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On the Conditional Effect of Fine Particulate Matter on Cancer Mortality: Case Study of OECD Countries

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Abstract

Given the adverse effects of air pollution on human health, a lot of studies have empirically investigated the causal effect of air pollution on health. However, no study has considered how fine particulate matter interacts with GDP per capita to affect cancer mortality. This study therefore uses data for 20 OECD countries to estimate the conditional effect of air pollution on cancer mortality. To this end, a fixed effect panel regression model which takes both country and time fixed effects into consideration is estimated. The conditional causal effect of fine particulate matter was found to be negative 0.22 and significant at 1% level.

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Introduction

The problem of pollution has continued to worsen both in developing and developed countries. It is more pronounced in emerging economies due to the struggle to become industrialized. Having realized the effects it has on health, eliminating the problem has become a goal that every country of the world seeks to achieve. Though the problem could not be eradicated completely, a lot has been done to reduce it and mitigate its effects on human health. Different countries have employed different means, including the siting of industries in non-residential areas, producing technologies that emit less smokes, imposing high pollution tax on industries according to their emission levels and sensitizing people about pollution.

Empirical studies have identified a strong relationship between air pollution and health problems. For instance, the study of Tang *et al.*, (2017) showed that deaths from circulatory and respiratory problems and tumors were associated with sulphate, nitrate, ammonium and formaldehyde. Owens *et al.*, (2017) in their study showed that causality runs from air pollution to certain health problems.

Moore *et al.*, (2017) investigated to see if pollution is associated with regional changes in death by lung cancer in the United States. Their results suggest that a positive associated exists between them. See also the studies of Pope and Dockery (2006), Ghosh *et al.*, (2013), Hamra *et al.*, (2014), Hankinson & Danforth (2006), and Risbridger *et al.*, (2010).

On the contrary, some studies have found no relationship between air pollution and some health issues. Take the study of Toledo *et al.*, (2017) for instance. They investigated the relationship between air pollution and lung functioning in Brazil. They found no association between them. Pedersen *et al.,* (2016) in their study examined if there is a relationship between ambient air pollution and the problem of cancer of the bladder in European countries. Their results showed no evidence in support of that.

Again, a lot of studies have estimated the effect of air pollution on human health in various countries. Chen *et al.,* (2017) used data for China to estimate the effect of pollution including its spillover effect on health. Their result showed that pollution and the spillover effect negatively impact on human health. The effect of industrial pollution on the incidence of breast and prostate cancer in Spain was investigated by Perez *et al.,* (2016). They found no evidence in support of the claim. They however, pointed out that some statistical relationship they found suggest the need for further studies in that line. See also the work of Calle *et al.,* (2009), Hosgood *et al.,* (2015), Nielsen *et al.,* (2011), Stober & Abel (1996), and Katsouyanni & Pershagen (1997).

This study will establish the relationship between fine particulate matter and death by cancer mortality and also estimate the effect the former has on the latter. Also, it will consider something different by looking at how fine particulate matter interacts with per capitra Gross Domestic Product (GDP) to affect death by from cancer. In this way, it will contribute to existing literature.

Review of Empirical Literature

Highlighted below are empirical studies that have examined the effect of pollution on cancer-related health problems.

Lipfert (1991) examined the effect of pollution on mortality for short run, daily and long run periods. The results of his short run analysis showed that particulate matter and Sulphur dioxide are significant in explaining mortality. The results of his long run study were not clear, but there were indications that long run mortality rate is affected by air pollution. This study is consistent with the findings of Park *et al.,* (2015). They found that mortality is associated with air pollution in South Korea.

The relationship between air pollution, smoking and lung cancer in Shanghai, China was examined by Jie *et al.,* (1994). Their sample size included a total both males and females living in urban, suburb and outer suburb of Shanghai. They estimated standardized mortality ratio (SMR) for both smokers and nonsmokers. While there are no meaningful changes in SMR for nonsmokers, they found the highest SMR for smokers in urban areas with outer suburb having the lowest SMR. Their study also showed that cigarette smoking is significantly related with the risk of lung cancer. Xu *et al.,* (2013) investigated how the air pollution affects survival length of respiratory cancer in Los Angeles, United State for a period of 17 years. They found that the survival length of respiratory cancer patients got shortened when exposed to air pollution.

To find out the link through which traffic-related air pollution affect breast cancer in Denmark, Huynh *et al.,* (2015) carried out a cohort analysis. They employed logistic regression to estimate the relationship between of long term exposure to traffic air pollution and mammographic density (MD). This is because they believed that MD is the link which connects them. Their study revealed a negative significant relationship between them. They therefore concluded that traffic-related air pollution could cause breast cancer, but not through MD. This is at variance with the study of Hystad *et al.,* (2015). They found that traffic-related air pollution is associated with breast cancer.

The study of White *et al.,* (2014) showed something somewhat different. They investigated the relationship between indoor air pollution and the risks of breast cancer. They used unconditional logistic regression to estimate probabilities and confidence intervals. Nothing definitive could be concluded from their results. Thus, they suggested the need for further studies to be done.

In a bid to understand how exposure to pollution due to occupation relates with the risk of cancer among urban mail carriers in Denmark, Soll-Johanning & Bach (2004) conducted a cohort study covering a sample size of 17,233 for 99 years. They found that male mail carriers who have been employed for more than 3 months had low incidence of cancer as shown by the low risk estimates for different types of cancer. However, there is excess risk of cervical cancer for female mail carriers. Again, Moore *et al.,* (2017) estimated a logistic regression to understand if regional variations on cancer mortality are explained by pollution in the United States from 2004 to 2014. They categorized counties as clustered and non-clustered before estimating their model. Their results suggest that cancer mortality is high in counties with high pollution.

Some studies have clearly shown the absence of relationship between air pollution and certain health problems. For instance, Winters *et al.*, (2015) investigated the relationship between ambient air pollution and the risk of leukemia in Canada. They found no relationship between chronic leukemia and air pollution, but they found weak relationship for other forms of leukemia.

A recent study by Downward *et al.*, (2017) investigated the effect exposure to quartz on lung cancer. They found no significant effect. Perez *et al.*, (2016) also found that no significant relationship exists between residing in the area of pollutant industries and the risk of breast and prostate cancer.

Given the lack of agreement and inconsistency of results, this study will show the relationship between fine particulate matter and cancer mortality, the effect of the former on the latter, and the conditional effect of the former on the latter given the level of per capita GDP.

Materials and Methods

This study involves 20 OECD and it covers the period of 1998 and 2014. The country names can be found in the appendix. All the data come from OECD website. The Panel fixed effect model below will be estimated.

$$CMORT_{it} = \psi_1 PM2.5_{it} + \psi_2 GDPPC_{it} + \psi_3 PM2.5_{it} \times GDPPC_{it} + \psi_4 NMEDG_{it} + C_i + T_t + \mu_{it} \quad (1)$$

Where CMORT is cancer mortality and it stands for the number of people that die from cancer-related health problems. PM2.5 is fine articulate matter, GDPPC is GDP per capita, NMEDG is number of medical doctor graduates, i and t are entity and time subscripts, C_i and T_t are country and time fixed effects, and μ_{it} is the error term. We expect ψ_1 to be positively signed, ψ_2 to be either positively or negatively signed, and ψ_3 and ψ_4 to be negatively signed. Also, both country and entity fixed effects are taken into consideration. Logs of the explanatory variables are taken so aa to interpret the coefficients as percentages. Thus, the working model is stated as

$$CMORT_{it} = \psi_1 \log(PM2.5_{it}) + \psi_2 \log(GDPPC_{it}) + \psi_3 [\log(PM2.5_{it}) \times \log(GDPPC_{it})] + \psi_4 \log(NMEDG_{it}) + C_i + T_t + \mu_{it} \quad (2)$$

Results and Discussion

From the result, it is seen that log (PM2.5) is correctly signed and significant. It means that 1% increase/decrease in fine particulate matter would lead to a 2.38 increase/decrease in cancer mortality. Log (GDPPC) is significant and negatively signed. Thus, a 1% increase in/decrease GDP per capita would lead to 0.81 increase/decrease in cancer mortality. This is true if we consider the fact that increase GPD through industrial production would increase air pollution level.

Table.1 Regression Results Dependent Variable: Cancer Mortality (CMORT)

Dependent Variable: Cancer Mortality (CMORT)

Variables	Coefficients
log(PM2.5)	238.2741*** (3.9310)
log(GDPPC)	81.2440*** (1.1656)
log(NMEDG)	1.2963 (2.4088)
log(PM2.5) * log(GDPPC)	-22.1865*** (3.6954)
R^2	0.15783
F-statistic	13.165
Observations	320

Note:*** shows significance at 1% level while none indicates no significance at either, 1%, 5% or 10%

Source: Prepared by authors.

Table of Countries

Austria	France	Japan	Switzerland
Belgium	Germany	Netherlands	United States
Czech Republic	Hungary	Norway	Israel
Denmark	Iceland	Spain	Slovenia
Finland	Ireland	Sweden	Latvia

Log (NMEDG) was included to control for the number of medical doctors that graduate each year in the countries of interest. It was not significant. Finally, log (PM2.5)*log (GDPPC) which is the main interest of this study is negatively signed and significant. This is the conditional effect of PM2.5 on cancer mortality given GDP per capita and it is 0.22. It does make sense, since countries with higher GDP per capita are in better position and have the economic wherewithal to treat the adverse effects of pollution, thereby reducing the number of people that die from cancer. Our model explains 15.8% of the variation in the dependent variable while the significant f-statistic shows the overall significance of the model.

Having shown how fine particulate matter interacts with per capita GDP to affect cancer mortality, this study recommends the need to raise per capita income, so as to mitigate the negative effect of pollution on human health.

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