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Do Political Institutions protect the poor?

Intra Countries Health Inequalities and

Air Pollution in Developing Countries

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Abstract

This paper examines the link between health inequalities, air pollution and political institutions. In health economics literature, many studies have assessed the association between environmental degradation and health outcomes. This paper extends this literature by investigating how air pollution could explain health inequalities both between and within developing countries, and the role of political institutions in this relationship. Theoretically, we argue that differential in exposition to air pollution among income classes, prevention ability against health effect of environment degradation, capacity to respond to disease caused by pollutants and susceptibility of some groups to air pollution effect are sufficient to expect a positive link between air pollution and income related health inequality. Furthermore, in democratic countries, this heterogeneity in the health effect of pollution may be mitigated since good institutions favour universal health policy issues, information and advices about hygiene and health practices, and health infrastructures building. Our econometric results show that sulphur dioxide emission (SO_2) and particulate matter (PM_{10}) are in part responsible for the large disparities in infant and child mortalities between and within developing countries. In addition, we found that democratic institutions play the role of social protection by mitigating this effect for the poorest income classes and reducing the health inequality it provokes.

Keywords: health inequality, air pollution, political institutions, social protection

JEL classification: C13, D63, I1; Q53

1. introduction

The importance of human capital in general and population health in particular as a component of economic development predictors, has been investigated by many scholars (Cuddington & Hancock, 1994; Caselli et al., 1996; Bhargava et al., 2001; Carstensen & Gundlach, 2006; Sachs & Warner, 1997). It is recognized by economists as well as international community[1] that health contributes largely to the improvement of population welfare and economic growth through productivity and availability of healthy workforce (Bloom et al., 2001; Weil, 2007). Giving this important role, researchers identified variables that may influence population health, and environment quality is commonly accepted as one of these determinants. Indeed, many studies have assessed the association between air pollution and health status through macroeconomic studies (Gangadharan & Valenzuela, 2001) as well as microeconomic studies (Burnett & Krewski, 1994; Jerrett et al., 2005). Some authors showed that air quality degradation increases all causes mortality (Woodruff et al., 1997; Gangadharan & Valenzuela, 2001; Chay et al. 2003; Aunan & Pan, 2004; Jerrett et al., 2005) while others confirm its impact on cause-specific mortality or morbidity (Aunan & Pan, 2004; Burnett & Krewski, 1994; Jerrett et al., 2005).

Moreover, other scholars investigated the heterogeneity in the health effect of air pollution according to socioeconomic status (Charafeddine & Boden, 2008; O'Neill et al., 2003), but these studies remain theoretical or specific in a given region and focus only on health status. In addition, international studies on this topic are based on average health in the population. One of the drawbacks of the use of average health is its inability to take into account the extent of health disparities within a population, given the differential in policy response. This can be solved by using health distribution. In this paper, we investigate how air pollution may

[1] Importance of health concerns among the MDGs

impact income related health inequality within a country and the role of political institutions in such relation using data from developing countries.

Some theoretical arguments - namely, heterogeneity in exposition to air pollution among income classes, prevention ability against health effect of environment degradation, ability to respond to sickness caused by pollutants and susceptibility of some groups to air pollution effect – allow us to predict a larger impact of pollution on the poorest as compare to its effect on the richest class of income. Therefore, this may increase income related health disparities among the population. Good political institutions may mitigate this health inequality effect of environmental degradation through universal health policy issues, information and advices about health practices, and health infrastructures availability.

This article is different from previous literature since it is the first, from our knowledge, that explicitly links air pollution to within country health inequalities. Moreover, it uses a rich database from the World Bank that allows us to take into account both within and between countries characteristics of health outcomes.

Our empirical results confirm our theoretical expectations. Indeed, air pollution degrades population health and the poorest populations suffer more from this degradation than the richest. This heterogeneity in health consequences of pollution is alleviated by good political institutions.

The rest of the paper is organized as follows. In section 2 we define and discuss the different measures of health inequalities in the literature. Section 3 develops the theoretical links between health inequalities, air pollution and political environment. In this section we explore how environmental degradation may increase this disparities and the role of institutions quality. Section 4 is devoted to the empirical design. We expose the econometric methodology and the data we use in this section. The results are presented in section 5 and section 6 presents some robustness checks. Finally section 7 concludes.

2. Health inequality: definition and measures

Health inequality in a population can be defined as the differences, variations, and disparities in health achievements among individuals or groups of this population. This descriptive term includes health inequity which is the normative part of health inequality since it depends on personal judgement (Kawachi et al. 2002). As argued by Deaton & Paxson (1998), the measurement of health inequality raises at least two important issues. First, the identification of a reliable and available measure of health status data can be considered as a challenge. Several indicators are suggested in the literature, but all of them are source of critics or suffer from data unavailability. Fang et al. (2010) classified these indicators into two categories. The traditional one based on ill health incidents such as vital statistics, disease statistics and children growth data. The second category constituted of newer indicators focuses on healthy life span such as potential years of life lost (PYLL), life expectancy free of disability (LEFD), active life expectancy (ALE), disability adjusted life years (DALY) and disability adjusted life expectancy (DALE). Another important issue is whether the chosen indicator is qualitative or quantitative. The qualitative or categorical data prevents the straightforward use of traditional tools of distributional analysis, such as the Lorenz curve, in evaluating inequality. Allison & Foster (2004) present a methodology for evaluating overall inequality in health when the data are qualitative rather than quantitative in nature.

Once the appropriated measure of health is identified, the second issue is how to measure inequality in health status. In economic literature, health inequality is assessed through two different approaches. On the one hand, some scholars measure health inequality through the distribution of health status across individuals in a population, like measures of income distribution in a population (Legrand 1987; Kawachi et al. 2002). Indicators from this approach include the lorenz curve, the gini coefficient or other measures of health dispersion

(Wagstaff & van Doorslaer, 2004). On the other hand researchers assess health distribution by measuring health difference across social groups (income class, social class, age, race, place or neighbouring) and these indicators include the index of dissimilarity (ID), the slope relative indices of inequality, the Index of concentration, the range, the pseudo lorenz curve, the adapted gini coefficient. Some measures that are based on both health and social position utilize the ordered nature of socioeconomic status (the slope and the concentration index) while others including the adapted Gini coefficient and the index of dissimilarity do not.

As argue by Kunst (2008), the choice of measuring method depends on the health outcomes of interest, the data sources that can be accessed, and the socioeconomic information that is available. For Manor et al. (1997), the measures based only on the distribution of health are inadequate in examining social inequalities in health. The joint distribution of both health and socioeconomic status should be considered in this context. Wagstaff et al. (1991) and Schneider et al. (2002) detailed the calculation methods and the advantages and disadvantages of the various measurements. According to Szwarcwald (2002), the measure of variations in health status across individuals in a population depends at the same time on the performance of the health system in diminishing the socioeconomic health inequalities and the extent of the income inequalities in the population. So, it is a matter of choice whether one should or should not consider the distribution of the population across socioeconomic groups. If one considers that what is important about health inequalities is to assess the magnitude of the inter-individual differences in health status, the index of health inequalities will inevitably reflect the inequality in socioeconomic status. If the main goal is to assess the performance of health systems, this is clearly a restriction because the extent of inequalities in socioeconomic status within the population is generally outside the field of control of public health policies and actions. According to Levine et al. (2001) inequality in health is a relative rather than an absolute concept, and ratios rather than absolute differences are a more valid measure of inequality. They calculated time series for black/white ratios of age-adjusted, all-cause mortality and life expectancy in the USA. Lai et al. (2008) used two classes of generalized Gini coefficients (G1 and G2) of life expectancy to measure health inequalities among the provinces of China and the states of the United States. G1 is the measure of individual/mean absolute differences and G2 measures inter-individual absolute differences. For China, their results indicated that there was statistically significant health inequality by both G1 and G2. However, for the US, their results showed that there was significant health inequality by G1 but no statistical significance was found in health inequality by G2. Overall, from their study, China has higher health inequality than the United States.

3. Health inequality, pollution and institutions quality

A healthy labour force is essential for the development of an economy and requires a healthy environment (clean air, water, recreation and wilderness). As argue by Pearce & Warford (1993), the immediate and most important consequences of environmental degradation are damage to human health through different forms of diseases. Many authors have assessed how air quality may be associated to population's health. On the one hand, scholars showed that air pollution may increase mortality rate (Woodruff et al., 1997 ; Gangadharan & Valenzuela, 2001; Chay et al. 2003; Aunan & Pan, 2004; Jerrett et al., 2005). Aunan & Pan (2004) propose exposure-response functions for health effects of PM_{10} and SO_2 pollution in China, based on Chinese epidemiological studies. They found 0.03% (S.E. 0.01) and 0.04% (S.E. 0.01) increase in all-cause mortality per $\mu g/m^3$ PM_{10} and SO_2, respectively. Furthermore, Jerrett et al. (2005) investigated whether chronic exposure to particulate air pollution is significantly associated with mortality when the effects of other social, demographic, and lifestyle confounders are taken into account. Their results show substantively large and statistically significant health effects for women and men.

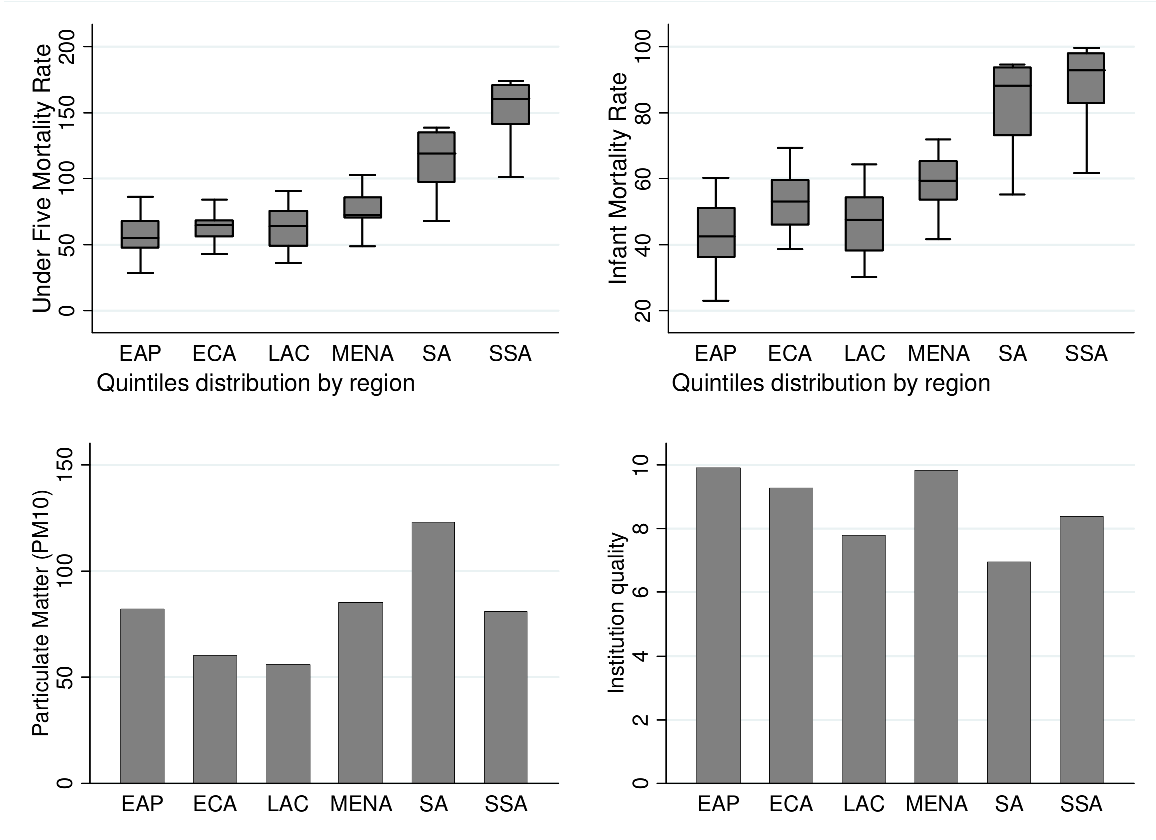
On the other hand, authors assess the link between pollution and particular illness, such as cardio-respiratory disease (Aunan & Pan, 2004; Burnett & Krewski, 1994; Jerrett et al., 2005), asthma (Nauenberg & Basu, 1999) and congenital anomalies (Rankin et al., 2009). Burnett & Krewski (1994) find strong associations between the number of daily health events (hospital admissions or emergency-room visits for respiratory illnesses) and daily levels of ambient air pollutants in the vicinity of several hospitals with data obtained from 164 acute-care hospitals in Ontario over the May-to-August period from 1983 to 1988 and a random-effects relative-risk regression model. Rankin et al. (2009) investigate the association between exposure to particulate matter with aerodynamic diameter less than 4 mg/m^3 (BS) and sulphur dioxide (SO_2) during the first trimester of pregnancy and risk of congenital anomalies through a case–control study design among deliveries to mothers resident in the UK Northern health region during 1985–1990 and logistic regression models. They found a significant but weak positive association between nervous system anomalies and BS, but not with other anomaly subtypes. For SO2, they found a significant negative association with congenital heart disease combined and patent ductus arteriosus.

In addition to the effect of air pollution on population health, this paper assesses the association between pollution and income related health inequalities within a country. At least three theoretical arguments allow the expectation of a positive association between physical environment quality and inequalities in health. Firstly, air pollution exposure is differentially distributed by income level. Indeed, poor communities are more likely to be exposed than others, since they generally live in more polluted area and they cannot afford moving from polluted area to a less polluted one. That is at the core of environment justice movement. Moreover, poor people are more exposed to pollutants at work. Populations with less wealth are more likely to be employed in dirtier occupations and may also be more likely to be exposed to pollutants indoors from heating and cooking. That may be due to the low and less prestigious position their generally occupied. The heterogeneity of exposure over space varies by pollutant type. Fine particles are distributed fairly homogeneously over large urban areas due mostly to the contribution of small, long-range transport particles (O'Neill et al., 2003). Secondly, at a given level of exposition, rich communities have more prevention than poor. In fact, because their parents are poor, some children do not have access to immunization against illness caused or conveyed by air pollution such as meningitis. Poor communities may also lack access to stores that sell fresh fruits and vegetables or the income to buy them, resulting in reduced intake of antioxidant vitamins that can protect against adverse consequences of air pollution exposure (Romieu et al., 1998; O'Neill et al., 2003). Another way of prevention is to respect certain rules of hygiene. For example, protection of foods by covering them and the purchase of packaged products may reduce the health consequences of exposure. But these rules are more respected by the rich than the poor because of education and financial reasons. This differential prevention deepens inequalities in health caused by pollution since it mitigates the consequences for the wealthier. Finally, differential access to medical care (because of inequalities in access to health insurance) is another fact explaining inequalities in the health effect of air pollution. Indeed, poor people may not have the appropriate prescription for a respiratory condition such as asthma. Medication can alleviate symptoms aggravated by pollution exposure, and more consistent use of corticosteroids lowers baseline inflammation, potentially lowering responsiveness to pro-inflammatory pollutants (O'Neill et al., 2003). All that arguments increase the vulnerability of income disadvantaged population as compare to the richest. Makri & Stilianakis (2008) identify and evaluate information on population characteristics associated with vulnerability to ambient air pollution from a risk analysis perspective and based on available evidence. They found higher risks for foetuses and children, the elderly, and persons with pre-existing diseases. They also found that epidemiologic evidence of higher risks for racial minorities and social economically disadvantaged populations may be partly related to physiological capacity due to pre-existing diseases as well as health status. Charafeddine & Boden (2008) showed that income inequality plays a modifier role in the association between general self-reported health and particulate pollution. They hypothesize that individuals living in states with lower income inequality are significantly more likely to report fair or poor health if they lived in counties where particulate pollution is high. But, their results contradict their hypothesis.

In countries with good institutions, these disparities in health effect of air pollution could be mitigated. Institutions are understood here as democratic principles, such as regular elections, universal suffrage, representation, one person–one vote, multiparty competition, and civil liberties. Thus, good institutions might produce competition for popular support among leaders who are trying to conserve or win elected office. Democratic institutions might therefore reduce health effect of pollution of the poor through their general impact on universal health policy issues, such as universal access to high quality services and universal health insurance and accessible programs. Good institutions may in addition, provide information and advices about hygiene, good health practice, and other knowledge useful for the population in general, and the poorest in particular. Political institutions could also alleviate social disparities and income inequalities that results from greater political voice and participation. Finally, governments are likely to build infrastructures (road, hospital) that could reduce air pollution or its effect for the poor. By contrast, authoritarian regimes prevent human development, since its improvement mobilizes citizens to advocate for greater participation and more resources (Ruger, 2005).

Figure 1 depicts the inter quintiles distribution of mortality rates among regions (top graphs) as well as pollution level (bottom left) and institutional quality (bottom right). From this figure we can notice that mortality rates are more unequally distributed in Sub Saharan Africa (SSA) and South Asia (SA) than other region.

Figure 1: Distributions of Mortality rates and its link to pollution and institution by region



Source: Construction of author

These regions are also those with more Particulate Matter (PM10) emission. Middle East and North America (MENA) and East Asia and Pacific (EAP) also experience high pollution level, but inter quintiles health inequality is not very large. This may be due to the fact they have the best political institutions. This statistically shows that there is a link between health inequality, air pollution and political institutions.

4. Empirical design

a. Estimation methodology

The object of this article is to evaluate the effect of air pollution on income related health inequalities and the role of political institutions in mitigating such impact. For this purpose, three econometric models are successively estimated:

The first equation assesses the effect of air pollution on health inequality between countries, while controlling for other potential determinants of health outcomes. Based on some existing empirical works (Gwatkin et al., 2007; Berthelemy & Seban, 2009; white et al., 2003), the following model is specified:

$$health_{ijt} = X'_{ijt}\beta + \delta environment_{jt} + \mu_i + \varepsilon_{ijt} \quad (4.1)$$

Where, the variable $health_{ijt}$ represents the health outcomes (infant and child mortality rates) of the i^{th} quintile in country j in the year t. *environment* represents the variable of air pollution (sulphur dioxide emission per capita and particulate matter) and X is the vector of control variables (mother education, gross domestic product per capita, immunization rate against DPT, fertility rate, population density and the percentage of urban population). μ_i represents the quintile fixed effect and ε_{ijt} is the error terms. In this model, the coefficient of the environmental variable (δ) is of special interest. We expect a positive coefficient since this expresses the deterioration of population health caused by an increasing in environment pollution (marginal effect).

This equation is estimated with the ordinary least squares since we do not expect any potential source of endogeneity of our variable of interest (environment) that may lead to biased estimate of δ. Indeed, three sources of endogeneity are generally pointed out in the literature. Endogeneity may firstly be caused by the reverse causality between the variable of interest and the dependent variable. In our model, this is not a problem since we do not expect any mechanism through which population health may affect environment quality. One could suppose that health may impact environment through its effect on income and development level. Even though this argument seems less relevant, it can not affect our identification strategy since we control for development level.

Another source of endogeneity is omitted variables bias. This problem occurs when there is a third variable, which could simultaneously affect the environment quality and population health. In our model we control for all potential variables in this sort to avoid this problem.

Finally, endogeneity may be caused by measurement error. We do not suspect any error in the measure of our variable of interest.

In order to assess the heterogeneity in the effect of pollution on health within population, we add the interactions terms of quintile dummies and environmental variables and we obtain the following model:

$$health_{ijt} = X'_{ijt}\beta + \delta environment_{jt} + \sum_{i=2}^{5} \lambda_i (environment_{jt} * \mu_i) + \mu_i + \varepsilon_{ijt} \qquad (4.2)$$

In this model the marginal effect of air pollution on quintile i^{th}'s health outcomes is: $\frac{\partial(health_i)}{\partial(environment)} = \delta + \lambda_i$. We expect a higher impact of environment degradation on poor income quintile as compare to richer ones ($\lambda_2 > \lambda_3 > \lambda_4 > \lambda_5$) and environment quality may be considered as a determinant of income related health inequality.

Finally, we assess whether political institutions may mitigate this gap in the health effect of environment among poor and rich income classes. For this aim, we include in equation (3.2) the interaction term of environment, quintile dummies and institution variable, the interaction term of environment and institution variable, and the interaction term of institution and quintile dummies. The third model can be written as follows:

$$\begin{aligned} health_{ijt} = {} & X'_{ijt}\beta + \delta environment_{jt} + \sum_{i=2}^{5} \lambda_i (environment_{jt} * \mu_i) + \sum_{i=2}^{5} \varphi_i (institution_{jt} * \mu_i) \\ & + \psi (environment_{jt} * institution) + \sum_{i=2}^{5} \gamma_i (environment_{jt} * institution * \mu_i) + \mu_i + \varepsilon_{ijt} \end{aligned} \qquad (4.3)$$

Where, *institution* denotes political institution variables. The marginal effect of environment on the health outcomes of quintile i becomes: $\frac{\partial(health_i)}{\partial(environment)} = \delta + \lambda_i + (\psi + \gamma_i) * institution$.

This marginal effect depends on institutions quality, and its effect is given by: $\frac{\partial^2(health_i)}{\partial(environment)\partial(institution)} = \psi + \gamma_i$. Political institutions alleviate the disparities in the health effect of environment if γ is higher for rich income classes as compare to poor income quintiles, namely, $\gamma_2 < \gamma_3 < \gamma_4 < \gamma_5$.

Like the first equation (4.1), equations (4.2) and (4.3) are estimated with ordinary least squares and we make a cluster for each country and all variables are expressed in natural logarithm.

b. Data and variables

In this article, we use data from different sources and largely utilized in health economics literature.

Health outcomes: Data on health variables are taken from the study leaded by Gwatkin *and al.* (2007) on Health, Nutrition and Population in 56 developing countries, and all the data are disaggregated by income quintiles. In this database, more than half of the countries are African. The report of Gwatkin *et al.* (2007) is based on data drawn from several demographic and health surveys (DHS) conducted in these countries. These surveys target especially maternal and child health with a standardized questionnaire. Data also include socioeconomic variables like mother education for each quintile.

The report includes several indicators of health status and utilization of health services. In this paper, we are only interested in infant and under five mortality rates. These data have already been used in the literature by Fay et al. (2005), Ravallion (2007), McGillivray et al. (2008) and Berthelemy & Seban (2009). We use the logistic form of mortality rates.[2] Table 1 presents important statistics of health, education and fertility indicators. This table points out

[2] The mortality indicators are limited asymptotically, and an increase in this indicator does not represent the same performance when its initial level is weak or high, the best functional form to examine is that where the variable is expressed as a logit (Grigoriou 2005).

the large disparities among income classes in favor of rich people for all these variables. Figure 2 confirms this inequality for mortality rates.

Table 1. Summary Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Full sample					
Infant mortality (a)	380	72.13	33.75	11.90	187.70
Child mortality (b)	380	113.80	67.00	14.20	354.90
Fertility rate (c)	380	4.55	1.80	1.20	8.50
Female educational attainment (d)	380	50.44	31.94	0.50	99.80
Poorest quintile (by an "asset index")					
Infant mortality (a)	76	86.88	31.32	32.00	187.70
Child mortality (b)	76	140.08	62.82	39.10	297.90
Fertility rate (c)	76	5.92	1.48	2.20	8.50
Female educational attainment (d)	76	29.15	25.98	0.50	98.70
Second quintile					
Infant mortality (a)	76	82.62	32.71	23.80	152.30
Child mortality (b)	76	132.33	69.25	27.30	354.90
Fertility rate (c)	76	5.14	1.55	1.80	8.20
Female educational attainment (d)	76	39.24	29.75	1.00	99.50
Third quintile					
Infant mortality (a)	76	75.91	34.14	19.70	157.20
Child mortality (b)	76	120.08	69.44	23.50	348.30
Fertility rate (c)	76	4.68	1.65	1.40	7.80
Female educational attainment (d)	76	48.38	30.98	1.50	99.80
Fourth quintile					
Infant mortality (a)	76	65.64	32.17	11.90	142.00
Child mortality (b)	76	102.63	64.63	14.20	314.90
Fertility rate (c)	76	4.02	1.61	1.50	7.20
Female educational attainment (d)	76	59.09	29.71	4.80	99.60
Richest quintile					
Infant mortality (a)	76	49.58	24.51	13.80	97.20
Child mortality (b)	76	73.88	45.93	15.80	183.70
Fertility rate (c)	76	2.96	1.15	1.20	6.20
Female educational attainment (d)	76	76.34	20.13	27.00	99.80

Notes :

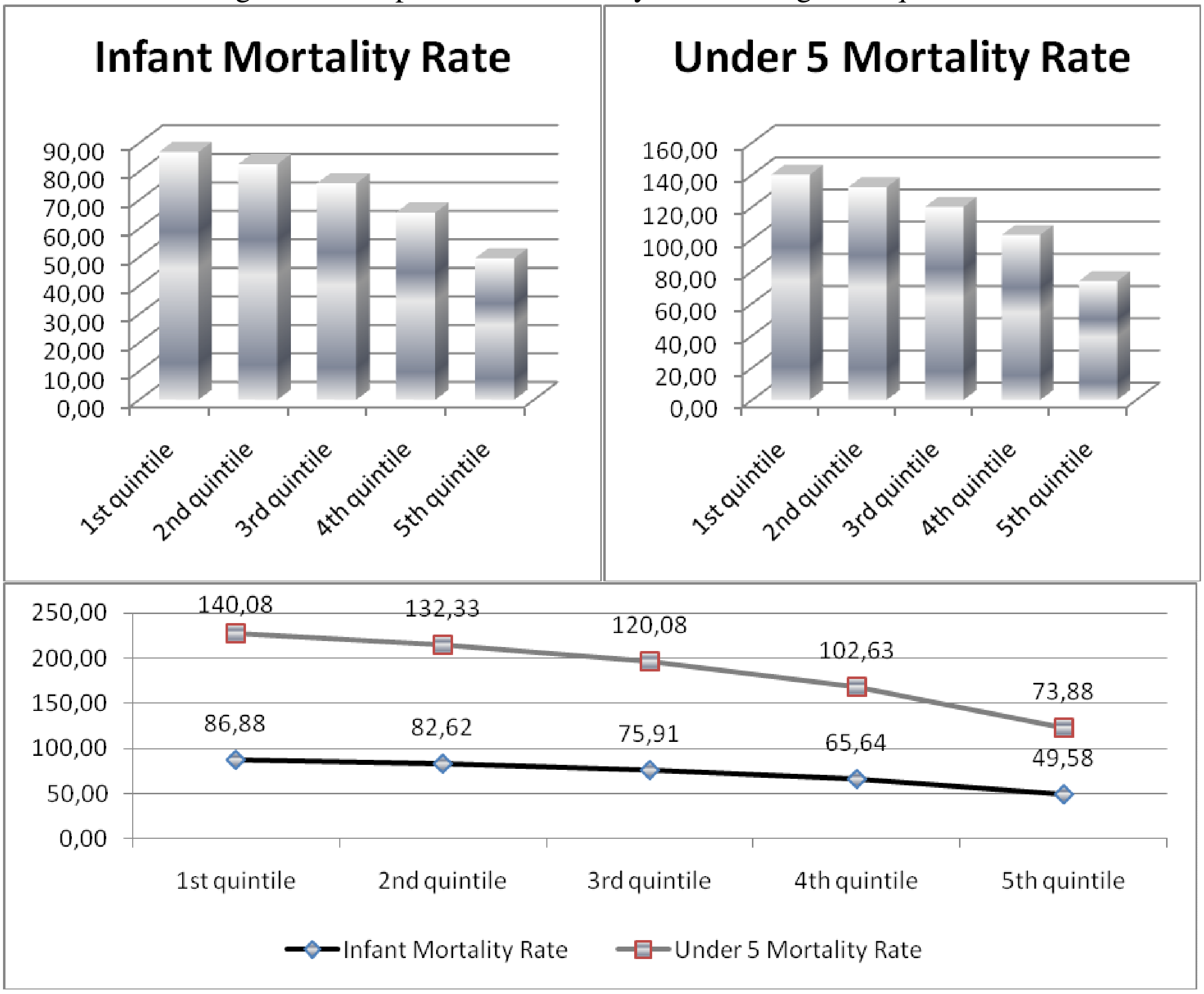
(a) Infant mortality: number of deaths to children under twelve months of age per 1,000 live births, based on experience during the ten years before the survey.

(b) Child mortality: number of deaths to children under five years of age per 1,000 live births, based on experience during the ten years before the survey.

(d) Fertility rate: average number of births a woman could expect to have during her lifetime if she followed the levels of fertility currently observed at every age. The TFR is calculated as the sum of average annual age specific fertility rates for all reproductive age groups (usually 15-49 years) in the three years before the survey.

(c) Female educational attainment: percent of women aged 15-49 years who had completed the fifth grade.

Figure 2: Comparison of mortality rates among asset quintiles



Source: Author's construction with data from Gwatkin et al. (2007)

Environmental quality variable: Air pollution is represented in this article by two indicators. The first is sulphur dioxide emission per capita (SO_2) taken from the database compiled by stern (2005) and used in many papers (De Melo et al., 2008). The second environmental indicator is particulate matter less than 10 µm aerodynamic diameter (PM10)[3] taken from World Development Indicator 2007 (WDI 2007).

Institution indicators: In economic literature, there are many sources of institution data. Here, we used indicators compiled by "International Country Risk Guide" (ICRG) and freedom house (corruption, military in politics, bureaucracy quality, law and order, democracy accountability and internal conflict indices for ICRG and freedom status index for freedom

[3] See Dockery (2009) for a large explanation of particulate air pollution.

house). The ICRG model for forecasting political risk was created in 1980 by the editors of International Reports, a weekly newsletter on international finance and economics. They produce a comprehensive system that enables various types of risk to be measured and compared between countries. The system is based on a set of components for political risk. Each component is assigned a maximum numerical value (risk points), with the highest number of points indicating the lowest potential risk for that component and the lowest number (0) indicating the highest potential risk. Government Stability index is an assessment both of the government's ability to carry out its declared program(s), and its ability to stay in office. The risk rating assigned is the sum of three subcomponents (Government Unity, Legislative Strength and Popular Support).

Corruption index is an assessment of corruption within the political system. Such corruption is a threat to foreign investment for several reasons: it distorts the economic and financial environment; it reduces the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability; and, last but not least, introduces an inherent instability into the political process.

The institutional strength and quality of the bureaucracy is another shock absorber that tends to minimize revisions of policy when governments change. Therefore, high points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. In these low-risk countries, the bureaucracy tends to be somewhat autonomous from political pressure and to have an established mechanism for recruitment and training. Countries that lack the cushioning effect of a strong bureaucracy receive low points because a change in government tends to be traumatic in terms of policy formulation and day-to-day administrative functions.

The military is not elected by anyone. Therefore, its involvement in politics is a diminution of democratic accountability. However, it also has other significant implications.

Democracy Accountability is a measure of how responsive government is to its people, on the basis that the less responsive it is, the more likely it is that the government will fall, peacefully in a democratic society, but possibly violently in a non-democratic one. The points in this component are awarded on the basis of the type of governance enjoyed by the country in question.

Law and Order are assessed separately. The Law sub-component is an assessment of the strength and impartiality of the legal system, while the Order sub-component is an assessment of popular observance of the law.

Internal Conflict is an assessment of political violence in the country and its actual or potential impact on governance. The highest rating is given to those countries where there is no armed or civil opposition to the government and the government does not indulge in arbitrary violence, direct or indirect, against its own people. The lowest rating is given to a country embroiled in an on-going civil war. The risk rating assigned is the sum of three subcomponents (Civil War/Coup Threat, Terrorism/Political Violence and Civil Disorder).

Other explanatory variables: As variables of control, we use several indicators. Schooling in the population is represented by mother education. Data about this indicator are taken from Gwatkin et al. (2007). We also control for Gross Domestic Product (GDP) per capita, immunization rate against DPT, fertility rate, population density and the percentage of urban population, all taken from WDI (2007). Finally, year and quintile fixed effects dummies are used and we make a cluster for each country, given data availability. Table 1 displays the characteristics of health and education data for each quintile while table A1 summarizes the characteristics, and sources of each indicator used in this paper.

5. Results

a. *impact of air pollution on inter countries health inequality*

In this subsection, we access the effect of air pollution on health inequality between countries. More precisely, this part presents the results obtained from the estimation of equation (4.1). These results are summarized in table 2, with logit of infant and under five mortality rates as dependent variables, and sulphur dioxide and particulate emissions as environmental variables.

Table 2. Impact of air pollution on health inequalities between countries

	Dependent variables			
	(1)	(2)	(3)	(4)
independent variables	child mortality	infant mortality	child mortality	infant mortality
Sulphur dioxide emission (SO2)	0.0861**	0.0695**		
	(2.610)	(2.692)		
Particulate Matter (PM10)			0.125**	0.127**
			(2.092)	(2.254)
fertility rate	0.521***	0.342***	0.627***	0.451***
	(5.000)	(3.233)	(5.125)	(3.530)
schooling	-0.0661	-0.0616	-0.0211	-0.0155
	(-1.615)	(-1.564)	(-0.544)	(-0.430)
immunization rate	-0.673***	-0.499***	-0.656***	-0.496***
	(-4.412)	(-3.611)	(-4.069)	(-3.401)
institution quality	0.0329	0.0396	0.0279	0.0346
	(0.993)	(1.321)	(0.620)	(0.899)
GDP per capita	-0.358***	-0.234***	-0.304***	-0.186**
	(-6.372)	(-4.134)	(-4.182)	(-2.649)
urban population	-0.0946	-0.0950	-0.0381	-0.0409
	(-0.908)	(-0.847)	(-0.374)	(-0.381)
population density	0.0115	0.0340	-0.0300	0.000896
	(0.390)	(1.269)	(-1.215)	(0.0355)
Constant	3.678***	1.682**	1.173	-0.556
	(4.267)	(2.234)	(1.274)	(-0.612)
year dummies	yes	yes	yes	yes
quintile dummies	yes	yes	yes	yes
Observations	300	300	330	330
R-squared	0.87	0.78	0.86	0.79

***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

Regarding the impact of our variables of interest, we find that the elasticity of infant and child mortality rates with respect to environmental variables is positive and statistically significant for each health outcome and each pollution variable. These coefficients indicate that environmental degradation worsens population health outcomes and explains in part health inequalities between countries. These results are in conformity with the literature on this topic as well as our theoretical hypothesis. Our important variables of control also present the expected signs and are statistically significant. Indeed, increasing in Gross Domestic Product per capita (GDP), mother education and immunization rate improve significantly health outcomes while fertility rate degrades them.

b. Heterogeneity in the health effect of air pollution (intra country inequalities)

In the previous subsection, we found that pollution is in part responsible to health inequality between countries. This section extends these results and explores whether environmental degradation may contribute to within country income related health inequalities. It presents the results obtained from the estimation of equation (4.2) and these results are summarized in table 3. In this table, the coefficients of interest are those of the interaction terms of environmental variables and quintile dummies (λ_i).

These coefficients are higher for poor quintiles as compare to those of richest quintiles. In addition, they are negative and statistically significant for richest quintiles and not significant for poorest quintiles. These results show that, environmental degradation degrades more the health outcomes of poorest quintiles than it worsens those of the richest quintiles. This heterogeneity in the health effect of air pollution increases income related health inequality within country. These results are in conformity with our theoretical hypothesis and arguments. Besides these findings, all the variables already analysed in previous subsection present the correct signs and are statistically significant.

Table 3. Impact of air pollution on health inequalities within countries

	Dependent variables			
	Sulphur dioxide emission (SO2)		Particulate Matter (PM10)	
	(1)	(2)	(3)	(4)
Independent variables	Child mortality	Inf. mortality	Child mortality	Inf. mortality
air pollution	0.129***	0.116***	0.208**	0.187**
	(3.395)	(3.459)	(2.352)	(2.238)
(air pollution)x(quintile 2)	-0.0321	-0.0209	-0.0176	-0.0181
	(-1.307)	(-0.969)	(-0.412)	(-0.426)
(air pollution)x(quintile 3)	-0.0479**	-0.0592**	-0.0511	-0.0394
	(-2.021)	(-2.268)	(-0.978)	(-0.694)
(air pollution)x(quintile 4)	-0.0549*	-0.0591	-0.0979	-0.0794
	(-1.938)	(-1.567)	(-1.278)	(-0.938)
(air pollution)x(quintile 5)	-0.0823*	-0.0934*	-0.192**	-0.128
	(-1.706)	(-1.680)	(-2.256)	(-1.514)
fertility rate	0.505***	0.323***	0.665***	0.478***
	(4.884)	(3.063)	(5.086)	(3.500)
schooling	-0.0776*	-0.0754*	-0.000414	-0.00177
	(-1.848)	(-1.928)	(-0.00939)	(-0.0425)
immunization rate	-0.658***	-0.481***	-0.680***	-0.512***
	(-4.337)	(-3.571)	(-4.204)	(-3.470)
institution quality	0.0321	0.0387	0.0290	0.0353
	(0.956)	(1.277)	(0.639)	(0.904)
GDP per capita	-0.357***	-0.232***	-0.303***	-0.185**
	(-6.325)	(-4.133)	(-4.095)	(-2.586)
urban population	-0.0978	-0.0988	-0.0313	-0.0361
	(-0.948)	(-0.893)	(-0.302)	(-0.329)
population density	0.00958	0.0316	-0.0264	0.00340
	(0.329)	(1.202)	(-1.028)	(0.129)
Constant	4.242***	2.286***	0.740	-0.874
	(4.871)	(2.900)	(0.737)	(-0.866)
year dummies	yes	yes	yes	yes
quintile dummies	yes	yes	yes	yes
Observations	300	300	330	330
R-squared	0.87	0.78	0.87	0.79

***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

c. *Roles of political institutions in the health inequality effect of pollution*

We have previously found that pollution is harmful for population health and the poorest income classes are those that suffer more from this effect. This section is devoted to the roles played by political institutions regarding this effect of air pollution on health inequality. It shows the results obtained from the estimation of equation (4.3) and the findings are presented in table 4.

In this table, we are interested by the coefficients of the interaction terms of environmental variables, institutions and quintile dummies (γ_i). These coefficients are higher for richest quintiles than poorest quintiles. That result demonstrates that good political institutions mitigate more the health effect of air pollution for the poorest quintiles than they do for richest income classes. We can conclude that political institutions contribute to reduce the health inequalities created by environmental degradation by mitigating its impact on the poor.

To test the robustness of our result to the choice of institutional indicator, we replace our institutional variable (military in politics) by successively bureaucracy quality, corruption, law and order, democracy accountability, internal conflict, and freedom status indices. The results obtained are presented in Table A6 and they remain unchanged, namely, the coefficients of the interaction terms of environmental variables, institutions and quintile dummies (γ_i) are higher for richest income quintiles as compare to poorest ones.

Table 4. Social protection role of political institutions

	Dependent variable			
	Sulphur dioxide emission (SO2)		Particulate Matter (PM10)	
	(1)	(2)	(3)	(4)
Independent variables	Inf. mortality	Child mortality	Inf. mortality	Child mortality
air pollution	0.280***	0.319***	0.0718	0.0963
	(2.996)	(3.086)	(0.467)	(0.558)
(air pollution)x(quintile 2)	0.0102	0.0116	0.129	0.156
	(0.180)	(0.232)	(1.431)	(1.599)
(air pollution)x(quintile 3)	-0.140	-0.109	0.0995	0.125
	(-1.596)	(-1.418)	(1.022)	(1.307)
(air pollution)x(quintile 4)	-0.107	-0.107	0.0323	0.0447
	(-1.157)	(-1.307)	(0.220)	(0.336)
(air pollution)x(quintile 5)	-0.290***	-0.281***	0.0266	-0.00222
	(-3.090)	(-3.085)	(0.229)	(-0.0189)
(institution)x(quintile 2)	-0.117	-0.162	0.241*	0.287**
	(-0.557)	(-0.788)	(1.758)	(2.072)
(institution)x(quintile 3)	0.272	0.201	0.217	0.282*
	(1.009)	(0.829)	(1.386)	(1.903)
(institution)x(quintile 4)	0.146	0.162	0.162	0.222
	(0.542)	(0.645)	(0.621)	(0.939)
(institution)x(quintile 5)	0.664**	0.675**	0.219	0.285
	(2.282)	(2.265)	(0.908)	(1.209)
(institution)x(air pollution)	-0.0388**	-0.0449**	0.0401	0.0396
	(-2.191)	(-2.274)	(0.749)	(0.685)
(institution)x(air pollution)x(quintile 2)	-0.00852	-0.0121	-0.0585**	-0.0688**
	(-0.500)	(-0.719)	(-2.033)	(-2.255)
(institution)x(air pollution)x(quintile 3)	0.0236	0.0179	-0.0568	-0.0710**
	(1.142)	(0.957)	(-1.636)	(-2.120)
(institution)x(air pollution)x(quintile 4)	0.0139	0.0144	-0.0438	-0.0551
	(0.684)	(0.736)	(-0.766)	(-1.047)
(institution)x(air pollution)x(quintile 5)	0.0543**	0.0550**	-0.0581	-0.0730
	(2.532)	(2.478)	(-1.095)	(-1.386)
fertility rate	0.328***	0.504***	0.471***	0.661***
	(3.035)	(4.552)	(3.601)	(5.274)
schooling	-0.107***	-0.107***	-0.0261	-0.0212
	(-2.904)	(-2.804)	(-0.613)	(-0.473)
immunization rate	-0.538***	-0.732***	-0.542***	-0.724***
	(-4.374)	(-4.650)	(-4.176)	(-4.859)
GDP per capita	-0.241***	-0.371***	-0.179**	-0.299***
	(-4.560)	(-6.783)	(-2.411)	(-3.841)
institution quality	-0.434*	-0.518**	-0.110	-0.112
	(-1.945)	(-2.118)	(-0.455)	(-0.441)
urban population	-0.0944	-0.0953	-0.0272	-0.0177
	(-0.939)	(-1.016)	(-0.238)	(-0.157)
population density	0.0551*	0.0358	0.0137	-0.0141
	(1.765)	(1.047)	(0.487)	(-0.500)
Constant	4.588***	6.981***	-0.318	1.295
	(3.175)	(3.996)	(-0.289)	(1.052)
year dummies	yes	yes	yes	yes
quintile dummies	yes	yes	yes	yes
Observations	300	300	330	330
R-squared	0.80	0.88	0.79	0.87

***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

6. Robustness checks

In the previous section we showed that air pollution is more disastrous for poor people's health (poor income quintiles health) than that of rich people (rich income quintile), and therefore increases income related health inequality within population. On could argue that these results suffer from at least three drawbacks. First, because environmental variable is not disaggregated by asset quintile, we did not take into account country fixed effects and this could bias our results. The second problem also comes from the structure of our data. In fact, the dependent variables (health variables) are more disaggregated than the variables of interest (environment and institution variables), and that may downward-bias the standard deviations because of Moulton bias (Moulton, 1987 and 1990). Moulton (1990) demonstrated that if the disturbances are correlated within the groupings that are used to merge aggregated with micro data, the standard errors from Ordinary Least Squares (OLS) are seriously biased downward. Third, one could argue that we assessed the effect of environment on health inequality, but we did not use explicitly any health inequality indicator. To solve for this, we replace health indicator by the range, more precisely we use as alternative dependent variable the logarithmic form of the ratio of the first quintile of mortality rates to those of the fifth quintile. This indicator is largely used in the literature to measure health inequality (Wagstaff et al. 1991; Levine et al. 2001). That is, all the variables are expressed in country level.

$$health_{jt} = X'_{jt}\beta + \delta environment_{jt} + \mu_i + \varepsilon_{jt} \qquad (6.1)$$

The results obtained from the estimation of this equation with fixed effect are presented in table 5. The coefficients of environment indicators are positive and statistically significant showing that air pollution increases mortality gap between rich and poor asset groups in a given country, and this confirms our previous results.

Table 5: Effect of air pollution on health inequality

	Dependent variable: log of the Ratio of poorest quintile to richest quintile of infant mortality rate (Q1/Q5)	
VARIABLES	(1)	(2)
Sulphur dioxide emission (SO2)	0.0541***	
	(4.045)	
Particulate Matter (PM10)		0.968***
		(5.412)
fertility rate ratio (Q1/Q5)	0.838***	0.760***
	(8.662)	(3.411)
Schooling ratio (Q1/Q5)	1.086	3.883**
	(1.330)	(2.493)
Schooling	68.78***	-29.04
	(4.057)	(-1.550)
Institution quality	-0.159***	0.0720
	(-3.688)	(1.301)
GDP per capita	-4.016***	0.668
	(-8.938)	(1.597)
Immunization ratio (Q1/Q5)	3.294***	1.688*
	(11.45)	(1.690)
Constant	18.70***	-9.814***
	(7.569)	(-2.880)
Fixed effects	yes	yes
Quintiles dummy	yes	yes
Observations	60	66
R-squared	0.94	0.84

Note: ***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

To verify the role played by institutions quality in this effect of pollution on health inequality, we add to the previous equation the interaction term of environment and institutional variables and we obtain the following equation.

$$health_{jt} = X'_{jt}\beta + \delta environment_{jt} + \psi(environment_{jt} * institution) + \varepsilon_{jt} \quad (6.2)$$

We also estimate this equation with fixed effect and the results are summarized in table 6. The coefficients of environment indicators remain positive and statistically significant, and those of the interaction terms are negative and significant.

Table 6: Role of political institutions in effect of air pollution on health inequality

	Dependent variable: log of the Ratio of poorest quintile to richest quintile of infant mortality rate (Q1/Q5)			
VARIABLES	(1)	(2)	(3)	(4)
Sulphur dioxide emission (SO2)	0.371*	0.967***	1.100***	0.305***
	(1.991)	(22.92)	(5.070)	(5.538)
(Sulphur dioxide emission)x(institution)	-0.0783*	-0.286***	-0.265***	-0.0297***
	(-1.707)	(-21.10)	(-5.145)	(-5.442)
Institution quality	-1.193*	-4.066***	-4.054***	-0.422***
	(-1.965)	(-22.08)	(-5.565)	(-6.242)
fertility rate ratio (Q1/Q5)	1.188***	1.737***	0.820***	1.089***
	(4.454)	(39.10)	(11.23)	(10.87)
Schooling ratio (Q1/Q5)	1.601*	4.732***	0.612	1.809***
	(1.914)	(22.33)	(1.188)	(3.694)
Schooling	78.34***	39.00***	15.19	34.35***
	(5.885)	(13.63)	(1.504)	(4.555)
GDP per capita	-5.412***	-4.361***	-0.0215	-3.888***
	(-5.172)	(-40.11)	(-0.0559)	(-8.264)
Immunization ratio	4.205***	6.444***	2.572***	3.828***
	(6.187)	(38.85)	(17.13)	(13.25)
Constant	29.58***	28.92***	12.48***	21.92***
	(3.847)	(29.48)	(5.295)	(6.692)
Institution quality indicator	corruption index	Bureaucracy quality	law and order	internal conflict
Fixed effects	yes	yes	yes	yes
year dummies	yes	yes	yes	yes
Observations	60	60	60	60
R-squared	0.95	0.99	0.97	0.96

Note: ***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

These results confirm our previous findings, namely good political institutions contribute to reduce the health inequalities created by environmental degradation. However, as argue by Wagstaff et al. (1991), the range overlooks what is going on in the intermediate groups. The gap between the first and the fifth quintiles might, for example, remain unchanged, but the extent of inequality between the intermediate quintiles might well be diminishing (or increasing). In addition, it does not take into account the sizes of the indicators being compared. This can lead to misleading results when comparisons are performed over time or across countries.

This can be solved by using as health inequality indicator, the concentration index of mortality rates. This indicator is commonly used to represent health inequality, because of its affinity with the Gini coefficient, its visual representation by means of the Concentration Curve and the ease with which it can be decomposed. It can be calculated at individual level as well as socioeconomic group level (income quintile level). It cannot be lower than -1 and higher than 1. A negative (positive) value of the concentration index of mortality rates designates a more concentrated mortality within poor (rich) people. A zero value indicates an equal distribution of mortality according to income quintiles. As argue by Erreygers (2006), this indicator is far from perfect. The first criticism is from Wagstaff (2005). He argues that if the health variable is binary, the bounds of the Concentration Index depend upon the mean of the health variable. The bounds turn out to be much wider for populations with a low mean than for populations with a high mean. To address this issue, he proposes to divide the health Concentration Index by its upper bound. According to Erreygers (2006) Wagstaff procedure exaggerates the correction it applies to the index and to its bounds, and an alternative solution has been formulated originally by Wagstaff et al. (1991). This indicator called Generalized health Concentration Index is obtained by multiplying the health Concentration Index by the average health level.

We use in this section as alternative health inequality indicator in equations (6.1) and (6.2) the Generalized Concentration Index of mortality rates. The results obtained with fixed effects estimator are presented in Tables A3 and A4 in Appendix A. They remain similar to previous results.

7. Concluding remarks

This article extends economic literature on the association between environment and health by investigating the responsibility of air pollution in the explanation of health inequalities both between and within developing countries. It examines also the importance of the role played by good political institutions in this effect.

We argue that population belonging to poorest income quintiles are those likely to suffer more from environmental degradation, because they receive the highest exposure, and this exposure then exercises larger effects on their health than it does on the average population. Furthermore, richest communities have more prevention than poorest and have more access to medical care when they are sick from pollution.

In countries with good political institutions, this heterogeneity in the health effect of pollution may be mitigated since these institutions favour universal health policy issues, information and advices about hygiene, and health infrastructures building.

Globally, our econometric results corroborate these theoretical arguments and hypothesis about the positive association between air pollution and income related health inequalities. In addition, our empirical results confirm the significant role played by democratic institutions in protecting poor population from environmental degradation.

These important findings raise some policy implications. First, to be effective, health policies should not be based only on average health of a given population, but also on its distribution. In addition, differential distribution of health effects of pollution should be considered alongside differential distribution of the benefits related to the emission sources. Indeed, those who pollute more in a population, such as car ownership may compensate those who bear the adverse effect by paying a tax. Finally, improving political institutions is not only important for economic growth, but it is also essential for population wellbeing.

This study could be extended in many ways. Firstly, a limit of this work is doubtless the unavailability of environmental data varying across income quintiles. This kind of data takes into account the differential of exposure. Future works on this topic should solve for this and test our hypothesis with more accurate data. Researchers may also use other environmental and health indicators to verify our hypothesis. We focus only on developing countries. It will be interesting to extend our results by testing whether they may be generalized for developed countries or compare them across different geographical regions.

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APPENDICES A.

Table A1. Data characteristics and sources

variables	characteristics	sources
infant mortality rate	number of deaths to children under twelve months of age per 1,000 live births, based on experience during the ten years before the survey.	Gwatkin et al. (2007)
child mortality rate	number of deaths to children under five years of age per 1,000 live births, based on experience during the ten years before the survey.	Gwatkin et al. (2007)
Sulphur dioxide emission (SO2)	sulphur dioxide emission	Stern (2005)
Particulate Matter (PM10)	particulate matter less than 10 µm aerodynamic diameter	WDI 2007
fertility rate	average number of births a woman could expect to have during her lifetime if she followed the levels of fertility currently observed at every age.	Gwatkin et al. (2007)
schooling	percent of women aged 15-49 years who had completed the fifth grade.	Gwatkin et al. (2007)
immunization rate	immunization rate against DPT	WDI 2007
institution quality	corruption, bureaucracy quality, ethnic tension, military in politics, law and order, external conflict, democracy accountability, internal conflict and freedom status	"International Country Risk Guide" (ICRG) and freedom house
GDP per capita	Gross Domestic Product per capita	WDI 2007
urban population	Proportion of urban population	WDI 2007
population density	Population density	WDI 2007

Table A2: Descriptive Statistics of Important variables

Variables	mean	min	max	Coef. var.	N
Infant mortality rate	74,65	22,10	147,40	0,39	95
Under five mortality rate	118,60	25,70	302,60	0,51	95
Sulphur dioxide emission (SO2)	239,86	0,53	2926,53	2,18	73
Particulate Matter (PM10)	77,99	7,30	225,86	0,62	82
urban population percentage	38,43	11,40	80,10	0,47	95
population density	110,19	1,85	1156,40	1,75	95
fertility rate	5,88	2,20	8,50	0,26	95
schooling	30,25	0,00	99,10	0,92	94
GDP per capita	815,38	120,11	4286,50	1,03	95
ICRG Bureaucracy quality	1,71	0,00	3,50	0,50	79
ICRG corruption index	2,54	0,00	4,00	0,36	79

Table A3: Effect of air pollution on health inequality

	Dependent variable: Generalized Concentration index of infant mortality rate	
VARIABLES	(1)	(2)
Sulphur dioxide emission (SO2)	-0.00121***	
	(-5.911)	
Particulate Matter (PM10)		-0.00883***
		(-4.525)
fertility rate ratio (Q1/Q5)	-0.00479***	-0.00815***
	(-2.983)	(-3.935)
schooling concentration index	-1.122	2.619***
	(-1.565)	(4.966)
schooling	-1.396***	0.0986
	(-7.114)	(0.523)
Institution quality	0.00446***	-0.00225***
	(4.148)	(-3.166)
GDP per capita	0.0732***	-0.00914
	(8.958)	(-1.622)
Immunization ratio (Q1/Q5)	-0.0122***	0.0135
	(-3.754)	(1.477)
Constant	-0.390***	0.0650
	(-9.511)	(1.596)
Fixed effects	yes	yes
year dummies	yes	yes
Observations	60	66
R-squared	0.97	0.77

Note: ***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

Table A4: Role of political institutions in effect of air pollution on health inequality

VARIABLES	Dependent variable: Generalized Concentration index of infant mortality rate			
	(1)	(2)	(3)	(4)
Sulphur dioxide emission (SO2)	-0.00671***	-0.00798***	-0.0285***	-0.00414***
	(-37.62)	(-70.49)	(-14.90)	(-36.68)
(Sulphur dioxide emission)x(institution)	0.00140***	0.00242***	0.00695***	0.000398***
	(29.64)	(65.79)	(14.66)	(38.15)
Institution quality	0.0220***	0.0331***	0.107***	0.00641***
	(39.67)	(66.75)	(14.36)	(39.77)
fertility rate ratio (Q1/Q5)	-0.0115***	-0.0133***	-0.00362***	-0.0105***
	(-32.50)	(-180.1)	(-4.670)	(-64.31)
schooling concentration index	-0.416***	0.344***	-0.444***	-0.0460***
	(-4.366)	(80.10)	(-6.109)	(-3.082)
schooling	-1.455***	-0.626***	0.209***	-0.413***
	(-46.64)	(-91.34)	(4.103)	(-21.31)
GDP per capita	0.0912***	0.0539***	-0.0372***	0.0621***
	(78.93)	(176.8)	(-5.696)	(41.23)
Immunization ratio (Q1/Q5)	-0.0237***	-0.0230***	0.00338**	-0.0191***
	(-42.15)	(-51.19)	(2.444)	(-26.11)
Constant	-0.555***	-0.389***	-0.171***	-0.406***
	(-77.07)	(-146.1)	(-8.083)	(-38.31)
Institution quality indicator	corruption index	Bureaucracy quality	law and order	internal conflict
Fixed effects	yes	yes	yes	yes
year dummies	yes	yes	yes	yes
Observations	60	60	60	60
R-squared	0.98	0.98	0.99	0.99

Note: ***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.

Table A5. list of countries in the regression sample

country name	Year		country name	Year
Armenia	2000		Madagascar	1997
Benin	1996, 2001		Mali	1995, 2001
Burkina Faso	1992, 1998, 2003		Mozambique	1997, 2003
Bangladesh	1996, 1999, 2004		Mauritania	2000
Bolivia	1998, 2003		Malawi	1992, 2000
Brazil	1996		Namibia	1992, 2000
Central African Republic	1994		Niger	1998
Côte d'Ivoire	1994		Nigeria	1990, 2003
Cameroon	1991, 1998, 2004		Nicaragua	1997, 2001
Colombia	1995, 2000, 2005		Nepal	1996, 2001
Comoros	1996		Pakistan	1990
Dominican Republic	1996, 2002		Peru	1996, 2000
Egypt	1995, 2000		Philippines	1998, 2003
Eritrea	1995		Paraguay	1990
Ethiopia	2000		Rwanda	2000
Gabon	2000		Senegal	1997
Ghana	1993, 1998, 2003		Chad	1996, 2004
Guinea	1999		Togo	1998
Guatemala	1995, 1998		Turkmenistan	2000
Haiti	1994, 2000		Turkey	1993, 1998
Indonesia	1997, 2002		Tanzania	1996, 1999, 2004
India	1992, 1998		Uganda	1995, 2000
Jordan	1997		Uzbekistan	1996
Kazakhstan	1995, 1999		Vietnam	1997, 2002
Kenya	1993, 1998, 2003		Yemen	1997
Kyrgyzstan	1997		South Africa	1998
Cambodia	2000		Zambia	1996, 2001
Morocco	1992, 2003		Zimbabwe	1994, 1999

Table A6. Robustness checks : Social protection role of political institutions.

	Dependent variables											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Independent variables	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.
air pollution	0.153**	0.153***	0.184**	0.196**	0.0339	0.0110	0.120*	0.114	0.0509	0.104	0.223**	0.259***
	(2.683)	(2.862)	(2.225)	(2.654)	(0.447)	(0.147)	(1.953)	(1.632)	(0.498)	(0.829)	(2.665)	(2.936)
(air pollution)x(quintile 2)	0.0341	0.0290	0.0596	0.0627*	0.0984***	0.0846**	0.0760**	0.0607*	0.119*	0.107	0.0602	0.00915
	(0.758)	(0.963)	(1.351)	(1.712)	(3.565)	(2.437)	(2.048)	(1.886)	(1.860)	(1.489)	(0.836)	(0.149)
(air pollution)x(quintile 3)	-0.0580	-0.0320	-0.0224	0.00145	0.0447	0.0865*	-0.0640	-0.0332	-0.0908	-0.0568	-0.128*	-0.102*
	(-1.049)	(-0.621)	(-0.306)	(0.0244)	(0.801)	(1.877)	(-0.807)	(-0.500)	(-1.110)	(-0.798)	(-2.004)	(-1.772)
(air pollution)x(quintile 4)	-0.137*	-0.0948	-0.116	-0.0940	-0.0262	0.0497	-0.150**	-0.106*	-0.119	-0.119	-0.163*	-0.151*
	(-1.842)	(-1.293)	(-0.772)	(-0.795)	(-0.420)	(0.943)	(-2.152)	(-1.964)	(-1.146)	(-1.300)	(-1.905)	(-1.859)
(air pollution)x(quintile 5)	-0.245***	-0.181**	-0.234	-0.177	0.00118	0.0739	-0.116	-0.0857	-0.379***	-0.317***	-0.457***	-0.417***
	(-3.602)	(-2.444)	(-1.571)	(-1.365)	(0.00734)	(0.508)	(-0.759)	(-0.614)	(-3.361)	(-3.024)	(-4.204)	(-4.459)
(institution)x(quintile 2)	-0.355	-0.387***	-0.364**	-0.430***	-0.725***	-0.694***	-0.400***	-0.385**	-0.518**	-0.520*	-0.117	-0.0543
	(-1.542)	(-2.958)	(-2.369)	(-2.777)	(-4.960)	(-2.950)	(-2.907)	(-2.406)	(-2.121)	(-1.769)	(-1.013)	(-0.489)
(institution)x(quintile 3)	0.0590	-0.0332	-0.164	-0.221	-0.605*	-0.759***	0.00889	-0.0641	0.126	0.0423	0.115	0.0936
	(0.228)	(-0.141)	(-0.585)	(-0.975)	(-1.940)	(-3.107)	(0.0352)	(-0.302)	(0.438)	(0.163)	(1.250)	(1.074)
(institution)x(quintile 4)	0.623	0.370	0.264	0.182	-0.0138	-0.467	0.363	0.199	0.238	0.273	0.170	0.162
	(1.456)	(0.954)	(0.404)	(0.368)	(-0.0343)	(-1.523)	(1.403)	(0.972)	(0.627)	(0.866)	(1.328)	(1.350)
(institution)x(quintile 5)	1.124**	0.764*	0.644	0.434	-0.445	-0.813	0.0739	0.00179	1.080**	0.900**	0.559***	0.522***
	(2.631)	(1.832)	(0.917)	(0.725)	(-0.430)	(-0.882)	(0.126)	(0.00334)	(2.608)	(2.278)	(3.398)	(3.666)
(institution)x(air pollution)x(quintile 2)	-0.0252	-0.0265***	-0.024**	-0.0296**	-0.060***	-0.0584***	-0.0312***	-0.0298**	-0.0411**	-0.0406*	-0.0103	-0.00561
	(-1.531)	(-2.956)	(-2.077)	(-2.359)	(-4.785)	(-2.907)	(-2.805)	(-2.274)	(-2.186)	(-1.782)	(-1.142)	(-0.633)
(institution)x(air pollution)x(quintile 3)	0.0110	0.00482	-0.00615	-0.0102	-0.0507**	-0.0633***	0.00237	-0.00449	0.00855	0.00225	0.00746	0.00583
	(0.562)	(0.279)	(-0.296)	(-0.584)	(-2.057)	(-3.212)	(0.124)	(-0.277)	(0.413)	(0.120)	(1.077)	(0.850)
(institution)x(air pollution)x(quintile 4)	0.0563*	0.0380	0.0268	0.0203	-0.00539	-0.0410*	0.0300	0.0171	0.0161	0.0170	0.0115	0.0105
	(1.765)	(1.328)	(0.553)	(0.558)	(-0.180)	(-1.814)	(1.544)	(1.114)	(0.597)	(0.740)	(1.175)	(1.138)
(institution)x(air pollution)x(quintile 5)	0.0956***	0.0678**	0.0541	0.0377	-0.0326	-0.0649	0.00793	0.000878	0.0813***	0.0666**	0.0430***	0.0392***
	(3.081)	(2.261)	(1.006)	(0.827)	(-0.417)	(-0.927)	(0.177)	(0.0217)	(2.754)	(2.372)	(3.386)	(3.558)
(institution)x(air pollution)	-0.0188	-0.0147	-0.0279	-0.0274	0.0344	0.0507	-0.000535	0.00673	0.0192	0.00839	-0.0109	-0.0134
	(-0.644)	(-0.538)	(-1.044)	(-1.142)	(1.032)	(1.488)	(-0.0283)	(0.326)	(0.660)	(0.248)	(-1.373)	(-1.606)
fertility rate	0.353***	0.528***	0.336***	0.515***	0.419***	0.694***	0.338***	0.520***	0.342***	0.524***	0.360***	0.546***
	(3.085)	(4.843)	(3.108)	(4.938)	(3.540)	(5.686)	(2.937)	(4.565)	(2.977)	(4.807)	(3.542)	(5.887)
schooling	-0.0862**	-0.0859*	-0.0744*	-0.0765*	-0.0601*	-0.0747*	-0.0833**	-0.0863*	-0.0904**	-0.0864*	-0.0870**	-0.0853*

	Dependent variables											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Independent variables	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.	inf. mort.	child mort.
	(-2.119)	(-1.943)	(-1.891)	(-1.818)	(-1.680)	(-1.985)	(-2.035)	(-1.948)	(-2.092)	(-1.860)	(-2.114)	(-2.009)
immunization rate	-0.380***	-0.583***	-0.47***	-0.650***	-0.228*	-0.339**	-0.428***	-0.601***	-0.402***	-0.603***	-0.343**	-0.524***
	(-2.864)	(-3.780)	(-3.513)	(-4.293)	(-1.831)	(-2.243)	(-3.099)	(-3.808)	(-2.790)	(-3.541)	(-2.398)	(-3.173)
GDP per capita	-0.219***	-0.342***	-0.23***	-0.353***	-0.235***	-0.328***	-0.237***	-0.357***	-0.220***	-0.350***	-0.242***	-0.370***
	(-3.303)	(-4.851)	(-4.014)	(-6.142)	(-4.226)	(-5.305)	(-4.231)	(-6.093)	(-3.865)	(-5.953)	(-4.328)	(-6.719)
institution quality	-0.225	-0.154	-0.268	-0.266	0.395	0.599	0.0280	0.0887	0.249	0.0986	-0.180	-0.220*
	(-0.575)	(-0.420)	(-0.772)	(-0.882)	(0.886)	(1.340)	(0.113)	(0.329)	(0.581)	(0.198)	(-1.668)	(-1.988)
urban population	-0.104	-0.106	-0.102	-0.104	-0.0642	-0.0570	-0.0913	-0.0906	-0.101	-0.0939	-0.0918	-0.0887
	(-0.843)	(-0.896)	(-0.879)	(-0.952)	(-0.649)	(-0.574)	(-0.832)	(-0.842)	(-0.953)	(-0.942)	(-0.813)	(-0.825)
population density	0.0377	0.0153	0.0349	0.0132	0.0393	0.0377	0.0278	0.00991	0.0213	0.00474	0.0203	-0.00226
	(1.390)	(0.497)	(1.308)	(0.443)	(1.312)	(1.134)	(1.059)	(0.317)	(0.680)	(0.140)	(0.678)	(-0.0690)
Constant	2.240*	4.105***	2.953**	4.893***	-0.0392	0.726	2.121*	3.812***	1.201	3.752*	3.484**	5.803***
	(1.916)	(3.652)	(2.319)	(3.903)	(-0.0349)	(0.609)	(1.878)	(2.964)	(0.779)	(1.987)	(2.632)	(4.056)
Institution indicators	Bureaucracy quality		corruption index		freedom status		democracy accountability		law and order		internal conflict	
year dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
quintile dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	300	300	300	300	360	360	300	300	300	300	300	300
R-squared	0.80	0.88	0.79	0.87	0.74	0.84	0.79	0.87	0.79	0.87	0.79	0.87

***significant at 1%, **significant at 5%, *significant at 10%. t-statistics enter parenthesis.