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# Economic Activity Indicators, Environmental Pollution and Infant Mortality Relations: Evidence from Ghana

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## Abstract

Negative health effects of environmental pollution on infants, have become an issue of serious concern for health experts and researchers. Recent studies have proposed that ecological pollution, particularly carbon dioxide emissions, is associated with infant mortality and the development of asthma and other respiratory diseases. Empirical findings from other research works supports our hypothesis, that, economic activity indicators have a significant impact on environmental pollution and eventually on infant mortality. Using data from World Development Indicators to find the link between ecological pollutants and infant mortalities in Ghana for the period 1971 to 2012. Hypotheses were pragmatically tested and validated using structural equation modeling (SEM). The study findings provided standardized estimates of the various economic activity indicators to emissions as well as the indirect effect to infant mortality in Ghana. Factor loading of the path analysis clear shows that a change in emission will cause a decline of infant deaths.

## Keywords

Economic Activity Indicators, Infant Mortality, Carbon Dioxide Emissions, Economic Growth, Environmental Pollution

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## 1. Introduction

The effect of air pollution on human health has been kept quiet and has not been featured in recent research work for years now. Most of the health reports do not disclose the negative effect or contribution of air pollution to disease like asthma, cardiovascular disease, lung cancer, chronic obstructive pulmonary disease and other respiratory diseases from both human and industrial activities [1, 2]. Poor air quality affects humanoid and living species and among humans, the most vulnerable once are infants [3, 4]. That is, infants are exposed to ecological pollution and therefore, requires exceptional concern because their immune system and lungs are not fully grown. Although environmental pollution has long been thought to aggravate minor acute illnesses, however, recent research has proposed that ecological pollution, particularly carbon dioxide emissions, is associated with infant mortality and the development of asthma and other respiratory diseases [5]. The link between the economic pointers and carbon dioxide emissions has been established by many research findings [6]. Other empirical findings also provided evidence to the theory that economic activity indicators such as economic growth, agriculture and industrialization have an impact on the health of human species as results of changes in air quality. Copious studies have found a relationship between ecological pollutants and infant mortality in countries with fairly high levels of ecological toxins as well as in countries at lower pollution

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levels [7-9]. Findings from these studies revealed a strong association between environmental pollution and infant's mortality with breathing complications as the cause [10]. Common example is the study by [11] in Dublin, Ireland, which found evidence of a reduction in cardiovascular and respiratory health conditions of people, due to the ban of sale of coal in 1990. Similarly, [12] also found a drop of infant deaths due to fall of production output of industries between 1981 and 1982. To add to [12] discoveries, [13] study in Utah also found a decline in the number of admissions in hospitals with respiratory complications after the closure of major air pollution industries. These empirical study's findings provide the strong basis which supports our hypothesis, that, economic activity indicators have a significant impact on environmental pollution and eventually of infant mortality.

[14] report, indicate that 47, 337 deaths in Ghana, which constitute 23% are deaths attributable to poor environmental circumstances. However, [14] expressed that even-though infant mortality in Ghana has declined from 61.1% (2002) to 42.4% (2015), the rate is still high above Sustainable Development Goal target of 3.2%. Nevertheless, the question remains unanswered as to the magnitude of the various environmental pollutant's contributions to the infants' respiratory cause of death in Ghana. That is, the relationship of the pollutants such as carbon dioxide emissions ($CO_2$) and infant mortality in Ghana. Some studies have been conducted to find the effect of various pollutants on human health [4, 15-17]. Nonetheless, to the best of our knowledge, little or no work has been done in developing countries, like Ghana, to find whether the rate at which infants die can be attributed to $CO_2$ emissions, and if so, by what magnitude. It is against this background, which the study seeks to look at the association between economic activity indicators, environmental pollution and infant's mortality in Ghana.

## 2. Literature Review

In finding solution to the problem of infant mortality, recent study by [18], which seek to find whether environmental regulation set up by the Indian government is helping to mitigate the negative effect of environmental practices in India. Using data set of air, water and ecological regulations, the study claimed that the implementation of air pollution regulation has help to improve the air quality in India. On the other hand, not many declines in infant mortality were seen with the enforcement of the regulation. The study concluded that the success for the regulation enforcement was due to the public support to ensure that right things are done.

Quite number of research work have discovered the causal relationship between economic growth, agriculture, industrialization and carbon dioxide emissions. Findings of these studies show a discrepancy in terms of the relationship between the variables. Some studies established carbon dioxide emissions been swayed by economic growth [19-26], while's others found the reverse of the case whereby economic growth is influenced by carbon dioxide emission [21, 27-33]. A study of [34] scrutinized the nexuses between carbon dioxide ($CO_2$) emissions per capita and economic growth in Next Eleven (N-11) 1 for the period 1981-2009. The study found positive relationship between $CO_2$ emission and GDP. Study by [22] applied dynamic panel threshold framework of 31 developing countries. The Study findings support the view that economic growth contributes to the emissions level in these countries. Notwithstanding, the effect of economic growth on $CO_2$ is negative when the growth is low, however, the effect becomes positive when the growth is high. To reinforce [22] findings, [23] research results asserted the views that economic growth causes carbon dioxide emissions.

Another key issue of concern is the relationship between agriculture and carbon emissions. Agricultural production, play a significant role for economic growth and food to sustain living species [35]. The usages of carbon-based and non-living material as inputs or output in the management of agronomic structures also add to emissions. That is, the use of these materials releases significant amounts of $CO_2$ [36]. On this premise, some empirical work holds the view that agriculture contributes to $CO_2$ emissions due to the input factors and other related energy issues, which are unavoidable during the production process [37, 38]. On the contrary, other researcher findings indicate that agriculture helps in the reduction of emissions due to plant photosynthesis [39, 40]. [39] Study in Pakistan found an increase in forest contribute to a reduction in emission. The study also found agriculture production as one of the key contributors to emissions in Pakistan. Autoregressive Distributed Lag model was applied to find the relationship renewable-energy consumption, agriculture production and forest on carbon dioxide emissions for the period 1990 to 2014. Similarly, [37] also found the use of fertilizer and cattle rearing contributes a lot of carbon dioxide emissions in China. [38] as well found an agricultural value increase causes an increase in emissions in Tunisia in the long run.

As Ghana, industrial processes keep on increasing especially with the implementation of government policy one district one factory, all things been equal, energy consumption would also increase [41]. Study by [42] in 20 African countries between the period 1980 to 2013, found industrialization to have negative effect on the environment. The study was undertaken by looking at both direct and indirect effects. However, the study also found that industrialization in another brief has an indirect positive effect on environment.

That is, industrialization reduces environmental degradation at a certain in time by swarming over the direct effect. Similarly, [43] examined the relation between carbon dioxide emissions from industrial operations and energy consumption in Taiwan. Test for a result was performed using Grey relation analysis of 34 industries. Results shows that industrial production has contiguous relationship with $CO_2$ emissions in Taiwan. [44] conducted a study to find the effect of pollution on infant mortality differ between developing and developed countries. Using novel instrumental variables approach, findings indicate statistical significant effects of greenhouse gasses such as PM10 and CO on infant death in Mexico City. That is, a 1% increase in PM10 over the period leads to 0.40% rise in infant mortality, while 1% increase in CO upshots causes 0.33% growth in infant death. Comparing developed and developing countries, the findings postulate PM10 to be same or lesser than that of developed country like US whiles CO was found to be greater than that of US.

# 3. Materials and Methods

## 3.1. Data

Our study used data from World Development Indicators to find the link between ecological pollutants and infant mortalities in Ghana for the period 1971 to 2012. The data includes IM, Infant Mortality (number of infant death); $CO_2$, Carbon dioxide emissions (kt); AGR, Agriculture, value added (current US$); GDP, GDP per capita (current US$) as proxy of economic growth and IND, Industry, value added (current US$) used as a proxy for industrialization. Conceptual framework as depicted in figure 1, which shows the causal relationship between economic activity indicators, environmental pollution and infant mortality were hypothesized. These hypotheses were pragmatically tested and validated using structural equation modeling (SEM). The empirical analysis is meant to expose the association between diverse variables in the model which are hypothesized.

## 3.2. Methods

Different variables have been used as a proxy for environmental pollution and health conditions in various research works. Our choice of carbon dioxide emissions ($CO_2$) as proxy for ecological pollution was based on reviewed literature and theoretical findings. Most researchers have exposed the diverse theories linked with the economic-ecological pollution relationship. Vital among them is the Environmental Kuznets Curve (EKC). Our study is based on EKC, which was hypothesized by [45]. This theory juxtaposes that ecological pollution increases as the country starts to develop but at a certain level of economic development and growth, the environmental pollution level lessens [46]. Measurement of $CO_2$ was based on three indicators (i.e. items) namely; economic growth, agricultural value added and industry value added. Agriculture is considered as the main economic activity in Ghana and that its emissions are inescapable. Ensuing deforestation as results of small-scale mining "galamsey", burning of fossil fuel to improve electricity generations are factors that contribute to $CO_2$ emissions in Ghana. Additionally, since the country industrial processes keep on accumulating is a recipe for an increase of emissions. The releases of carbon dioxide toxins into the atmosphere are detrimental to health of the citizenry.

Preliminary test would be to test for the normality and suitability of the data set for factor analysis. This will then be followed by development of a hypothesis of the study. Model specifications would be done to state the causal relationship between the variables. Measurement of model fit would be performed to enable us to interpret the connecting paths of the structural model. We will then carry out reliability and validity test of the model using composite reliability and convergent validity respectively. In order to draw conclusions, the hypotheses would be tested using Maximum Likelihood Estimates as discrepancy. To test for the statistical significance of standard errors of indirect effects of observed variables, the study performed a bootstrap of 500 sample size with bias-corrected confidence intervals of 95%.

## 3.3. Development of Research Hypothesis

Based on the preliminary test of data normality and suitability, our study hypothesized the model as give in figure 1, using the software package of Structure Equation Modeling (SEM) called Analysis of Moment Structures (AMOS). Some of the key reasons for the adoption of AMOS in this study are that; (1) AMOS software package is user friendly; (2) it can analyses the inter-relationships in a model among constructs; (3) paths for the analysis can be created using drawing tools; (4) AMOS provides an analysis which is accurate, effective and above all efficient; to mention a few. The study, therefore, hypothesized as follows:

Hypothesis-1 ($H_1$): GDP has a significant positive relationship with $CO_2$.

Hypothesis-2 ($H_2$): Agricultural value added has a significant positive relationship with $CO_2$.

Hypothesis-3 ($H_3$): Industry value added has a significant positive relationship with $CO_2$.

Hypothesis-4 ($H_4$): $CO_2$ has a significant negative relationship with infant mortality.

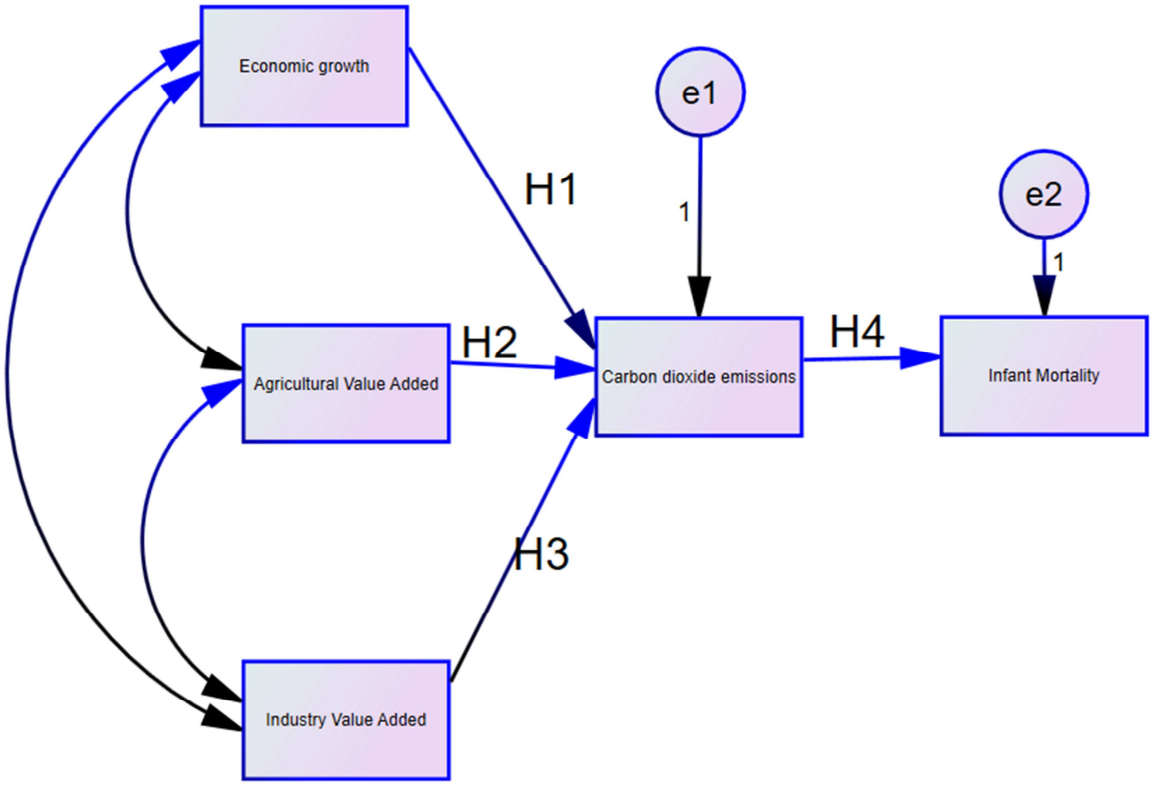


**Figure 1.** Hypothesized model showing the relationship between economic activities, environmental pollution and infant mortality.

### 3.4. Model Specifications

Figure 1 demonstrates the causal relationship between economic activity indicators, environmental pollution and infant mortality in Ghana. Among the two constructs and three indicators of carbon dioxide emissions ($CO_2$) which include economic growth (GDP), agriculture value added (AGR) and industry value added (IND). Our hypothesis consists of four models of which the first three models look at the relationship between economic growth, agriculture, industry and $CO_2$ emissions. Our fourth model which is the main hypothesis also looks at the relationship between $CO_2$ emissions and infant mortality. In all, there are seven variables in our model, five observed and two unobserved variables. The unobserved variable consist of two error terms in the model whiles the observed variable encompasses two endogenous and three exogenous variables.

## 4. Results and Discussions

### 4.1. Data Normality and Suitability for Factor Analysis

The study performed a test for normality of the data using Shapiro-Wilk and Kolmogorov-Smirnov normality test. Our results show that variables are normally distributed with all the variable having a significant value less than 5% significance level. Whiles Kaiser-Meyer-Olkin (KMO) and Bartlett's test of Sphericity were undertaken to discover data suitability for factor analysis, with acceptable values greater than 0.5 and less than 0.05 respectively. Results in Table 1 show KMO value of 0.77>0.50 and Barlett test of Spehericity value of 0.00<0.05.

**Table 1.** Normality and Suitability test results.

| **Normality test** | | | | |
|---|---|---|---|---|
| | **Kolmogorov-Smirnov** | | **Shapiro-Wilk** | |
| | **Statistics** | **Sig.** | **Statistics** | **Sig.** |
| IM | 0.155 | 0.01 | 0.906 | 0.00 |
| $CO_2$ | 0.149 | 0.02 | 0.915 | 0.00 |
| GDP | 0.299 | 0.00 | 0.776 | 0.00 |
| AGR | 0.214 | 0.00 | 0.896 | 0.00 |
| IND | 0.119 | 0.14 | 0.952 | 0.07 |
| Suitability test | | | | |
| | Results | Acceptable Value | | |
| KMO | 0.77 | Greater than 0.5 | | |
| Barlett's test | 0.00 | Less than 0.05 | | |

## 4.2. Descriptive Analysis

The descriptive analysis specifies agriculture value added with the highest mean of 21.70, which makes it the critical variable in Ghana, especially in terms of emissions. However, industry value added is considered as the most unpredictable variable with the highest standard deviation of 0.96. The kurtosis in Table 2 depicts that all the variables exhibit platykurtic distribution. Results from our descriptive statistics indicate that all the variables exhibit negative skew ness (long-left tail) except infant mortality, which displayed a positive skew ness (long-right tail). Our correlation analysis support the findings of [6] in Switzerland where the industrial growth rate is highly correlated with gross national product.

**Table 2.** Descriptive Statistics and correlation.

| Observed Variables | IM | $CO_2$ | GDP | AGR | IND |
|---|---|---|---|---|---|
| Mean | 10.69 | 8.42 | 6.06 | 21.70 | 20.87 |
| Min | 10.58 | 7.74 | 5.45 | 20.71 | 19.35 |
| Max | 10.79 | 9.38 | 7.40 | 22.96 | 23.16 |
| Std. Dev. | 0.07 | 0.49 | 0.51 | 0.58 | 0.96 |
| Skewness | -0.07 | 0.33 | 1.53 | 0.75 | 0.59 |
| Kurtosis | -1.53 | -1.31 | 1.38 | 0.34 | -0.29 |
| Correlation: | | | | | |
| IM | - | -0.94 | -0.63 | -0.70 | -0.87 |
| $CO_2$ | -0.94 | - | 0.73 | 0.79 | 0.93 |
| GDP | -0.63 | 0.73 | - | 0.96 | 0.84 |
| AGR | -0.70 | 0.79 | 0.96 | - | 0.85 |
| IND | -0.87 | 0.93 | 0.84 | 0.85 | - |

## 4.3. Model Evaluation and Validation Results

Measurement of model fit is one of the fundamental steps to perform to be able to interpret the causal paths of the operational model. To measure or evaluate the hypothesized model in order to accomplish the desired model-fit, the study applied three key measurement of model fit [47-51]. This includes; standardized root mean square residual (SRMR), confirmatory fit index (CFI); and likelihood ratio chi-square of goodness of fit statistics. Subsequent to this, the study weighed the goodness-of-fit under three common indices [52, 53]; (1) parsimonious fit; seek that to achieve virtuous model, our chi-square and degree of freedom of the model should be less than 2; (2) absolute fit; using GOF index (GFI) and adjusted GOF index (AGFI) which is expected to be in the range of 0.5 and 1; (3) incremental fit; applying comparative fit index (CFI) and Tucker-Lewis index (TLI), of which their acceptable resulting value should be more than 0.9.

To measure and test for meticulousness or uniformity of a measure [53], the study used composite reliability (CR) technique. The test was performed based on equation (1) as:

$$CR = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum Var(\varepsilon_i)} \quad (1)$$

Where $\left(\sum \lambda_i\right)^2$ represents the square of the sum of all factor loadings of a construct, whiles $\sum Var(\varepsilon_i)$ specifies the sum of all error variances of a construct, with its error variance, which is equal to one minus squared multiple covariance. Acceptable CR should be above 0.7, which will indicate that the measures used are consistent.

Having a good model does not confirm the validity of the model [54-56]. Therefore, there is the need to undertake a convergent validity tests, to look at the correlation of items of the construct. The average variance extracted (AVE) was performed as equation (2) below:

$$AVE = \frac{\sum_{i=1}^{n} \lambda_i^2}{\sum_{i=1}^{n} \lambda_i^2 + \sum_{i=1}^{n} \varepsilon_i} \quad (2)$$

Where $\lambda_i^2$ is the factor loading of item $i$, $n$ is the number of items and $\sum_{i=1}^{n} \varepsilon_i$ is the variance of the error of item $i$.

Results in Table 3 show that the values of all the indices predict our model to be fit. That is, our model achieved the desired goodness-of-it (Chi-sq/df=0.163<2; both GFI and AGFI values fall between 0.5 and 1; CFI and TLI values>0.9). Our test of convergent validity in Table 4 shows that average variance extracted (AVE) for each constructs is greater than 0.5 but however, less or equal to the value of composite reliability (CR) of that particular construct [57]. Findings of the CR test indicate CR value of 0.83 for $CO_2$ and 0.88 for IM, which are all greater than the least acceptable CR value of 0.7 recommended by [58] and that of 0.6 from [57].

**Table 3.** Model-fit indices.

| Model-Fit indices | | Results | Acceptable Fit indices |
|---|---|---|---|
| Parsimonious fit | Chi-Square/df | 0.163 | Less than 2 |
| Absolute | GFI | 0.956 | Between 0.5 and 1 |
| | AGFI | 0.780 | |
| Incremental | CFI | 0.994 | Greater than 0.9 |
| | TLI | 0.979 | |

**Table 4.** Composite Reliability (CR) and Average Variance Extracted (AVE) Results.

| **Composite Reliability** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Hypothesis:** | **Estimates (Loadings)** | **Squared Loadings** | **Delta=1-Squared Loadings** | **Sum of Loading** | **Sum of Loading squared** | **Sum of Delta** | **CR Deno.** | **CR** |
| $CO_2$ ⟵ AGR | 0.636 | 0.404 | 0.596 | | | | | |
| $CO_2$ ⟵ GDP | -0.710 | 0.504 | 0.496 | | | | | |
| $CO_2$ ⟵ IND | 0.984 | 0.968 | 0.032 | 2.33 | 5.43 | 1.12 | 6.55 | 0.83 |
| IM ⟵ $CO_2$ | -0.938 | 0.880 | 0.12 | 0.94 | 0.88 | 0.12 | 1.00 | 0.88 |
| Average Variance Extracted | | | | | | | | |
| Hypothesis | | | | | | | | AVE |
| $CO_2$ ⟵ AGR | 0.636 | 0.404 | | | | | | |
| $CO_2$ ⟵ GDP | -0.710 | 0.504 | | | | | | |
| $CO_2$ ⟵ IND | 0.984 | 0.968 | | | 1.876 | | | 0.62 |
| IM ⟵ $CO_2$ | -0.938 | 0.880 | | | 0.880 | | | 0.88 |

Note: CR Deno. denotes CR denominant

## 4.4. Structural Equation Model Results of the Model

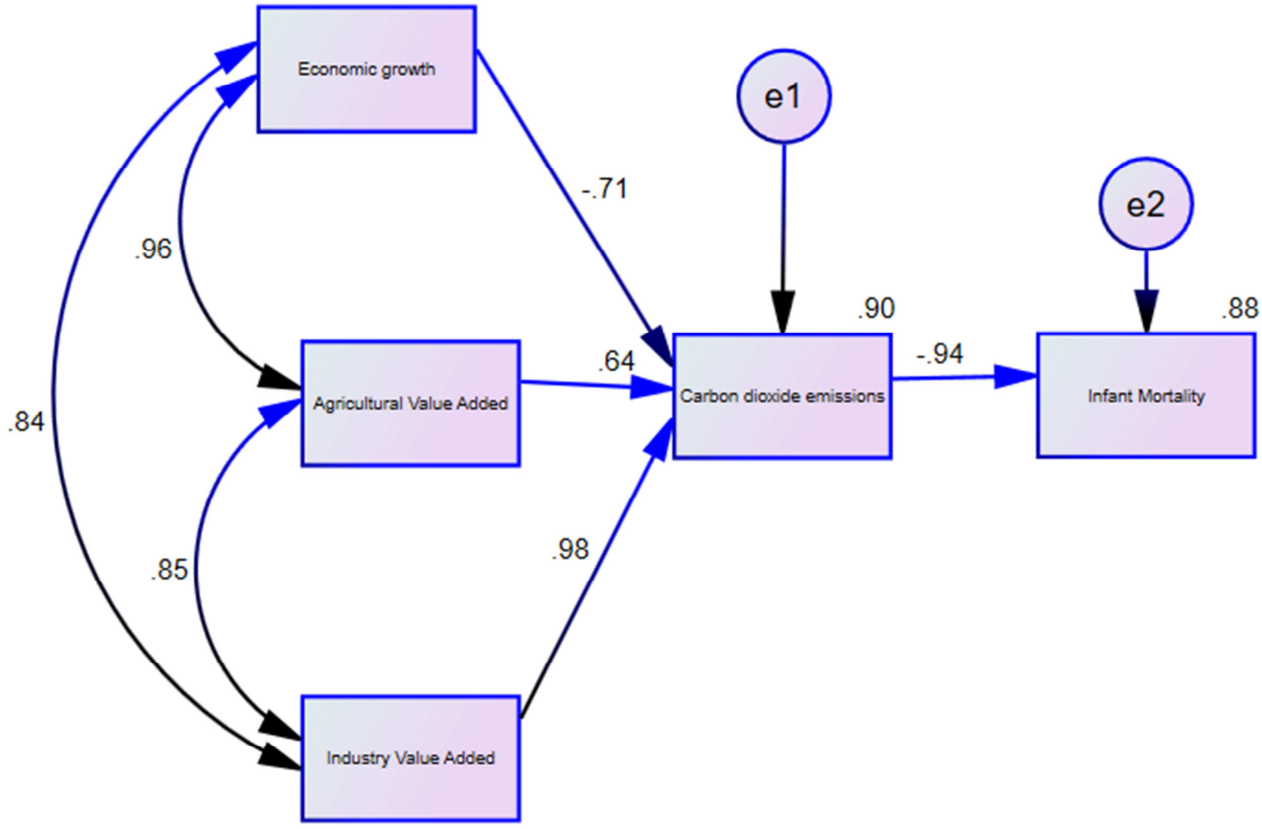


**Figure 2.** SEM results depicting factor loadings of both endogenous and exogenous variables and its covariance values.

## 4.5. Hypotheses Testing Results

Standardized estimates of our hypothesis $H_1$ shows negative but significant relationship between economic growth and carbon dioxide emissions. That is, a percentage change in economic growth would cause 71% decrease in carbon dioxide emissions in Ghana. However, indirect effect of economic growth on infant mortality is that, 1% change in economic growth will cause 9.3% increase in infant's death. Agricultural and industry one percent change will cause an increase of 63.6% and 98.4% correspondingly to carbon dioxide emissions. On the other hand, indirect effect of a change of agricultural and industry will cause a decrease in infant mortality by 7.2% and 6.8% respectively. Subsequent to this, a change of emissions will cause a decline of infant death in Ghana by 93.8%. However, the direct effect of a change in emissions will decrease the infant transience by 13.4%. Both error terms (i.e. e1 and e2) are less than 0.05 as shown in Table 5, which means that our data equals our model. The $R^2$ of 90% shown in Table 5 indicates the percentage variation of $CO_2$ emissions that can be explained by all the indicating variables of emissions whiles 88% indicates the percentage variations of infant mortality that can be explained by $CO_2$ emissions in Ghana. With

covariance value between economic growth and agriculture; economic growth and industry; agriculture and industry are 96%, 84%, 85% correspondingly.

**Table 5.** Direct and Indirect effects of Variables on constructs.

| Hypothesis | Outcome Variables | IND | GDP | AGR | $CO_2$ | Error Term | $R^2$ |
|---|---|---|---|---|---|---|---|
| Direct | $CO_2$ | 0.508 | -0.693 | 0.539 | 0.000 | 0.025 (e1) | 0.90 |
| | IM | 0.000 | 0.000 | 0.000 | -0.134 | 0.001 (e2) | 0.88 |
| Indirect | $CO_2$ | 0.000 | 0.000 | 0.000 | 0.000 | | |
| | IM | -0.068** | 0.093** | -0.072** | 0.000 | | |
| Bootstrap (Effect) | | | | | | | |
| Lower Bound | IM | -0.097 | 0.052 | -0.129 | 0.000 | | |
| Upper Bound | | -0.048 | 0.147 | -0.018 | 0.000 | | |

Note: "0.000" means that no predicting relationship between predictors and outcome variable. **indicate the factor loading of the indirect effect to be statistically significant.

## 5. Conclusions

The Study looked at the linkage or association between environmental pollution and infants' mortality in Ghana by citing key research studies to the support the relationship, and also to draw conclusions from the evidence found in the analysis. Since pollution has serious health implications for human beings, especially less-developed countries, there is the need to confront it with all the seriousness. Reasons since, a small addition to the existing pollution level has the detrimental effect on human health, particularly infants. Therefore, the need to look at cause-effect relationship, to find the marginal effects of $CO_2$ emissions to infant mortality in Ghana. Results of various indices in determining the robustness indicates that our model achieved the desire goodness-of-fit. Composite reliability test indicates that our model is dependable while's convergent test shows that no correlation exists.

Standardized estimates of our hypothesis $H_1$ shows negative but significant relationship between economic growth and carbon dioxide emissions. That is, a percentage change or increase in economic growth would cause 70% decrease in carbon dioxide emissions in Ghana. However, indirect effect of economic growth on infant mortality is that, 1% increase in economic growth will cause 9.3% increase in infant death. Considering the path coefficients of the hypothesis $H_2$ and $H_3$ show that, a change of agriculture value added will cause an increase of 63.6% of emissions while industry change contributes 98.4% to $CO_2$. On the other hand, indirect effect of change of agricultural value added and industry value added will cause a decrease in infant mortality by 7.2% and 6.8% respectively. Subsequent to this, a change of emissions will cause a decline of infant death in Ghana by 13.4%. Hypothesis $H_4$, on the other hand, also shows that a change of $CO_2$ will cause a decrease in infant death by 93.8%. Echoing the findings of [44, 59, 60], our study has attested to the fact carbon dioxide emissions contribute significantly to infant mortality in Ghana.

The study has confirmed the acceptance of hypothesis $H_2$ and $H_3$ that, agriculture value added and industry value added contributes positively to emissions in Ghana. The reasons may be due to the fact that the two sectors are bedrocks of Ghana's economic development. Notwithstanding, our study failed to confirm hypothesis $H_1$ that, economic growth contribute positively to $CO_2$ emissions in Ghana. This may be as results of the fact that Ghana failed to add value to its raw materials from agriculture activities to increase its GDP. Subsequent to this, our findings affirms the hypothesis $H_4$ that, $CO_2$ emissions contribute significantly but negatively to infant deaths in Ghana. Therefore, there is the need for government of Ghana to work hard to increase economic growth since it helps to decrease emission's level, which will eventually also help to curtail or mitigate the infant mortality rate. Hence, there is the need to set up regulatory bodies, create public awareness on dangers of environmental degradation and enforcement agencies to check the activities of individuals and industries that are detrimental to the eco-system in order to save the lives of infants in Ghana.

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## Author Contributions

All authors contributed equally to the research presented in this paper and to the preparation of the final manuscript.

## Conflict of Interest Statement

No conflict of interest to be declared by all authors of the study.

## References


[1] Darçın, M., *Association between air quality and quality of life.* Environmental Science and Pollution Research, 2014. 21 (3): p. 1954-1959.

[2] Foy, D., *Energy & Air Pollution*. 1991, American Gas Association ad: www.kean.edu.

[3] Glinianaia, S. V., et al., *Does Particulate Air Pollution Contribute to Infant Death? A Systematic Review.* Environmental Health Perspectives, 2004. 112 (14): p. 1365-1370.

[4] Raizenne, M., R. Dales, and R. Burnett, *Air pollution exposures and children's health.* Can J Public Health, 1998. 89 (1): p. 43-48.

[5] Fotourehchi, Z., *Health effects of air pollution: An empirical analysis for developing countries.* Atmospheric Pollution Research, 2016. 7 (1): p. 201-206.

[6] Kuebler, J., H. van den Bergh, and A. G. Russell, *Long-term trends of primary and secondary pollutant concentrations in Switzerland and their response to emission controls and economic changes.* Atmospheric Environment, 2001. 35 (8): p. 1351-1363.

[7] Ritz, B., M. Wilhelm, and Y. Zhao, *Air pollution and infant death in southern California, 1989–2000.* Pediatrics, 2006. 118 (2): p. 493-502.

[8] Woodruff, T. J., J. D. Parker, and K. C. Schoendorf, *Fine particulate matter (PM2. 5) air pollution and selected causes of postneonatal infant mortality in California.* Environmental Health Perspectives, 2006. 114 (5): p. 786.

[9] Committee on Environmental Health, *Ambient air pollution: health hazards to children.* Pediatrics, 2004. 114 (6): p. 1699-1707.

[10] Ha, E.-H., et al., *Infant susceptibility of mortality to air pollution in Seoul, South Korea.* Pediatrics, 2003. 111 (2): p. 284-290.

[11] Clancy, L., et al., *Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study.* The lancet, 2002. 360 (9341): p. 1210-1214.

[12] Chay, K. Y. and M. Greenstone, *The impact of air pollution on infant mortality: evidence from geographic variation in pollution shocks induced by a recession.* The quarterly journal of economics, 2003. 118 (3): p. 1121-1167.

[13] Pope 3rd, C., *Respiratory disease associated with community air pollution and a steel mill, Utah Valley.* American Journal of Public Health, 1989. 79 (5): p. 623-628.

[14] World Health Organisation, *Global Health Observatory (GHO) data*. 2016: apps.who.int.

[15] Tong, S. and P. Colditz, *Air pollution and sudden infant death syndrome: a literature review.* Paediatric and perinatal epidemiology, 2004. 18 (5): p. 327-335.

[16] Luechinger, S., *Air pollution and infant mortality: A natural experiment from power plant desulfurization.* Journal of health economics, 2014. 37: p. 219-231.

[17] Luechinger, S., *Air pollution and infant mortality: a natural experiment from power plant desulfurization.* 2010.

[18] Greenstone, M. and R. Hanna, *Environmental regulations, air and water pollution, and infant mortality in India.* American Economic Review, 2014. 104 (10): p. 3038-72.

[19] Azam, M., et al., *The impact of CO 2 emissions on economic growth: evidence from selected higher CO 2 emissions economies.* Environmental Science and Pollution Research, 2016. 23 (7): p. 6376-6389.

[20] Kasman, A. and Y. S. Duman, *$CO_2$ emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis.* Economic Modelling, 2015. 44: p. 97-103.

[21] Saboori, B. and J. Sulaiman, *Environmental degradation, economic growth and energy consumption: Evidence of the environmental Kuznets curve in Malaysia.* Energy Policy, 2013. 60: p. 892-905.

[22] Aye, G. C. and P. E. Edoja, *Effect of economic growth on $CO_2$ emission in developing countries: Evidence from a dynamic panel threshold model.* Cogent Economics & Finance, 2017. 5 (1): p. 1379239.

[23] Elliott, R. J., P. Sun, and T. Zhu, *The direct and indirect effect of urbanization on energy intensity: A province-level study for China.* Energy, 2017. 123: p. 677-692.

[24] Appiah, K., et al., *Investigation of the Relationship between Economic Growth and Carbon Dioxide (CO 2) Emissions as Economic Structure Changes: Evidence from Ghana.* Resources and Environment, 2017. 7 (6): p. 160-167.

[25] Mensah, J. T., *Carbon emissions, energy consumption and output: A threshold analysis on the causal dynamics in emerging African economies.* Energy Policy, 2014. 70: p. 172-182.

[26] Ertugrul, H. M., et al., *The impact of trade openness on global carbon dioxide emissions: evidence from the top ten emitters among developing countries.* Ecological Indicators, 2016. 67: p. 543-555.

[27] Hatzigeorgiou, E., H. Polatidis, and D. Haralambopoulos, *$CO_2$ emissions, GDP and energy intensity: a multivariate cointegration and causality analysis for Greece, 1977–2007.* Applied Energy, 2011. 88 (4): p. 1377-1385.

[28] Alam, M. J., et al., *Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis.* Energy Policy, 2012. 45: p. 217-225.

[29] Soytas, U., R. Sari, and B. T. Ewing, *Energy consumption, income, and carbon emissions in the United States.* Ecological Economics, 2007. 62 (3-4): p. 482-489.

[30] Ghosh, S., *Examining carbon emissions economic growth nexus for India: a multivariate cointegration approach.* Energy Policy, 2010. 38 (6): p. 3008-3014.

[31] Ozturk, I. and A. Acaravci, *$CO_2$ emissions, energy consumption and economic growth in Turkey.* Renewable and Sustainable Energy Reviews, 2010. 14 (9): p. 3220-3225.

[32] Alam, M. J., et al., *Dynamic modeling of causal relationship between energy consumption, $CO_2$ emissions and economic growth in India.* Renewable and Sustainable Energy Reviews, 2011. 15 (6): p. 3243-3251.

[33] Lim, K.-M., S.-Y. Lim, and S.-H. Yoo, *Oil consumption, $CO_2$ emission, and economic growth: Evidence from the Philippines.* Sustainability, 2014. 6 (2): p. 967-979.

[34] Chen, J.-H. and Y.-F. Huang, *The study of the relationship between carbon dioxide ($CO_2$) emission and economic growth.* Journal of International and Global Economic Studies, 2013. 6 (2): p. 45-61.

[35] Funk, C. C. and M. E. Brown, *Declining global per capita agricultural production and warming oceans threaten food security.* Food Security, 2009. 1 (3): p. 271-289.

[36] Change, I.P.o.C. *Agriculture, Forestry and Other Land Use (AFOLU)*. 2016 [cited 2018 20th February].

[37] Luo, Y., et al., *Decoupling $CO_2$ emissions from economic growth in agricultural sector across 30 Chinese provinces from 1997 to 2014.* Journal of Cleaner Production, 2017. 159: p. 220-228.

[38] Ben Jebli, M. and S. Ben Youssef, *Renewable energy consumption and agriculture: evidence for cointegration and Granger causality for Tunisian economy.* International Journal of Sustainable Development & World Ecology, 2017. 24 (2): p. 149-158.

[39] Waheed, R., et al., *Forest, agriculture, renewable energy, and $CO_2$ emission.* Journal of Cleaner Production, 2018. 172: p. 4231-4238.

[40] Dong, G., et al., *Carbon footprint accounting and dynamics and the driving forces of agricultural production in Zhejiang Province, China.* Ecological economics, 2013. 91: p. 38-47.

[41] Sadorsky, P., *Do urbanization and industrialization affect energy intensity in developing countries?* Energy Economics, 2013. 37: p. 52-59.

[42] Raheem, I. D. and J. O. Ogebe, *$CO_2$ emissions, urbanization and industrialization: Evidence from a direct and indirect heterogeneous panel analysis.* Management of Environmental Quality: An International Journal, 2017. 28 (6): p. 851-867.

[43] Chang, T. and S. Lin, *Grey relation analysis of carbon dioxide emissions from industrial production and energy uses in Taiwan.* Journal of Environmental Management, 1999. 56 (4): p. 247-257.

[44] Arceo, E., R. Hanna, and P. Oliva, *Does the effect of pollution on infant mortality differ between developing and developed countries? Evidence from Mexico City.* The Economic Journal, 2016. 126 (591): p. 257-280.

[45] Kuznets, S., *Economic growth and income inequality.* The American economic review, 1955: p. 1-28.

[46] Kanjilal, K. and S. Ghosh, *Environmental Kuznet's curve for India: Evidence from tests for cointegration with unknown structuralbreaks.* Energy Policy, 2013. 56: p. 509-515.

[47] Barrett, P., *Structural equation modelling: Adjudging model fit.* Personality and Individual differences, 2007. 42 (5): p. 815-824.

[48] Tabachnick, B. G. and L. S. Fidell, *Using multivariate statistics*. 2007: Allyn & Bacon/Pearson Education.

[49] Miles, J. and M. Shevlin, *A time and a place for incremental fit indices.* Personality and individual differences, 2007. 42 (5): p. 869-874.

[50] McDonald, R. P. and M.-H. R. Ho, *Principles and practice in reporting structural equation analyses.* Psychological methods, 2002. 7 (1): p. 64.

[51] Bentler, P. M., *Comparative fit indexes in structural models.* Psychological bulletin, 1990. 107 (2): p. 238.

[52] Wu, C., et al., *Core dimensions of the construction safety climate for a standardized safety-climate measurement.* Journal of Construction Engineering and Management, 2015. 141 (8): p. 04015018.

[53] Patel, D. and K. Jha, *Structural equation modeling for relationship-based determinants of safety performance in construction projects.* Journal of Management in Engineering, 2016. 32 (6): p. 05016017.

[54] Bentler, P. M. and D. G. Bonett, *Significance tests and goodness of fit in the analysis of covariance structures.* Psychological bulletin, 1980. 88 (3): p. 588.

[55] Williams, L. J., *Decomposing model fit: Measurement vs. theory in organizational research using latent variables.* Journal of Applied Psychology, 2011. 96 (1): p. 1.

[56] Tanaka, J. S., *"How big is big enough?" Sample size and goodness of fit in structural equation models with latent variables.* Child development, 1987: p. 134-146.

[57] Awang, Z., *Structural equation modeling using AMOS graphic*. 2012: Penerbit Universiti Teknologi MARA.

[58] Hair, J. F., et al., *Multivariate data analysis*. Vol. 5. 1998: Prentice hall Upper Saddle River, NJ.

[59] Sinha, A., *Carbon emissions and mortality rates: a causal analysis for India (1971-2010).* International Journal of Economic Practices and Theories, 2014. 4 (4): p. 486-492.

[60] Dales, R., et al., *Air pollution and sudden infant death syndrome.* Pediatrics, 2004. 113 (6): p. e628-e631.