UNIVERSITI PUTRA MALAYSIA

FACTORS AFFECTING THE ENVIRONMENT AND THEIR IMPACT ON PUBLIC HEALTH OUTCOMES IN AFRICA

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By

ALHAJI JIBRILLA ALIYU

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

March 2016

DEDICATIONS

This work is dedicated to Allah (S.W.T), Prophet Muhammad (S.A.W), my Parents and Family.

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Doctor of Philosophy.

FACTORS AFFECTING THE ENVIRONMENT AND THEIR IMPACT ON PUBLIC HEALTH OUTCOMES IN AFRICA

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March 2016

Chairperson : Associate Prof. Normaz Wana Ismail, PhD.
Faculty : Economics and Management

This thesis presents empirical studies on some important issues in African countries and aims to contribute to the literature on i) the environmental impacts of trade liberalization, ii) the effect of institutional quality on the cooperation to reduce global carbon dioxide (CO_2) across African countries and iii) the effect of air pollution on public health outcomes.

In the first objective, the study examines the role of trade liberalization as an important determinant of greenhouse gas emissions. Following related theoretical arguments, the study focuses on examining whether the changes in environmental pollutants emanating from freer trade across African countries are better explained by the differences in environmental regulations and/or the differences in physical capital endowments. The changes in production and trade-related greenhouse gas emissions are also decomposed into scale, technique and composition effects.

Using the generalized method of moment (GMM) estimation technique and by controlling other relevant factors, the study finds evidence that supports the factor endowment hypothesis for both PM_{10} and CO_2. However, there are no convincing evidence of pollution haven hypothesis for both pollutants. In addition, the study finds that trade openness has different scale, technique, composition and trade intensity effects on different types of pollutants analysed in this study. Specifically, the technique effect is greater than the scale effect for PM_{10}, whereas the technique effect is dominated by the scale effect for CO_2. The scale, technique and direct composition effects on both pollutants are found to be greater than the trade-induced composition effect.

The second objective investigates the effect of institutional quality on the cooperation of African countries to reduce global emissions of CO_2. Using the GMM estimation technique and by controlling for real per capita GDP, its growth rate and other conditional control variables, the study minimized the unexplained change in the

dependent variable. The results provide evidence for the significant effect of institutional quality on the growth rates of CO_2 emissions.

The third objective evaluates the effect of air pollution on the public health outcome in African countries. Specifically, by employing the GMM estimation technique, the study analyses the effect of air pollution on adult and child mortality rates. Regarding air pollution and adult mortality, the results show that an increase in the level of particulate air pollution have a significant effect on increasing adult mortality rates. This effect is found to differ across gender, but not statistically significant. The analysis also establishes a significant effect of particulate air pollution on infant and under-five mortality rates across the sample of African countries. However, this effect is also found to be statistically insignificant.

Finally, the findings from this thesis show that more openness would have more positive effect on PM_{10} compared to CO_2. However, more general, none of the two pollutants seems to increase steadily with economic progress. The findings also demonstrates that more commitment to improve political institutions (control of corruption, the rule of law and bureaucratic quality could promote self-interest in African countries to reduce global "concentration of greenhouse gas in the atmosphere". Also more elevated air pollution would lead to increasing mortality across African countries, irrespective of gender or demographic. This is in addition to a rising demand for healthcare services.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Iijazah Doktor Falsafah.

FAKTOR YANG MENJEJASKAN ALAM SEKITAR DAN IMPAKNYA TERHADAP HASIL KESIHATAN AWAM DI AFRIKA

Oleh

ALHAJI JIBRILLA ALIYU

Mac 2016

Pengerusi : Profesor Madya Normaz Wana Ismail, PhD.
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Tesis ini membentangkan kajian empirikal mengenai isu-isu penting di negara-negara Afrika dengan tujuan untuk menyumbang kepada literatur kajian berkaitan i) kesan liberalisasi perdagangan terhadap alam sekitar, ii) kesan kualiti institusi terhadap kerjasama untuk mengurangkan karbon dioksida (CO_2) global di negara-negara Afrika dan iii) kesan pencemaran udara terhadap hasil kesihatan awam di negara-negara Afrika.

Dalam objektif pertama, kajian ini didorong oleh hujah bahawa liberalisasi perdagangan boleh menjadi penentu penting pelepasan gas rumah hijau. Berdasarkan hujah teori yang berkaitan, fokus kajian adalah untuk mengkaji sama ada perubahan pencemaran alam sekitar akibat perdagangan bebas di seluruh negara-negara Afrika boleh dijelaskan dengan lebih baik oleh perbezaan undang-undang alam sekitar dan/atau perbezaan endowmen modal fizikal. Perubahan dalam pengeluaran dan pelepasan gas rumah hijau berkaitan perdagangan dipecahkan kepada kesan skala, teknik dan komposisi.

Dengan menggunakan kaedah penganggaran Generalized Method of Moments (GMM) dan mengawal faktor-faktor lain yang berkaitan, kajian mendapati bukti yang menyokong hipotesis endowmen faktor untuk kedua-dua PM_{10} dan CO_2. Walau bagaimanapun, tiada bukti meyakinkan yang menyokong hipotesis lindungan pencemaran untuk kedua-dua jenis pencemar. Di samping itu, kajian ini mendapati bahawa keterbukaan perdagangan mempunyai kesan-kesan skala, teknik, komposisi dan keamatan perdagangan yang berbeza terhadap jenis pencemar yang berbeza. Khususnya, kesan teknik adalah melebihi kesan skala bagi PM_{10}, manakala kesan teknik pula diatasi oleh kesan skala bagi CO_2. Kesan-kesan skala, teknik dan komposisi langsung adalah didapati lebih besar daripada kesan komposisi akibat perdagangan.

Objektif kedua mengkaji kesan kualiti institusi terhadap kerjasama negara-negara Afrika untuk mengurangkan pengeluaran global CO_2. Anggaran dilakukan menggunakan kaedah penganggaran GMM dan dengan mengawal KDNK sebenar per

kapita, kadar pertumbuhannya serta pemboleh ubah kawalan yang lain, kajian ini meminimumkan perubahan yang tidak dapat dijelaskan dalam pemboleh ubah bersandar. Keputusan kajian menunjukkan bukti kesan kualiti institusi yang ketara terhadap kadar pertumbuhan pengeluaran CO_2.

Objektif ketiga menilai kesan pencemaran udara terhadap hasil kesihatan awam di negara-negara Afrika. Khususnya, teknik GMM digunakan dalam kajian analisis kesan pencemaran udara terhadap kadar kematian orang dewasa dan kanak-kanak. Kajian kesan pencemaran udara terhadap kematian orang dewasa pula menunjukkan bahawa peningkatan tahap pencemaran zarah udara mempunyai kesan yang besar terhadap peningkatan kadar kematian orang dewasa. Kesan ini adalah berbeza antara jantina tetapi tidak signifikan dari segi statistik. Analisis ini juga menunjukkan kesan pencemaran zarah udara yang besar terhadap kadar kematian bayi dan kanak-kanak bawah lima tahun di seluruh sampel negara-negara Afrika. Walau bagaimanapun, kesan ini juga didapati tidak signifikan dari segi statistik.

Akhirnya, dapatan tesis ini menunjukkan bahawa sikap lebih terbuka akan memberikan kesan yang lebih positif kepada PM_{10} berbanding dengan CO_2. Walau bagaimanapun, secara yang lebih umum, tiada satu pun daripada kedua-dua bahan pencemar ini yang menunjukkan peningkatan seiring dengan kemajuan ekonomi. Dapatan kajian juga menunjukkan bahawa komitmen yang lebih besar untuk memajukan institusi politik (pengawalan rasuah, kedaulatan undang-undang dan kualiti birokrasi) boleh mempromosikan kepentingan bagi negara Afrika sendiri dalam usaha mengurangkan “kepekatan gas rumah hijau di atmosfera". Juga menyedari bahawa pencemaran udara yang lebih tinggi akan membawa kepada peningkatan kadar kematian di seluruh negara Afrika, tanpa mengira jantina atau demografi, sebagai tambahan kepada peningkatan permintaan bagi perkhidmatan penjagaan kesihatan.

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Lastly, I would like to thank my family for all their love and encouragement. For my parents who raised me with a love of knowledge and supported me in all my pursuits. And most of all for my loving, encouraging, supportive, and patient Wife Jamila, and Kids Abu Bakar Saddique (Haske) and Nur Nana Aisha whose endurance during all stages of this Ph.D. is unforgettable. Thank you.

I certify that a Thesis Examination Committee has met on 16 March 2016 to conduct the final examination of Alhaji Jibrilla Aliyu on his thesis entitled "Factors Affecting the Environment and their Impact on Public Health Outcomes in Africa" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of philosophy. The members of the supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

ACT	Antweiler, Copeland and Taylor
ADB	African Development Bank
CO_2	Carbon dioxide emissions
EKC	Environmental Kuznets Curve
FEH	Factor Endowment Hypothesis
GMM	Generalized-Method-of-Moments
H-O	Heckscher-Ohlin (theory)
ICRG	International Country Risk Guide
IID	Independently and Identically Distributed
IFAD	International Fund for Agricultural Development
GHGs	Greenhouse gases
KP	Kyoto protocol
LDCs	Less Developed Countries
NAFTA	North American Free Trade Agreement
OECD	Organization for Economic Co-operation and Development
PHH	Pollution Haven Hypothesis
PM10	Particulate matter 10 micrometers or less in diameter
PWT	Penn World table
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund (formerly known as United Nations International Children's Emergency Fund)
WDI	World development indicators
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Thesis preview

Globalisation has made it possible for African countries to open up their trade regimes, either regionally or multilaterally. This, eventually, has significantly facilitated and broadened their participation in the global trade, thus making them more integrated into the global economy (Fjeldsted, 2014; Hartzenberg & Maasdorp, 1998). More essentially, international trade is seen as a vital tool that facilitates transnational production networks organised by various Multinational Corporations and global competitiveness (Akyuz, 2005).

Furthermore, experience has shown that successful participation of a nation or a region in the global economy could lead towards attainment of higher economic progress, besides allowing its participants to increase the economic well-being of their citizens and achieving intense reductions in poverty prevalence (see Wade, 2004; Akyuz, 2005; Milanovic, 2002). Although freer trade could have a positive effect upon the economic progress of a country, some globalisation critics are consistently worried that it might facilitate the distribution of pollution across nations, which, unfortunately, causes global warming (Fankel, 2009).

Moreover, the common arguments of these critics are the negative implications of the globalisation process on the environment, particularly, with regard to the production and the consumption of 'externalities' that have antagonistic safety, health, and environmental consequences (Frankel, 2009; Callan & Thomas, 2010). In addition, although it has been expressed by some groups of environmental economists that all things being equal, openness to trade may have a beneficial effect of reducing pollution on the environment (Shafik et al., 1992; Cole, 2004), some have argued that the process, if unchecked, might lead to more greenhouse gas emissions and rapid resource depletion (Grossman & Krueger, 1991; Esty, 2001). Of particular concern is the potential effects that trade liberalisation may have on the environment across African countries whose environmental standards are relatively weak (Kranz, Börzel & Héritier, 2008; ADB, 2012).

In fact, some have blamed unhealthy political institutions, such as corruption among politicians/government officials, dishonesty among bureaucrats, and lack of respect for the rule of law, for weak environmental standards (Kaufman, & Wei, 1999; Fredriksson, List & Millimet, 2003; Fredriksson & Svensson, 2003; Infante & Smirnova, 2011). Hence, the presence of lax environmental/air quality standards poses fundamental threats to both human health and sustainable development across the African region (Page & Redclift, 2002).

Although, public health effects of poor air quality are not fully understood in African countries, air pollution has been linked with a wide range of public health consequences, including mortality (De Longueville, Hountondji, Henry & Ozer, 2010; Pickett & Bell, 2011). As one of the most fundamental needs, every African has a right to live in a clean environment (to breathe clean air). However, many African communities have been exposed to poor air quality in places that should be safe

(Rhefuess, 2006). Therefore, in order to aid policy makers in making the right choices that can minimise public health risk of poor air quality, this thesis looked into the effects of air pollution on public health outcomes across African countries.

In spite of lax environmental standards, there are signs of optimism for environmental sustainability across African countries. A number of countries have moved away from dictatorial rules and established democratic regimes. This has initiated the process of promoting good governance by strengthening the political institutions across the region (Page & Redclift, 2002; Affa'a-Mindzie, 2013). Moreover, by considering the commitment made by the countries within the region towards the betterment of institutions and good governance, they have been expected to take advantage of globalisation; not just to improve their technical capacity, but also to enhance environmental awareness, including its health consequences.

On top of that, the conventional wisdom in the area of environmental research tells us that more openness to trade may cause pollution to increase across African countries, which may, in turn, aggravate the health consequences of environmental/air pollution. This problem is likely to become more severe given the laxity of environmental regulations across the region. Nonetheless, inasmuch as domestic institutional quality affects policy decisions, evidence of its role and that of freer trade in determining environmental quality, alongside evidence of how poor air quality affects demographics (especially those that can have an influence on the economic productivity) across the continent, can trigger the willingness of policy makers to adopt effective environmental standards.

1.1.1 Distribution of income, trade intensity, institutional quality, and pollution levels in Africa

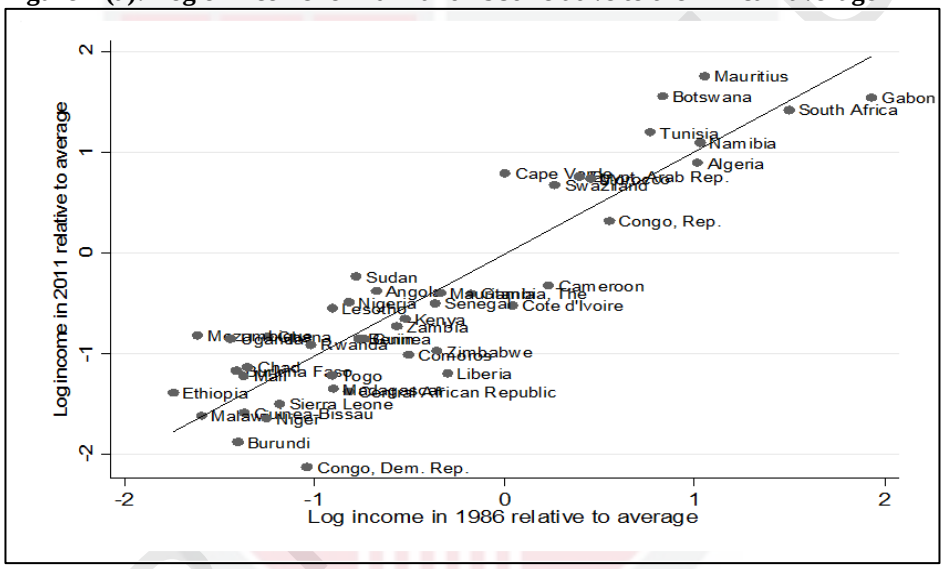
Available statistics from the World Bank classification of economies by income (2015) indicated that of the entire countries in Africa, two had been classified as upper income, nine as upper middle income, seventeen were lower middle income, and twenty six as low-income. Most of these countries are rich in natural resources and are known to be highly dependent upon exports of the primary product, though, the production structure of, particularly those within the upper-middle-income have considerably moved away from primary towards manufacturing-based production—partly due to the increasing importance of international trade (Collier & Venables, 2007). Moreover, the growing openness of the continent to the global market in recent years has further enabled many countries in the lower income group to diversify their export products, and especially, exports of manufactured goods, though, exports from the continent have remained mainly of primary nature (Samen, 2010).

Furthermore, exploitation of natural resources due to the rising demand for raw materials and industry inputs has been seen as the primary driver of environmental degradation (see Cronin & Pandya, 2009). While natural resource extraction in the continent could cause substantial damage to the environment, it might also hurt local habitats. Besides, it is also reasonable to expect that the ever increasing diversification through manufacturing activities would produce similar consequences as the expansion

of manufacturing activities across the continent, which may be associated with rising combustion of fossil fuels and increase of pollution (see Gessese, 2006) [1].

In fact, it is also clear from the preceding section that increase in economic activities and its possible impacts on the environment may significantly depend on the intensity of a nation's trade with the rest of the world, as well as the strength of its institutional quality (see, for example, Grossman & Krueger, 1995; Copeland & Taylor, 1995; Fredriksson & Svensson, 2003). While certainly the level of income for a country is not the only causal determinant of environmental quality, a number of researchers have revealed that low-income countries are more likely to experience lax environmental standards than those of high-income countries (Grossman & Krueger, 1995; Copeland & Taylor, 1995; Cole & Elliott, 2003).

Figure 1 (a): Log of income for 2011 and 1986 relative to the African average

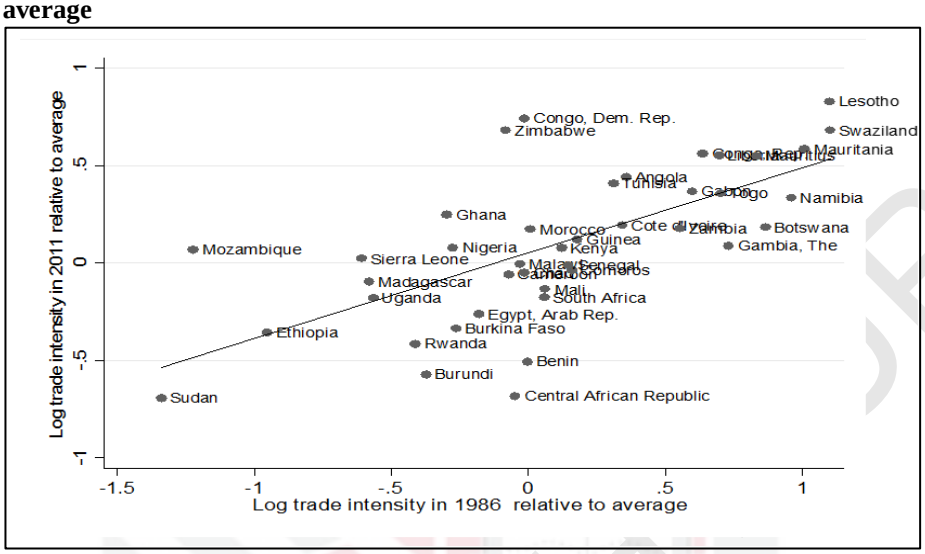


Source: Computed from the African development indicators (based on data from World Bank's WDI, 2013.

Figure 1 (a) depicts the country-specific income level relative to the African average in 2011 against its 1986 value and draws the 45-degree line for comparison. This scattered plots illustrates that Gabon, along with South Africa and Mauritius, was at one end of the distribution with the highest income level. Meanwhile, Democratic Republic of Congo, along with Burundi at the other extreme, displayed the lowest levels of income. It should be noted that although it may be thought that countries with higher levels of income tend to have more intensity of foreign trade due to more diversified production base, workers with the same human capital levels earn vastly different wages in different countries. A higher income nation may experience a lower degree of trade intensity because it has a relatively large economic size and citizens can purchase more goods and services locally (see Li & Cheng, 2015). Obviously, not all countries at the top northwest of figure 1 (a) appeared in the same position in figure 1 (b).

[1] See also Hübler, & Keller (2010), among others.

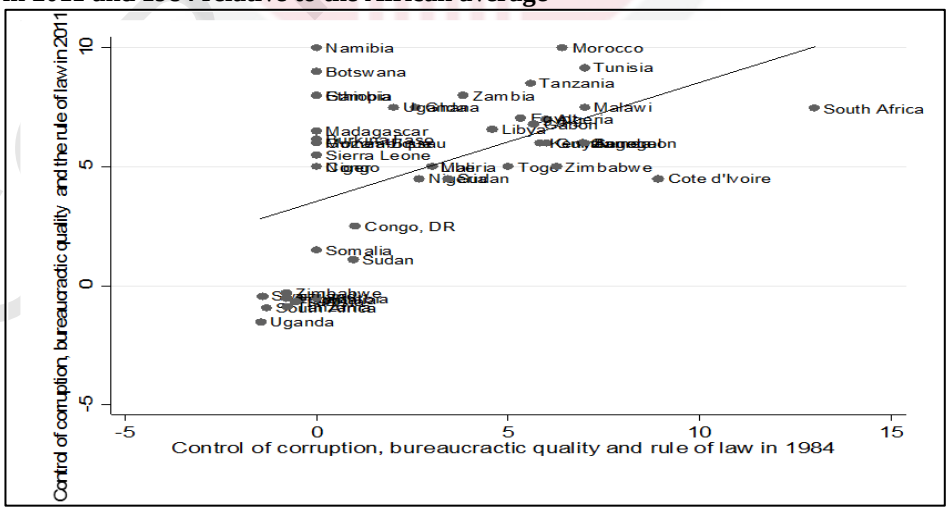
Figure 1 (b): Log of trade intensity for 2011 and 1986 relative to the African average



Source: Computed from the African development indicators (based on data from World Bank's WDI, 2013.

Figure 1 (b) depicts the country-specific trade intensity relative to the African average in 2011 against its 1986 value and draws the 45-degree line for comparison. This Scattered diagram demonstrates that Lesotho, along with Swaziland and Mauritania, was at one end of the distribution with the highest degree of openness. Meanwhile, Sudan, along with Mozambique and Ethiopia displayed the lowest level of trade intensity.

Figure 1 (c): Control of corruption, bureaucratic quality, as well as the rule of law in 2011 and 1984 relative to the African average

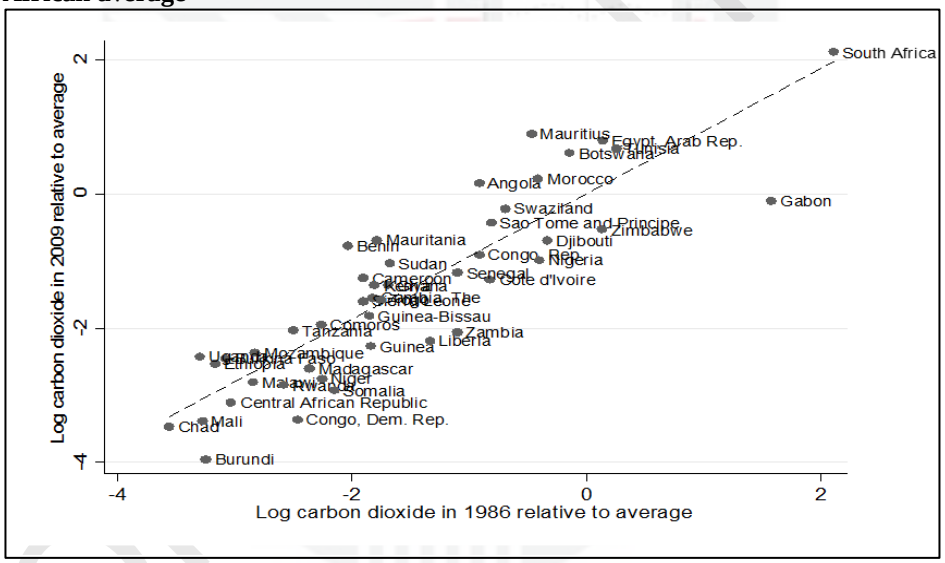


Source: Computed based on data from the International Country Risk Guide (ICRG, 2014).

While trade openness may induce increased economic activities and then more environmental impact (see Antweiler et al., 2001; Copeland & Taylor, 1994, Frankel, 2009), according to the 'new institutional economics' institutional quality may play a significant in accounting for variations in environmental behaviour among economic agent as well as the performance of environmental quality in the continent (see Steg & Vlek, 2009; Pfahl, 2005, Young, 2008).

Figure 1 (c) shows the country-specific institutional quality relative to the African average in 2011 against its 1984 value and draws the 45-degree line for comparison. This figure reveals that some countries, such as Namibia and Morocco, show better improvement in the quality of institutions in 2011 compared to 1984 while countries such as Uganda does not seem to improve its quality of institutions since 1984. However, more generally, the institutional quality in most countries in the region seems to have been relatively stable since 1984.

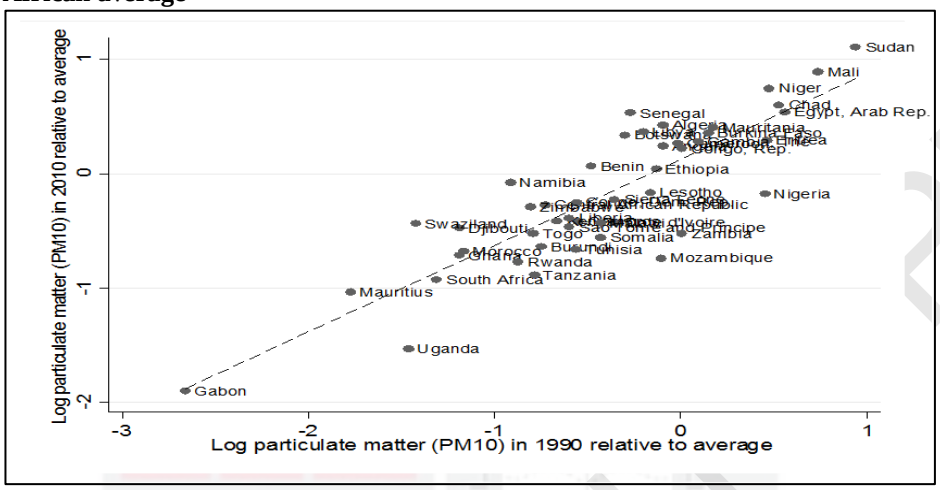
Figure 1 (d): Log of carbon dioxide emission for 2009 and 1986 relative to the African average



Source: Computed from the African development indicators (based on data from World Bank's WDI, 2013.

In theory, both trade intensity and institutional quality along with income growth impact a country's pollution level (see, for example, see Cronin & Pandya, 2009; Antweiler et al., 2001; Copeland & Taylor, 1994). Figures 1 (d) and 1 (e) show the country-specific trade carbon dioxide emissions and the level of PM10 relative to the African average in 2009 and 2010, respectively against its 1986 value and draws the 45-degree line for comparison. These graphs reveal that, on the one hand, for the case of Figure 1 (d), South Africa was at the highest emitter of CO2 while Burundi along with Chad and Mali emit less. On the other hand, Figure 1 (e) shows that Sudan along with Mali have the highest concentration of PM10 while Gabon displayed the lowest level.

Figure 1 (e): Log of particulate matter (PM10) for 2010 and 1990 relative to the African average



Source: Computed from the African development indicators (based on data from World Bank's WDI, 2013.

Although the dispersion of income across countries in the region did not change significantly over this period—the greatest number of the countries had been around the 45-degree line, the observed income inequality across nations over this period raised the possibility that environmental standards might differ. Additionally, such differences, coupled with the differences in the trade intensity and quality of institutions, as shown in Figures 1 (b) and (c) respectively, might result in greater inequality in the distribution of environmental impact of economic activities and its public health consequences (see, for example, Figures 1 (d) & (e) for sketches concerning the distribution of environmental pollutants in Africa).

Therefore, the possibility that trade openness will not share a similar relationship with pollution in all countries across Africa—the sign of the relationship will hinge on a nation's characteristic, is in accordance with the established theory in both the environmental economics and the management literature (see Cole & Elliott, 2003). Note that this same conclusion also applies to the relationship between institutional quality and pollution behaviour, as well as the possible effects of environment upon public health across the continent.

Moreover, although it may be thought that pooling some countries with diverse characteristics, for instance, the differences in income level in a single regression, may produce unreliable estimates, panel data modelling does not necessarily imply that the parameter estimate is always biased. In effect, panel data allow analysing a number of important economic issues that cannot be addressed by using cross-sectional or time-series data (Hsiao, 2003). For example, if country-specific behaviours are related conditional on certain factors, the panel data would provide the possibility of learning the behaviour of an individual in each country by observing the behaviour of others. Thus, it is possible to obtain a more accurate account for the behaviour of economic agents at the country level by supplementing observations of the individual in question with data on others from a different country (Hsiao, 2007; Hsiao, Appelbe & Dineen,

1993). For this reason, efficient parameter estimates can be obtained from a model that pools the number of African countries.

Simply stated, the coefficient estimates of the determinants of environmental quality, and how it affects public health are assumed to be identical across countries. Put differently, the manner in which trade openness and institutional quality affect the environment, and how it, in turn, affects public health is more likely to be similar across the pool of countries that have similar characteristics—in terms of economic development—that is, the pool of African nations will likely have similar coefficient estimates (see also, Stromquist & Monkman, 2014; Strong & Mackey, 2009).

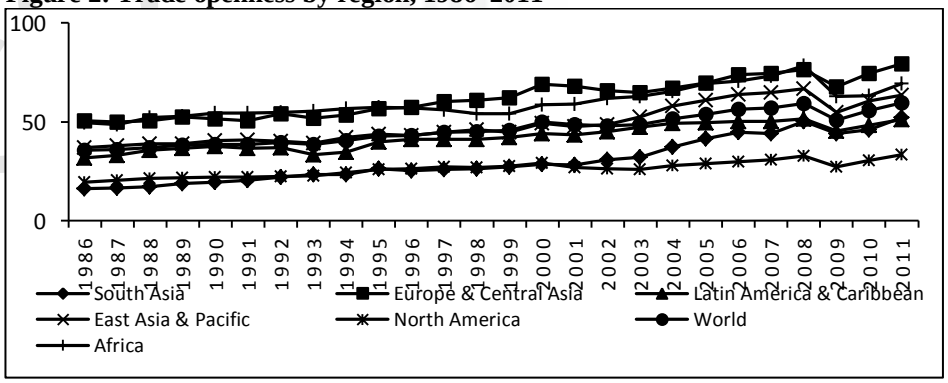
1.2 Background to the Study

This thesis comprises three related and independent issues that each donates new understandings on the primary sources of environmental pollution and the most likely feedback of such pollution on public health outcomes. The first issue investigates the effects of trade liberalization on the performance of environmental quality in Africa; the second issue examines the role institutional set up in explaining environmental behaviour in the continent; finally, the third issue identifies the possible responses of health outcomes on air pollution.

1.2.1 Trade liberalization and environmental quality in Africa

Certainly openness to international trade facilitates the participation of Africa in the global economy (see, for example, Goff & Singh, 2013). Compared to other regions of the world, trade to and from the continent has considerably expanded since the later part of the 1980s. For example, exports from African countries have accelerated, on average, by close to 3%, 8% and 15% in the 1980s, 1990s, and 2000s, respectively. To make comparisons over the last decade, this rate of trade increase in Africa outpaced the world average of 9.7%. During the same period, the average annual growth rate of the continent's imports reached close to 17% (see Goff & Singh, 2013). This upsurge in both exports and imports has led to greater trade intensity in the continent, measured as the share of exports and imports to GDP (figure 2).

Figure 2: Trade openness by region, 1986–2011



Source: Computed based on data from World Bank's WDI, 2014

Figure 2 indicates that, on average, from 1986 to 2011, trade between Africa and the rest of the world has been increasing steadily. This has been the result of the fact that most countries in the region have been involved in economic reforms and have been taking measures to open their economies to the outside markets since the beginning of the structural adjustment in 1986 (Heidhues & Obare, 2011; Adejumobi, & Olukoshi, 2008; Sachs, Warner, Åslund & Fischer, 1995). Yet, this could be additional sources of environmental pollution in the continent as increasing openness may likely constitute higher energy demand and perhaps considerably increase emissions across the continent. Although it is commonly believed that trade liberalization is closely tied to long-run economic progress through its likely positive effect on productive economic activities, environmental activists fear, however, that successful open trade regimes may negate nations' ability to protect the environment (see, for example, Frankel, 2009). It is of concern because pollution regulations in African countries are relatively lax (ADB, 2012).

There exist two fundamental theoretical interdependencies that explain trade liberalization–environment relationships. One of the leading hypothesis that provided an understanding of the link between trade liberalization and environmental quality contends that differences in income has a corresponding effect on the strength of environmental regulations across countries (Dasgupta, Mody, Roy & Wheeler, 1995 in Cole & Elliott, 2003). This argument implies that less developed countries (LDCs) or regions tend to be subjected to pollution haven while advanced nations become cleaner by offloading their pollution-intensive production to LDCs. However, pollution haven hypothesis have been criticized for its limited empirical support. One reason given by the critics of the pollution haven hypothesis is that the theorem gives only superficial explanation out of the numerous factors that stimulate location of pollution-intensive industries.

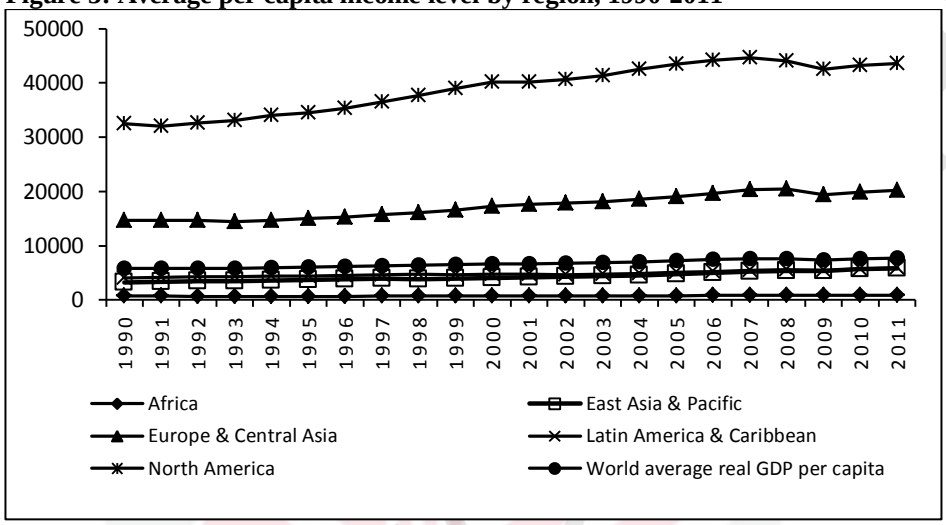
It has been claimed in this perspective that by virtue, environmental regulations are more stringent in most of the OECD member nations, yet those countries "appear to be net exporters in many pollution intensive industries (Bogmans, 2011, P.4)." As relatively those countries are more abundant in capital, which is believed to have a high correlation with pollution–intensity (see, Copeland & Taylor, 2004; Bogmans, 2011). Thus, led to the emergence of an alternative theory which argues that countries with abundant capital tend to specialize in pollution–intensive production while those with less capital specializes in cleaner production (Cole & Elliott, 2003; Cole, 2004). This viewpoint implies that with trade liberalization, advanced countries that are more capital - abundant relative to LDCs, tend to emit more pollution than the LDCs. Of particular concern is: how could more openness to trade affect environmental quality in Africa?

Both theoretically and empirically, the impact of trade openness on the environment is ambiguous. Building on the two arguments discussed in the preceding paragraph, Antweiler, Copeland and Taylor (ACT, 2001) distinguish two possible theoretical ways through which trade can affect the environment based on a country-comparative advantage: differences in environmental regulations and differences in the physical capital endowment.

Given the low income levels across Africa relative to the world average (see figure 3), which also implies laxity of environmental laws in the continent, the first case suggests that the continent may be subjected to "haven" for dirty industries from advanced

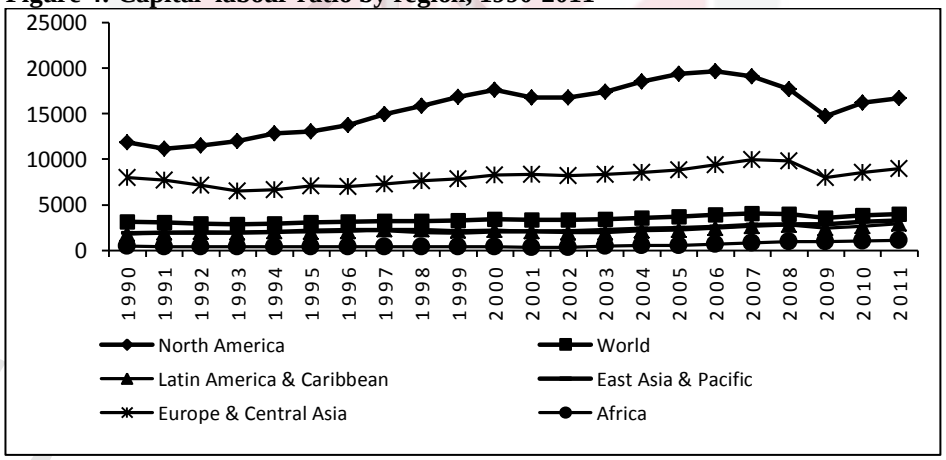
countries that have more stringent environmental laws. Figure 3 plots Africa's income level compared to other regions of the world. It can be seen from the figure that, the region has the lowest per capita income level, below the global average. Antweiler et al. (2001) show that trade openness leads to higher pollution in economies with relatively less income level.

Figure 3: Average per capita income level by region, 1990-2011



Source: Computed based on data from World Bank's WDI, 2014

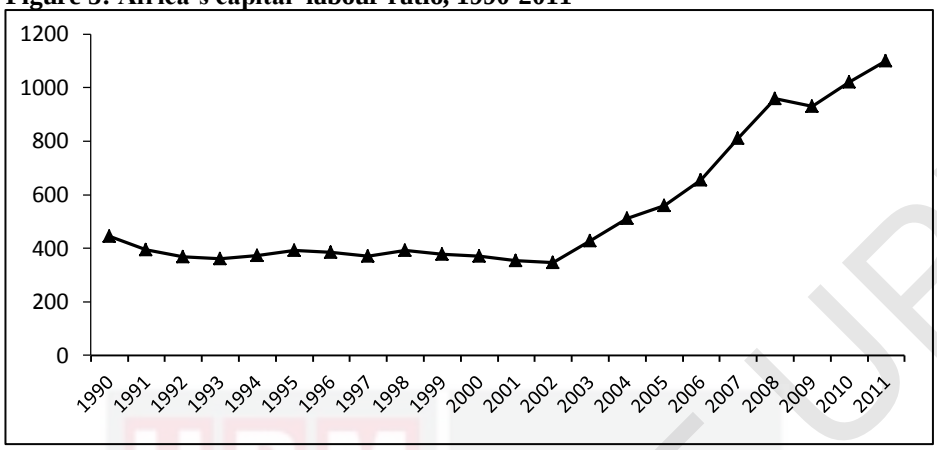
Figure 4: Capital–labour ratio by region, 1990-2011



Source: Computed based on data from World Bank's WDI, 2014

While 'pollution haven' argument appears reasonable in Africa, the latter case suggests that the continent's relative capital and labour force scarcity (see, for instance, Ndulu, 2004; Austin, 2008; Ndikumana & Boyce, 2008) tend to make her exhibit reverse scenario of pollution rise. Figure 4 plots Africa's capital-labour ratio compared to other regions of the world. As can be seen in the figure, the continent has the lowest capital-labour ratio, below the global average. Antweiler et al. (2001) show that trade openness leads to lower pollution in economies with relatively less physical capital.

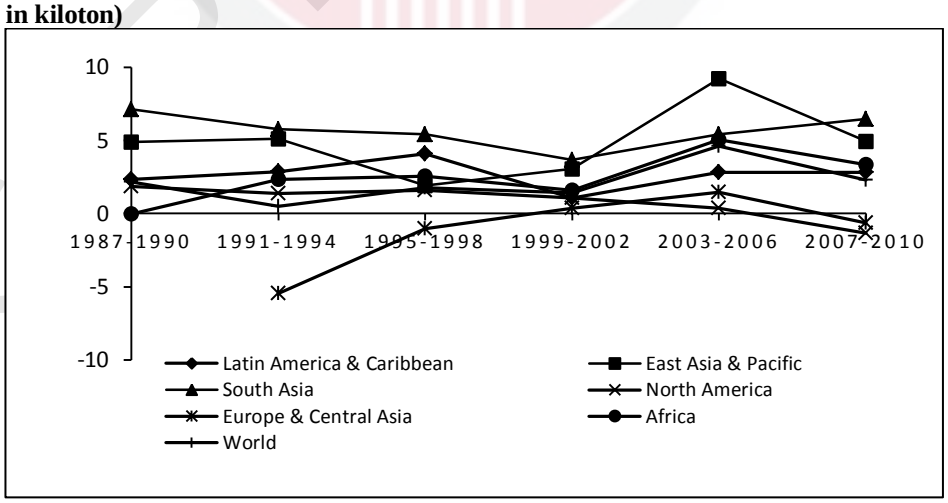
Figure 5: Africa's capital–labour ratio, 1990-2011



Source: Computed based on data from World Bank's WDI, 2014

Despite its relatively lower performance globally, Africa's capital-labour ratio has been increasing steadily in recent years, which is possible due to an increased economic productivity and exports following more openness to international trade (see Thirlwall, 2000; Acemoglu & Ventura, 2002). Increasing openness to trade together with rising corporate profits and commodity prices across African countries (see UNCTAD, 2006) may, well have been the reason for the recent capital-labour surge in the continent (figure 5). At this point, the laxity of African environmental regulation together with the recent surge in its capital–labour ratio since 2002 (see, figure 5) may have led to its current record of rising pollution emissions. For example, Figure 6 plots the percentage of variation in carbon dioxide emissions in Africa along with other regions of the world from 1987 to 2010. The figure indicates that, on average, although, emission variation has been declining steadily since around 2006 (except in the South Asia), its growth rates in Africa have been higher than that of the world average since around 1990.

Figure 6: World carbon dioxide emissions percentage change by region (measured in kiloton)



Source: Computed based on data from World development indicators, World Bank, 2014

The observed decrease in the CO_2 growth rates (globally) may be partly attributable to changes in economic structure and implementation of energy saving policies in line with the pollution reduction goals of the Kyoto Protocol (European conference of ministers of transport, 2007; OECD, 2014). While the higher growth observed in African countries, relative to the global average, could be attributed to the fact that they (being non-Kyoto members) may have an incentive to free ride on countries (for example Kyoto members) who are more committed to the reduction of global emissions. Besides, available data show that between the year 1986 and 2011 merchandise trade as a share of GDP between Africa and the rest of the world has increased by more than 67% (World Bank's WDI, 2014). This situation could lead to more pollution emissions. In fact, over the same period, CO2 emissions (measured in kiloton) from burning fossil-fuel and manufacture of cement have increased by over 74% (World Bank's WDI, 2014).

Whether openness to trade leads to more economic progress for any given level of environmental quality or damage the environment for any given rate of economic development in Africa and/or, the continent's difference in relative factor endowment tends to subject her to specialise in the production and export of pollution-intensive goods so far remain ambiguous. Therefore, understanding the in-depth relationship between trade liberalization and environmental quality is one of the objectives of this study. This study is crucial for the efficient design and implementation of environmental policies to sustain growth potentials of the continent.

1.2.2 Institutions and environmental quality in Africa

The increasing awareness that most of the environmental problems are rooted in the behaviour of individuals or economic agents has obliged concern policy-makers to come up with active policies that can significantly impact on such conduct to reduce environmental impact (Lucas, Brooks, Darnton & Jones, 2008; Steg & Vlek, 2009). Moreover, the adverse effects that the continued accumulation of greenhouse gas (GHGs) might have on economic and social lives has attracted more persistent calling for its reduction. In line with this recognition, countries adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 (United Nations, 1992, Article 2), which encourage them to partake actively in the reduction of global emission of greenhouse gases. The aim of which is to stabilize its "concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate change". Unlike the Kyoto Protocol (KP), which specify pollution reduction goals for a limited number of countries, UNFCCC does not limit the number of countries to be committed nor define pollution reduction targets.

Indeed, changes in human behaviour are needed, for example, individuals or economic agents need to understand and agree to use economic resources in an environmentally sustainable way (Steg & Vlek, 2009). Research, however, suggest that the success of environmental standards in changing relevant behaviour toward pollution reduction will to some extent depend on the strength of a country's institutional quality (Hurwitz, 1973; Adger et al. 2003; Pfahl, 2005; Young, 2008; Castiglione, Infante & Smirnova, 2011).

Given the importance of institutional quality in shaping pollution behaviour, countries need to strengthen the quality of their governance to achieve the UNFCC's objective

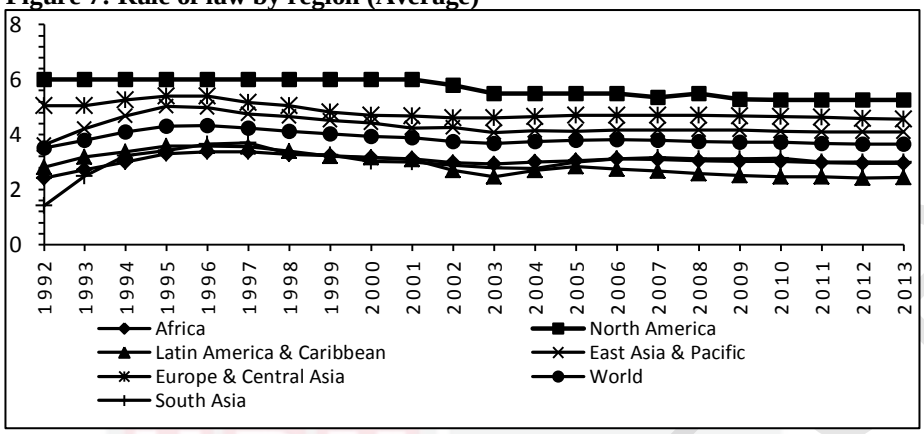
of stabilising the concentration of greenhouse gases in the atmosphere. This issue has been highlighted in recent articles, suggesting that institutional quality should not only play a vital role in the reduction or control of domestic pollution, but also on the international commitment to pollution reduction (see Bätting & Bernauer, 2009; Neumayer, 2002 among others). A study by Neumayer (2002) argued further that the effects of institutional quality should be stronger on pollution growth rates rather than absolute pollution levels. Consequently, one of the primary goals of this thesis is to test whether the strength of the institutional framework is significant in explaining pollution variations in Africa countries. In particular, to evaluate the strength of institutional support of Africans' cooperation to reduce global emissions of greenhouse gases that followed the establishment of the UNFCCC.

Without healthy institutions (say, lack of the rule of law, poor bureaucratic quality, and corruption in government, etc.), individuals in a country may be reluctant to change/improve their environmental behaviours. As such, the country in question may not be able to stabilise the growth rate of greenhouse gases. Many African countries recognized that poor governance is one of the critical obstacles of decent public policies and have invested efforts in institutional reforms (Okereke & Agupusi, 2015). Evidence suggests that since the collapse of African dictatorships that follow the end of cold war in 1989 several countries in the region have experienced political transition to democracy (Albrecht & Klip, 2013).

Recently, African countries through the leadership of the African Union (AU) have demonstrated the political will in promoting good governance. The commitments of African leaders to improve the quality of leadership process has reinforced adherence to the separation of powers and the rule of law (NEPAD, 2012). Although, in comparison to the other regions of the world, African countries, on average, have continually ranked at the bottom (lower than the global average) in terms of political risk rating, reported by the international country risk guide (2014), their overall quality of institutions broadly remain steady for over a decade (World Bank, 2014, ICRG, 2014). Sound economic management, policies for social inclusion and equity and, public sector managements are becoming the norms in most countries in the region (NEPAD, 2012, World Bank, 2014). And many countries have recorded an improvement in the quality of institutions such as control of corruption and bureaucratic quality with greater democratic checks and balance between the various arms of government, although some are still struggling with poorly performing institutions due mainly to disruptions from political instability (Carothers, 1998; Alence, 2004; Ogbazghi, 2011).

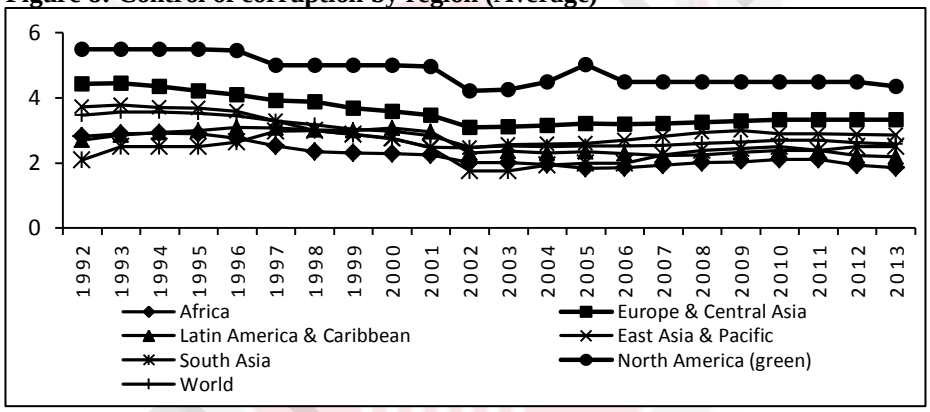
Weak institutions are often associated with economic inefficiencies and lower per capita income (see, for example, Jaimovich & Rud, 2014). However, strengthening institutional quality would help influence compliance behaviour in pollution control.
The average annual indicators of institutional quality in Africa are shown in figures (7), (8) and (9). These indicators are measured on a scale of 0 to 6, where a higher score indicates healthy institutions while a lower score implies deterioration. These indicators, characterized by African political risk rating are constructed by International Country Risk Guide (ICRG, 2014). The figures indicate the likelihood of encountering with interference (or otherwise) from corrupt public officials and bureaucratic red tape in either formulating and/or enforcing urgently needed public policies (including environmental policies) in the continent.

Figure 7: Rule of law by region (Average)



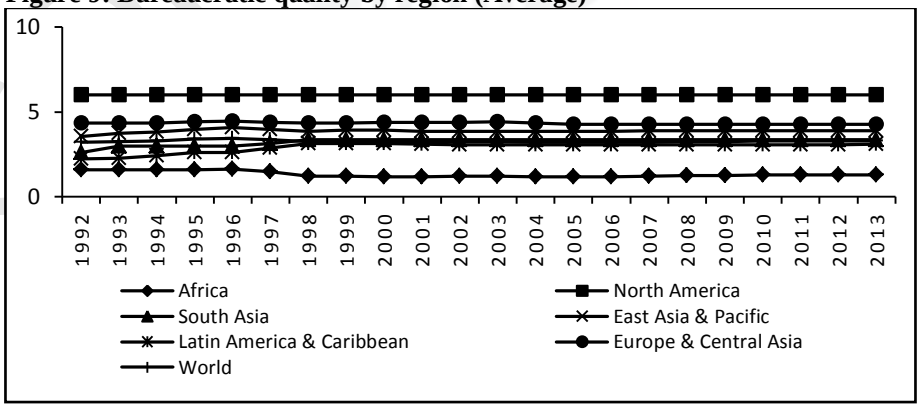
Source: Computed based on data from the International Country Risk Guide (ICRG, 2014)

Figure 8: Control of corruption by region (Average)



Source: Computed based on data from the International Country Risk Guide (ICRG, 2014)

Figure 9: Bureaucratic quality by region (Average)



Source: Computed based on data from the International Country Risk Guide (ICRG, 2014)

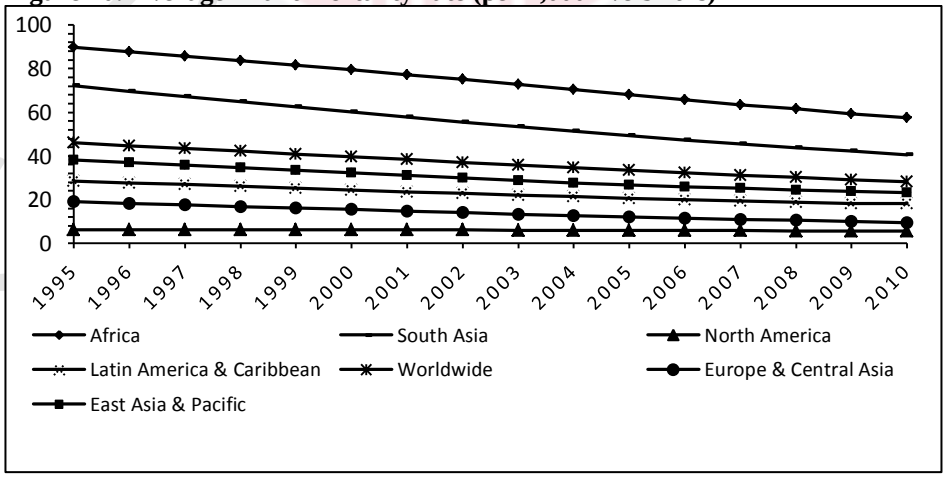
The assumption is that having a record of progress regarding institutional quality improvement across African countries since the late 1980s, economic agents in the region may have taken voluntary measures of reducing pollution emissions as recommended by the UNFCCC. The validity of this claim can best be ascertained through empirical investigation.

1.2.3 Environment and Public health outcomes in Africa

Recent research in the area of public health has focused on the role of environmental hazards in determining public health outcomes. An emergent body of research established that not only social and/or economic characteristics such as income level, wealth and education levels, among others influence public health outcomes, but also environmental factors such as air pollution (Drabo, 2010; Sun & Gu, 2008; Gangadharan & Valenzuela, 2001, among others). For example, air pollution has long been acknowledged to have extensive effects on public health outcomes such as excess morbidity and premature mortality (Shumway, Azari, & Pawitan, 1988; Stieb, Judek & Burnett, 2002; Lim et al., 2013; Pascal et al., 2013). People that will be more severely affected by exposure to air pollution are those who are already ill, children and the have-nots (WHO, 2014).

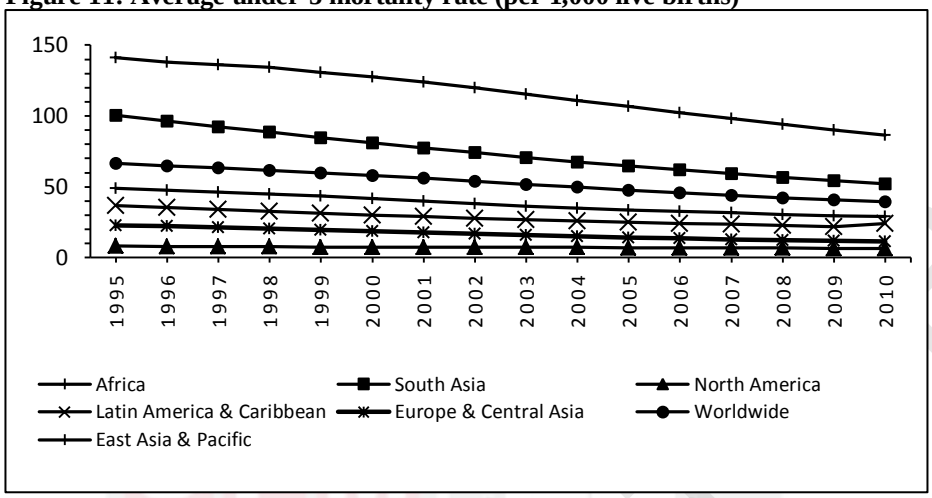
It is, however, noteworthy that air quality in Africa is among the worst in the world (WHO, 2014; Fajersztajn et al., 2013). In effect, research indicates that over 60% of the countries that experience worst air quality in the world are situated in Africa (Osabuohien et al., 2013). Of particular concern is that a wide range of public health problems that the continent faces, which include high child and adult mortality rates may be attributable to the observed poor air quality. For example, figures 10 and 11 provide infant and under-five mortality rates by continent. As can be seen in these figures, although, there is a steady decline in mortality rate worldwide in recent years, African countries still have the highest levels of child and adult mortality compared to any other region of the world.

Figure 10: Average infant mortality rate (per 1,000 live births)



Source: Computed based on data from World Bank's WDI, 2013

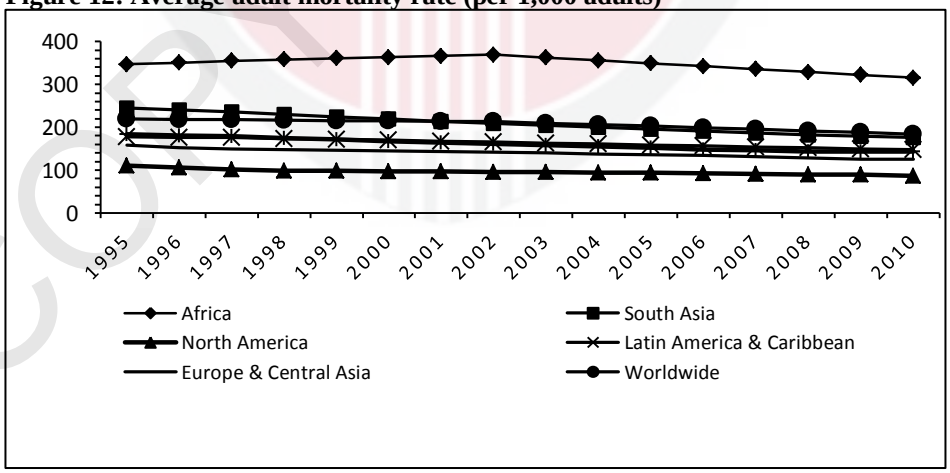
Figure 11: Average under-5 mortality rate (per 1,000 live births)



Source: Computed based on data from World Bank's WDI (2013)

If, for example, air pollution causes adult mortality in Africa it could undermine not only labour supply but also its productivity. For example, the untimely death of parents, particularly "mothers", could reduce the chances of their surviving child or children to get access to quality education, health care, and emotional well-being (see, for example, Crase & Crase, 1995). Moreover, parent's death could even lead to increasing depression and social vices such as drug abuse and crime among orphans (see, for example, Brent, Melhem, Donohoe & Walker, 2009). All these could thus adversely affect labour supply, and its productivity and, as well could undermine sustainable economic progress (see also Cai & Kalb, 2006; Bhargava, Jamison Lau & Murray, 2001).

Figure 12: Average adult mortality rate (per 1,000 adults)



Source: Computed based on data from World Bank's WDI (2013)

An indication that air pollution poses a threat to the sustainability of economic progress in African countries is the adverse effect it may have on the survival rates of the labour force (or adult mortality rates). A better understanding of the relationship between air

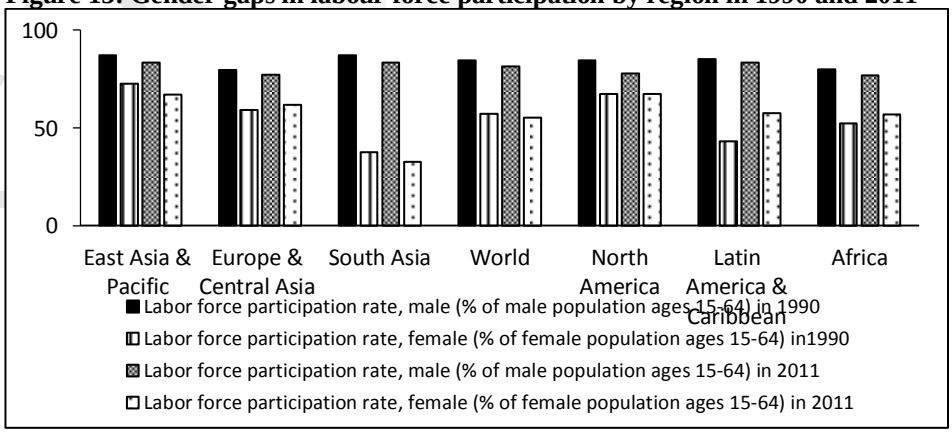
pollution and adult mortality (or labour force survival rates) is necessary to estimate the costs of poor air quality to the economy. Figure 12, for example, shows that Africa is not only the continent with the highest level of infant and under-five mortality rates, it also remains the region with higher adult mortality rate than any other region of the world.

Another issue of particular concern is that the effect of air pollution, particularly, on adult mortality rate may be gender specific with women also likely to be most affected (see Clougherty, 2010). Such gender disparity may be possible through biological mechanisms or exposure pattern or cultural differences (see, for example, Sunyer et al., 2000; Haskell et al., 2007; Kan et al., 2008; Oiamo & Luginaah, 2013 among others), which are outside the scope of the present study.

The household energy practice, especially among women in many African countries could also provide additional reasons to expect a varied effect of air pollution across gender. It is not uncommon that a greater number of women in African nations, who are predominantly occupied with household activities substantially rely on unprocessed biofuels such as charcoal, firewood and other traditional fuels for domestic energy needs (Schlag & Zuzarte, 2008; Rhefuess, 2006; World Bank, 1997).
Studies have shown that burning of such biofuels can produce a high level of indoor toxic gasses such as PM10 and carbon monoxide (CO), among others. Women in Africa countries like in many low-income nations are likely to be more exposed to the harmful effects of such pollutants due to inefficient cooking and other domestic energy use (Rhefuess, 2006; Torres-Duque, Maldonado, Pérez-Padilla, Ezzati & Viegi, 2008; Kim, Jahan & Kabir, 2011).

Of particular concern is that if air pollution has a more significant effect on adult female mortality than male, it may lead to a widening of the gender gap in labour force participation. Although the likelihood that women participate less in the labour market than men seems to be a global phenomenon (World Bank, 2012), available data appeared to indicate that Africa is one of the continents with lowest women's labour force participation rate in the world. As shown in the Figures (13) plots the regional-specific gender gap in labour force participation in 1990 against its 2011 value, respectively.

Figure 13: Gender gaps in labour force participation by region in 1990 and 2011

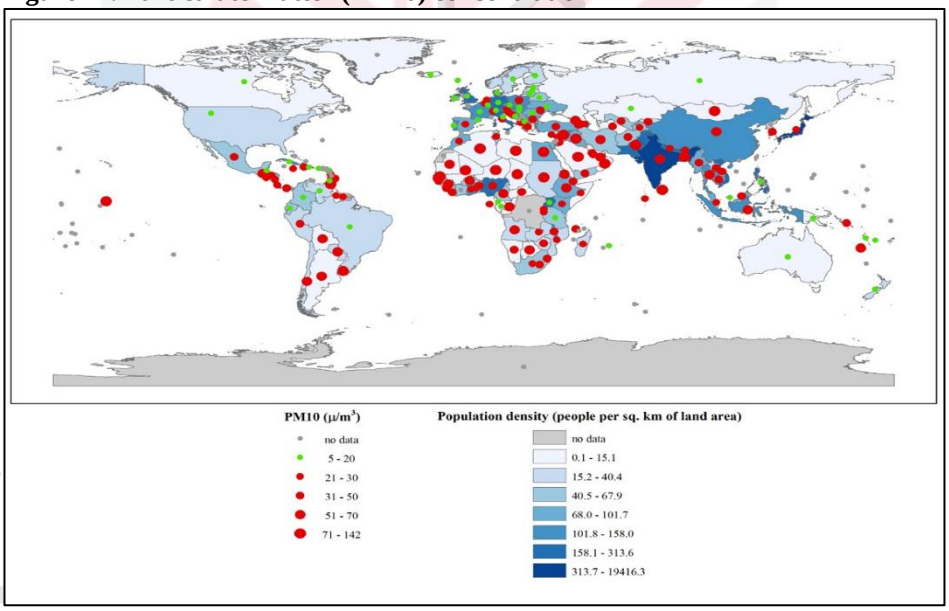


Source: Computed based on data from World Bank's WDI (2013)

The figure shows that although the gender gap in participation improves in 2011 compared to 1990 across all regions (except for South Asia, the reason of which is outside the scope of the present thesis), Women participation continues to lag behind their male counterparts in Africa (along with that South Asia). It has been found that nations with greater women participating in the labour force, see greater economic growth and prosperity (see, for example, Psacharopoulos & Tzannatos, 1989). On the other hand, their health status and survival rate, which might partly be reflective of air quality could largely determine their participation rates in the labour market. Evaluating air pollution effect on adult gender mortality can, therefore, help to determine the relevance of environmental standards on reducing the gender gap in the labour force participation.

The possible heterogeneity in the effect of air pollution on the infant (newborn) and under-5 mortality is also an important issue to investigate as infants may breathe more air per body weight (see Rom & Markowitz, 2007). Research also suggests that, though air quality standard is yet to be defined broadly for Africa, air pollution that has a direct impact on public health in the continent is among the highest in the world. For example, the air pollution recorded recently in the most part of African countries have far exceeded air quality standards set by the World Health Organization (WHO) of less than 20 micrograms of inhalable particulate matter per cubic meter of air, µg/m3 (see figure 14).

Figure 14. Particulate matter (PM10) concentration



Source: Fajersztajn, Veras, Barrozo, and Saldiva (2013)

In spite of this recognized threat of air pollution, empirical evidence of air pollution effect on public health effect has been limited in Africa (De Longueville, et al., 2010). The paucity of this evidence may well have been the reason for the lack of comprehensive air quality standard in the continent. Such a study is relevant not only because it would enable formulation of policies that can improve health condition for the affected people, but more generally for the evaluation of alternative ambient air

quality standards which would be considered socially optimum for the existence of both human and another biodiversity.

In light of the three issues discussed above, it seems necessary to take into account: (i) the economic externalities that might emanate from liberalization of trade, especially in regard to 'pollution haven effect' and/or 'factor endowment effect' of trade openness, (ii) how institutional quality affects pollution behaviour and, (iii) more importantly, the environmental threats to public health in shaping the future policy interventions in Africa.

1.3 Statement of the Research Problems

Motivated by the discussion in the previous sections, three environmental implications are of interest. First, while more openness to trade has a potential to speed up African's economic growth, the existing differences in environmental regulation between the continent and, particularly the advanced or higher income nations will offer the latter with a comparative advantage in clean production. African countries could, therefore, persistently specialize in the production and exports of pollution-intensive goods. This trade pattern may turn them a haven for pollution shifted from advanced countries that have more stringent environmental laws.

Although, it seems reasonable to expect evidence of pollution haven hypothesis in African countries due to openness to international trade, the continent's relative capital, and labour force scarcity (Ndulu, 2004; Austin, 2008; Ndikumana & Boyce, 2008) tend to overwhelm the possible existence of 'pollution haven.' However, as can be observed in figure 5, the recent capital-labour ratio upsurge in the continent might have adverse environmental effects with more openness to international trade. Another practical issue in the trade and environment nexus, which is vital in the environmental policy making is the decomposition of the structural effect of trade on the environment. In other words, which trade-induce effect, dominates the economic growth environment relationship: the trade influence on the composition of the nation's production, increased scale of economic activities and/or changes in the technique of production (see Grossman & Krueger, 1995; Antweiler et al., 2001; Cole & Elliott, 2003; Frankel, 2009).

Therefore, whether pollution which may be associated with the openness to trade in Africa is better explained by factor endowment hypothesis or pollution haven hypothesis/effect that arises as a result of global income inequality (see figure 3) can only be clarified through empirical investigation. It is also important to determine whether the trade-induce—growth effect on the environment is dominantly explained by scale effect, technique effect and/or composition effect.

Second, although African countries are often seen as the lowest global emitters of carbon dioxide (see, for example, Stott, 2006; Sunstein, 2008; Davis & Caldeira, 2010), they may have a strong incentive to free ride on countries (for example Kyoto members) who are more committed to the reduction of global pollution. Undoubtedly, no matter how little carbon dioxide a country can emit, it will inevitably contribute to the global climate change and/or global warming. Moreover, the problem of climate change, which could gravely affect both human and other biodiversity is believed to be a long-term problem and an intergenerational whose solution cannot be effectively

enforced by just a single nation or some group of few nations (Bätting & Bernauer, 2009).

However, following the argument linking institutional quality with a pollution behaviour (Bätting & Bernauer, 2009; Neumayer, 2002; Congleton, 1992), and given the recent efforts by most countries in Africa to strengthen the quality of their political institutions since the collapse of the continent's dictatorship in the late 1980s, need therefore arises to examine how institutional quality has been affecting pollution growth rates. Such an investigation is relevant from the environmental sustainability outlook. In particular, how institutional quality affects African cooperation to reduce global emissions of greenhouse gas.

Third, the potential adverse effect of higher level(s) of air pollution on public health outcomes, demands that individuals understand the health threats of exposure to poor air quality and take suitable actions to minimise those risks. However, what is clear in most of the African countries is that pollution control laws have been relatively weak. Certainly, understanding how air pollution, for, example, affects human health is vital for the formulation of effective pollution control strategies (Callan & Thomas, 2010). Research has acknowledged the scarcity of empirical investigation of the African-specific public health effect of air pollution (De Longueville, et al., 2010). Should the paucity of African-specific research on the air pollution public health effect persists, then the formulation of effective pollution regulation strategies may be difficult to achieve. Need thus arises to examine how air pollution has been affecting public health outcomes across African countries.

1.4 Research Questions

(i) What are the effects of trade liberalization on the rate of environmental degradation in Africa?
(ii) What is the effect of institutional quality on the environmental behaviour in African countries?
(iii) What are the effects of air pollution on public health in African countries?

1.5 Objective of the Research

The general purpose of this research is to examine empirically the factors affecting the environment and its impact on public health outcomes in African countries.

1.5.1 Specific Objectives

1. To evaluate the effects of trade liberalization on the rate of environmental degradation in Africa;
2. To examine the effect of institutional quality on environmental behaviour in African countries; and
3. To assess effects of air pollution on public health outcomes in African countries.

1.6 Significance of the study and contributions to knowledge

This thesis contributes to the existing literature in three different, but related issues. First, unlike the previous works that focus on the aggregated effect of trade openness on the quality of the environment in Africa, this study extends beyond the earlier studies by considering the regulatory and/or comparative physical capital effects. Although Antweiler et al. (2001) have introduced the so-called ACT model, which is suitable to address the strength of the environmental regulatory effect and the effect of the physical capital endowment on environmental quality, there are very limited studies that evaluate these effects. Only a few African countries were included in the sample of the available studies.

Evaluating the effect of free trade on the environment in the continent is vital because most countries in the continent have been slow to develop effective environmental laws (ADB, 2012). Very few studies in the region, for example, Kahn (2003) and, more recently Baliamoune-Lutz (2012) have claimed to provide supportive evidence for pollution haven effect. But they are limited because they ignored to evaluate further the potential effect of relative physical capital abundance on the trade-related environmental pollution in the continent. Limited empirical studies, particularly from Africa also meant the continent could not take advantage practical evidence for the evaluation of environmental policy options. Hence, the present study sheds light on how decision makers can make right choices that can help African countries benefit from freer trade without compromising environmental sustainability—particularly given that the many countries in the Africa are in dire need of capital accumulation (Habiyaremye & Soete, 2010).

In an attempt to fill this gap, the present study distinguishes between the pollution haven effect and the factor endowment effect of trade liberalization, and consequently is better able to decompose the scale, composition and the technique effects of trade liberalization on the quality of the environment (Antweiler et al. 2001). Thus, when the trade-related determinants of environmental quality are distinguished from each other, policy makers may well have relevant information in shaping future policy interventions in Africa, a continent that is in dire need of development with a better environment.

Moreover, it should be noted that ACT model is a somewhat more general model as it was designed to include different countries/regions. Rather than focus on the effect of trade liberalisation on a country's comparative advantage alone, the present study extends the ACT model to examine further trade liberalisation effects on the environment due to the difference in relative environmental stringency and factor abundance within the African region (that is regional comparative advantage effects of freer trade).

Second, while elsewhere, the effects of institutions on environmental behaviour/pollution growth rates have been investigated (Bättig & Bernauer, 2009; Murdoch & Sandler, 1997; Congleton, 1992), available empirical evidence in Africa, mostly focused on its role on environment-growth nexus; that is, on the environmental outcomes. For example, although, handful studies have claimed to find evidence for institutional effects on environmental quality across Africa (for example, Bhattarai & Hamming, 2001; Culas, 2007; Baliamoune-Lutz, 2012; Ibrahim & Law, 2015), however, these studies are limited because they only consider the role of institutions on

absolute pollution levels without further examining institutional effect on the pollution growth rates.

Although this line of empirical inquiry is still expanding, it can be thought that this research shortfall is remarkable and, neglecting it signifies a substantial gap in the literature because institutions are tending to be more active in environmental policies addressing pollution changes (Neumayer, 2002). It is worthy of note that, the few studies to date that have examined this issue were limited to democratic influence on pollution changes/trends. However, evidence from such studies do tend to be misleading as the democracy is necessary, but may not be sufficient to influence and sustain a country's pollution reduction behaviour (rather, it can be facilitated by institutions such as control of corruption, the rule of law and bureaucratic quality[2].
In this study, the role of the institutions mentioned above on African environmental behaviour will be examined. Such an interactive investigation would present emerging evidence for the strength of institutional support of pollution reduction, and may provide a useful guide in future research effort in the continent.

Third, although, the channels through which public health outcomes are related to air pollution are modestly investigated empirically, most of the available studies are based on high-income countries. As a result, research on the public health effects of exposure to poor air quality in low-income countries are very limited and, have mostly focused on infant and/or child mortality and life expectancy.

The available studies that include low-income countries have applied the combination of only a few countries in Africa in their sample countries (Gangadharan & Valenzuela, 2001; Drabo, 2010). In addition, the mixture of the few African countries—which are areas with considerably higher levels of ambient air pollution—with some advanced nations—who substantially have recorded improved air quality (Fajersztajn et al., 2013)—in these studies may not accurately reflect the real air pollution–health problems in Africa and may not, as well tell us the direction of future policy target for the continent.

The effect of air pollution on mortality rates among adults (labour force) in low-income countries such as Africa may differ from those in advanced countries (see Antweiler et al., 2001 among others). Such a disparity which could likely be due to the presences of relatively strict environmental regulations and a quite more advanced health care system in developed countries (see, for example, Van Doorslaer et al., 1997; Wagstaff, 2002).

While studies on the effect of air pollution on infant mortality are relatively common, there has been little research on how air pollution affects mortality among adults. Yet, there is a question about gender differences regarding the effect of air pollution on adult mortality rates that is tended to remain unanswered, particularly in Africa.

Although previous studies have attempted to examine the air pollution effect on life expectancy or child mortality rates, they seem to ignore distinguishing among gender differences in adult mortality due to air about which may concern African countries.

[2] See chapter three, section 3.3 for a detail theoretical argument.

Review of existing literature tended to suggest that there are sound reasons to expect difference responses to air pollution between women and men, which is considered by the present study. The fact that, infant breathe more air per body weight (Rom & Markowitz, 2007) signifies the need to distinguish air pollution effect between infant and under-five mortality rates, the issue that has largely been ignored in the African literature.

Studies in areas with high ambient air pollution levels, such as Africa (Fajersztajn et al., 2013) are relatively scarce and may well have been the reason for the environmental policy neglect. Thus, this study will add some new evidence on the adverse public health outcomes, including infant mortality rate and gendered differences in adult mortality rates as well as between infant and under-five mortality rates promoted by low air quality standard (high pollution) in the continent. It differs from those of Gangadharan and Valenzuela (2001) and Drabo (2010), among others, who neither investigate the particular effect of air pollution on adult mortality rate nor distinguish this effect among gender.

The study also complements those from advanced countries and represents an attempt to provide a multi-country evidence of gender differences in response to air pollution, using African-specific data. Such investigation has become essential to inspire the formulation of ambient air quality standards in Africa, and also to assess necessary actions that may be required for the adaptation and possible mitigation of pollution emissions.

In general, the results of this thesis will, therefore, provide convincing evidence that can be useful for evaluation of environmental policy options in African countries. Policies that can not only unveil the need for intervention measures that can minimize public exposure to air pollution, but also identify vital issues for environmental health researchers and those responsible for public policy.

1.7 Scope of the Study

This study covers the impact of trade liberalization on the quality of the environment in African countries. The study is also limited to two pollutants: carbon dioxide (CO2) emissions and the concentration of particulate matter (PM10) associated with public health outcomes. The study will include the investigation of how institutional quality affects pollution behaviour in African countries.

Particulate matter, on the one hand, consists of solid and liquid particles found in the air (US EPA, 2015). This pollutant is created primarily as a by-product of burning fossil fuels emitted from agricultural activities, power plants, industrial production, transport—largely from diesel-fuelled vehicles, domestic energy use—such as smokes from biofuels burning, fugitive dust (from paved and unpaved roads), among others (see, for example, Cole, Rayner & Bates, 1997; Rhefuess, 2006; US EPA, 2015). It can also be formed secondarily from fine particles in the atmosphere due to the reaction of some gaseous pollutants such as Sulphur dioxide (SO2) and nitrogen oxides (NOx)[3]. On

[3] See US EPA (2015)

the other hand, carbon dioxide (CO2) is formed through burning substances (fossil fuels) that contain carbon. Other sources include breathing and fermentation (see, for example, Andreae et al. 1998).

In trying to understand how the environmental damages affect human development, the study is limited to investigating the effects of air pollution on public health outcomes, with particular emphasis on infant mortality, under- five mortality and adult mortality rates. The study also considered distinguishing the air pollution effect on adult mortality based on gender as well as among infant and under-five mortality rates. The study does not cover pollutant other than the two pollutants mentioned above (limited by data availability).

The African countries included are selected based on the availability of all the data required for analysing every objective of the study. Countries that do not have suitable and up-to-date data are excluded from the study (which, however, depends on the required data for every objective and the methodology applied).

1.8 Organization of chapters

The rest of the thesis is organized as follows. Chapter 2 consists of literature reviews. The chapter critically discusses both theoretical and empirical literature on the relationships between trade openness and the environment, institutional quality and environmental behaviour. The chapter also surveys the literature on the pollution and public health nexus.

Chapter 3 comprises the theoretical frameworks. The chapter contains derivations of relevant mathematical models based on theoretical considerations that supported the empirical estimations of the thesis. Chapter 4 forms the research methodology. The chapter presents and discusses the empirical models, study variables and econometric methods used. Next, the chapter explains the sample size and describes the sources of data.

Chapter 5 covers regression results. It begins with the presentation of descriptive statistics of the study variables. Next, is followed by the presentation of estimated results, interpretations, and discussions. Finally, Chapter Six consists of summary and conclusion. The chapter provides the summary of the whole thesis. It also discusses the policy implications and highlights the limitations of the study and conclude with recommendations for future research directions.

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