The Relationship between Globalization and Air Pollution: Panel Analysis

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Abstract: This study examines the role of globalization on the environmental pollution by taking into account social, economic, and political aspects. The focus area of this research is specifically air pollution. Changes in the atmospheric levels of greenhouse gases attributable to land use change activities and forest areas are utilized as an indicator of air pollution. Besides, the percent of population living in places where average concentration of PM2.5 exceeds World Health Organization (WHO) thresholds is used as an indicator of air pollution as well. Panel vector autoregression (Panel VAR) analysis reveals the existence of a causal relationship from globalization to those air pollution indicators.

Keywords: Globalization, air pollution, greenhouse gas emission, PM2.5, Panel VAR.

1. Introduction

Globalization is a concept having its origins in the geographical discoveries. Since then, it has grown stronger and developed. However, the core ideas have never changed: Production and liberalization. 18th century's steam engine pioneered globalization resulted with enormous increase especially in the industrial production, and free trade of the products. Liberalization of the markets and their global integration gave stimulus to growth and more liberalization of the economies in the 19th century and afterwards. At the end of the 20th century, most of the world had already achieved liberalization of international trade, and financial markets with some exceptions namely China, North Korea, and a few South American economies.

The part of the world adopting the outcomes of globalization is composed of developed and developing countries. According to Stiglitz, developing countries have been incorporated to the system as markets for the industrial products of the developed countries and as the production centers of the agricultural goods with low added value. In his opinion, for a globalization with a more human face, reform packages should be implemented on the international economic institutions such as International Monetary Fund (IMF), the World Bank (WB), and World Trade Organization (WTO) to look out for developing countries' benefit as well. Moreover, there is a need for the establishment of international public institutions to deal with the troubles that globalization created such as environmental problems and health issues. In this way, global collective action might be catalyzed to fight back the adverse outcomes of the globalization. Because, every problem has its own dynamics, there should be specific prescriptions to use on the resolution of the issue. For this reason, institutions have to become specialized on the problems, but also must be in communication with each other because the problems are interrelated (Stiglitz, 2003: 222-224).

Health issues and environmental problems such as global warming and high greenhouse gas emissions are correlated with each other. Yet, the first step is to detect if the globalization is really the reason causing those problems. If it is, then there will be a need for alteration of the policies that globalization dictates. To this end, this study examines the role of the globalization on a specific environmental problem, air pollution. For this aim two variables, greenhouse gases and the population living areas with high levels of PM2.5 which is a common measure of air pollution, are utilized as the indicators of air pollution. As it is stated above, environmental problems, namely global warming and air pollution have direct effects on health. So, the two indicators of air pollution utilized in this study indicate both environmental and health issues.

Globalization affects air pollution mainly through economic channels. With the expansion of the markets and integration of them by liberalized international trade as a result of globalization, supply side of the production process has been promoted. Thus, increasing productivity with the inclusion of high technology methods into industry and economic growth especially in the developed and developing countries can be listed as the primary factors causing air pollution via industrial waste. Globalization is the triggering factor starting all the reaction and shaped the process itself.

Shahbaz et al. (2013) examines the relationship between globalization and CO_2 emissions for the period between 1970 and 2012 in India. Globalization is reviewed in three aspects namely economic, social, and political globalization. They reveal that the impact of the overall globalization results with an environmental degradation in India

(Shahbaz et al., 2013). Lau et al. (2014) also mention about the effect of the FDI and trade openness, which could be regarded as indicators related to economic globalization, on the degradation of environmental quality in Malaysia. The study in which Ertugrul et al. (2016) investigate the relationship between real income, energy consumption, trade openness and carbon emissions in the "Environmental Kuznets Curve" structure among top ten emitters of the emerging economies reveals that trade openness, which can be regarded as an indicator of globalization degree of the economy, raises CO_2 emissions in Turkey, India, China and Indonesia.

Greenhouse gas emissions has increased in the recent years especially in developing countries because developed countries have tendency to shift their industries with high carbon emissions to developing countries which have limited environmental regulations (Carvalho et al., 2013; Copeland & Taylor, 2004; Baek et al., 2009). For instance, according to study conducted by Li and Hewitt (2008), UK decreased its CO_2 emissions by 11% in 2004 just because of the trade with China. Moreover, because the production is less efficient and has high carbon-intensity in China, this relocation of the industry would create 19% increase in the national CO_2 emissions of the UK if it was counted in the UK's account (Li & Hewitt, 2008). In addition, Heil and Selden (2001) show how the trade intensity lowers carbon emissions in the upper income countries, while it causes carbon emissions in the lower income countries to increase by studying on a sample composed of 132 countries for the years between 1950 and 1992).

Thus, outsourcing of the production of industrialized countries to developing countries does not only relocate the emission source but also deepen the environmental problems due to inefficient production technology. However, according to Herrmann and Hauschild (2009), if the CO_2 emissions of those goods produced by a subcontracted developing country for the benefit of a developed country were added to the developed country's national CO_2 accounts, this might create pressure to lower emissions and to use emission efficient technologies in the industry sector of the developing countries. On the other hand, this might not be the desired outcome of the outsourcing process of production for industrialized economies. That is so because they would not transfer those industries to other countries if they knew that they would face with "unnecessary" investment items to decrease air pollution in the first place.

There are many studies focusing on the effects of globalization on the environmental problems especially the CO_2 emissions. There are a few on the impact of the indicators of globalization on environmental degradation as well. This study, on the other hand, deals with the effect of overall globalization on the greenhouse gas emissions and PM2.5 which can be employed as the indicators of air pollution interrelated to other environmental problems. Unlike developing countries, the main focus of this research is on OECD countries. That is, the main sample is composed of developed countries and a few developing countries.

The rest of the study is arranged as follows. The second part explains the characteristics and the details of the methodology utilized, while the third part is composed of empirical findings. The las part concludes the study.

2. Data and the Methodology

2.1. The Data

The globalization data are retrieved from the KOF Swiss Economic Institute (2018a) which has been publishing the data from 1970 and afterwards in annual base. There are three dimensions covered by the index namely economic, social and political. It is very hard to isolate one dimension from another, so composite index of globalization is utilized for the purposes of this study. Each dimension composes 33.3% of the composite index. So, they are assumed to effect globalization in equal weights (KOF Swiss Economic Institute, 2018b). The index has a scale from one to one hundred where 100 indicates the maximum level of globalization, and one is for the lowest.

The data for the variables of air pollution are from the World Development Indicators Database of the World Bank (2018a). The first indicator, greenhouse gas emissions/removals by LUCF, shows the "changes in atmospheric levels of all greenhouse gases attributable to forest and land-use change activities" (World Bank, 2018b). It covers the items such as "emissions and removals of CO2 from decreases or increases in biomass stocks due to forest management, logging, fuelwood collection, etc.", "conversion of existing forests and natural grasslands to other land uses", "removal of CO2 from the abandonment of formerly managed lands", "emissions and removals

of CO2 in soil associated with land-use change and management" (World Bank, 2018b). The second variable used as an indicator of air pollution

is PM2.5, i.e population exposed to levels exceeding WHO guideline value. It is the "percent of population exposed to ambient concentrations of

PM2.5 that exceed the WHO guideline value" (World Bank, 2018b). As reported by World Health Organization (WHO) (2018), PM2.5 is small particulate matter with a diameter of 2.5 microns or less causing respiratory, vascular and cardiac diseases, and especially lung cancer. Actually, even low concentrations of particulate matter are effective on the health of the person exposed. The 2.5 diameter threshold is the lowest possible threshold that WHO could identify. Even in a relatively developed region, European Union, WHO estimates that the mean life expectancy is lowered by 8.6 months because of particulate matter exposures (World Health Organization, 2018).

The panel is balanced only if the period is restricted to the years between 2010 and 2016 if the greenhouse gas emissions are considered as an indicator for air pollution. On the other hand, the panel is balanced when Korea Republic, Chile, Israel and Mexico are excluded from the sample if PM2.5 is considered as the air pollution indicator for the period between 1990 and 2009.

2.2. The Methodology

Panel Vector Autoregreesion (VAR) model estimation in generalized method of moments (GMM) framework (Abrigo & Love,2016) is utilized as the method to find out the characteristics of the relationship between globalization and the air pollution. It gives robust GMM estimates. To this end, first, panel unit root tests are conducted to determine if the series are stationary or non-stationary. Then, Schwarz's Bayesian Information Criteria is used to determine the lag selection and panel VAR estimation is conducted. Finally, as a post-estimation check, stability is controlled.

3. Empirical Findings

Table 1 shows the results for the panel unit root tests, i.e. Fisher type unit root test statistics based on the augmented Dickey-Fuller test. Both log Globalization and log PM2.5 are non-stationary at level, but they become stationary after the first difference. On the other hand, log GHG is stationary both at level and after the first difference. So log Globalization and log PM2.5 are I(1), and log GHG is I(0).

Table 1: Panel Unit Root Tests

Panel A: Log Globalization		
Method & Null Hypothesis	**Statistic for Level**	**Statistic for 1st Difference**
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	2.59884	575.906***
Panel B: Log Greenhouse Gas Emissions		
Method & Null Hypothesis	**Statistic for Level**	**Statistic for 1st Difference**
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	119.95***	568.053***
Panel C: Log PM2.5		
Method & Null Hypothesis	**Statistic for Level**	**Statistic for 1st Difference**
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	47.6887	120.999***
***p<0.01, **p<0.05		

In table 2, panel VAR model selection statistics are listed based on the Schwarz's Bayesian Information Criteria (MBIC). In panel A the panel VAR structure for the relationship between globalization and greenhouse gas emissions is displayed. In panel B, the same structure is displayed for the relationship between globalization and PM2.5. In both models, the lowest SIC is captured in the first trial. So, the optimal number of lags is 1 among 3 in both models based on the MBIC.

Table 2: Panel VAR Model Selection

Panel A: Log Globalization & Log GHG

Lags	**Hansen's J Statistic**	**MBIC**
1	7.1118	-40.3032
2	5.2851	-26.3249
3	0.6112	-15.1938

Panel B: Log Globalization & Log PM2.5

Lags	**Hansen's J Statistic**	**MBIC**
1	13.2949	-28.2939
2	13.53342	-14.1925
3	5.425162	-8.4378

Table 3 summarizes the GMM robust estimation results for panel VAR seeking the two relationships mentioned above. There are three main findings deduced from table 3. First, the direction of the relationship between globalization and greenhouse gas emission is from globalization to greenhouse gas emission at a 1% significance level. Second, the direction of the relationship between globalization and PM2.5 is also from globalization to PM2.5 at 10% level of significance. Third, globalization has a statistically significant negative effect on the air pollution at 10% level of significance.

Table 3: Panel VAR with GMM Style

Dependent Variable	**Lagged Independent Variable**	**Coeffiient**
Log Globalization	Log Globalization	0.8711*** (0.0264)
	Log GHG	0.0033 (0.0042)
Log GHG	Log Globalization	-4.1827*** (1.4329)
	Log GHG	-0.0634 (0.2791)
Log Globalization	Log Globalization	0.9940*** (0.1765)
	Log PM2.5	0.0006 (0.0008)
Log PM2.5	Log Globalization	-10.7736* (5.6271)
	Log PM2.5	0.2057 (0.1693)

***p<0.01, **p<0.05, *p<0.1

As it is seen from figure 1 and 2, stability conditions which are required for panel VAR estimation are satisfied. All the eigenvalues lie in the unit circle in both models.

Figure 1: Stability and the Eigenvalues for Log Globalization & Log GHG

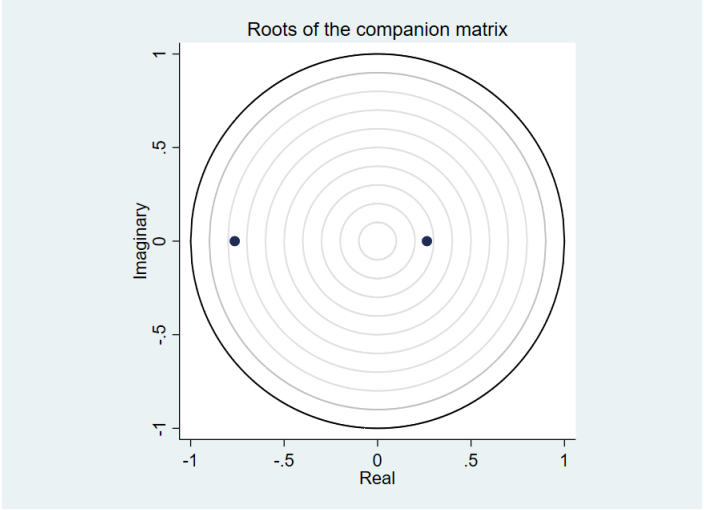
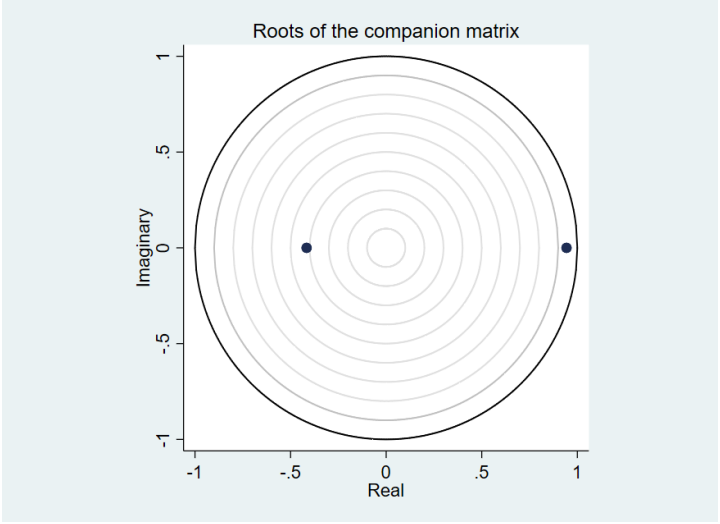


Figure 2: Stability and Eigenvalues for Log Globalization & Log PM2.5



5. Conclusion

This study reveals that the relationship between globalization and air pollution is negative and significant. Moreover, the direction of the relationship is from globalization to air pollution but not the opposite. So, the relationship is not bi-directional. Although, there is a common perception that globalization can bring economic growth by increasing production efficiency, it has negative effects on the environment. As it is stated in the literature, by shifting the industries from developed countries to developing countries, gas emissions in the developed countries shrink which is consistent with the findings of this research. This research is a partial proof of the effect of globalization to reduce environmental problems in OECD countries. On the other hand, whether this situation is sustainable or not is still an unanswered question. The paper can be developed by adding control variables such as trade openness, energy consumption and FDI into analysis in further studies. By so doing, the magnitude of the relationship between globalization and air pollution can be isolated in a more efficient and informative way. It is highly likely to have different results about the effect of globalization on air pollution in non-OECD countries. Actually, the characteristics of the sample is the main determinant on the relationship between globalization and air pollution. So, another upgrade of this research might be to replicate the study on non-OECD sample.

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