included in the calculation of GDP. GDP gives only a quantitative picture and not the qualitative aspects of the life of people. It does not count free goods or non-market goods and services, thereby ignoring household chores and assigns no value to activities such as domestic work, housekeeping work by women, care for children and elderly, etc. In this sense, it is not gender neutral also and neglects women's contribution to economic activities. Apart from this, the events such as crime, pollution, depletion of natural resources, diseases are counted as positive transactions because they lead to increased spending. Thus, GDP figures would ignore the welfare loss resulting from these activities.

Thus, a better approach to measuring the performance of a nation would be to include other social, economic or environmental factors along with GDP to get a more complete picture.

1.3 Objectives of the study

This study has the following objectives:

(i) To assess the impact of unemployment rate, CO2 emissions, gross enrollment ratio and life expectancy at birth on gross domestic product.

(ii)To determine the interdependency and the direction of causation among the 5 aforementioned variables for India over the period 1991-2018.

1.4 Methodology and data source

This study attempts to achieve the same. It considers 5 variables, namely economic growth, unemployment rate, CO2 emissions, school enrollment ratio and life expectancy at birth for India and then examine their inter-relationships and inter-dependencies. We have chosen Vector Autoregressive Model (VAR) for our analysis along with Granger Causality test, Impulse response function and variance decomposition. The reason for the selection of this study is that previous literature suggests possible causal relationships among the variables considered. Since VAR model is a system of equations and it treats all variables as endogenous is nature, it seems apt for this study. The data has been taken from World Development Indicators maintained by the World Bank over the period 1991-2018.

II. REVIEW OF LITERATURE

2.1 Studies using panel data analysis

Bansal et al. (2021) examine the impact of various economic, social and environmental indicators on economic growth in South Asian countries using a panel data approach. The results of the study indicate a long-term positive effect of biological capacity, financial development, human development index, income inequality on economic growth while the effect of energy use is the opposite. Verma et al. (2020) attempted to synthesize economic growth and human development using a logistic regression of high and middle human development countries across 1990 to 2017. The results showed a negative association between economic growth and human development; moreover, such associations were statistically significant. For East Mediterranean countries, Bayati et al. (2013) found that employment ratio, per capita income, education index, food availability and level of urbanization were specified as determinants for health (an indicator for life expectancy at birth).

Ulas et al. (2017) examined the economic performances of 20 selected countries, in terms of their growth rate, for the period 2010–2014. The study revealed an association between HDI and economic performance measured by Spearman's rank correlation coefficient of 0.804. Taqi et.al (2021) examined the effect of HDI on economic growth in Pakistan. The results of the study indicated that each country had a strong and significant correlation between HDI and GDP. Cibulka et al. (2019) examined the overall relationship between resource footprints, quality of life, and economic development. The empirical results showed that the relationship between various resource footprints and quality of life generally follows a logarithmic path of development, while resource footprints and GDP per capita are linearly connected.

2.2 Studies using cross section analysis

Nabi et al. (2020) investigated the dynamic linkages between population growth, price level, poverty headcount ratio, and carbon emissions in the cross-sectional setting of 98 developed and developing countries for the period of 2011. The results showed a positive relationship between changes in price level and carbon emissions while there is a negative relationship between population growth and poverty. Further, there is a positive relationship between poverty rates and carbon emissions across countries and a u-shaped relationship is found between economic growth and carbon emissions in the given time period. Rajesh et al. (2021) examined the long run and short-run impacts of per capita income, renewable energy, life expectancy, and population density on the ecological footprint in the eight developing countries of south and southeast Asia from 1990 to 2015 using the cross-sectional augmented autoregressive distributed lag (CS-ARDL) approach. The long-run results revealed the association between per capita income and ecological footprint to be n-shaped. Similarly, the effect of life expectancy on the ecological footprint is found to be positive but insignificant.

2.3 Studies using time series analysis

Sede and Ohemeng (2015) used VAR and VECM technique and found that conventional economic variables used in studies of life expectancy just as income per capita, government expenditures on health and education are not significant in Nigeria. Audi and Ali (2016) showed that food availability, school enrollment at the secondary level, CO2 emissions, per capita income and population growth in Lebanon have a significant impact on life expectancy. However, Delavari et al. (2016) found that the significant positive effect of per capita GDP, literacy rate, number of doctors per 10,000 population and access to food all have a statistically significant effect on life expectancy at birth (LEB) in Iran, while inflation rate, urbanization quality and CO2 emission did not have a significant impact on LEB. According to Jalal and Khan (2015), an increasing GNI per capita, GDP improvement and life expectancy were associated together.

Dahliah et al. (2021) analyzed the effect of unemployment, HDI and GDP on the level of poverty in East Luwu. The results of this study revealed that unemployment has a positive and insignificant effect on the level of poverty; Partially, the HDI and GDP have a negative and insignificant effect on the level of poverty and simultaneously unemployment, HDI and GDP have a significant effect on the level of poverty. Arriani and Chotib (2021) investigated the SDG 1 and 8 factors that affect HDI in Central Java. This study found that the SDG 1 and 8 variables have significant results and implicates spatial effects through Spatial Lag in the HDI of Central Java. Sušnik and Zaag (2017) analyzed the UN Human Development Index for correlation and causation with economic and resource parameters. The study showed that the national totals of GDP, water withdrawal and electricity generation and consumption, along with per-capita water withdrawal, are not strongly correlated to the HDI and its dimension indices. However, per-capita GDP and access to safe water and an electricity supply are strongly correlated to the HDI. Khan, Ruby & Salam, Md. Abdus. (2020) investigated the relationship between Gross Domestic Product Per Capita PPP $(GDP Per Capita), Human Development Index (HDI) and the Economic Freedom Index (EFI) in context of India. They used Granger causality test results to find that unidirectional causality is running between HDI and GDP Per capita as well as between HDI and EFI whereas there was no causality between GDP Per Capita and EFI.

Audi and Ali (2016) investigated the impact of socio-economic status on life expectancy in the case of Lebanon. The variables included in the study were Availability of food, CO2 emissions, secondary school enrollment, per capita income and population growth. The results of the study reveal that there is co-integration among the variables of the model and all selected explanatory variables of the model have significant impact on life expectancy in case of Lebanon. The causality test results reveal that all the independent variables have causal relationship with life expectancy at birth in the Lebanese case over the selected time period. Rasha M. S. Istaiteyeh (2017) investigated socio-economic determinants for life expectancy in Jordan. The results suggested that the change in life expectancy comes from per capita GDP (LGDP) with 21% and unemployment (LUNPR) with 19%. This is followed by a small change in of 6%, 5% and 2% of government expenditure on health (LGHE), secondary school enrolment (LSEER) and urban population (LURBAN) respectively.

III. ECONOMETRIC METHODOLOGY AND EMPIRICAL ANALYSIS

3.1 Logic behind the variables used in the study

As seen from previous researches, all variables can be expected to have a relationship with each other. Let us determine each pair in turn.

GDP-Unemployment nexus

There is expected to be a negative relationship between unemployment and economic growth as measured by GDP. This relationship has been confirmed by various researches in the literature. The negative relationship can also be ascribed to Okun's Law that first measured the relationship between the two variables in early 1960s. A bi directional relationship may exist as high unemployment rate shows that there is huge amount of idle labor which is not being efficiently used. At the same time, nations with higher GDP are expected to spend a larger proportion of their GDP on employment generation and developmental and infrastructural projects which will reduce unemployment.

GDP- CO2 emissions nexus

There are various relationships between GDP and CO2 emissions. Some studies have shown a unidirectional causality running from GDP to CO2. Some have shown a positive relationship between GDP and CO2 implying that as a nation grows, its production leads to higher CO2 emissions creating more environmental degradation (negative externality). There is also a claim that the relationship is negative in the long run as at higher rates of economic growth, a nation moves to more efficient and clean sources of energy thereby reducing carbon dioxide emissions. Another study showed an inverse U-shaped relationship consistent with the Environmental Kuznets Curve (EKC).

GDP- school enrollment nexus

Many studies have shown a significant positive bi-directional relationship between GDP and primary school enrollment ratio. This could be due to the fact that a better educated workforce adds more value to the growth of the nation. Enrollment ratio affects the human capital of a nation. In turn, nations with higher GDP can be expected to spend a substantial portion of their GDP on education sector. Thus, a bi-directional causality may be expected.

GDP- life expectancy nexus

It is expected that a positive bi-directional relationship exists between GDP and life expectancy at birth. When a nation grows, it has better healthcare facilities for the people thereby increasing life expectancy. In turn, a healthier, longer living workforce will add value to the economic growth of a nation. However, CO2 emissions do have a role to play here which can complicate this relationship.

CO2- life expectancy nexus

More CO2 emissions can cause higher environmental degradation. The data shows that when economies are growing relatively fast, emissions and pollution are also on the rise. New diseases are discovered every day. This can negatively impact the life expectancy of people

School enrollment-life expectancy nexus

Most studies suggest a positive causal relationship between primary school enrollment ratio and life expectancy at birth. They both affect economic growth and hence affect each other. The strength of their relationship may also depend on the stage of demographic transition of the nation.

CO2-Unemployment nexus

Some studies have shown moderate correlation between CO2 emissions and unemployment rate. Their relationship is complex. It involves a multi-disciplinary analysis. Using an example of coal mines, burning coals releases large amounts of CO2 but the extraction of coal employs hundred and thousands of people. Employment and CO2 emissions are positively related. Thus, there exists a negative relationship between unemployment rate and CO2 emissions however a causal relationship was not yet identified.

3.2 Measurement and reason for inclusion of variables in the study

The details for measurement of the variables are included in Table 3.1.

Table 3.1. Measurement and reason for inclusion of variables in the study

S.NO.	VARIABLE NAME	MEASUREMENT	REASON FOR INCLUSION
1	Gross Domestic Product (GDP)	PPP, Constant 2017 international $	It is among the main economic indicators.
2	Unemployment rate (UR)	% of total labor force	Previous literature and economic theory suggest relationship with GDP.
3	CO2 emissions (CO2)	Kg/2017 PPP $ of GDP	It is one of the main environmental indicators. Previous literature suggests relationship with GDP and life expectancy.
4	Gross Enrollment Ratio (ER)	Primary, % gross	It is an important social indicator forming part of HDI
5	Life expectancy at Birth (LEB)	Total, years	It is an important social indicator forming part of HDI

3.3 An overview of Vector Autoregression (VAR) model- the methodology used in the study

As described in section 3.1.1, this study has the following objectives:
(i) To assess the impact of unemployment rate, CO2 emissions, gross enrollment ratio and life expectancy at birth on gross domestic product.
Correlation analysis and logarithmic regression has been used to address this objective. GDP is taken as the dependent variable and unemployment rate, CO2 emissions, gross enrollment ratio and life expectancy at birth are taken as independent variables for the logarithmic regression. The results of correlation and regression are given in section 3.4
(ii)To determine the interdependency and the direction of causation among the 5 aforementioned variables for India over the period 1991-2018.
In order to address this objective, the study in this paper uses Vector Autoregression (VAR) model to check the interdependencies and direction of causation among 5 selected socio-economic and environmental variables for India over the period 1991-2018.
Lütkepohl, H. (2007), Bernhard Pfaff (2008) and Sims, C. (1980) suggest that a simple VAR model can be written as

$$\begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{pmatrix} y_{1t-1} \\ y_{2t-1} \end{pmatrix} + \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix} \qquad (3.1)$$

Or, more compactly,

$$y_t = A_1 y_{t-1} + e_t, \qquad (3.2)$$

Where $y_t = \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix}$, $A_1 = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$ *and* $e_t = \begin{pmatrix} e_{1t} \\ e_{2t} \end{pmatrix}$.

Basically, such a model implies that everything depends on everything. But as can be seen from this formulation, each row can be written as a separate equation, so that

$$y_{1t} = a_{11} y_{1t-1} + a_{12} y_{2t-1} + \epsilon_{1t} \qquad (3.3)$$

and

$$y_{2t} = a_{21} y_{1t-1} + a_{22} y_{2t-1} + \epsilon_{2t}. \qquad (3.4)$$

Hence, the VAR model can be rewritten as a series of individual ADL models as described above. In fact, it is possible to estimate VAR models by estimating each equation separately.
The VAR will contain several procedures like Granger causality test, impulse response functions and variance decomposition to evaluate the various relationships arising. The variables considered are log of GDP (LGDP), log of unemployment rate (LUR), log of CO2 emissions (LCO2), log of school enrollment ratio (LER), log of life expectancy at birth (LLEB). Gross Domestic Product and unemployment rate represent economic factors; CO2 emissions represents environmental factor; and school enrollment ratio and life expectancy at birth represent social factors.

3.3 Results of Correlation and logarithmic regression

Correlation coefficients are given in Table 3.2.

Table. 3.2 Correlation Matrix

	GDP	*UR*	*CO2*	*ER*	*LEB*
GDP	1				
UR	-0.88882	1			
CO2	-0.86624	0.736013	1		
ER	0.830664	-0.74857	-0.84167	1	
LEB	0.95779	-0.87831	-0.90031	0.899321	1

Table 3.2 shows that all the variables are correlated. However, since the correlation is not near to perfect, the problem of multicollinearity among variables can be ruled out. GDP is negatively correlated to UR and CO2 emissions while positively related to ER and LEB. UR is positively correlated to CO2 while negatively related to ER and LEB. CO2 is positively correlated to both ER and LEB. ER is also positively correlated to LEB.

We move further to determine the impact of economic, environmental and social factors on GDP individually and then jointly. We have taken 4 models.

Model 1

(Model with only economic variables)

$$LGDP_t = \alpha_{1t} + LUR_t + u_{1t} \qquad (3.5)$$

Model 2

(Model with only environmental variables)

$$LGDP_t = \alpha_{2t} + LCO2_t + u_{2t} \qquad (3.6)$$

Model 3

(Model with only social variables)

$$LGDP_t = \alpha_{3t} + LER_t + LLEB_t + u_{3t} \qquad (3.7)$$

Model 4

(Model with all economic, environmental and social variables)

$$LGDP_t = \alpha_{4t} + LUR_t + LCO2_t + LER_t + LLEB_t + +u_{4t} \qquad (3.8)$$

The results of regression equations as presented in equations 3.5, 3.6, 3.7 and 3.8 respectively are given in Table 3.3.

Table. 3.3 Logarithmic Regression estimates

Dependent variable:	GDP			
Independent variable	**Model 1 (Model with only economic variables)**	**Model 2 (Model with only environmental variables)**	**Model 3 (Model with only social variables)**	**Model 4 (Model with all economic, environmental and social variables)**
LUR	-20.17031 ** (2.089762)	-	-	-1.710085 * (0.857311)
LCO2	-	-5.320878 ** (0.501746)	-	-0.427047 * (0.239357)
LER	-	-	-0.064611 (0.286613)	-0.029029 (0.272775)
LLEB	-	-	9.792042 ** (0.429898)	8.475092 ** (0.665827)

Note: 1. *** 1% sig , ** 5% sig , * 10% sig

2. The coefficients are given for all models. Standard errors are given in brackets under each coefficient.

We can see from table 3.3 that unemployment, CO2 and life expectancy at birth have a statistically significant impact on GDP when taken individually. Looking at the coefficient of Model 1, there is a negative relationship between economic growth and unemployment rate which is statistically significant at 5% level. A percentage increase in unemployment rate will lead to a decrease of $20.17 in GDP on average. Looking at model 2, there is again a negative relationship between economic growth and CO2 emissions which is statistically significant at 5% level. A kg increase in CO2 emissions will lead to a decrease of $5.32 in GDP on average. Looking at model 3, there is a negative relationship between economic growth and gross enrollment ratio which is statistically insignificant at even 10% level. There is a positive relationship between economic growth and life expectancy at birth which is statistically significant at 5% level. A one year increase in life expectancy will lead to a increase of $9.79 in GDP on average. However, when all the variables are taken together unemployment rate and CO2 are significant at 10% level while life expectancy at birth is still highly significant at even 5% level.

3.3 Specification and Results of VAR model

To address the second of our objectives (To determine the interdependency and the direction of causation among the 5 variables viz. GDP, unemployment rate, CO2 emissions, school enrollment ratio and life expectancy at birth for India over the period 1991-2018), VAR model is undertaken.

Apart from normality, it is important to check whether the series is stationary or not as it is an integral part of time series analysis. This is because non stationary data can give nonsense results. In this study Augmented Dickey Fuller test (ADF) with a null hypothesis of unit root is used. After determining the stationarity and selecting the appropriate lag length, VAR model is applied. In VAR, each of the series is regressed on its own lag as well as the lags of other series. This system of equations will allow each of the series to be affected not only by its own past but also the past of other series thereby minimizing the problem of simultaneity. For our model with 5 variables and j lags, the VAR(j) model would have the following form:

$$\mathbf{LGDP_t} = \boldsymbol{\alpha_{1t}} + \sum_j \boldsymbol{\beta_{1j} LGDP_{t-j}} + \sum_j \boldsymbol{\lambda_{1j} LUR_{t-j}} + \sum_j \boldsymbol{\theta_{1j} LCO2_{t-j}} + \sum_j \boldsymbol{\gamma_{1j} LER_{t-j}} + \sum_j \boldsymbol{\delta_{1j} LLEB_{t-j}} + \boldsymbol{\mu_{1t}}$$

(3.5)

$$\mathbf{LUR_t} = \boldsymbol{\alpha_{2t}} + \sum_j \boldsymbol{\beta_{2j} LGDP_{t-j}} + \sum_j \boldsymbol{\lambda_{2j} LUR_{t-j}} + \sum_j \boldsymbol{\theta_{2j} LCO2_{t-j}} + \sum_j \boldsymbol{\gamma_{2j} LER_{t-j}} + \sum_j \boldsymbol{\delta_{2j} LLEB_{t-j}} + \boldsymbol{\mu_{2t}}$$

(3.6)

$$\mathbf{LCO2_t} = \boldsymbol{\alpha_{3t}} + \sum_j \boldsymbol{\beta_{3j} LGDP_{t-j}} \quad + \sum_j \boldsymbol{\lambda_{3j} LUR_{t-j}} + \sum_j \boldsymbol{\theta_{3j} LCO2_{t-j}} + \sum_j \boldsymbol{\gamma_{3j} LER_{t-j}} + \sum_j \boldsymbol{\delta_{3j} LLEB_{t-j}} + \boldsymbol{\mu_{3t}}$$
(3.7)

$$\mathbf{LER_t} = \boldsymbol{\alpha_{4t}} + \sum_j \boldsymbol{\beta_{4j} LGDP_{t-j}} \quad + \sum_j \boldsymbol{\lambda_{4j} LUR_{t-j}} + \sum_j \boldsymbol{\theta_{4j} LCO2_{t-j}} + \sum_j \boldsymbol{\gamma_{4j} LER_{t-j}} + \sum_j \boldsymbol{\delta_{4j} LLEB_{t-j}} + \boldsymbol{\mu_{4t}}$$
(3.8)

$$\mathbf{LLEB_t} = \boldsymbol{\alpha_{5t}} + \sum_j \boldsymbol{\beta_{5j} LGDP_{t-j}} \quad + \sum_j \boldsymbol{\lambda_{5j} LUR_{t-j}} + \sum_j \boldsymbol{\theta_{5j} LCO2_{t-j}} + \sum_j \boldsymbol{\gamma_{5j} LER_{t-j}} + \sum_j \boldsymbol{\delta_{5j} LLEB_{t-j}} + \boldsymbol{\mu_{5t}}$$
(3.9)

Where

LGDP= log of Gross Domestic Product

LUR= log of unemployment rate

LCO2= log of carbon dioxide emissions

LER = log of school enrollment ratio

LLEB= log of life expectancy at birth

Using VAR will provide significant insights into the relationships between various series. For this, VAR has 3 main procedures. Firstly, granger causality test will determine the direction of causation among variables (Section 3.6). Secondly, variance decomposition will measure the magnitude of an impact, i.e., the percentage error variance of each of the variables that can be explained by exogenous shocks to the other variables (Section 3.7). Lastly, impulse response function (IRF) measures the changes in the future responses of all variables in the system when a variable is shocked by an impulse (Section 3.8).

Before beginning our VAR model, we first need to make sure that all the series are stationary. All the series are stationary after the first difference as the null hypothesis is rejected for the ADF test. One period lag is selected for all variables as per automatic lag selection based on SIC criterion.

The analysis proceeds with the VAR model. Table 3.4 displays the VAR estimation results.

The results of VAR estimation as given in table 3.4 suggest that looking at row 1, past value of GDP(LGDP) affects the current level of GDP, current level of unemployment rate, current level of school enrollment ratio and the current level of life expectancy at birth with the impacts being approximately 93%,-10.4%,-23.6% and -0.5%. Row 2 suggests that the past value of unemployment rate does not affect any of the present values. In row 3, the past value of CO2 (LCO2) affects current value of CO2 and the current value of life expectancy at birth with the impacts being approximately 90% and 0.7%. In row 4, the past value of enrollment ratio (LER) affects the current value of CO2, school enrollment ratio and life expectancy at birth with the impacts being approximately 37.2%,84.6% and 1.6%. Finally, in row 5, the past value of life expectancy (LLEB) affects the current value of school enrollment ratio and life expectancy at birth with the impacts being approximately 233% and 101%. The R^2 values, given at the end of each column, are very high for all the estimates implying that the model is a good fit to the data. The Jarque Bera test of normality [The test statistic is JB=$\frac{n}{6}(S^2 + \frac{1}{4}(K-3)^2)$ where n is the number of observations or degrees of freedom; S is the sample skewness and K is the sample kurtosis] also suggests that the residuals are normally distributed. The White heteroscedasticity test suggests that the errors are homoscedastic. The White heteroscedasticity test is for constant variance. The statistic is nR^2~chi-square distribution, with degrees of freedom equal to P-1, where P is the number of estimated parameters (in the auxiliary regression).

Table.3.4 VAR estimation

Vector Autoregression Estimates
Date: 04/15/22 Time: 10:05
Sample (adjusted): 1992 2018
Included observations: 27 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LGDP	LUR	LCO2	LER	LLEB
LGDP(-1)	0.929927	-0.103723	-0.066024	-0.236035	-0.004919
	(0.07890)	(0.04474)	(0.11872)	(0.12121)	(0.00154)
	[11.7855]	[-2.31822]	[-0.55615]	[-1.94734]	[-3.18484]
LUR(-1)	-0.057077	0.011329	0.077533	0.087505	0.001668
	(0.32045)	(0.18171)	(0.48214)	(0.49227)	(0.00627)
	[-0.17811]	[0.06234]	[0.16081]	[0.17776]	[0.26591]
LCO2(-1)	-0.006148	-0.006129	0.900725	-0.060649	0.007726
	(0.09292)	(0.05269)	(0.13980)	(0.14274)	(0.00182)
	[-0.06617]	[-0.11633]	[6.44280]	[-0.42490]	[4.24781]
LER(-1)	0.075145	0.056601	0.372129	0.846406	0.016018
	(0.10996)	(0.06235)	(0.16544)	(0.16891)	(0.00215)
	[0.68341]	[0.90779]	[2.24939]	[5.01103]	[7.44224]
LLEB(-1)	0.606126	0.499911	-0.045248	2.331310	1.013951
	(0.70531)	(0.39995)	(1.06119)	(1.08347)	(0.01381)
	[0.85937]	[1.24994]	[-0.04264]	[2.15171]	[73.4434]
C	-0.688928	2.345593	0.121135	-2.378026	0.022217
	(1.27927)	(0.72541)	(1.92474)	(1.96515)	(0.02504)
	[-0.53853]	[3.23348]	[0.06294]	[-1.21010]	[0.88725]
R-squared	0.999146	0.870351	0.931851	0.917042	0.999968
Adj. R-squared	0.998942	0.839482	0.915625	0.897290	0.999960
Sum sq. resids	0.005662	0.001821	0.012817	0.013361	2.17E-06
S.E. equation	0.016420	0.009311	0.024705	0.025224	0.000321
F-statistic	4911.421	28.19508	57.42997	46.42796	131179.9
Log likelihood	76.03081	91.34815	65.00121	64.44024	182.2366
Akaike AIC	-5.187467	-6.322085	-4.370460	-4.328907	-13.05457

(Source: World Development Indicators, World Bank)

3.4 Results of Granger Causality Test

In order to determine the existence of bi-directional relationship among our variables as part of objective (ii) we conduct Granger Causality test. The estimated results of VAR Granger Causality/ Block Exogeneity Wald Tests are presented in table 3.5.

The results of table 3.5 show that there is a unidirectional causality running from GDP to unemployment rate. There is no causal relationship between CO2 emissions and unemployment rate over the selected period. There is a unidirectional relationship running from enrollment ratio to CO2 emissions. There is a unidirectional relationship running from GDP to life expectancy at birth. There is no causal relationship between unemployment rate and life expectancy. There is a unidirectional relationship between CO2 emissions and life expectancy at birth. There is a bi-directional causality between school enrollment ratio and life expectancy at birth.

Table. 3.5 VAR Granger Causality Test

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 04/15/22 Time: 10:27
Sample: 1991 2018
Included observations: 27

Dependent variable: LGDP

Excluded	Chi-sq	df	Prob.
LUR	0.031724	1	0.8586
LCO2	0.004378	1	0.9472
LER	0.467051	1	0.4943
LLEB	0.738515	1	0.3901
All	1.235711	4	0.8722

Dependent variable: LUR

Excluded	Chi-sq	df	Prob.
LGDP	5.374143	1	0.0204
LCO2	0.013532	1	0.9074
LER	0.824081	1	0.3640
LLEB	1.562347	1	0.2113
All	32.63451	4	0.0000

Dependent variable: LCO2

Excluded	Chi-sq	df	Prob.
LGDP	0.309298	1	0.5781
LUR	0.025859	1	0.8722
LER	5.059752	1	0.0245
LLEB	0.001818	1	0.9660
All	7.496378	4	0.1119

Dependent variable: LER

Excluded	Chi-sq	df	Prob.
LGDP	3.792130	1	0.0515
LUR	0.031598	1	0.8589
LCO2	0.180539	1	0.6709
LLEB	4.629839	1	0.0314
All	5.193286	4	0.2680

Dependent variable: LLEB

Excluded	Chi-sq	df	Prob.
LGDP	10.14318	1	0.0014
LUR	0.070707	1	0.7903
LCO2	18.04393	1	0.0000
LER	55.38687	1	0.0000
All	66.45871	4	0.0000

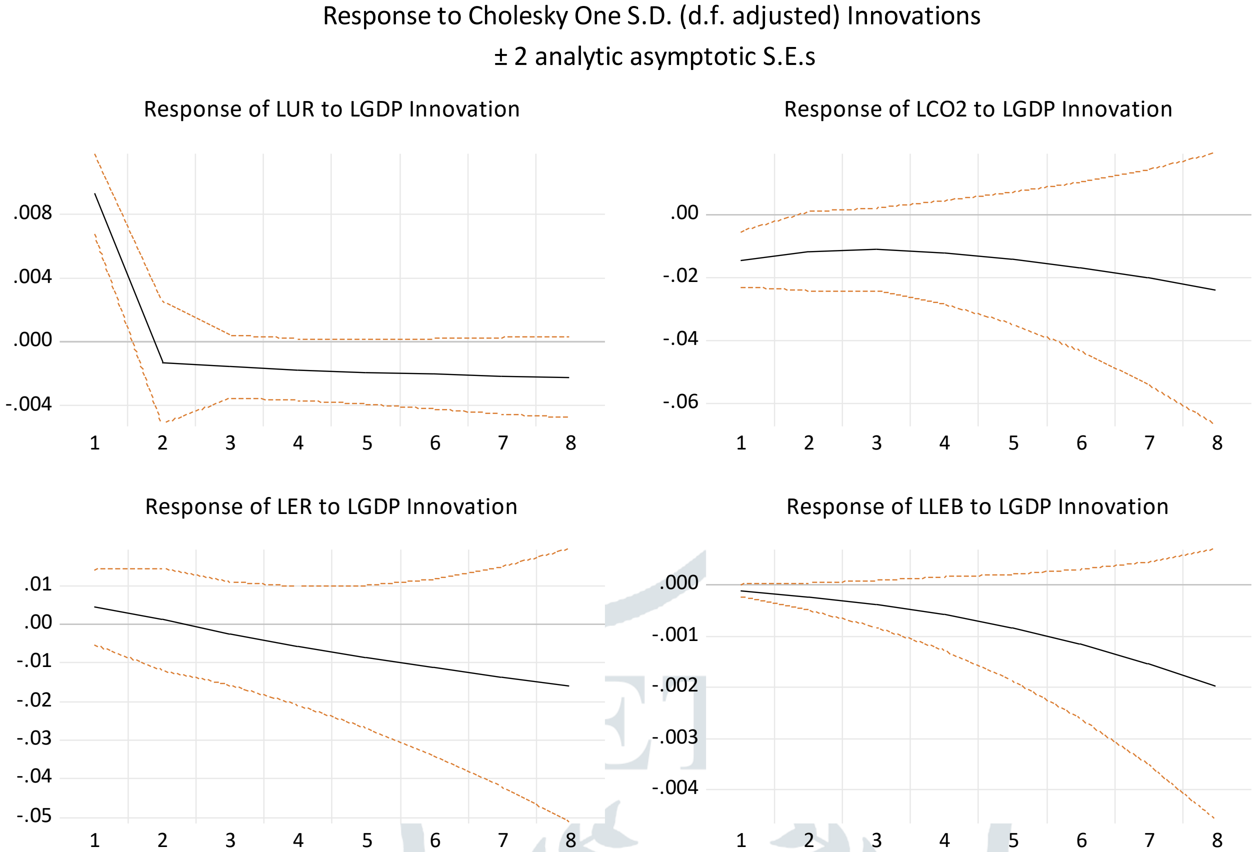
(Source: World Development Indicators, World Bank)

3.5 Results of Impulse Response Functions

Next, we use impulse response functions which traces the effects of a shock to one endogenous variable on to the other variables in the VAR.

The response of other variables to a shock to GDP is displayed in Figure 3.1. We can see that in period one after the shock, LUR declines rapidly from period 1 to 2 to become negative and then becomes almost flat. CO2 slightly increases from period 1 to 3 and then begins to slowly fall. The impact is very minimal. LER falls continuously in response to the shock to GDP. LEB also falls slightly and remains negative throughout the period. Similarly, responses of all other variables to a shock to UR, CO2, ER, LEB can be observed.

Figure 3.1. Impulse response graph of shock to LGDP



(Source: World Development Indicators, World Bank)

3.6 Results of Variance Decomposition

Finally, we move on to variance decomposition to find the percentage of shocks or changes in one variable that are based on its own shocks, versus shocks on other variables. The results are given in Table 3.6.

The results of table 3.6 suggest that in the short run LUR, LCO2, LER and LLEB exhibit strong exogeneity in that 100% of the forecast error variance in GDP is attributed to itself. In the long run apart from the 76% share of shock from itself, the change in GDP spurs from school enrollment ratio (LER) with 21% followed by a small change of 1.98% from CO2 emissions (LCO2), 0.23% from life expectancy at birth (LLEB) and 0.07% from unemployment rate (LUR). Similarly, the results of all other variables are given in Table 3.6.

Table. 3.6 Variance decomposition estimates (in percentages)

Variance Decomposition of LGDP:

Period	S.E.	LGDP	LUR	LCO2	LER	LLEB
1	0.016420	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.022380	99.22764	0.000261	0.105058	0.664476	0.002568
3	0.026709	97.61986	0.000222	0.311950	2.057548	0.010421
4	0.030090	95.20565	0.001411	0.594115	4.172624	0.026203
5	0.032828	91.94697	0.006049	0.926752	7.067321	0.052905
6	0.035126	87.76003	0.017212	1.286353	10.84266	0.093741
7	0.037163	82.55776	0.038703	1.648373	15.60344	0.151722
8	0.039130	76.31859	0.074552	1.984692	21.39341	0.228753

Variance Decomposition of LUR:

Period	S.E.	LGDP	LUR	LCO2	LER	LLEB
1	0.009311	99.39669	0.603313	0.000000	0.000000	0.000000
2	0.009523	96.95335	0.576945	0.361815	2.098239	0.009646
3	0.009729	95.44758	0.555065	0.558312	3.417277	0.021766
4	0.009940	94.52060	0.537363	0.642196	4.264667	0.035171
5	0.010162	93.93716	0.523524	0.658962	4.831537	0.048822
6	0.010397	93.54460	0.513040	0.642350	5.238043	0.061971
7	0.010646	93.24568	0.505261	0.613884	5.560991	0.074183
8	0.010911	92.97949	0.499490	0.585076	5.850671	0.085270

Variance Decomposition of LCO2:

Period	S.E.	LGDP	LUR	LCO2	LER	LLEB
1	0.024705	33.56405	2.198008	64.23794	0.000000	0.000000
2	0.032301	32.63923	2.111992	58.06463	7.184145	6.87E-06
3	0.038804	30.86422	1.842964	46.96479	20.32661	0.001418
4	0.045730	29.11568	1.526686	35.70302	33.64557	0.009048
5	0.053303	28.26030	1.247100	26.65937	43.80715	0.026081
6	0.061456	28.60370	1.028799	20.08428	50.23071	0.052513
7	0.070123	30.07378	0.867439	15.43227	53.54023	0.086275
8	0.079304	32.43777	0.751324	12.10527	54.58116	0.124475

Variance Decomposition of LER:

Period	S.E.	LGDP	LUR	LCO2	LER	LLEB
1	0.025224	2.915541	0.191701	11.71013	85.18262	0.000000
2	0.033278	1.799135	0.150455	12.99943	85.03380	0.017181
3	0.038339	1.783332	0.118500	13.73395	84.30844	0.055773
4	0.042128	3.370995	0.098899	13.83758	82.58094	0.111588
5	0.045434	6.587585	0.096631	13.36443	79.77328	0.178078
6	0.048695	11.16845	0.113614	12.45099	76.01926	0.247683
7	0.052170	16.66884	0.147937	11.26674	71.60291	0.313575
8	0.056018	22.59492	0.194851	9.968188	66.87113	0.370910

Variance Decomposition of LLEB:

Period	S.E.	LGDP	LUR	LCO2	LER	LLEB
1	0.000321	13.75548	32.23590	5.326365	14.79453	33.88772
2	0.000697	13.58943	14.81729	2.794960	54.19717	14.60116
3	0.001226	13.92322	7.774062	1.260774	69.68993	7.352012
4	0.001890	15.34288	4.736503	0.566507	74.97308	4.381031
5	0.002680	17.50549	3.221178	0.284121	76.03378	2.955430
6	0.003593	20.16543	2.373725	0.191349	75.08822	2.181275
7	0.004632	23.14822	1.858500	0.179105	73.09400	1.720176
8	0.005804	26.31566	1.525318	0.194212	70.53950	1.425306

Cholesky One S.D. (d.f. adjusted)
Cholesky ordering: LGDP LUR LCO2 LER LLEB

(Source: World Development Indicators, World Bank)

IV. SUMMARY AND CONCLUSIONS

This study focusses on two objectives. First, to assess the impact of unemployment rate, CO2 emissions, gross enrollment ratio and life expectancy at birth on gross domestic product. And second, to determine the interdependency and the direction of causation among the 5 aforementioned variables for India over the period 1991-2018. The data for the variables has been taken from the World Development Indicators, maintained by the World Bank.

The variables considered are Gross Domestic Product (GDP), unemployment rate (UR), CO2 emissions, school enrollment rate (ER) and life expectancy at birth (LEB). To address the first objective, correlation analysis and logarithmic regression was performed. The results of correlation suggested a strong correlation among the variables but not so strong to suspect multicollinearity. GDP is negatively correlated to UR and CO2 emissions while positively related to ER and LEB. UR is positively correlated to CO2 while negatively related to ER and LEB. CO2 is positively correlated to both ER and LEB. ER is also positively correlated to LEB. The results of logarithmic regression shows that unemployment, CO2 and life expectancy at birth have a statistically significant impact on GDP when taken individually. However, when all the variables are taken together unemployment rate and CO2 are significant at 10% level while life expectancy at birth is still highly significant.

To address the second objective, Vector Autoregression (VAR) model was undertaken.

The results of Granger Causality test show that there is a unidirectional causality running from GDP to unemployment rate. There is no causal relationship between CO2 emissions and unemployment rate over the selected period. There is a unidirectional relationship running from enrollment ratio to CO2 emissions. There is a unidirectional relationship running from GDP to life expectancy at birth. There is no causal relationship between unemployment rate and life expectancy. There is a unidirectional relationship between CO2 emissions and life expectancy at birth. There is a bi-directional causality between school enrollment ratio and life expectancy at birth.

REFERENCES

1. Sanchita Bansal, Gagan Deep Sharma, Mohammad Mafizur Rahman, Anshita Yadav, Isha Garg (2021). Nexus between environmental, social and economic development in South Asia: evidence from econometric models, Heliyon, Volume 7, Issue 1.

2. Verma, N. M. P., Gaur, M., & Kant, R. (2020) GDP Movements in High and Moderate HDI Economies: An Empirical Investigation. Archives of Business Research, 8(6). 19-31.

3. Ulas, Efehan & Keskin, Burak. (2017). Is There a Relation Between HDI and Economic Performances?

4. Taqi, Muhammad & Sibt-E-Ali, Muhammad & Parveen, Sabiha & Khan, Inam. (2021). An analysis of Human Development Index and Economic Growth. A Case Study of Pakistan.

5. Cibulka, Stefan & Giljum, Stefan. (2019). Towards a comprehensive framework of the relationships between resource footprints, quality of life and economic development.

6. Rahman, M.M., Saidi, K. and Ben Mbarek, M. (2017), "The effects of population growth, environmental quality and trade openness on economic growth: A panel data application", Journal of Economic Studies, Vol. 44 No. 3, pp. 456-474.

7. Dahliah, D., & Nirwana Nur, A. (2021). The Influence of Unemployment, Human Development Index and Gross Domestic Product on Poverty level. Golden ratio of Social Science and Education, 1(2), 95-108

8. R R Arriani and Chotib. (2021). *IOP Conf. Ser.: Earth Environ. Sci.*

9. Janez Sušnik & Pieter van der Zaag (2017) Correlation and causation between the UN Human Development Index and national and personal wealth and resource exploitation, Economic Research-Ekonomska Istraživanja, 30:1, 1705-1723

10. Khan, Ruby & Salam, Md. Abdus. (2020). Inadequacy of Economic Growth for Economic Development. American Journal of Economics and Business Management. 3. 136-152. Vol3.Iss5.208.

11. Sede, P.I., Ohemeng, W. (2015). Socio-economic determinants of life expectancy in Nigeria (1980 – 2011). Health Econ Rev 5, 2

12. Delavari S, Zandian H, Rezaei S, et al. (2016). Life Expectancy and its Socioeconomic Determinants in Iran. Electron Physician.;8(10):3062-3068.

13. Audi, Marc and Ali, Amjad. (2016). *Socio-Economic Status and Life Expectancy in Lebanon: An Empirical Analysis. MPRA Paper.*

14. Rasha M. S. Istaiteyeh1. (2017). Economic and Social Factors in Shaping Jordan’s Life Expectancy: Empirical Analysis (1990-2014). Advances in Management & Applied Economics, vol. 7, no. 5, 2017, 45-59

15. Nabi, A.A., Shahid, Z.A., Mubashir, K.A. et al. (2020). Relationship between population growth, price level, poverty incidence, and carbon emissions in a panel of 98 countries. Environ Sci Pollut Res 27, 31778–31792

16. Audi, Marc; Ali, Amjad, (2016). “Socio-Economic Status and Life Expectancy in Lebanon: An Empirical Analysis,” Munich Personal RePEc Archive. MPRA Paper No. 72900.

17. Delavari Somayeh; Zandian, Hamed; Rezaei, Satar; Moradinazar, Mehdi; Delavari, Sajad; Saber, Ali; Fallah, Razieh. (2016). “Life Expectancy and its Socioeconomic Determinants in Iran,” Electronic Physician, vol. 8, no. 10, , pp. 3062-3068.

18. Enders, W. (1995). “Applied Econometric Time Series”, Hoboken, NJ: Wiley.

19. Lütkepohl, H. (2007). *New Introduction to Multiple Time Series Analyis*. Berlin: Springer.

20. Rajesh Sharma, Avik Sinha, Pradeep Kautish. (2021). “Does renewable energy consumption reduce ecological footprint? Evidence from eight developing countries of Asia”, Journal of Cleaner Production, Volume 285, 124867.