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Institutional Quality and Air Pollution: International Evidence

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Abstract

This study aims to examine the effect of institutional quality on air quality using data on fine particulate matter, PM2.5, and six dimensions of good governance from the World Bank for 167 nations over the period from 2000 to 2013. After controlling for economic and international openness variables, the empirical results show that countries with better quality regarding voice and accountability, political stability, government effectiveness and control of corruption have higher reported emissions of PM2.5 air pollution. This study confirms that energy use, population size and gross fixed capital formation help increase PM2.5 air pollution, whereas we support an inverted U-shape Environmental Kuznets Curve effect. These results suggest that government institutions should effectively take appropriate pollution control strategies and enforce environmental laws for the public good in the form of better air quality for their citizens.

Key words: institutional quality; air pollution; fine particulate matter; trade openness; corruption

JEL classification: F33; F43; P48

1. Introduction

Air pollution is an important issue that has been shown to be worse in rapidly developing countries, e.g., China and India, than in wealthy or very poor nations. Air pollution may be a product of industrialization and urbanization. Coal plants, population expansion, and vehicle emissions contribute to dirty air. Brauer et al. (2016) observe that air pollution is the fourth highest-ranking risk factor for death globally. A new World Health Organization (WHO) analysis of global data also indicates that 92 percent of the global population lives in areas where air quality levels exceed WHO limits.[1] In addition, air pollution is rarely confined to national borders, and this contamination can, therefore, lead to international disputes. For example, massive forest fires in Indonesia led to severe air pollution that blanketed Singapore and Malaysia in smoke, and the notorious air pollution in China is often blamed for the dirty air in South Korea and Japan.

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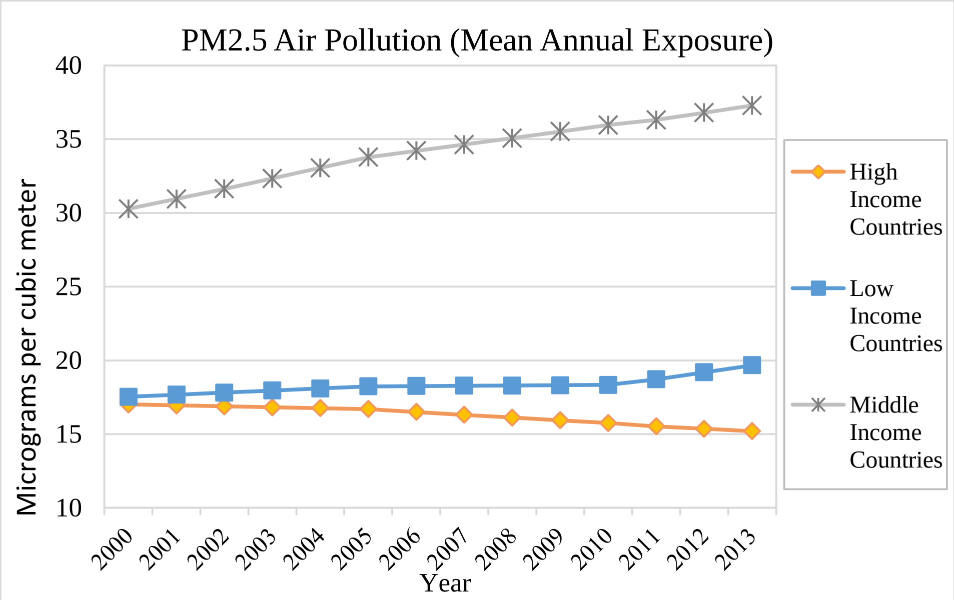
The issue of pollution control has caught the attention of policymakers worldwide for decades. Many policies, regulations, and laws have been enacted that have forced firms to internalize these externalities. The successful implementation of such measures depends on the quality of societal institutions. The term “institutions” refers to structures that affect economic relations. North (1993) defines institutions as the constraints that are built by men and that are designed to organize social relations. Although the nexus between environmental protections and economic development has attracted the attention of researchers, only a few studies have systematically analyzed the impact of institutional quality, which is related to country governance, on air pollution. To achieve environmental sustainability, air pollution controls require certain capabilities of the governing institutions and the regulated community. Panayotou (1997) suggests that policies and institutions can significantly reduce environmental degradation at low-income levels and accelerate improvements at higher income levels.

In this research, we aim to examine whether better institutional quality enhances improvements in air quality control by considering the effect of economic and international openness variables. First, institutional quality is measured using a comprehensive set of governance variables, including voice and accountability, political stability, government efficiency, regulation quality, rule of law, and control of corruption. Our research systematically analyzes the role of institutional quality in considering different modes of governance as determinants of air pollution. The existing literature has only used individual institutional indicators, e.g., corruption or rule of law, to examine this relationship (see Goel et al., 2013; Bernauer and Koubi, 2009). Second, by using datasets from a wide range of countries, this study systematically explores the variations in institutional quality across countries regarding reductions in air pollution from a global perspective. However, a more complex analysis of institutions and their interaction with environmental sustainability may be necessary to propose variants of environmental policies to increase social welfare based on this research.

The existing literature has focused on the effect on economic development of air pollution and has generally used carbon dioxide (CO2) and sulfur dioxide (SO2) as proxies for air quality (e.g., Bernauer and Koubi, 2009; Tamazian and Rao, 2010; Omri, 2013; Omri et al., 2015). The choice of these two proxies as environmental variables is driven by the fact that emissions data are more reliable and are available for a large number of countries over a longer time series. In contrast to the above-noted studies, we use an ambient pollutant – fine particulate matter within an aerodynamic diameter of less than 2.5 micrometers (hereafter, PM2.5) – as a proxy for air quality. Most fine particulate matter comes from fuel combustion from mobile sources such as vehicles and stationary sources such as power plants, industry, households and the burning of biomass. Compared with CO2 and SO2, fine particulate matter has significant effects on human health, because this pollutant is associated with a broad spectrum of acute and chronic illnesses such as lung cancer, chronic obstructive pulmonary disease, and cardiovascular diseases. Fine particulate matter is more appropriate for studies that examine the impact of institutional quality on air quality because citizens feel threatened by this air pollutant, which makes them increase their demands for better air quality. Recently, more countries have begun to monitor this air pollutant in response to the growing environmental awareness of their citizens. Monitoring results can be provided for countries to take required actions to improve air quality if they have benchmarks.[2] In addition, data of greater quality and better reliability on fine particulate matter are available for researchers to examine its effects on climate, mortality rates, and economic activities. Based on the latest report by the WHO, global urban air pollution levels of small and fine particulate matter (PM10 and PM2.5) increased by approximately eight percent from 2008 to 2013. Based on the data that are presented in Figure 1, middle-income countries have the highest concentrations of PM2.5 air pollution.

Figure 1. PM2.5 Air Pollution (Mean Annual Exposure)



Note: All data are acquired from the WDI, World Bank.

Using pooled annual data for 167 nations over the period from 2000 to 2013, our empirical results suggest that after controlling for the required economic and international openness variables, countries with better quality regarding voice and accountability, political stability, government effectiveness, and control of corruption have higher recorded emissions of PM2.5 air pollution. These are measured based on either mean annual exposure (micrograms per cubic meter) or population exposed to levels that exceed WHO guideline values (% of total population). Further, we find that governance quality, which is calculated as the average of the six governance indicators, also has a positively and statistically significant effect on PM2.5 air pollution. Two potential explanations for poor air quality may be linked to our evidence: 1) Countries that have implemented improvements in institutional quality have undertaken appropriate air pollution control strategies through enhanced audits, better processes and severe punitive measures, which shift emissions of PM2.5 air pollution from the unrecorded or under-recorded sector to the recorded sector. 2) Growing industrialization and/or urbanization processes among low- and middle-income countries within the past two decades have contributed to higher energy consumption and have led to higher recorded emissions of PM2.5, even though these countries have moderately improved their quality of governance institutions. From a global perspective, this phenomenon reveals that government institutions, especially for middle-income countries, should develop aggressive pollution control strategies and pay more attention to the impact of poor air quality on human health and ecosystems.

In contrast to the observation by Goel et al. (2013) that more corrupt nations and nations with a large shadow sector have lower recorded pollution levels, this study suggests that nations with better institutional quality may promote air quality controls, which may lead such countries to have higher recorded emissions of PM2.5 air pollution. As economic freedom that is promoted by well-defined, well-designed and well-managed institutions creates incentives to abate local air pollution, Wood and Herzog (2014) find that a one-point increase in the economic freedom index results in a 7.15% decrease in concentrations of fine particulate matter over the long run. Our results are different from their findings and show that better quality of government institutions may first lead to a sharp increase in recorded emissions of PM2.5 air pollution through effective audits and severe punitive measures. Such higher emissions may result from economic activities or a government that begins to monitor PM2.5 air pollutants. We expect that such a government will soon take the required control actions to improve air quality and reduce the recorded levels of PM2.5 air pollution based on its observations in response to the growing expectations of its citizens.

The remainder of the study proceeds as follows. In Section 2, we provide the conceptual framework and hypotheses to be tested. Section 3 discusses the research methodology and the data. Section 4 presents the empirical results. Section 5 presents our conclusions.

2. Conceptual Framework and Hypotheses

Institutions are fundamental to market-based economies. North (1990) suggests that institutions can be defined as the humanly devised constraints that structure political, economic, and social interaction. Thus, institutions are associated with "the rules of the game in a society," which include informal constraints (e.g., norms of behavior, conventions, traditions, and, codes of conduct), formal rules (e.g., constitutions, laws, and rules), and the characteristics of their enforcement. Further, the criterion of formality refers to the rule component of institutions.

Improved institutional quality can promote economic development and environmental protections because well-functioning institutions can maximize social well-being and minimize deadweight losses from environmental pollution. Jalilian et al. (2007) suggest that economic development is defined as a matter of institution building that reduces the transaction costs that are related to information asymmetries and externalities. Such institution building, which includes laws and political and social rules and conventions, are fundamental for market production and exchange.

The available measures of institutional quality are provided by many databases, e.g., the World Bank's Worldwide Governance Indicators (WGIs), the Fraser Institute's Economic Freedom of the World, and Transparency International's Corruption Perception Index. Most of these sources have different concepts of institutions, especially formal institutions. For this study, we use measures from a widely available database – the Worldwide Governance Indicators – as proxies for institutional quality. The WGIs comprise six aggregate indicators that were developed by the World Bank (Kaufmann et al., 2010). The six indicators include the following: 1) voice and accountability, 2) political stability, 3) government efficiency, 4) regulation quality, 5) rule of law and 6) control of corruption, which describe various aspects of a country's quality of governance. The six indicators have various causes and effects, and many studies have been devoted to investigating their relationships to economic development. In the study, we focus on the impacts of the six indicators on air quality control, which is an issue that has received a great deal of attention, and we discuss their relationship with air quality. We expect that the indicators will have a crucial bearing on air quality.

Of the six WGIs, voice and accountability best captures the most common notion of how democratic institutions that foster voice and accountability affect pluralism. According to many authors, democratic institutions help to enhance air quality; e.g., Payne (1995) argues that with democracy, people are more aware of environmental problems (freedom of media). They can express their concerns about the environment (freedom of expression) and create lobbying groups (freedom of association). Political leaders are prompted (right to vote) to implement environmental policies. However, based on empirical evidence, some studies find that democratic institutions have positive effects on air quality control, whereas others find a negative impact. These two effects are determined by the net effect of bureaucratic efficiency and societal variables – e.g., income inequality and urbanization. For example, Farzin and Bond (2006) show that democracies have lower pollution emissions. Moreover, income inequality, the age distribution, education, and urbanization may reduce or reinforce the net impact of the type of regime. Kinda (2011) provides evidence that democratic institutions attract investments that hurt environmental quality. Further, the direct negative effect of democratic institutions is higher for local pollutants (SO2) than for global pollutants (CO2). Povitkina (2015) suggests that democracies emit fewer pollutants only if their bureaucratic capacity is high; otherwise, democracies never do better than authoritarian regimes. These conflicting research results lead us to hypothesize the following:

Hypothesis 1. Countries with higher levels of voice and accountability, i.e., democratic institutions, may have either positive or negative impacts on air quality, depending on whether societal or other factors reduce the net impact on air quality control.

Second, political stability reflects perceptions of the likelihood that the government will not be destabilized or overthrown through unconstitutional or violent means. Political stability is fundamental for a better quality of governance, which leads to strong governing institutions – e.g., effective judiciary systems and high-quality regulation emerge. Meanwhile, policymakers have a long-term time horizon to set optimal policies, which may lead to environmental improvements. Fredriksson and Svensson (2003) find that political instability has a negative effect on the stringency of environmental regulation when the corruption level is low. Zugravu et al. (2009) suggest that emission reductions may be obtained in transition economies through the convergence of the indicators of institutional quality such as corruption control and political stability, toward those in industrialized economies. However, two effects may be observed from the model. On the one hand, a reduction in air pollution emissions on the record can be observed from stable governmental regimes if governments monitor air pollution over time and effectively implement better pollution control strategies. On the other hand, countries with stable political systems, especially emerging markets, may report high levels of air pollution emissions because the emissions might move from the unreported/underreported to the reported sector when the countries begin to monitor and control air pollution emissions. Both effects come from stable environmental regulations and policies. Based on these two results, we hypothesize the following:

Hypothesis 2. Countries with stable political institutions have effectively implemented air quality controls.

Government effectiveness measures the quality of public services, civil service, policy formation and implementation process, and governmental commitment to implementing policies. Air quality controls can benefit from a high level of government effectiveness. However, the effectiveness of government is determined by the bureaucracy, the influence of special-interest groups, and the prevalence of state-owned enterprises. Bernauer and Koubi (2013) find that countries with larger governments tend to suffer from lower environmental quality because large governments are less effective in delivering services. In addition, state-owned enterprises usually increase with government size, and exemptions from regulation controls can worsen air pollution. Li and Chan (2016) show that, on average, small and medium state-owned enterprises spend less on pollution abatement technologies and are less likely to meet national air emissions standards. As studied by Mueller and Murrell (1986) and Bernauer and Koubi (2009), among others, special-interest groups, e.g., labor unions, may support a large government to derive private benefits, which is linked to a high level of environmental degradation. Thus, governments with a higher bureaucratic capacity provide appropriate inspections and well-targeted enforcement in environmental policy implementation. They can force firms to use pollution abatement technologies and equipment, which reduce air pollution. Thus, we expect the following:

Hypothesis 3. Higher government effectiveness helps to improve air quality control.

Regulatory quality is critical for air cleanliness. Esty and Porter (2005) provide evidence that environmental results vary with the sophistication of the national regulatory regime. In this study, regulation quality is the ability of a government to formulate and implement sound policies and regulations for the public's well-being. Effective regulations aim to maximize the social welfare and achieve a sustainable environment. Priyadarshini and Gupta (2003) suggest that developing countries, e.g., India, have a lower level of compliance with environmental regulations because the costs of mitigation are high, the laws are ambitious, and the probability of being caught is low. Greenstone et al. (2012) find that stricter air quality regulations are associated with an approximately 2.6 percent decline in total factor productivity. Additionally, the annual economic costs of the regulation of manufacturing plants are approximately 8.8 percent of the manufacturing sector's profits. While a tradeoff between economic growth and air pollution emissions may occur, stringent environmental regulations may lead to innovations in green technologies and improved environmental performance (Jaraite and Di Maria, 2012). Managi et al. (2005) find that the negative short-term effects of regulation on productivity levels in US offshore oil and gas fields disappear over time. Dechezlepretre and Sato (2014) also suggest that environmental regulations marginally affect international competitiveness; further, the benefits of environmental regulations outweigh those costs. Based on these arguments, we hypothesize the following:

Hypothesis 4. Countries with better quality regulation will better control air pollution emissions.

The rule of law is essential to protecting the environment and achieving sustainable development. The rule of law measures the extent to which agents have confidence in and abide by the rules of society and the quality of contract enforcement, the police, and the courts. The rule of law can only exist in a transparent legal system that has a clear set of laws that are accessible to all, strong enforcement structures, and an independent judiciary to protect citizens against the arbitrary use of power. A weak rule of law and an inefficient judicial system reduce the effectiveness of environmental regulations. Fredriksson and Mani (2002) provide evidence for and suggest that a greater degree of rule of law raises environmental policy stringency. However, this effect can be weakened because firms have increased incentives to bribe officials to circumvent environmental laws. Chen (2010) finds that the rule of law had positive effects on environmental policy stringency in 71 countries in the year 2000. Castiglione et al. (2012) find that the rule of law has differential effects on carbon emissions in 28 European countries, partly based on the sector composition of the country and whether the country has a socialist past. Because the rule of law has a positive effect on air quality control, we hypothesize the following:

Hypothesis 5. A higher level of rule of law will lead to improvements in air quality.

Finally, control of corruption measures the extent to which public power is not exercised for private gain. Goel and Nelson (1998) and La Porta et al. (1999) suggest that corruption tends to increase with government size. Meanwhile, corruption also conflicts with the rule of law. The main reason for this conflict is that in corrupt societies, bureaucrats can be bribed and rules are simply not followed. Many studies confirm that corruption has a negative effect on environmental policies, which leads to an increase in air pollution emissions; e.g., Welsch (2004) provides evidence that at low-income levels, the level of air pollution (e.g., NO2 and CO2) strongly increases with corruption. Biswas et al. (2012) show that better control of corruption reduces the negative effects on air quality of unregulated production in the shadow economy. Goel et al. (2013) provide evidence that greater corruption decreases CO2 emissions due to the misreporting or underreporting of emissions because corruption may contribute to a weakening of environmental control. An increase in governmental bureaucratic efficiency and the continuous search for corrupt activities through better governance are critical to the success of environmental sustainability. Fredriksson and Mani (2002) also conclude that greater policy stringency must go hand-in-hand with efforts to reduce corruption if environmental policies are to have their intended effects. Therefore, we hypothesize the following:

Hypothesis 6. A high level of control of corruption can improve air quality control.

Keeping in mind that if the effect of only an individual governance indicator on the environment is considered, the level of the individual governance indicator on its own is insufficient to determine environmental quality. An individual indicator does not fully account for how the remaining governance indicators mutually interact with each other. Thus, we must carefully examine and explain the overall effect of governance indicators on air quality control.

3. Method and Data

Based on above hypotheses, we aim to provide empirical results to examine the determinants of air pollution. This research assumes that air pollution is a function of institutional, economic, social and international openness factors. In the model, we use PM2.5 (fine particulate matter in micrograms per cubic meter ($\mu g/m^3$)) as a proxy for air quality. Institutional quality is measured using six governance indicators from the World Bank, including voice and accountability, political stability, governance effectiveness, regulatory quality, rule of law, and control of corruption.

To test whether the level of institutional performance has a systematic relationship with the degree of air pollution in a country, our empirical model is estimated using panel data methodology. Panel data methods allow a study to control for individual heterogeneity and to eliminate the risk of biased results. To address potential country-specific unobserved heterogeneity, we use a random effect specification for our empirical model as follows:

$$
\begin{aligned}
&PM2.5_{i,t} \\
&= \alpha + \beta_1(VA_{i,t}) + \beta_2(PS_{i,t}) + \beta_3(GE_{i,t}) + \beta_4(RQ_{i,t}) + \beta_5(RL_{i,t}) + \beta_6(CC_{i,t}) \\
&+\beta_7(LN(GPC)_{i,t}) + \beta_8(LN(GPC)^2_{i,t}) + \beta_9(IP_{i,t}) + \beta_{10}(LN(ENGUSE)_{i,t}) \\
&+\beta_{11}(FIXCAP_{i,t}) + \beta_{12}(LN(POPUL)_{i,t}) + \beta_{13}(TRADOPEN_{i,t}) \\
&+\beta_{14}(FDI_{i,t}) + \beta_{15}(FINOPEN_{i,t}) + \varepsilon_{i,t},
\end{aligned} \tag{1}
$$

where $PM2.5_{i,t}$ is the measure of PM2.5 air pollution in country *i* at time *t*; $VA_{i,t}$ is the voice and accountability in country *i* at time *t*; $PS_{i,t}$ is the political stability in country *i* at time *t*; $GE_{i,t}$ is the government effectiveness in country *i* at time *t*; $RQ_{i,t}$ is the regulatory quality in country *i* at time *t*; $RL_{i,t}$ is the rule of law in country *i* at time *t*; and $CC_{i,t}$ is the control of corruption in country *i* at time *t*. $LN(GPC)_{i,t}$ is the natural log of the GDP per capita in country *i* at time *t*; $LN(GPC)^2_{i,t}$ is the natural log of the GDP per capita squared in country *i* at time *t;* $IP_{i,t}$ is inflation in country *i* at time *t;* $LN(ENGUSE)_{i,t}$ is the natural log of energy use in country *i* at time *t*; and $FIXCAP_{i,t}$ is the gross fixed capital formation in country *i* at time *t*. This set of variables measures economic development. $LN(POPUL)_{i,t}$ is the natural log of the total population in country *i* at time *t*. This variable defines country size. $TRADOPEN_{i,t}$ indicates the trade openness in country *i* at time *t*; $FDI_{i,t}$ is the foreign direct investment in country *i* at time *t*; and $FINOPEN_{i,t}$ is the financial openness in country *i* at time *t*. These three variables define the international openness of a country. $\varepsilon_{i,t}$ indicates the random error term. A detailed explanation and the sources of the variables are shown in Table 1. The sample includes 167 countries (see Appendix A for the full list of countries) and covers the period from 2000 to 2013.

We provide the rationale of our selected variables below. To begin, we define the measure of air quality as a dependent variable in our empirical tests. Because no single measure of air quality exists in the real world, most studies use CO2 and SO2 as proxies for air pollutants. Based on the 2016 Environmental Performance Index (EPI), air quality measures exposure to fine particulate matter (PM), nitrogen dioxide (NO2), and the percentage of the population that burns solid fuel indoors. We use fine particulate matter (PM2.5) as a proxy for air quality. We utilize two measures of PM2.5 air pollution that are obtained from the World Bank. The first measure is PM2.5 air pollution in mean annual exposure – PM2.5MEAN. The second measure is PM2.5 air pollution, which is defined as the percentage of the total population exposed to levels exceeding WHO guideline values – PM2.5WHO. Then, we transform the first measure by taking the natural logarithm, which is expressed as *LN*(*PM*2.5*MEAN*) in the model. PM2.5 emissions have direct effects on human health, ecosystems, and economies. In addition, these emissions can be controlled if governments wish to intervene more forcefully to improve air quality or if firms choose to alter their modes of production.

Table 1. Variable Definitions and Data Sources

Variable	Definition	Source
LN (PM2.5MEAN)	Natural log of PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	World Bank
PM2.5WHO	PM2.5 air pollution, population exposed to levels exceeding WHO guideline value (% of total)	World Bank
VA	An index of the voice and accountability, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
PS	An index of the political stability, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
GE	An index of the government effectiveness, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
RQ	An index of the regulation quality, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
RL	An index of the rule of law, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
CC	An index of the control of corruption, ranges from -2.5 (weak) to 2.5 (strong) governance performance	WGI, World Bank
GQ	An annual average of the six WGI indicators, which is proxied for governance quality	WGI, World Bank
LN(GPC)	Natural log of GDP per capita (constant 2005 US$)	World Bank
IP	Inflation, consumer prices (annual %)	World Bank
LN(ENGUSE)	Natural log of Energy use (kg of oil equivalent per capita)	World Bank
FIXCAP	Gross fixed capital formation (% of GDP)	World Bank
LN(POPUL)	Natural log of total population	World Bank
TRADOPEN	Trade (% of GDP)	World Bank
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank
FINOPEN	An index measuring a country's degree of capital account/financial openness	Chinn and Ito (2008)

Notes: The sample consists of 167 countries and covers the period from 2000 to 2013. For missing values, we use data interpolation to create an estimate of the missing values.

As discussed above, we obtain six indicators of country governance from the World Bank, summarized by Kaufmann et al. (2010), and use them as alternative proxies for institutional quality. These indicators are as follows: 1) voice and accountability (VA), 2) political stability (PS), 3) government effectiveness (GE), 4) regulatory quality (RQ), 5) the rule of law (RL), and 6) control of corruption (CC). These six indicators range from -2.5 to 2.5. Higher values represent better governance performance. Gani (2012) confirms that political stability, the rule of law, and control of corruption are negative and significantly correlated with CO2 emissions per capita. Goel et al. (2013) argue that many policies have been implemented that cause economic agents to internalize their environmental externalities. The institutional quality of a country is the key determinant of the success of such policies. Tamazian and Rao (2010) provide evidence that an improvement in institutional quality helps to reduce CO2 emissions. Air quality is an important environmental example of a public good. In addition, a high level of institutional quality may bolster positive perceptions of the quality of public services. We expect that better institutional quality is positively related to better air quality in a country. We also follow Abdioglu et al. (2013) and Beltratti and Stulz (2009) in using the average of the six WGI governance indicators as a proxy for the governance quality of a country, i.e., governance quality (GQ), as a robustness check.

Based on previous studies, we also utilize some control variables in our model, including economic development, social development, and international openness variables, to explain air quality. First, previous studies provide empirical examinations regarding the relationship between economic development and air pollution over three decades. An inverted U-shaped relationship is presented by Grossman and Krueger (1995), which confirms the Environmental Kuznets Curve (EKC) hypothesis. That is, environmental quality deteriorates in its initial stages, and then the status improves as income per capita increases. We may observe that poor countries struggle for an increase in living standards in exchange for poor air quality. After a certain level of income, people prefer better air quality to achieving higher economic development. Further, economic development is tied to industrial production, and such production is directly or indirectly correlated with the usage of fossil fuels. Sun (2006) suggests that the GDP growth rate should be used in CO2 emission forecasting. To examine the relationship between economic growth and air quality, we follow past studies, e.g., Bernauer and Koubi (2009), Gani (2012) and Omri et al. (2015), and use the natural log of GDP per capita ($LN(GPC)$) as a proxy for economic development. In addition, we also include GDP per capita squared ($LN(GPC)^2$) to test the EKC effect in the model.

In the structure of economic development, economic growth is usually intertwined with other factors. Many studies, e.g., Apergis and Payne (2010) and Omri et al. (2014), suggest that energy consumption together with economic growth may worsen environmental quality. While higher economic growth may lead to a high level of energy consumption, the acceleration of industrialization and urbanization processes also has a positive effect on energy use. However, efficiency in energy consumption may reduce air pollution emissions (Herrala and Goel, 2012).

To shape the effect of energy consumption on air pollution, we use energy use (kg of oil equivalent per capita) from the World Bank as a proxy for energy consumption. We take the natural logarithm of this variable as *LN*(ENGUSE) in the model.

Based on economic theory, economic growth is driven by capital stock because the benefits of technological progress on an economy are positively related to the size of the capital stock. Capital accumulation encourages firms to adopt new environmentally friendly technologies and production facilities to enhance energy efficiency and minimize pollution without causing harm to economic growth in the production process. To model the effect of capital stock on air quality, we use the ratio of gross fixed capital formation to GDP (FIXCAP) from the World Bank as an alternative measure of capital stock.

Among the control variables, macroeconomic stability can be defined as a situation in which key economic relationships are broadly in balance without regard for the environment, but such stability may not be sustainable. A stable macroeconomic context may encourage a longer investment horizon, which would thus have a positive effect on the environment. Thus, macroeconomic stability is positively related to a reduction in environmental degradation, and better air quality will emerge because many environmental investments pay off in the future and cannot be made without the belief that the economy will be stable until profits are obtained. Further, Tamazian and Rao (2010) provide evidence that macroeconomic stability helps to reduce CO2 emissions. In the model in the current study, we use inflation (consumer prices, annual %) obtained from the World Bank as a proxy for macroeconomic stability.

The population of a country is associated with social development and country size. Further, social development involves an improvement in the living standards and general well-being of all members of any given society. A better social development may coexist with a higher intensity of energy consumption, which worsens air quality. While population size is used to establish country size in the model, urbanization is usually intertwined with industrialization and modernization. Sylwester (2008) suggests that developing countries had higher rates of urbanization during the 1990s because some of these countries received large amounts of foreign aid. Grossman and Krueger (1995) and Hamilton and Turton (2002) suggest that the population growth rate is a key determinant for increases in CO2 emissions, i.e., poor air quality. Omri et al. (2015) suggest that urbanization has no significant impact on environmental degradation for countries in the Middle East and North Africa (MENA). To observe the relationship between population size and air quality, we take the natural logarithm of total population *LN*(POPUL), which is obtained from the World Bank, and use this variable as a proxy for social development.

International trade, foreign direct investment (FDI), and financial openness are the main channels for the globalization of the world economy. However, the direction of the effect of international openness on air pollution is unclear in the model. According to past studies, first, the relationship between international trade and air pollution is ambiguous because many driving forces and the effect of trade on the scale of production may offset each other, as described, e.g., in the pollution haven hypothesis. On the one hand, trade openness can help technological progress and lead to a reduction in air pollution. On the other hand, trade openness is related to emissions-related production. Antweiler et al. (2001) find that SO2 concentrations decrease as per capita income increases and they decrease as trade openness increases. In contrast, Cole and Elliott (2003) find that trade openness increases SO2 emissions. Tamazian and Rao (2010) find that the effect of trade openness is to increase environmental degradation, but this result is attenuated when trade openness interacts with institutional quality.

Second, similar results can also be obtained from the relationship between FDI and air pollution. That is, FDI may be beneficial or harmful to the environment. For example, Liang (2006) finds a negative correlation between foreign direct investment and air pollution and suggests that the overall effect of foreign direct investment may be beneficial to the environment. Conversely, Xing and Kolstad (2002) report a positive relationship between the amount of sulfur emissions in a host country and inflows of US FDI in heavily polluting industries. The main reason for this result is that environmental controls increase manufacturing costs. Thus, firms transfer to developing countries where environmental standards are low, which leads these countries to have a high level of air pollution.

Financial openness also plays an important role in air pollution emissions. A high level of financial openness may attract more FDI inflows and produce an accumulation of required capital, which can encourage firms to use new energy-efficiency or pollution abatement technologies and equipment to reduce air pollution emissions. However, greater openness in financial development also increases and fosters domestic demand to ensure relatively rapid economic growth. This process results in more air pollution emissions and environmental degradation. Tamazian and Rao (2010) provide empirical evidence that financial liberalization may be harmful to environmental quality if this openness is not accomplished within a strong institutional framework. In contrast, Tamazian et al. (2009) show that a higher degree of economic and financial development decreases environmental degradation. Omri (2013) finds that financial development promotes business activities and adds to the demand for energy through cheaper credit. Similar results can also be found in Sadorsky (2010) and Wong et al. (2013), among others.

Because previous studies also provide mixed evidence about the impact of international openness on the economy and air quality, in this study, we provide three proxies for international openness. The first is trade openness (TRADOPEN), which is defined as the ratio of total trade value to GDP. The second is FDI, which is defined as the ratio of the net inflows of FDI to GDP. Both variables are obtained from the World Bank. Finally, we follow Chinn and Ito (2008) and define financial openness (FINOPEN) as the degree of capital account openness.[3]

Panel A of Table 2 provides the descriptive statistics of the individual variables. In addition, the correlation coefficients between the key variables that are used in the analysis are provided in Panel B of Table 2. Based on the definitions of the WGIs from the World Bank, the six measures of institutional quality may have overlapping effects. Panel B of Table 2 confirms that, except for population and gross fixed capital formation, the dependent variable *LN*(PM2.5MEAN) is negatively but less correlated with the six governance indicators and the control variables in the model. Because the six governance variables are highly correlated in the model, our empirical model is estimated by regressing one of six governance indicators and individually differentiating them from the others to avoid any overlapping effects.

Table 2. Summary Statistics

Panel A: Descriptive Statistics

	MEAN	STD DEV	MAX	MIN	OBS
LN(PM2.5MEAN)	2.776	0.530	4.301	1.634	2,296
PM2.5WHO	0.746	0.359	1	0	2,316
VA	-0.180	0.998	1.826	-2.284	2,493
PS	-0.187	0.968	1.668	-3.324	2,481
GE	-0.074	1.013	2.430	-2.480	2,474
RQ	-0.069	1.011	2.231	-2.666	2,474
RL	-0.149	1.002	2.121	-2.669	2,490
CC	-0.109	1.023	2.586	-1.924	2,477
GQ	-0.131	0.927	1.986	-2.491	2,470
LN(GPC)	8.098	1.641	11.974	4.904	2,409
IP	0.062	0.109	3.250	-0.181	2,192
LN(ENGUSE)	7.249	1.090	10.033	2.274	1,801
FIXCAP	0.224	0.086	1.457	0.011	2,304
LN(POPUL)	16.020	1.687	21.034	10.376	2,504
TRADOPEN	0.898	0.547	4.553	0.003	2,360
FDI	0.049	0.080	1.423	-0.590	2,380
FINOPEN	0.527	0.380	1	0	2,370

Notes: The sample consists of 167 countries and covers the period from 2000 to 2013. The definitions and sources of all variables are provided in the Table 1. For missing values, we use data interpolation to create an estimate of the missing values.

Panel B: Correlation Matrix of Key Variables

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
LN(PM2.5MEAN)	(1)	1															
VA	(2)	-0.446	1														
PS	(3)	-0.326	0.662	1													
GE	(4)	-0.245	0.817	0.716	1												
RQ	(5)	-0.283	0.847	0.711	0.941	1											
RL	(6)	-0.210	0.807	0.768	0.959	0.922	1										
CC	(7)	-0.261	0.790	0.739	0.951	0.902	0.957	1									
GQ	(8)	-0.316	0.883	0.824	0.968	0.955	0.974	0.961	1								
LN(GPC)	(9)	-0.172	0.676	0.673	0.848	0.822	0.841	0.837	0.845	1							
LN(ENGUSE)	(10)	-0.038	0.492	0.580	0.718	0.691	0.710	0.692	0.698	0.876	1						
IP	(11)	-0.001	-0.232	-0.300	-0.323	-0.332	-0.327	-0.325	-0.331	-0.306	-0.204	1					
FIXCAP	(12)	0.059	0.017	0.234	0.121	0.089	0.138	0.087	0.123	0.110	0.129	-0.010	1				
LN(POPUL)	(13)	0.257	-0.095	-0.400	-0.073	-0.131	-0.142	-0.156	-0.178	-0.160	-0.096	0.135	-0.118	1			
TRADOPEN	(14)	-0.103	0.005	0.293	0.192	0.207	0.172	0.166	0.185	0.153	0.165	-0.086	0.185	-0.416	1		
FDI	(15)	-0.110	0.102	0.187	0.112	0.162	0.120	0.126	0.145	0.088	0.074	-0.016	0.203	-0.214	0.402	1	
FINOPEN	(16)	-0.222	0.559	0.490	0.615	0.683	0.605	0.597	0.636	0.616	0.508	-0.258	0.070	-0.185	0.140	0.151	1

Notes: This panel reports correlation coefficients among *LN*(PM2.5MEAN), institutional quality, and key control variables. The sample consists of 167 countries and covers the period from 2000 to 2013. The definitions and sources of all variables are provided in the Table 1. For missing values, we use data interpolation to create an estimate of the missing values.

4. Results

Our empirical estimates that relate institutional quality to PM2.5 with random effect specification to address potential unobserved country-specific heterogeneity are presented in Tables 3 and 4. In Table 3, we present the effect of the governance indicators on mean annual exposure to PM2.5 air pollution, i.e., *LN*(*PM25MEAN*). In Table 4, we use another dependent variable – the percentage of the total population exposed to levels of PM2.5 that exceed the WHO guideline value, i.e., *PM25WHO* – to provide a robustness check for the impact of the governance indicators.

Our model reveals that a better quality of institutions can influence the level of air pollution. Column (1) in Tables 3 and 4 consists of the base model of the control variables. Columns (2) through (7) in Tables 3 and 4 focus on the effect of individual governance indicators on PM2.5 air pollution. At first glance, only four hypotheses, i.e., Hypotheses 1, 2, 3 and 6, are statistically significant based on our empirical results. That is, voice and accountability (VA), political stability (PS), government efficiency (GE) and, control of corruption (CC) have positive and statistically significant effects at the one and five percent levels on PM2.5 air pollution. In contrast, regulation quality has a negatively and statistically significant effect on PM2.5 air pollution at the five percent level in Table 3. We also observe that the coefficients of the rule of law are negative but with no statistically significant effect on air quality in Tables 3 and 4. Finally, column (8) in Tables 3 and 4 reveals that the emissions level of PM2.5 air pollution increases with the level of governance quality and is statistically significant at the one percent level. This evidence confirms that even when institutional quality becomes increasingly better for all countries, people are still exposed to poor air quality.

Table 3. Institutional Quality and PM2.5 Mean Annual Exposure

	Dependent Variable: PM2.5MEAN							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VA		0.021**						
		(2.369)						
PS			0.015***					
			(3.032)					
GE				0.049***				
				(4.53)				
RQ					-0.035**			
					(-2.572)			
RL						-0.002		
						(-0.285)		
CC							0.037***	
							(3.833)	
GQ								0.036***
								(3.113)
LN(GPC)	0.812***	0.786***	0.803***	0.835***	0.786***	0.807***	0.82***	0.814***
	(10.097)	(9.898)	(10.016)	(9.47)	(11.019)	(9.857)	(9.405)	(9.435)
LN(GPC)^2	-0.053***	-0.051***	-0.052***	-0.055***	-0.05***	-0.052***	-0.054***	-0.054***
	(-9.946)	(-9.627)	(-9.756)	(-9.278)	(-10.349)	(-9.442)	(-9.189)	(-9.138)
IP	0.011	0.016	0.016	0.019	0.01	0.011	0.029	0.019
	(0.293)	(0.429)	(0.406)	(0.47)	(0.286)	(0.289)	(0.708)	(0.451)
LN(ENGUSE)	0.15***	0.149***	0.152***	0.145***	0.145***	0.15***	0.15***	0.152***
	(6.18)	(5.978)	(5.956)	(6.04)	(6.035)	(5.969)	(6.007)	(5.892)
FIXCAP	0.301***	0.302***	0.285***	0.307***	0.316***	0.301***	0.285***	0.292***
	(5.24)	(5.459)	(5.159)	(5.461)	(5.423)	(5.163)	(5.247)	(5.411)
LN(POPUL)	0.079***	0.083***	0.084***	0.085***	0.076***	0.079***	0.085***	0.085***
	(4.148)	(4.497)	(4.493)	(4.362)	(3.979)	(4.178)	(4.61)	(4.529)
TRADOPEN	-0.059***	-0.057***	-0.058***	-0.054***	-0.064***	-0.059***	-0.057***	-0.056***
	(-3.399)	(-3.436)	(-3.358)	(-3.371)	(-3.713)	(-3.457)	(-3.451)	(-3.38)
FDI	-0.032	-0.03	-0.03	-0.022	-0.031	-0.032	-0.032	-0.03
	(-0.759)	(-0.71)	(-0.704)	(-0.549)	(-0.701)	(-0.753)	(-0.806)	(-0.716)
FINOPEN	-0.033***	-0.032***	-0.034***	-0.033***	-0.032***	-0.033***	-0.026**	-0.032***
	(-3.289)	(-3.296)	(-3.484)	(-3.011)	(-3.114)	(-3.419)	(-2.498)	(-3.223)
CONSTANT	-2.575***	-2.525***	-2.613***	-2.674***	-2.453***	-2.552***	-2.683***	-2.65***
	(-6.275)	(-5.708)	(-5.939)	(-5.618)	(-6.455)	(-6.037)	(-5.627)	(-5.577)
Adjusted R-squared	0.190	0.187	0.190	0.198	0.194	0.189	0.196	0.190
Prob(F-statistic)	0	0	0	0	0	0	0	0
No. of observations	1,442	1,442	1,442	1,442	1,442	1,442	1,442	1,442

Notes: This table presents the regression results of air pollution on institutional quality. The dependent variables are *LN*(PM2.5MEAN). The definitions and sources of all variables are provided in the Table 1. The sample consists of 167 countries and covers the period from 2000 to 2013. For missing values, we use data interpolation to create an estimate of the missing values. We use random-effect specification, with t-statistics (in parentheses) computed using standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Institutional Quality and PM2.5 Exceedance

	Dependent Variable: PM2.5WHO							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VA		0.037***						
		(4.504)						
PS			0.02***					
			(2.979)					
GE				0.035***				
				(3.52)				
RQ					-0.012			
					(-1.223)			
RL						-0.002		
						(-0.267)		
CC							0.021**	
							(2.417)	
GQ								0.042***
								(3.77)
LN(GPC)	0.307***	0.295***	0.306***	0.331***	0.299***	0.304***	0.316***	0.325***
	(4.86)	(4.59)	(4.869)	(5.341)	(5.041)	(4.789)	(4.83)	(4.842)
LN(GPC)^2	-0.02***	-0.02***	-0.02***	-0.022***	-0.019***	-0.02***	-0.021***	-0.022***
	(-4.612)	(-4.429)	(-4.623)	(-5.192)	(-4.61)	(-4.472)	(-4.65)	(-4.723)
IP	-0.009	0.001	-0.002	-0.003	-0.009	-0.009	0.001	0
	(-0.23)	(0.038)	(-0.051)	(-0.073)	(-0.247)	(-0.235)	(0.017)	(0.005)
LN(ENGUSE)	0.075***	0.076***	0.077***	0.072***	0.073***	0.074***	0.074***	0.077***
	(3.7)	(3.656)	(3.581)	(3.555)	(3.706)	(3.586)	(3.675)	(3.621)
FIXCAP	0.204***	0.202***	0.181***	0.21***	0.209***	0.205***	0.197***	0.194***
	(3.202)	(3.367)	(2.889)	(3.362)	(3.325)	(3.177)	(3.207)	(3.216)
LN(POPUL)	0.026*	0.033**	0.033***	0.03**	0.026*	0.027**	0.031**	0.034***
	(1.897)	(2.569)	(2.595)	(2.396)	(1.855)	(2.012)	(2.509)	(2.811)
TRADOPEN	-0.021**	-0.021**	-0.02**	-0.019**	-0.022**	-0.021**	-0.02**	-0.019**
	(-2.136)	(-2.393)	(-2.06)	(-2.204)	(-2.287)	(-2.117)	(-2.094)	(-2.015)
FDI	-0.031	-0.029	-0.028	-0.024	-0.03	-0.031	-0.03	-0.028
	(-0.958)	(-0.914)	(-0.876)	(-0.745)	(-0.932)	(-0.953)	(-0.958)	(-0.894)
FINOPEN	0.021**	0.024**	0.02**	0.021**	0.022**	0.021**	0.025***	0.023**
	(2.247)	(2.443)	(2.188)	(2.141)	(2.231)	(2.282)	(2.645)	(2.371)
CONSTANT	-1.376***	-1.424***	-1.471***	-1.466***	-1.346***	-1.369***	-1.455***	-1.522***
	(-5.511)	(-5.924)	(-5.857)	(-6.154)	(-5.867)	(-5.693)	(-5.988)	(-6.049)
Adjusted R-squared	0.060	0.069	0.067	0.067	0.061	0.059	0.063	0.066
Prob(F-statistic)	0	0	0	0	0	0	0	0
No. of observations	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455

Notes: This table presents the regression results of air pollution on institutional quality. The dependent variables are PM2.5WHO. The definitions and sources of all variables are provided in the Table 1. The sample consists of 167 countries and covers the period from 2000 to 2013. For missing values, we use data interpolation to create an estimate of the missing values. We use random-effect specification, with t-statistics (in parentheses) computed using standard errors. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Two potential explanations are provided for such findings. On the one hand, our consolidated empirical results reveal that countries with stable political institutions, democratic institutions, higher government effectiveness and/or bureaucratic capacity, and corruption that is kept under control shift previously un-reported and/or under-reported PM2.5 air emissions to the reported sector. Since more effective government institutions conduct inquiries into pollution activities through enhanced audits, better processes, and more severe punitive measures. If so, our four hypotheses, i.e., Hypotheses 1, 2, 3 and 6, are supported by this evidence. On the other hand, a better institutional environment is also favorable for economic and societal developments as well as urbanization, and higher recorded PM2.5 air pollution emissions can be observed. The question of how to strike a balance between economic development and environmental sustainability is a major issue for government institutions across countries. Government institutions should develop more aggressive strategies to control air quality. If this explanation were true, this might conflict with our four hypotheses. These two explanations would be the reason why we observe better institutional quality together with higher PM2.5 air emissions in the model. We, therefore, require further evidence to test the validity of our hypotheses.

Our findings are similar to those from Ivanova (2011), who finds that countries with effective regulation are likely to have relatively high reported emissions of sulfur. She also suggests that this result cannot be interpreted as weak environmental performance because these countries' actual pollution levels are likely to be lower than those of nations with less effective regulation. In contrast with Goel et al. (2013), who find that more corrupt nations have both qualitative and quantitative effects in yielding fewer recorded emissions, our results only show that countries with good governance may experience an increase in the measure of official emissions. This observation implies that governments with improved institutional quality may undertake appropriate air pollution controls and better provide for the public good, i.e., better air quality, which is more important for transition economies. Soderholm (1999) provides evidence that institutional inertia in economic and political systems is the largest barrier to successful environmental protection in Russia.

Observing the control variables from Tables 3 and 4, the results are dominated by GDP per capita (*LN*(*GPC*)), GDP per capita squared ($LN(GPC)^2$), energy use (*LN*(ENGUSE)), gross fixed capital formation (FIXCAP), population (*LN*(POPUL)), trade openness (TRADOPEN), and financial openness (FINOPEN). These variables are statistically significant at the one percent level across all specifications. As individual indicators are added to the model, the signs on these variables never change, and they remain statistically significant. However, the coefficients of FDI and the inflation rate are not statistically significant for PM2.5 air pollution in our model.

As expected, the effect of GDP per capita (*LN*(*GPC*)) is positively and statistically associated with PM2.5 air emissions. Further, the coefficient on GDP per capita squared ($LN(GPC)^2$) is negative, which is statistically significant at the one percent level. This result implies that PM2.5 air emissions increase as incomes grow at the initial stage; then, PM2.5 air emissions shrink as incomes increase past a certain level. Thus, our model conforms to the Environmental Kuznets Curve effect – an inverted U-shaped curve – for the relationship between PM2.5 emissions and income per capita. An increase in income up to a certain level leads people to demand higher living standards and a better-quality environment. These demands may force firms and governments to take certain actions to adopt new pollution abatement technologies and adjust industrial structures.

Regarding the energy use (*LN*(ENGUSE)) control variable, the significantly positive coefficient reveals that a higher level of energy use per capita may cause an increase in PM2.5 air emissions or environmental degradation. The results are similar to those of Soytas et al. (2007) for the United States and Zhang and Cheng (2009) for China.

The coefficients of gross fixed capital formation (FIXCAP) are positive and significant at the one percent level in the model. This result does not support our hypothesis that capital accumulation may encourage firms to adopt new environmentally friendly technologies and thereby minimize pollution. The results provide evidence that the higher capital stocks are, the higher the PM2.5 emissions and the lower the air quality will be. Previous studies also provide evidence on the relationship between capital stocks, economic development, and energy consumption. For example, Saidi and Hammami (2015) show that capital stock has a significant and positive effect on energy consumption. Lee et al. (2008) analyze data from 22 OECD countries and suggest that a bidirectional relationship between energy consumption and capital stock exists. Bartleet and Gounder (2010) also find that capital stock plays an important role in determining the direction of the causal relationship between energy consumption and economic growth. Such evidence leads us to provide the potential explanation that capital stock may cause an increase in energy consumption, which leads to higher levels of PM2.5 air emissions.

In the model, we include population (POPU) as a control variable to account for social development, and further, country size. Environmental degradation can be observed because resources are more intensively consumed in larger or more populous countries. The positive and statistically significant coefficients shown in Tables 3 and 4 provide strong evidence that more populous or larger countries have more emissions. This result can be linked with the findings of Grossman and Krueger (1995) and Panayotou (1998) that indicate that a large population coupled with an increase in GDP growth and higher per capita income leads to an increase in energy consumption.

Although countries that are more open to international trade may face greater pressure on their environmental standards, trade openness (TRADOPEN) can help firms adopt new technologies and reduce air pollution. However, trade openness may also affect PM2.5 air emissions if increased trade results in emissions-related production. Based on our model, the coefficients of trade openness are negatively and statistically significant at the one percent level. In contrast with Managi et al. (2009), who find that trade plays an important role in generating emissions in the transport sector and that greater emissions are attributable to exports rather than to imports, our model suggests that a high level of trade openness may reduce PM2.5 air emissions. Thus, trade openness is associated with less emissions-related production because firms should have greater incentives to adopt environmental management.

As can be observed from Tables 3 and 4, a conflicting result can be obtained from the sign on the coefficient of financial openness (FINOPEN). On the one hand, the negative sign in Table 3 implies that financial openness may reduce air pollution, which accords with the evidence that financial development may contribute to a reduction in CO2 emissions (Tamazian et al., 2009). On the other hand, the positive sign in Table 4 indicates that financial openness worsens air quality. This result also accords with results finding that financial development increases CO2 emissions (Sadorsky, 2010; Zhang, 2011). In this study, a potential explanation for this conflicting result may be that financial openness helps firms raise the required capital to adopt new technologies and environmentally friendly production, which leads to a reduction in mean annual exposure to PM2.5. However, financial openness enhances economic development, which leads to a higher level of urbanization and energy consumption. We can observe a high percentage of the total population exposed to levels of PM2.5 that exceed the WHO guideline value in the model.

5. Conclusions

Focusing on the institutional quality-pollution nexus, we test the effect of institutional quality on the level of PM2.5 air pollution. Whereas most studies analyze the links between CO2 or SO2 air pollution and individual governance indicators, formal research on PM2.5 air pollution has been lacking despite its strategic importance and concerns about the detrimental effects on health as well as on climate. This study systematically contributes to the study of this nexus based on different types of governance, because the interaction between governance indicators and certain control variables is more important for those environmental problems that require long-term thinking from decision-makers.

By using a dataset that covers 167 nations over the period from 2000 to 2013, our empirical results indicate that voice and accountability, political stability, government effectiveness, and control of corruption have positively and statistically significant effects on recorded PM2.5 air pollution across developed and developing countries. Our findings may be related to the view that nations that improve their institutional quality undertake appropriate air pollution controls through enhanced audits, better processes, and more severe punitive measures. These actions cause air pollution to move from the unrecorded and/or under-recorded sector to the recorded sector. Therefore, based on our empirical results, we observe that better quality institutions are associated with an increase in recorded PM2.5 air pollution. This finding cannot be interpreted as poor environmental performance as long as the government can develop some control strategies and take the required steps to reduce pollution in response to public expectations.

Our finds complement those of Goel et al. (2013), who find that more corrupt nations or nations with large shadow sectors have lower recorded emissions, and MENA countries engage in more polluting activities. We find that efforts to improve institutional quality can make nations report higher measured emissions. As people become more concerned about issues related to air quality control, our model implies that to control PM2.5 air emissions, nations should take the first step in improving the quality of their institutions. Further, nations should systematically, not partially, improve their institutions because components of institutional quality usually interact with each other.

Furthermore, based on our model analysis, PM2.5 air pollution is also found to more robustly support the EKC hypothesis, which was developed in previous studies. The highest air pollution levels are experienced in low- and middle-income countries. Analogous to Panayotou (1997), we argue that better quality institutions can significantly reduce environmental degradation at low-income levels and accelerate improvements in air quality at higher income levels. Our results also show that more energy use, larger gross fixed capital formation, and a higher population size all have positive effects on PM2.5 air pollution over the period from 2000 to 2013. This result implies that economic and social activities still play an important role in PM2.5 air pollution. In contrast, trade openness, as a proxy for international openness, has a negative effect on PM2.5 air pollution. This result suggests that firms should follow the rules for environmental protection to promote their international trade, which induces a decrease in PM2.5 air pollution in the model.

Three policy implications emerge from our research. First, a stable governance environment is fundamental to economic development and environmental sustainability. Thus, well-defined institutional frameworks are relevant for both economic growth and environmental sustainability because they work as a mediating influence, thereby creating a win–win situation because institutions determine the implementation and outcomes of governmental policies, which reflect the capacity to manage these two issues. To effectively control PM2.5 air pollution, policy makers must focus on various aspects of governance and their interactions, and further, they must determine how to improve their institutional quality. Moreover, they must take action to protect environmental sustainability. Such action includes stricter environmental lawmaking (e.g., limiting emissions from various sources or using cleaner modes of transport) and structural changes (e.g., reducing combustion-sourced energy consumption and engaging in land use planning).

Second, people and firms should conform to environmental regulations and enhance their awareness of environmental protection through environmental education. More importantly, they should change their behavior by using cleaner modes of transport and household energy sources and energy–efficient production technologies to minimize pollution. Only structural changes in their behavior can make air quality better. Finally, each country should follow international environmental agreements to enhance their environmental sustainability and reduce their PM2.5 air pollution. Based on international economic theories, the estimated effects of environmental regulations on trade and investment location choices are trivial in comparison to other determinants, e.g., market conditions and the quality of local workers. If polluting countries suffer from international pressure that is generated by the international community and international environmental laws, they will limit their air pollution and improve their environmental sustainability to maintain competitiveness in international trade.

The study faces two data limitations that are worth mentioning. First of all, no single agreed-upon measure of the quality of institutions exists in the real world. Although we use the WGIs as proxies for institutional quality, some researchers are concerned that the use of the WGIs may risk a loss of conceptual clarity because the WGIs have problems about the precision of the data, internal consistency, robustness, and the transparency of the indicators (e.g., Thomas, 2010). Second, as suggested by the World Bank, direct monitoring of PM2.5 air pollutants is still rare in many parts of the world, and measurement protocols and standards are not the same for all countries. These issues might affect our analysis regarding the precision of our estimates. Although these two data limitations exist, future research should further examine the consistency of the institutional quality-pollution nexus by using different measures of institutional quality and PM2.5 air pollutants. Further, future research methodologies should also take into account the potential simultaneity between institutional quality and air pollution in the model.

Notes

1. WHO, September 26, 2016, WHO releases country estimates on air pollution exposure and health impact: New interactive maps highlight areas within countries that exceed WHO air quality limits. Retrieved from http://www.who.int/mediacentre/news/releases/2016/air-pollution-estimates/en/.
2. WHO, May 12, 2016, Air pollution levels rising in many of the world's poorest cities. Retrieved from http://www.who.int/mediacentre/news/releases/2016/air-pollution-rising/en/.
3. Capital account openness is continuously updated by Chinn and Ito and is available at http://web.pdx.edu/~ito/Chinn-Ito_website.htm

Appendix A. List of countries included in the dataset (Countries = 167)

Afghanistan, Angola, Albania, United Arab Emirates, Argentina, Armenia, Australia, Austria, Azerbaijan, Burundi, Belgium, Benin, Burkina Faso, Bangladesh, Bulgaria, Bahrain, Bosnia and Herzegovina, Belarus, Belize, Bolivia, Brazil, Brunei Darussalam, Bhutan, Botswana, Central African Republic, Canada, Switzerland, Chile, China, Cote d'Ivoire, Cameroon, Congo, Colombia, Comoros, Costa Rica, Cuba, Cyprus, Czech Republic, Germany, Djibouti, Dominica, Denmark, Dominican Republic, Algeria, Ecuador, Egypt, Eritrea, Spain, Estonia, Ethiopia, Finland, Fiji, France, Gabon, United Kingdom, Georgia, Ghana, Guinea, The Gambia, Guinea-Bissau, Equatorial Guinea, Greece, Guatemala, Guyana, Hong Kong, Honduras, Croatia, Haiti, Hungary, Indonesia, India, Ireland, Iran, Iraq, Iceland, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kenya, Kyrgyz Republic, Cambodia, South Korea, Kuwait, Laos, Lebanon, Liberia, Libya, Sri Lanka, Lesotho, Lithuania, Luxembourg, Latvia, Macao, Morocco, Monaco, Moldova, Madagascar, Mexico, Macedonia, Mali, Myanmar, Montenegro, Mongolia, Mozambique, Mauritania, Malawi, Malaysia, Namibia, Niger, Nigeria, Nicaragua, Netherlands, Norway, Nepal, New Zealand, Oman, Pakistan, Panama, Peru, Philippines, Papua

New Guinea, Poland, North Korea, Portugal, Paraguay, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Sudan, Senegal, Singapore, Sierra Leone, El Salvador, Somalia, Serbia, South Sudan, Suriname, Slovakia, Slovenia, Sweden, Swaziland, Syria, Chad, Togo, Thailand, Tajikistan, Turkmenistan, Tonga, Tunisia, Turkey, Tanzania, Uganda, Ukraine, Uruguay, United States of America, Uzbekistan, Venezuela, Viet Nam, Yemen, South Africa, Zambia, Zimbabwe.

References

Abdioglu, N., A. Khurshed, and K. Stathopoulos, (2013), "Foreign Institutional Investment: Is Governance Quality at Home Important?" *Journal of International Money and Finance*, 32, 916-940.

Antweiler, W., B. Copeland, and S. Taylor, (2001), "Is Free Trade Good for the Environment?" *American Economic Review*, 91(4), 877-908.

Apergis, N. and J. E. Payne, (2010), "The Emissions, Energy Consumption, and Growth Nexus: Evidence from the Commonwealth of Independent States," *Energy Policy*, 38(1), 650-655.

Bartleet, M. and R. Gounder, (2010), "Energy Consumption and Economic Growth in New Zealand: Results of Trivariate and Multivariate Models," *Energy Policy*, 38(7), 3505-3517.

Beltratti, A. and R. Stulz, (2009), "Why Did Some Banks Perform Better During the Credit Crisis? A Cross-Country Study of the Impact of Governance and Regulation," *NBER Working Paper 15180*.

Bernauer, T. and V. Koubi, (2009), "Effects of Political Institutions on Air Quality," *Ecological Economics*, 68(5), 1355-1365.

Bernauer, T. and V. Koubi, (2013), "Are Bigger Governments Better Providers of Public Goods? Evidence from Air Pollution," *Public Choice*, 156(3), 593-609.

Biswas, A. K., M. R. Farzanegan, and M. Thum, (2012), "Pollution, Shadow Economy and Corruption: Theory and Evidence," *Ecological Economics*, 75, 114-125.

Brauer M., G. Freedman, J. Frostad, A. van Donkelaar, R.V. Martin, F. Dentener, R. van Dingenen, K. Estep, H. Amini, J. S. Apte, K. Balakrishnan, L. Barregard, D. Broday, V. Feigin, S. Ghosh, P. K. Hopke, L. D. Knibbs, Y. Kokubo, Y. Liu, S. Ma, L. Morawska, J. L. Sangrador, G. Shaddick, H. R. Anderson, T. Vos, M. H. Forouzanfar, R. T. Burnett, and A. Cohen, (2016), "Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013," *Environmental Science & Technology*, 50(1), 79-88.

Castiglione, C., D. Infante, and J. Smirnova, (2012), "Rule of Law and the Environmental Kuznets Curve: Evidence for Carbon Emissions," *International Journal of Sustainable Economy*, 4(3), 254-269.

Chen, M., (2010), "Rule of Law and Environmental Policy Stringency," *Working Paper 10–3*, Institute for the Study of International Aspects of Competition, University of Rhode Island.

Chinn, M. and H. Ito, (2008), "A New Measure of Financial Openness," *Journal of*

Comparative Policy Analysis, 10(3), 307-320.

Cole, M. and R. Elliott, (2003), "Determining the Trade-Environment Composition Effect: The Role of Capital, Labor and Environmental Regulations," *Journal of Environmental Economics and Management*, 46(3), 363-383.

Dechezleprêtre, A. and M. Sato, (2014), "The Impacts of Environmental Regulations on Competitiveness," Grantham Research Institute on Climate Change and the Environment, Policy Brief, LSE.

Esty, D. and M. Porter, (2005), "National Environmental Performance: An Empirical Analysis of Policy Results and Determinants," *Environment and Development Economics*, 10(4), 391-434.

Farzin, H. and C. Bond, (2006), "Democracy and Environmental Quality," *Journal of Development Economics*, 81(1), 213-235.

Fredriksson, P. and J. Svensson, (2003), "Political Instability, Corruption and Policy Formation: The Case of Environmental Policy," *Journal of Public Economics*, 87(7-8), 1383-1405.

Fredriksson, P. and M. Mani (2002), "The Rule of Law and the Pattern of Environmental Protection," *IMF Working Paper 02/49*.

Gani, A., (2012), "The Relationship between Good Governance and Carbon Dioxide Emissions: Evidence from Developing Countries," *Journal of Economic Development*, 37(1), 77-93.

Goel, R. and M. Nelson, (1998), "Corruption and Government Size: A Disaggregated Analysis," *Public Choice*, 97(1), 107-120.

Goel, R., R. Herrala, and U. Mazhar, (2013), "Institutional Quality and Environmental Pollution: MENA Countries versus the Rest of the World," *Economic Systems*, 37(4), 508-521.

Greenstone, M., J. List, and C. Syverson, (2012), "The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing," *Working Paper*.

Grossman, G. and A. Krueger, (1995), "Economic Growth and the Environment," *Quarterly Journal of Economics*, 110(2), 352-377.

Hamilton, C. and H. Turton, (2002), "Determinants of Emissions Growth in OECD Countries," *Energy Policy*, 30(1), 63-71.

Herrala, R. and R. Goel, (2012), "Global CO2 Efficiency: Country-Wise Estimates Using a Stochastic Cost Frontier," *Energy Policy*, 45, 762-770.

Ivanova, K., (2011), "Corruption and Air Pollution in Europe," *Oxford Economic Papers*, 63(1), 49-70.

Jalilian, H., C. Kirkpatrick, and D. Parker, (2007), "The Impact of Regulation on Economic Growth in Developing Countries: A Cross-Country Analysis," *World Development*, 35(1), 87-103.

Jaraite, J. and C. Di Maria, (2012), "Efficiency, Productivity and Environmental Policy: A Case Study of Power Generation in the EU," *Energy Economics*, 34(5), 1557-1568.

Kaufmann, D., A. Kraay, and M. Mastruzzi, (2010), "The Worldwide Governance Indicators: Methodology and Analytical Issues," *World Bank Policy Research Working Paper No. 5430*.

Kinda, R., (2011), "Democratic Institutions and Environmental Quality: Effects and Transmission Channels," MPRA Paper 27455, University Library of Munich.

La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. Vishny, (1999), "The Quality of Government," *Journal of Law, Economics, and Organization*, 15(1), 222-279.

Lee, C.-C., C.-P. Chang, and P.-F. Chen, (2008), "Energy-Income Causality in OECD Countries Revisited: The Key Role of Capital Stock," *Energy Economics*, 30(5), 2359-2373.

Li, X. and G.-W. Chan, (2016), "Who Pollutes? Ownership Type and Environmental Performance of Chinese Firms," *Journal of Contemporary China*, 25, 248-263.

Liang, F. H., (2006), "Does Foreign Direct Investment Harm the Host Country's Environment? Evidence from China," *Working Paper*, Haas School of Business, University of California Berkeley.

Managi, S., A. Hibiki, and T. Tsurumi, (2009), "Does Trade Openness Improve Environmental Quality?" *Journal of Environmental Economics and Management*, 58(3), 346-363.

Managi, S., J. Opaluch, D. Jin, and T. Grigalunas, (2005), "Environmental Regulations and Technological Change in the Offshore Oil and Gas Industry," *Land Economics*, 81(2), 303-319.

Mueller, D. C. and P. Murrell, (1986), "Interest Groups and the Size of Government," *Public Choice*, 48(2), 125-145.

North, D., (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge: Cambridge University Press.

North, D., (1993), *Economic Performance through Time*, Nobel Prize Lecture.

Omri, A., (2013), "CO2 Emissions, Energy Consumption and Economic Growth Nexus in MENA Countries: Evidence from Simultaneous Equations Models," *Energy Economics*, 40, 657-664.

Omri, A., D. K. Nguyen, and C. Rault, (2014), "Causal Interactions between CO2 Emissions, Foreign Direct Investment, and Economic Growth: Evidence from Dynamic Simultaneous Equation Models," *Economic Modelling*, 42, 382-389.

Omri, A., S. Daly, C. Rault, and A. Chaibi, (2015), "Financial Development, Environmental Quality, Trade and Economic Growth: What Causes What in MENA Countries," *Energy Economics*, 48, 242-252.

Panayotou, T., (1997), "Demystifying the Environmental Kuznets Curve: Turning a Black Box into a Policy Tool," *Environment and Development Economics*, 2(4), 465-484.

Panayotou, T., (1998), *Instruments of Change: Motivating and Financing Sustainable Development*, Earthscan Publications for United Nations Environment Program (UNEP), London.

Payne, R., (1995), "Freedom and the Environment," *Journal of Democracy*, 6, 41-55.

Povitkina, M., (2015), "Democracy, Bureaucratic Capacity and Environmental Quality," *QoG Working Paper Series 2015:13*, University of Gothenburg.

Priyadarshini, K. and O. Gupta, (2003), "Compliance to Environmental Regulations: The Indian Context," *International Journal of Business and Economics*, 2(1), 9-26.

Sadorsky, P., (2010), "The Impact of Financial Development on Energy Consumption in Emerging Economies," *Energy Policy*, 38(5), 2528-2535.

Saidi, K. and S. Hammami, (2015), "The Impact of CO_2 Emissions and Economic Growth on Energy Consumption in 58 Countries," *Energy Reports*, 1, 62-70.

Soderholm, P., (1999), "Environmental Policy in Transition Economies: The Effectiveness of Pollution Charges," *Working Paper No. 99006*, Cambridge, MA: MIT Center for Energy and Environmental Policy Research.

Soytas, U., R. Sari, and B. Ewing, (2007), "Energy Consumption, Income, and Carbon Emissions in the United States," *Ecological Economics*, 62(3-4), 482-489.

Sun, J. W., (2006), "An Alternative Viewpoint on the Forecasting of Energy-Related CO_2 Emissions in the OECD Countries," *Energy Policy*, 34(4), 377-382.

Sylwester, K., (2008), "Foreign Aid and Urbanization in Developing Countries," *International Journal of Business and Economics*, 7(2), 153-166.

Tamazian, A. and B. Rao, (2010), "Do Economic, Financial and Institutional Developments Matter for Environmental Degradation? Evidence from Transitional Economies," *Energy Economics*, 32(1), 137-145.

Tamazian, A., J. Chousa, and K. Vadlamannati, (2009), "Does Higher Economic and Financial Development Lead to Environmental Degradation: Evidence from BRIC Countries," *Energy Policy*, 37(1), 246-253.

Thomas, M. A., (2009), "What Do the Worldwide Governance Indicators Measure?" *European Journal of Development Research*, 22(1), 31-54.

Welsch, H., (2004), "Corruption, Growth, and the Environment: A Cross-Country Analysis," *Environment and Development Economics*, 9(5), 663-693.

Wong, S. L., Y. Chang, and W.-M. Chia, (2013), "Energy Consumption, Energy R&D and Real GDP in OECD Countries with and without Oil Reserves," *Energy Economics*, 40, 51-60.

Wood, J. and I. Herzog, (2014), *Economic Freedom and Air Quality*, Vancouver, Canada: Fraser Institute.

Xing, Y. and C. Kolstad, (2002), "Do Lax Environmental Regulations Attract Foreign Investment?" *Environmental and Resource Economics*, 21, 1-22.

Yale University, (2016), "Environmental Performance Index," http://www.epi.yale.edu.

Zhang, X.-P. and X.-M. Cheng, (2009), "Energy Consumption, Carbon Emissions, and Economic Growth in China," *Ecological Economics*, 68(10), 2706-2712.

Zhang, Y.-J., (2011), "The Impact of Financial Development on Carbon Emissions: An Empirical Analysis in China," *Energy Policy*, 39(4), 2197-2203.

Zugravu, N., K. Millock, and G. Duchene, (2009), "The Factors Behind CO2 Emission Reduction in Transition Economies," *Louvain Economic Review*, 75, 461-501.