PUBLIC HEALTH RESEARCH

The Causal Relationship Between Infant Mortality Rate, Health Expenditure And Economic Growth In India

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ABSTRACT

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Introduction The Infant Mortality Rate defined as the risk for a live born child to die before its first birthday, is known to be one of the most sensitive and commonly used indicators of the social and economic development of a nation. This paper investigates the causal relationship between infant mortality rate, economic growth and private health expenditure [% Gross Domestic Product (GDP)] in India using the co-integration and Granger causality frameworks for the period from 1995 to 2013 using secondary data from various sources.

Methods We have examined the presence of a long-run equilibrium relationship using the bounds testing approach to co-integration within the Unrestricted Error-Correction Model (UECM). We have also examined the direction of causality between infant mortality rate, economic growth and private health expenditure (% GDP) in India using the Granger causality test within the Vector Error-Correction Model (VECM).

Results and Conclusions As a summary of the empirical findings, we find the Infant Mortality Rate (IMR), Per-Capita Gross Domestic Product (PCGDP) and private health expenditure (% GDP) are co-integrated. The results of Granger Causality suggested that no short-run effect was existing between all the three variables. The error-correction term implies that the variable is non-explosive and long-run equilibrium relationship is attainable.

Keywords Infant Mortality Rate - Private Health Expenditure (% Gross Domestic Product) - Per-Capita Gross Domestic Product (PCGDP) - Co-integration and Granger Causality.

INTRODUCTION

Economic development of any country is mainly dependent on the kind of workforce that country is able to provide. Several indicators are used to measure the socio-economic development, important among these being, the amount of money spent on health (public and private spending) and the percentage of Gross Domestic Product (GDP) on health. Infant Mortality Rate (IMR) is one of the important parameter to measure overall health condition of a nation.[1]

The Infant Mortality Rate defined as the risk for a live born child to die before its first birthday, and is known to be one of the most sensitive and commonly used indicators of the social and economic development of a nation.[2] Deaths during the first four weeks are largely preventable by good health care. Much of the variations between developed and developing world in terms of death among newborn can be explained by differences in antenatal care. About half of all pregnant women in the least developed countries have no antenatal care, and 7 out of 10 babies are born without the help of a trained birth attendant. The other major factors being malnutrition and high parity of the mother, low birth weight of the baby, and congenital anomalies.[1]

In the industrial world, the dominant factor in the decline of infant mortality was economic and social progress (i.e. quality of life), with medical services playing a secondary role. On the other hand, in most of the developing countries, this pattern has been almost turned upside down. That is, medical services (e.g. mass control of disease, immunization, antibiotics and insecticides) have made the major impact, with social and economic progress taking the supporting role. Therefore, infant mortality rates are reluctant to fall below 100 per 1000 live births in many developing countries.[1] In India, according to Sample Registration System (SRS) bulletin 2012, the IMR at national level was 42 per 1000 live births in 2012 as compared to 44 in 2011.[3] It is now conceded that only socio-economic development can reaccelerate the progress and lead to further significant fall in infant deaths.

Financing health care is one of the critical determinants that influence health outcomes in a country. Available evidence suggests that mortality rates are influenced by low levels of public expenditure on health compared with private expenditure while at high development levels the opposite is true.[4] Gupta et al.[5] found that public spending on health is more important for the health of the poor in low-income countries than in the high-income countries in order to expect higher returns in health development. Agrawal and Hedau[6] concluded that financial status is dependent on the per-capita income of a family, which thereby indicates the improving consumption patterns and expenditures on health and hygiene; this later proves as a significant variable that leads in reducing Infant Mortality Rate. Analyses of the historical decline in childhood mortality rates in today's industrialized countries suggest that important drivers of this decline were improved nutrition, public health, and medical technological progress.[7,8,9]

Hence the main task of this paper is to see how infant mortality rate (IMR), private health expenditure (% GDP) (PHEXP) and per capita gross domestic product (PCGDP) relate to each other in India. As it should be always preferred, this study uses a multivariate approach over bivariate approach to exclude a chance of specification bias occurring due to omission of relevant variables.[10,11,12] The sample period of this study is from 1995-2013. The period for the analysis has been dictated by the availability of private health expenditure data which is available during the same period. This study also employed recently developed auto-regressive distributed lag (ARDL) bounds testing approach of co-integration developed by Pesaran and Shin[13] and Pesaran et al.[14] ARDL approach of co-integration has become popular not only in energy economics[15,16,17,18] but also in other areas like tourism, education, finance etc.

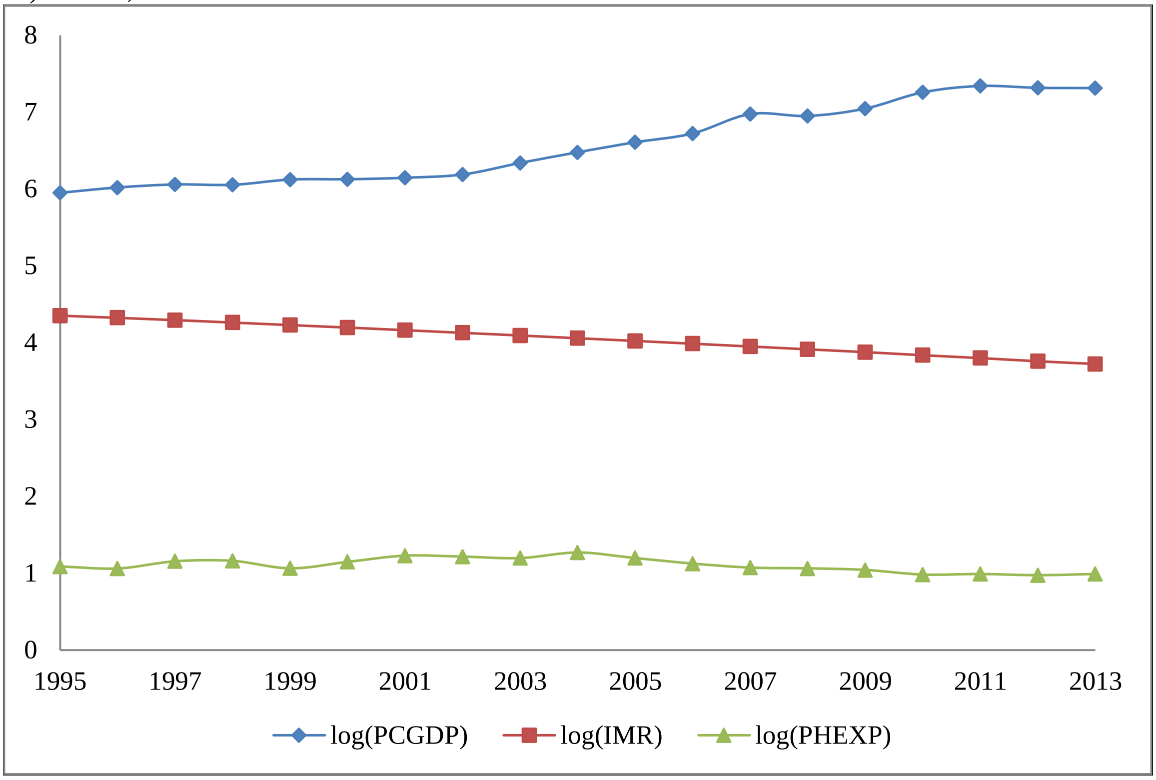
METHODOLOGY

Data description

This study uses annual data of Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP) from 1995 to 2013 in India. Annual data are used in this study to avoid the seasonal biases. Furthermore, as reported by Hakkio and Rush (1991), co-integration is a long run concept requiring long spans of data so as to give the tests for co-integration more power than merely increasing the data frequency. The data of Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP) of India were collected from World Bank, 2015 from 1995 to 2013. Finally, the econometric software's, namely Microfit 5 and Eviews 6 are used to complete the analysis in this study.

Figure 1 shows the trend of IMR and PCGDP and Private Health Expenditure (% GDP) in India, 1995-2013. An inverse relationship is noted between PCGDP and IMR i.e., during 1995 to 2013 the PCGDP showed an upward trend whereas; at the same time the rate of infant mortality showed downward trend. This implies that as the economic status of individuals/ families has improved the IMR has decreased. Another component private health expenditure (% GDP) shown upward trend from 1995 to 2004, which later it went on decreasing up to the year 2013.

Figure 1 Trend of Infant Mortality Rate, Per Capita Gross Domestic Product and Private Health Expenditure (% GDP) in India, 1995-2013



In the time series analysis, if the series are non-stationary or I(1) process, the regression results with variables at level will be spurious.[19,20] Thus, we start with examining the time series properties of the series through the Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) unit root tests. Pesaran et al.[14] noted that bounds testing procedure is applicable merely for either I(0) or I(1) process independent variables.

Co-integration

There are several approaches available in the economic literature for investigating the long-run association among variables. The well-known techniques include Engle and Granger,[21] and Johansen and Juselius[22] tests for co-integration. Such conventional approaches require the same order of integration for finding a long-run relationship among the variables. Pesaran et al.[14] developed an approach for co-integration, known as the autoregressive distributed lag (ARDL) bounds testing approach. This test for co-integration can be used to examine the co-integration properties even if the order of integration is mixed. In this study, the ARDL bound testing approach recommended by Pesaran et al.[14] has been employed to study log-run equilibrium relationship among variables: Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP). The other advantages of this approach include its ability to check for short run dynamics without loss of long run information as this approach is based on the following Unrestricted Error Correction Mechanism (UECM).

$$\begin{aligned}\Delta \ln IMR_t &= a_{0IMR} + \sum_{i=1}^{n} b_{iIMR}\Delta \ln IMR_{t-i} + \sum_{i=1}^{n} c_{iIMR}\Delta \ln PCGDP_{t-i} \\ &+ \sum_{i=1}^{n} d_{iIMR}\Delta \ln PHEXP_{t-i} + \sigma_{1IMR} \ln IMR_{t-1} \\ &+ \sigma_{2IMR} \ln PCGDP_{t-1} + \sigma_{3IMR} \ln PHEXP_{t-1} + \varepsilon_{1t} \qquad (1)\end{aligned}$$

$$\Delta \ln PHEXP_t = a_{0PHEXP} + \sum_{i=1}^{n} b_{iPHEXP} \Delta \ln PHEXP_{t-i} + \sum_{i=1}^{n} c_{iPHEXP} \Delta \ln PCGDP_{t-i} + \sum_{i=1}^{n} d_{iPHEXP} \Delta \ln IMR_{t-i} + \sigma_{1PHEXP} \ln PHEXP_{t-1} + \sigma_{2PHEXP} \ln PCGDP_{t-1} + \sigma_{3PHEXP} \ln IMR_{t-1} + \varepsilon_{2t} \quad (2)$$

$$\Delta \ln PCGDP_t = a_{0PCGDP} + \sum_{i=1}^{n} b_{iPCGDP} \Delta \ln PCGDP_{t-i} + \sum_{i=1}^{n} c_{iPCGDP} \Delta \ln PHEXP_{t-i} + \sum_{i=1}^{n} d_{iPCGDP} \Delta \ln IMR_{t-i} + \sigma_{1PCGDP} \ln PCGDP_{t-1} + \sigma_{2PCGDP} \ln PHEXP_{t-1} + \sigma_{3PCGDP} \ln IMR_{t-1} + \varepsilon_{3t} \quad (3)$$

Where Δ is the first difference operator, $\ln IMR_t$ is the natural logarithm of Infant Mortality Rate, $\ln PHEXP_t$ is the natural logarithm of Private health expenditure (% GDP) and $\ln PCGDP_t$ is the natural logarithm of per capita gross domestic product. The residuals ($\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}$) are assumed to be normally distributed and white noise error.

From equations (1)–(3), the F-test can be used to examine whether a long-run equilibrium relationship exists between the variables, by testing the significance of the lagged level variables (H_0: $\sigma_1 = \sigma_2 = \sigma_3 = 0$ against the alternative hypothesis H_1: $\sigma_1 \neq \sigma_2 \neq \sigma_3 \neq 0$).

The computed F-statistics for co-integration are denoted as:

$F_{IMR}(IMR \setminus PCGDP, PHEXP)$;

$F_{PHEXP}(PHEXP \setminus PCGDP, IMR)$;and

$F_{PCGDP}(PCGDP \setminus IMR, PHEXP)$ for each equation respectively.

Pesaran et al.[14] developed two sets of critical F values to check the presence of co-integration. The first set of critical values is called lower-bounds critical values, and the second set of critical values is known as upper- bounds critical values. According to Pesaran et al.,[14] the null hypothesis of no co-integration is rejected if calculated value F-statistics fall outside the critical band, without needing to know whether the variables are I(0) or I(1) or mixed order. On the other hand, if the value of F-statistics falls within the critical band then inference remains inconclusive.

Granger Causality Test

Apart from testing the presence of co-integration, the next stage of this paper is to ascertain the direction of causality via the Granger causality test. The Granger representation theorem suggests that there will be Granger causality in at least one direction if there is a co-integration relationship among the variables. However, the direction of causality can be detected through the vector error-correction model (VECM) of long-run co-integration vectors. Granger-Causality test is used for detecting causal relationship between two or more variables.

In our case, test for Granger causality is conducted within the frame- work of a vector error correction model (VECM) as follows:

$$(1-L)\begin{bmatrix} \ln IMR_t \\ \ln PHEXP_t \\ \ln PCGDP_t \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} + \sum_{i=1}^{p} (1-L) \begin{bmatrix} \phi_{11i}\phi_{12i}\phi_{13i}\phi_{14i} \\ \phi_{21i}\phi_{22i}\phi_{23i}\phi_{24i} \\ \phi_{31i}\phi_{32i}\phi_{33i}\phi_{34i} \end{bmatrix} \times \begin{bmatrix} \ln IMR_{t-1} \\ \ln PHEXP_{t-1} \\ \ln PCGDP_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} \times [ECT_{t-1}] + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (4)$$

Where (1−L) is the difference operator, ECT_{t-1} is the lagged error correction term. ε_{it} (i=1, 2, 3) are the serially uncorrelated random disturbance terms with zero mean. The F-statistics on the lagged explanatory variables of the error-correction model indicates the significance of the short-run causal effects. The t-statistics on the coefficient of error-correction term indicates the significance of the long-run causal effect. The optimum lag length p is selected for each variable by using either Schwarz-Bayesian (SBC) or Akike Information Criteria (AIC).

RESULTS

Results of unit roots and co-integration tests

When testing for unit roots and co-integration, this study has chosen to use a probability value of 0.10, which is an appropriate level of significance to be used with small sample sizes such as that used in the present study. Augmented Dickey-Fuller (ADF) and Phillips–Perron (PP) unit root tests for Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per Capita Gross Domestic Product (PCGDP) are reported in Table 1. The ADF and PP tests give the same results. The null hypothesis that the series contain a unit root cannot be rejected for any of the series in levels at the 10% level, but when the data are first differenced, the null of non-stationarity can be rejected for all series at the 10% level. This indicates that Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP) are the stationary variables at first difference.

Table 1 Results of Unit root tests

Variables	ADF (LL)	PP (BW)
$lnIMR_t$	3.8067(1)	8.1013(2)
$\Delta IMRL_t$	-3.0364(1)***	-5.2620(0)*
$lnPHEXP_t$	-0.9927(0)	-0.9493(2)
$\Delta lnPHEXP_t$	-3.9837(0)*	-3.9852(5)*
$lnPCGDP_t$	0.1297(3)	0.1297(0)
$\Delta lnPCGDP_t$	-3.2018(3)**	-3.1690(2)**

Notes: LL stands for lag length and BW stands for bandwidth.
*, ** and *** Represents the rejection of the null hypothesis of non-stationarity at 1%, 5% and 10% level of significance respectively.

The unique stationarity properties of the variables lead us to apply the ARDL bounds testing approach to examine co-integration between the variables for long-run relationship. The results of the bounds testing for co-integration together with exact critical values are reported in Table 2. Our empirical exercise illustrates the presence of co-integration once Infant Mortality Rate (IMR) and Per capita gross domestic product (PCGDP) are assigned as dependent variables. Our computed F-statistics are 3437.5 and 6.0990 which are greater than the upper critical bound at 5% and 10% levels, respectively. Therefore, we conclude that there is long-run equilibrium

Table 2 Bounds Testing Approach for Cointegration

F Statistics	Exact 5% critical bound		Exact 10% critical bound	
	Lower	Upper	Lower	Upper
$F_{NNMR}(IMR \setminus PCGDP, PHEXP)$ =3437.5	3.3220	4.6103	2.5377	3.6378
$F_{HEXP}(PHEXP \setminus PCGDP, IMR)$ =1.7074				
$F_{PCGDP}(PCGDP \setminus IMR, PHEXP)$ =6.0990				

Relationship among Infant Mortality Rate (IMR), Per capita gross domestic product (PCGDP) and Private health expenditure (% GDP) (PHEXP) over the period of 1995–2013 for the case of India. However, the bounds test indicates that the co-integration is absent when Private health expenditure (% GDP) (PHEXP) is the dependent variable because the F- Statistics is outside the lower and upper bound critical value at the 5% and 10 % levels.

Results of Granger Causality

Table 3 presents the results of short and long-run Ganger Causality within vector error-correction model (VECM) framework. The F-statistics on the lagged explanatory variables of the VECM indicates the significance of the short-run causal effects. The t-statistics on the coefficients of the lagged error-correction term indicates the significance of the long-run causal effect. In the short-run effect, the results indicate that, all the three variables are not significant. This suggests that no short-run effect was exists between Infant Mortality Rate (IMR), Per capita gross domestic product (PCGDP) and Private health expenditure (% GDP) (PHEXP) over the period of 1995–2013 for the case of India.

Table 3 Results of Granger Causality

Dependent Variable	Short run			Long run
	$\Delta lnIMR_t$	$\Delta lnPHEXP_t$	$\Delta lnPCGDP_t$	ECT_t (t-Statistics)
$\Delta lnIMR_t$	-	0.1627	1.8241	-0.0585***
$\Delta lnPHEXP_t$	1.5393	-	0.7839	
$\Delta lnPCGDP_t$	0.4852	0.1166	-	

*, ** and *** Represents the Significant at 1%, 5% and 10% level of significance respectively

Turning to the t-statistic on the coefficient of the lagged error-correction term, in the long-run causality, we find that the coefficient of the lagged error-correction term ECT_{t-1} has a negative sign and statistically significant at 10% level of significance only in the Infant Mortality rate (IMR) equation, which confirms the result of the bounds test for co-integration. The significant negative sign of error-correction term implies that the variable is non-explosive and long-run equilibrium relationship is attainable. This implied that Infant Mortality Rate (IMR), Per capita gross domestic product (PCGDP) and Private health expenditure (% GDP) (PHEXP) have causality in the long-run over the period of 1995–2013 for the case of India.

Constancy of co-integration space

One of the potential problems with time series regression models is that the estimated parameters may change over time. Although the PCGDP and its determinants are moving in the same direction and converge in the long run, there is no guarantee of parameters stability. The unstable parameter can result in model mis-specification error and ultimately may produce biased results. To account for this, here, we examine whether the estimated residuals are stable over time. As demonstrated by Bahmani-Oskooee and Bohl,[23] co-integration may not imply stable relationship among the set of variables. Thus, following Bahmani-Oskooee and Bohl[24] and Bahmani-Oskooee,[23] we carry out the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests to the recursive residuals of the estimated ARDL.

The plots of CUSUM and CUSUMSQ statistics in Figure 2 reveal that the test statistics are always within the 5% critical bounds, indicating that all coefficients in the estimated model are stable over the sample period 1995-2013.

Figure 2 Plots of CUSUM for the estimated ECM model

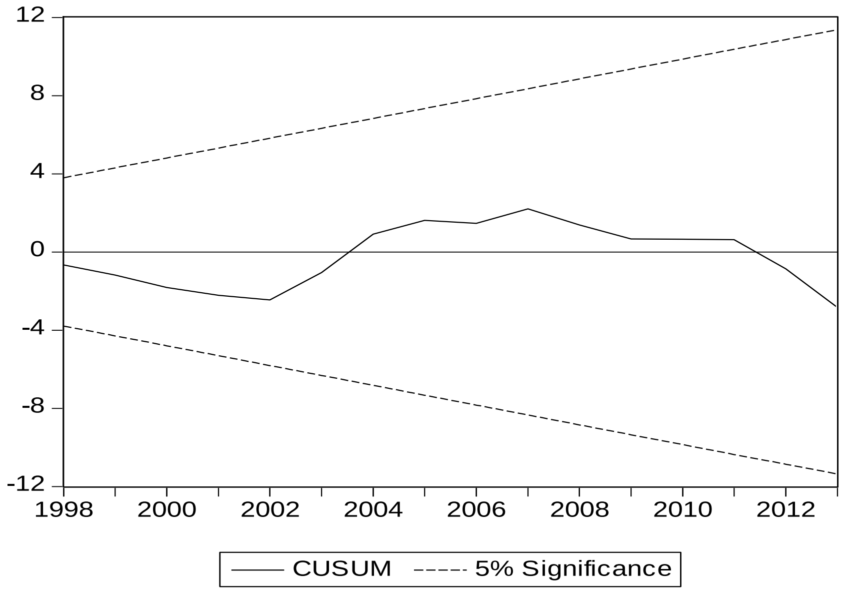
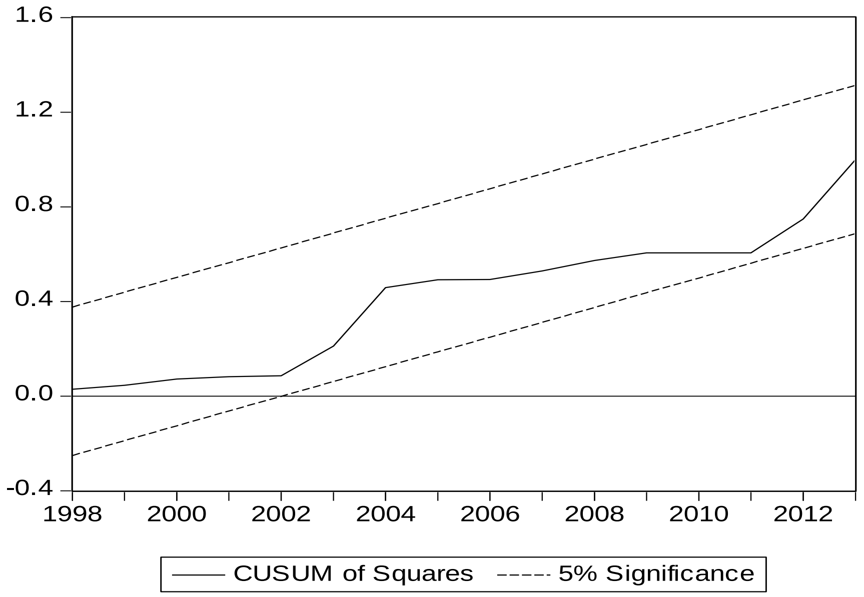


Figure 3 Plots of CUSUMSQ for the estimated ECM model



CONCLUSION

This study investigates causality between Infant Mortality Rate (IMR), Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP) from 1995 to 2013 in India. This study also utilizes the bounds testing approach for co-integration to examine the presence of long-run equilibrium. The main concern of this paper has been to assess the impact of private health expenditure and per capita gross domestic product on infant mortality rate. Specifically, the paper tests the changing roles of private expenditures on health along the development process.

Our main findings are that and infant mortality rate and per capita gross domestic product are co-integrated. The short-run causality not exists between all three variables but long-run causality exists when infant mortality rate is dependent variable. This implies that explanatory variables are coalescing with infant mortality to achieve their steady-state equilibrium in the long run, although deviations may occur in the short run. The study also suggests that the coefficients in the estimated ECM model are stable over the sample period. The study also indicates that the Infant Mortality Rate (IMR) is negatively related to Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP). This implies that as the Private health expenditure (% GDP) (PHEXP) and Per capita gross domestic product (PCGDP) increase the Infant Mortality Rate (IMR) decrease.

REFERENCES

1. Park K. Parks textbook of preventive and social medicine (23rd ed.). Banarisidas Bhanot: Jabalpur India; 2015.
2. Central Bureau of Health Intelligence (CBHI), Government of India. Definitions used in National Health Profile; 2013.
3. SRS bulletin. Sample Registration System, Registrar General of India. Government of India; 2012
4. Issa H. The Effect of Private and Public Health Expenditure on Infant Mortality. 2005.
5. Gupta S, Verhoeven M and Tiongson E. Public Spending on Health Care and the Poor. Unpublished manuscript. 2001
6. Agrawal D and Hedau V. Determinants of Infant Mortality Rate in India. International Journal of Research in Management Science and Technology. 2014; 2: 32-42.
7. Fogel R. The Escape from Hunger and Premature Death, 1700-2100- Europe, America and the Third World. Cambridge University Press: Cambridge; 2004.
8. Cutler D and Miller G (2005). The role of public health improvements in health advances: The twentieth century United States. Demography. 2005; 42: 1-22.
9. Cutler D, Deaton A and Lleras-Muney A. The determinants of mortality. Journal of Economic Perspectives. 2006; 20: 97-120.
10. Chang T, Fang W. and Wen LF. Energy consumption, employment, output and temporal causality: evidence from Taiwan based on co-integration and error-

correction modeling techniques. Applied Economics. 2001; 33, 1045–1056.
11. Stern DI. Energy growth in the USA: A multivariate approach. Energy Economics. 1993; 15: 137–150.
12. Stern DI. A multivariate co-integration analysis of the role of energy in the US macroeconomy. Energy Economics. 2000; 22: 267–283.
13. Pesaran MH. and Shin Y. An autoregressive distributed lag modelling approach to co-integration analysis. In: Storm, S. (Ed.), Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium (pp. 1–31). Cambridge University Press: Cambridge; 1999.
14. Pesaran MH, Shin Y and Smith RJ. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics. 2001; 16: 289–326.
15. Narayan PK and Smyth R. Electricity consumption, employment and real income in Australia evidence from multivariate Granger causality tests. Energy Policy. 2005; 33: 1109–1116.
16. Halicioglu F. An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy. 2009; 37: 1156–1164.
17. Ghosh S. Import demand of crude oil and economic growth: evidence from India. Energy Policy. 2009; 37: 699–702.
18. Odhiambo NM. Energy consumption and economic growth nexus in Tanzania: an ARDL bounds testing approach. Energy Policy. 2009; 37: 617–622.
19. Granger CWJ and Newbold P. Spurious regressions in econometrics. Journal of Econometrics. 1974; 2: 111-120.
20. Phillips PCB. Understanding spurious regressions in econometrics. Journal of Econometrics. 1986; 33: 311-340.
21. Engle RF and Granger CWJ. Co-integration and error correction: representation, estimation and testing. Econometrica. 1987; 55: 251–276.
22. Johansen S and Juselius K. Maximum likelihood estimation and inference on co-integration with application to money demand. Oxford Bulletin of Economics and Statistics. 1990; 52: 169–210.
23. Bahmani-Oskooee M and Bohl M. German monetary unification and the stability of the German M3 money demand function. Economics Letters. 2000; 66: 203-208.
24. Bahmani-Oskooee M. How stable is M2 money demand function in Japan? Japan and the World Economy. 2001; 13: 455-61.
25. Hakkio CS and Rush M. Co-integration: how short is the long run? Journal of International Money and Finance. 1991; 10: 571-581.