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Three Essays in Trade and International Development

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THREE ESSAYS IN TRADE AND INTERNATIONAL DEVELOPMENT

by

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ABSTRACT

Three Essays in Trade and International Development

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This dissertation studies three different topics in international trade and development. It studies the inter-laced relationship between corruption and economic growth, as well as exploring linkages between merchandise and service trade. In addition, it evaluates the effectiveness of foreign direct investments and environmental aid on emissions in developing countries.

The first essay studies the path of corruption at various development stages. In particular, using a neoclassical growth model, it provides a theoretical framework to study corruption level at various stages of development. I derive a testable proposition that corruption and income have an inverted u-shaped relationship. I then apply our theory to a panel data of 75 countries during 2001-2008. After controlling for other related variables such as government expenditures, trade openness, etc., the empirical results indeed support the theory by suggesting an inverted u-shaped relationship between corruption and income.

The second essay explores merchandise and services trade both theoretically and empirically using the gravity approach. It uses a general equilibrium framework to show that merchandise and service trade may be simultaneously determined. Our empirical analysis indeed supports our proposition regarding the simultaneity of merchandise and service trade.

The third essay examines the effects of foreign direct investment inflows and environmental aid disbursements on environmental degradation using panel data for some selected developing countries. Using a fixed effects model, the estimates suggest the existence of an Environmental Kuznets Curve for carbon dioxide as well as total green house gas emissions from the energy and industrial sectors but there was no evidence of this phenomenon for nitrous oxide and total green house gas emissions from the waste sector. I also find a hint of a technique effect, and investigate it further by exploring the responsiveness of capital and labor to investment inflows in the respective developing countries.

(116 pages)

PUBLIC ABSTRACT

Three Essays in Trade and International Development

This dissertation studies how society views corruption at different stages of economic development. It develops a theoretical framework that shows that at low levels of income or development, corruption increases and at high levels of income and development, corruption decreases. This theoretical proposition is also investigated empirically. The empirical analyses support the proposed theory and hint that fiscal policy, socioeconomic conditions, and incidences of war play significant roles in determining a country's corruption level.

In addition, this dissertation also explores the relationship between merchandise and service trade. I show theoretically that the two are related and determined simultaneously. An empirical investigation also confirms this proposition.

Lastly, I investigate the issue of pollution in developing countries. I explore the existence of an inverted u-shaped relationship between emissions and income. I examine the role played by foreign investment in improving emissions in developing countries. The results support the inverted u-shaped relationship and suggest that environmental aid does not reduce emissions in developing countries.

Nii Amon Neequaye

I dedicate this work to my entire family, especially my parents for nursing this dream. This work is a tribute to you.

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Nii Amon Neequaye

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CHAPTER 1

INTRODUCTION

This dissertation intends to explore three main areas in international trade and development that affect the economy of countries. The goal of these essays is to draw attention to issues that countries face at different stages of development and how they affect the economies of these countries.

The first essay studies the relationship between corruption and income; It analyzes how society reacts to anti-corruption at different levels of development and proves the possibility of an inverted u-shaped relationship between corruption and income. Corruption has been an issue plaguing our societies from time immemorial; Tanzi (1998) explains that books may have been written thousands of years back in an attempt to explain corruption. Some countries have even set up anti-corruption institutions in a bid to curtail it. Whilst most cultures frown at it others consider it as a means to an end. Tsalikis and Nwachukwu (1991) explain how people's cultures affect their views or perspectives on corruption. What really causes corruption? Price controls, law wages, taxes, inefficient regulations, trade restrictions, culture, natural resources (rent seeking behaviors), and the incidence of war may explain corruption levels in a country (see for example Tsalikis and Nwachukwu, 1991; Besley and McLaren, 1993; and Mauro, 1997).

Corruption may have dire consequences for the economy of countries, this explains why countries invest a lot of money and resources into monitoring institutions and law enforcement. Some literature argue that corruption erodes economic growth and societal developments. Others also argue that corruption is not entirely bad and could ensure Pareto efficiency in situations where government policies and reforms have failed. One might wonder where the line needs be drawn in relation to the positive and negative effects of corruption. What exactly induces corrupt activities in a society? Are corrupt activities results of need or greed? There is a need to not only investigate the consequences of corruption but also to explore factors that cause corruption as well as investigate the reason why developing countries are generally more corrupt than developed ones. Thus, this essay develops a theoretical model that investigates corruption at different phases of economic development. It proposes that there may exist a positive relationship between corruption and income at low income levels and a negative one at high income levels, thereby suggesting an inverted u-shaped relationship between corruption and income. Empirically, this essay tests this proposition using a two-way fixed effects model and finds supports for it. It also finds evidence that fiscal policy, socioeconomic conditions and wars influence corruption.

The second essay focuses on trade in merchandise and services. Economists in recent years have used the gravity model extensively. However, most papers focus on trade in merchandise consequently, trade in services has not received as much coverage as merchandise trade. Kimura and Lee (2006) have attempted to explore linkages between merchandise and services trade. For that reason, this essay builds on existing literature by developing a gravity equation that suggests a possible simultaneous relationship between merchandise and service trade and assesses how distance or remoteness affect trade flows. It also tests this proposition empirically using a panel dataset on OECD countries and a two-way fixed effects model. The empirical analysis confirm the proposed simultaneous relationship.

Economic literature widely accepts that trade can be mutually beneficial for the trading parties if they produce the goods for which they have a comparative advantage. Pollution levels in developing countries are generally lower than those of the developed world, however developing countries receive a larger portion if not all of global environment aid allocations. Why is this the case? Does environment aid play a role in reducing emissions in developing countries? Through the relocation of firms from foreign developed countries, developing countries may benefit by acquiring superior technology. These new technologies can then be employed in the manufacturing sectors. One interest is to know the extent to which these diffused technologies help in reducing pollution or emissions in developing countries. Thus, the third essay studies emissions in developing countries as they engage in international trade with developed countries. Two key concepts here are the Pollution Haven Hypothesis (PHH) and the Environmental Kuznets Curve (EKC). Environmental quality can be considered a normal good so that developed countries have more stringent environmental regulations than in developing countries. The PHH suggests that pollution intensive industries in a bid to avoid exorbitant emission taxes or costs associated with adhering to these stringent environmental regulations will migrate to developing countries where this costs are not as high. This essay explores the effects of Foreign Direct Investment (FDI) on emissions in developing countries.

The EKC explains the relationship between environmental degradation and development and suggest an inverted u-shaped between the two. Even though developed countries are more industrialized and emit more Green House Gases than developing countries, developing countries still receive a substantial disbursement of environmental aid from developed countries. As a result, this essay also explores the role environmental aid plays in reducing emissions in developing countries.

Developing countries may also benefit from diffusion of cleaner technology as foreign firms migrate from developed countries to the developing ones. As such, the essay also investigates the effects of technology diffusion on carbon dioxide and total Green House Gas emissions in developing countries and also assesses the extent to which technique effects help developing countries to move away from pollution intensive methods of production.

In this essay, I recognize that FDI affect emissions in developing countries at the same time, emission through the PHH affect FDI inflows. I therefore treat FDIs as endogenous in my empirical analysis of emissions in developing countries. The analysis employs a panel dataset and a fixed effects model.

The rest of this dissertation is organized as follows: Chapter 2 presents the study on the relationship between corruption and economic development. Subsequently, the analysis on merchandise and service trade can be found in Chapter 3. The study of environmental degradation in developing countries as they open up to trade is presented in Chapter 4. Chapter 5 draws the curtain on this dissertation by presenting the conclusion.

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CHAPTER 2
CORRUPTION AND GROWTH

2.1 Abstract

This chapter studies the path of corruption at various development stages. In particular, using a neoclassical growth model, I provide a theoretical framework to study corruption level at various stages of development. I derive a testable proposition that corruption and income have an inverted u-shaped relationship. I then apply the theory to a panel data of 75 countries during 2001-2008. After controlling for other related variables such as government expenditures, trade openness, etc., our empirical results indeed support our theory by suggesting an inverted u-shaped relationship between corruption and income.

2.2 Introduction

The issue of corruption has gained much attention over the last few years. Countries such as Uganda, Hong Kong, and Singapore have set up anti-corruption institutions in an effort to combat corruption. A lot of nongovernmental agencies such as Transparency International have sprung up in a bid to provide assessments of corruption in countries and to raise awareness on the subject.

Corruption has however existed since time immemorial and different cultures and laws have different takes on what corruption is. One thing is for sure though, most societies frown upon it. Tanzi (1998) explains that a book titled **Arthashastra** on corruption may have been written two thousand years ago. Whereas "lobbying" in order to gain certain advantages (normally economic and political) may be generally accepted in the west, other nations disapprove of it. Even though this phenomenon has existed for a while the views on what corruption is and how to curtail it are varied and debates on it still rage on. Some take a moral perspective and advocate for values and ethics as a viable means of solving it. Others have suggested the need for the establishment of incentives as well as punitive measures; see Rose-Ackerman (1978, 1999).

Corruption is hard to define; the complexity of the subject ensures that its definitions varies and not all of them fully capture its intricacies. Corruption is generally accepted as dishonesty however, different authors have put forth varied definitions of corruption. Huntington (1968) defines corruption as "behavior of public officials which deviates from accepted norms in order to serve private ends." van Duyne (2001) also defines corruption as "an improbity or decay in the decision-making process in which a decision-maker consents or deviates or demands deviation from the criterion which should rule his or her decision-making, in exchange for a reward or for the promise or expectation of a reward, while these motives influencing his or her decision-making cannot be part of the justification of the decision." In the strictest sense, corruption does not only pertain to government officials or the bureaucratic or political scenes. Any agent in an economy can perform corrupt acts.

Corruption has consequences that may stunt economic growth in countries. Mauro (1997) explains that corruption may lead to a misallocation of talent in situation where rent seeking is considered more beneficial than productive work. Corruption may also lead to a loss in tax revenue for the government if firms and businesses engage in tax evasions. Massive corruption could lead to political instability. In the past, public upheavals due to corrupt government leaders have led to the overthrowing of governments. Where contractors pay bribes in order to be awarded contracts this may lead to lower quality of infrastructure. Excessive corruption may reduce the flow of foreign direct investments into a country. Rose-Ackerman (1997) explains that corruption may lead to inequities. Corrupt bidders with inside connections are more likely to be awarded contracts than honest bidders. This has negative effects on the distribution of wealth and resources.

Some literature (for example, Mauro, 1997) suggest that trade restrictions may induce corrupt behavior. Indigenous producers and businessmen, in a bid to protect their businesses from foreign competition may lobby or bribe governments officials to impose tariffs on imports which may create a semi-monopoly for the indigenous firms.

Other works such as Hall (1976), Hofstede (1980), Kluckhohn and Strodtbeck (1961), and Ronen and Shenkar (1985) study how differences in culture affect people's perspective on corruption. Differences in culture may impact how different societies view competition, material wealth, fairness, and attitudes towards change (Sanyal and Samanta, 2002). This is also confirmed by Tsalikis and Nwachukwu (1991); they found that American and Nigerian students' views on corruption were influenced by their respective cultures.

Other factors such as price controls, low wages in the public sector, taxes, and regulations may affect corruption levels in a country (see Besley and McLaren, 1993 and Mauro, 1997).

Even though corruption may be generally frowned upon and discouraged, some authors (for example, Cheung, 1996) explain that in instances where government policy fails to efficiently allocate resources in an economy, corruption may ensure Pareto efficient levels are reached. Houston (2007) also argues that corruption can lead to an expansion in economic activity. He explains that inhabitants may result to bribing officials in order to evade bad laws. His study shows that even though corruption may restrict a country's development, it also has expansionary effects.

This chapter develops a model to depict how society may approach corruption at different phases of development. I use a neoclassical growth model in which corruption is treated as a public bad since corruption is frowned upon in most cultures. However, corruption is considered as an input in the production process and thus incorporates the notion that corruption facilitates the production process. In the model, it is assumed that the capital stock follows the general law of motion. Income, in this model is allocated to consumption, investment, and fighting corruption which can be viewed as a public good. The level of corruption in any period thus depends on the stock of capital as well as anti-corruption effort. The theory suggests that corruption is increasing in income at lower income levels and decreasing in income at higher levels of income, alluding to an inverted u-shaped relationship between corruption and income. This is analogous to the Kuznets curve that draws a relationship between income and inequality.[1] The economic intuition is that, at lower income levels a society may be more concerned with putting bread on the table rather that in anti-corruption but as income levels increase society becomes more interested in fighting corruption. Another explanation is that, at lower levels of income or development, there exist weak monitoring institutions as well as bureaucracies that promote the market for corruption thus as income increases, corruption increases as well. However, at higher levels of income or development characterized by improved monitoring systems and anti-corruption, this increase in income will reduce corruption supply.

This chapter also adds an empirical side that tests and establishes the existence of the inverted u-shaped relationship. It employs a panel dataset on 75 countries covering the period 2001-2008 and a two-way fixed effects model and demonstrates that factors such as government fiscal policy (government expenditure), socioeconomic conditions, trade, as well as war play vital roles in determining the level of corruption in a country.

2.3 Literature Review

Shleifer and Vishny (1993) use a principal agent model in examining corruption.Their model discusses the relationship between the principal who could be a top level government official and the agent who may well be an official. The official may accept bribes from individuals interested in acquiring a good produced solely by the government. They discuss ways to incentivize the official to be honest and not accept bribes. They provide a model whereby the official presides over the sale of this good. They assume that the good is homogeneous and that there exists a demand for this good by private agents. The official may restrict the supply of the good or deny a private agent the right to acquire the good. The official may do this without the risk of being found out or being punished. Shleifer and Vishny (1993) assume that this could be because top officials get a cut or portion of the bribes the official receives from selling this good to private agents. They provide two scenarios in determining the marginal cost of the official. If the government produces this good at a fixed

[1] The idea of the Kuznets curve has also been applied to environmental degradation and developed into a significant branch in environmental economics. For example see, Forster (1973) and Selden and Song (1995), among others.

cost "p", then depending on whether theft is possible or not the official sets his marginal cost. In the event that price discrimination and theft is not possible, the marginal cost of the official is the government's cost of producing the good. The official would then charge a higher price, keep the bribe then return the cost of producing the good to the government. In the case where theft is possible the official has a marginal cost of zero and can charge lower prices for the goods. In their paper, they discuss ways in which the risk of getting caught, the number of people who purchase the goods, and the severity of the penalties affect an official's decision to be corrupt. They conclude that, central governments' weaknesses may be a possible reason why government agencies impose bribes on private agents requiring permits and licenses. They also mention that corruption is often shrouded in secrecy which might create distortions that discourage investments and growth. A host of papers (see for example, Becker and Stigler, 1974; Rose-Ackerman, 1978; and Klitgaard, 1988) also provide more analyses on corruption using a principal agent models.

There are other models aside from the principal agents model for studying corruption. Faith (1980), Katz and Rosenberg (1989), and Kaufmann and Wei (1999) use resource allocation models (rent-seeking behaviors) to study corruption.

Another seminal work that explores numerous aspects of corruption is presented in Tanzi (1998). He cites the end of the cold war, a lack of information, an increase in the number of democratic government, globalization, increased roles for nongovernmental agencies, greater reliance on the market, and the United States roles as reasons why corruption has gained much attention in recent years. He also explains that growth in international trade and business as well as economic changes in countries have impacted corruption. He provides a simple definition of corruption. Corruption is the "abuse of public power for private benefit." This definition may however be too simple to capture all the facets of corruption. He cautions that corruption may not always involve the payment of bribes. Among the factors that promote corruption, he mentions taxes, regulations and authorizations, and spending decisions. Public sector wages may also be a key factor in combating corruption. He explains that at lower levels of income, corruption tends to be high and at higher levels of income, corruption tends to be lower. Most penalty systems for corruption tend to be inefficient and quite lenient. When corruption is politically motivated it becomes more difficult to effectively apply penalties. Judges may be biased themselves due to familiarity that may exist between them and the culprits. To effectively control corruption there must be leadership by example, transparency, and institutional controls.

On the empirical side, there are a few papers that explore and establish some relationships between corruption and a number of factors. For example, Larraín et al. (2000) analyze the effects of a country's level of openness on its level of corruption. They use foreign direct investment inflows, imports, and export as a percentage of GDP as indicators of a country's openness. They use corruption data from the International Country Risk Guide indicator. The data cover the years 1982 to 1995. Their results indicate that import intensity is not only associated with lower levels of corruption but may also reduce corruption. Their results also suggest that foreign direct investment and corruption have a negative relationship. Treisman (2000) also conducts an empirical assessment of the effects on corruption from historical and cultural traditions, political institutions, levels of economic development, and government policies. He uses data from 1980 to 1990 and compares different indexes of perceived corruption. Treisman finds that countries with protestant traditions and those with histories of British rule tend to be less corrupt. He also finds that federal states are more corrupt and countries with longer years of democracy, as well as those with more developed economies tend to have lower levels of corruption.

Some literature, such as Mo (2001) analyzes the effects of corruption on the economic growth of a country. Mo (2001) presents the following transmission channels: investment channel, human capital channel, and political stability channel through which corruption affects economic growth. Per his results, the direct impact, human capita, political stability, and investment channels make up for 11.8%, 14.8%, 53%, and 21.4% of the effect of corruption on economic growth, respectively.

This chapter contributes to the literature on corruption and development by exploring both theoretically and empirically the issue of corruption at different stages of income growth and development.

The rest of this chapter is organized as follows. Section 2.4 provides the theoretical framework and analysis. The empirical work is presented in section 2.5. Section 2.6 is allocated to the concluding remarks.

2.4 The Model

In developing a relationship between corruption and economic development or growth, I make use of a neoclassical growth framework where corruption is considered a public bad in the utility function.[2] For simplicity and effective analyses, I ignore labor as an input and assume that the production process in this economy uses corruption and capital as inputs.[3] The neoclassical production function which is dependent on both capital (K) and corruption (R) is given by $F = F(K, R)$ where $F_K > 0$, $F_R > 0$, $F_{KK} < 0$, and $F_{RR} < 0$ with neoclassical justification.[4] In adddition, the Inada conditions for the production function must also be satisfied with $\lim_{K\to\infty} F_K = 0$ and $\lim_{K\to 0} F_K = \infty$. This production structure is based on the earlier stated notion that corruption helps producers circumvent bureaucracies and policies that lead to production inefficiencies.

I assume that the level of corruption at a point in time is a function of capital and anti-corruption activities in the economy. Thus, $R(t) = R(K(t), A(t))$ where R and A denote the level of corruption and anti-corruption activities, respectively. Let us assume $R_A < 0$, $R_{AA} = 0$, $R_K > 0$, and $R_{KK} < 0$ which implies that capital corrupts but does so at a decreasing rate. Inada conditions are imposed so that $\lim_{K\to 0} R_K = \infty$ and $\lim_{K\to\infty} R_K = 0$.[5]

In this economy, income is allocated towards consumption, investment in new capital stock or anti-corruption activities. That is, $F(K, R) = C + I + A$, where C and I denote

[2] This is similar to Forster (1973) where pollution is incorporated into the neoclassical growth model.

[3] One can view labor as an input with constant endowment of labor so that all other inputs can be viewed in terms of per unit of labor.

[4] Subscripts denote partial derivatives throughout this chapter

[5] An example of corruption function that satisfies these assumption is $R(t) = K(t)^{\beta} - A$ where $0 < \beta < 1$. In this very simple case corruption reduction technology (that is, the second term in R) is Ricardian with a unity coefficient.

consumption and investment respectively. Assuming that δ represents depreciation rate, the evolution of capital over time is explained by $\dot{K} = I - \delta K$.

The utility function of this economy is given as $U(C, R)$ with the standard assumptions that $U_C > 0 \quad U_R < 0$, $U_{CC} < 0$, and $U_{RR} < 0$. Meaning, the marginal utility of consumption increases at a decreasing rate whilst the marginal utility of corruption decreases at a decreasing rate. It is assumed further that the Inada conditions hold for consumption. This then implies that its marginal utility is at its highest when corruption approaches zero.[6] That is, $\lim_{R\to 0} U_R = 0$.

The objective is to find a level of consumption and anti-corruption (thus, investment level) that maximizes the present value of utility. The planner's problem is given as

$$\max_{C,A} \int_0^\infty e^{-\rho t} U(C, R) dt$$

$$such \quad that:$$

$$\dot{K} = I - \delta K$$

$$R = R(K, A)$$

$$F(K, R) = C + I + A$$

The Hamiltonian for this problem is given as:

$$H = u(C, R(K, A)) + \pi(F(K, R) - \delta K - C - A)$$

where π is the co-state variable also known as the shadow price of capital. The optimal trajectories for K, C and A must satisfy the following first order conditions:

$$\frac{\partial H}{\partial C} = U_C - \pi = 0 \Rightarrow \pi = U_C \tag{2.1}$$

$$\frac{\partial H}{\partial A} = U_R R_A + \pi(F_R R_A - 1) = 0 \Rightarrow \pi = \frac{U_R R_A}{1 - F_R R_A} \tag{2.2}$$

[6]A simple example of for this utility function is $U = (C^\theta - 1)/(1 - \theta) - R^2/2$, $\theta \epsilon (0, 1)$ where the first term is the commonly used constant intertemporal elasticity of substitution utility function of consumption and the second term is a quadratic corruption disutility function.

$$\dot{\pi} = -\frac{\partial H}{\partial K} + \rho\pi = -(U_R R_K + \pi F_K + \pi F_R R_K - \delta\pi) + \rho\pi \tag{2.3}$$

By combining equations (2.2) and (2.3) and substituting in the time derivative of equation (2.1) I obtain:

$$\dot{C} = \frac{U_C}{U_{CC}}(\rho + \delta - \frac{R_K}{R_A} - F_K) \tag{2.4}$$

Equation (2.4) is known as the consumer Euler equation.[7] From equations (2.1) and (2.2) we see that:

$$U_C(1 - F_R R_A) - U_R R_A = 0 \tag{2.5}$$

Equations (2.2) and (2.5) imply that $U_C = u_R R_A/(1 - F_R R_A) = \pi$. My assumptions imply that $1 - F_R R_A > 0$. These equalities imply that the marginal benefit of consumption should equal the marginal gain from anti-corruption (after accounting for the effects of anti-corruption activities on production) which in turn equals the shadow price of capital. One should also notice that equation (2.5) defines the equilibrium level of corruption activities (A) implicitly as function of consumption and capital, that is, $A = A(C, K)$ with $\frac{\partial A}{\partial C} > 0$ and $\frac{\partial A}{\partial K} > 0$.[8] By substituting the equilibrium level of anti-corruption activities in the law of motion for capital, we obtain:

$$\dot{K} = F(K, R) - C - A(C, K) - \delta K$$

let:

$$\Phi(C, K) = F(K, R) - C - A(C, K) - \delta K \tag{2.6}$$

[7] To see this one has to note that $\frac{U_C}{U_{CC}} = -\frac{C}{\sigma}$ where σ is the inverse of the elasticity of inter-temporal substitution.

[8] A proof of this and a formal derivation of all equations can be found in the appendix 2.A.

Setting equation (2.6) equal to zero and totally differentiating it with respect to C and K, yields:

$$\frac{dC}{dK} = -\frac{\Phi_K}{\Phi_C} = \frac{F_K + F_R R_K - \left[\frac{\partial A}{\partial K}(1 - F_R R_A) + \delta\right]}{(1 + A_C - F_R R_A A_C)} \tag{2.7}$$

From equation (2.7), since the denominator is positive, the sign of $\frac{dC}{dK}$ rests ultimately on the sign of the numerator. Using the Inada conditions imposed on F and R we notice that there exist a K^* such that for $K < K^*$ the numerator is positive and the reverse holds where $K > K^*$. This implies that:

$$\frac{dC}{dK} = \frac{>}{<} 0 \quad \text{for} \quad K \frac{<}{>} K^*$$

That is, along the curve $\dot{K} \equiv \Phi(C, K) = 0$, C and K are positively related for low levels of K but this relationship is negative for sufficiently high K. From equation (2.4) we obtain an equation of motion for consumption. I set $\dot{C} = 0$ and define:

$$\Psi(K, C) = \rho + \delta - \frac{R_K}{R_A} - F_K$$

The derivative of Ψ with respect to K (Ψ_K) is $-(\frac{R_{KK} R_A}{R_A^2} + F_{KK})$.[9] The model assumptions also imply that Ψ_C is zero and hence $\frac{dC}{dK} = -\frac{\Psi_K}{\Psi_C} = \infty$. Figure 1 depicts the loci for which $\dot{K} = 0$ and $\dot{C} = 0$.

Next, note that $\Phi(K, C)$ is a decreasing function of C so for a fixed K and consumption levels below the locus $\Phi(K, C) = 0$, $\dot{K}$ is positive whereas above it the reverse is true. Also, since $\Psi_K = \frac{d\dot{C}}{dK} < 0$, then to the right of the locus $\dot{C} = 0$, consumption growth will be negative whereas to its left consumption growth will be positive. S represents the dynamic adjustment(saddle) path which satisfies all conditions(constraints) in the model.

We can find a level of anti-corruption $A(K, C)$ that solves equation (2.5) for any given level of C and K. We assume a minimum level of anti-corruption activity α, this is because even in the most corrupt societies there is always an opposition to corruption. Also no country or society can function without a justice system or law enforcement. If $U_C > \frac{U_R R_A}{1 - F_R R_A}$ at an initial point where $C = C_o$, $K = K_o$, and $A = \alpha > 0$, then the utility desired from

[9] I assume that that $R_{KK} R_A / R_A^2 + F_{KK} > 0$, that is, $\Psi_K < 0$, to ensure stability of steady-state equilibrium.

consumption outweighs the benefits a representative agent believes he/she will gain from anti-corruption activities or from being fair. In such an instance we can find a set of different combinations of consumption and capital such that anti-corruption activities would be at its possible minimum, that is, $A(K,C) = \alpha$. The frontier/boundary of this set satisfies:

$$\gamma = U_C(1 - F_R(R(K,R))\frac{\partial R(K,\alpha)}{\partial A}) - U_R(R(K,\alpha))\frac{\partial R(K,\alpha)}{\partial A} = 0$$

Below this frontier lies a region where society remains indifferent to corruption reduction at different combinations of C and K. Differentiating this equation with respect to C and K yields:

$$\frac{dc}{dk} = -\frac{\gamma_K}{\gamma_C} = -\frac{-U_C F_{RR}\frac{\partial R(K,\alpha)}{\partial K}\frac{\partial R(K,\alpha)}{\partial A} - U_{RR}\frac{\partial R(K,\alpha)}{\partial K}\frac{\partial R(K,\alpha)}{\partial A}}{U_{CC}(1 - F_R(R(K,\alpha))\frac{\partial R(K,\alpha)}{\partial A}} < 0 \tag{2.8}$$

which implies that the frontier for $A(K,C) = \alpha$ has a negative slope in the C-K space. This curve is denoted by $A(K,C)$ in Figure 2.E.1. Then, as it can be seen from Figure 2.E.1, for $K \in [K_0, K^A]$ corruption reduction activities will remain at the minimum possible level (α), implying that $\dot{A} = 0$. This is because the range lies within the zone of indifference to corruption reduction. For $K \in [K^A, \bar{K}]$, in order to determine the behavior of $\dot{A}$ we differentiate equation (2.5) with respect to t to obtain:

$$\dot{A} = \frac{U_{CC}\dot{C}(1 - F_R R_A) - \dot{K}(U_C R_A F_{RR} R_K + U_{RR} R_A R_K)}{U_C R_A^2 F_{RR} + U_{RR} R_A^2} > 0 \tag{2.9}$$

When we take the time derivative of the corruption reduction function, we get $\dot{R} = R_K\dot{K} + R_A\dot{A}$. In the range $K \in [K_0, K^A]$, $\dot{A} = 0$ implying that $\dot{R} = R_K\dot{K} > 0$ and hence corruption would increase as agents express an indifference to corruption. For the range $K \in [K^A, \bar{K}]$ however, equation (2.9) would imply:

$$\dot{R} = \frac{U_{CC} R_A(1 - F_R R_A)\dot{C}}{U_C R_A^2 F_{RR} + U_{RR} R_A^2} \tag{2.10}$$

The numerator in equation (2.10) is positive whilst the denominator is negative hence overall $\dot{R} < 0$. This implies that

$$\dot{R} = \begin{cases} > 0 & \text{for } K \in \left[K_o, K^A\right] \\ < 0 & \text{for } K \in \left[K^A, \bar{K}\right] \end{cases}$$

2.5 Empirical Analyses

2.5.1 Data

For the empirical analysis of the above model, I consider 75 countries (see Table 2.E.1 for the list of countries) over a period of eight years, 2001 to 2008 implying a total of 600 observations per variable. The countries represented in this analysis include developing, middle income, as well as high income countries. Table 2.E.2 presents a summary of key variable statistics used in the analysis.

Data on the corruption comes from the International Country Risk Guide's (ICRG) political risk ratings data set. The corruption rating reflects the extent of corruption in a country's political system. It takes into account forms of corruption faced by businesses such as bribes associated with imports, loans, and export licenses. This rating is more concerned with other forms of corruption such as nepotism and job reservations. For more information and technicalities on this rating see Howell (1998) as well as Howell (2011). Corruption's original rating was scored over 6 points with a higher score denoting less corruptibility and vice versa. This rating is thus rescaled to percentage points by dividing by 6, subtracting from 1, then multiplying by 100 i.e. (new corruption index=(1-corruption/6)*100). This transformation also ensures that high percentage scores imply higher levels of corruption.

GDP data comes from the World Bank database. The GDP data aggregates all gross value added in the economy by resident producers, as well as taxes, net of any subsidies not captured in the products value. The data values are expressed in current US dollars

Data on rent, military expenditure, and government expenditure also come from the World Bank database. Rent signifies total natural resource rent and is defined as the sum of rents from natural gas, oil, coal, forests, and minerals, expressed as a percentage of domestic GDP. Government expenditure represents general government final consumption and it captures all current government expenditures on goods and services as well as expenses on defense and security. They are also expressed as a percentage of Total GDP. Military Expenditure is expressed as a percentage of GDP and it encompasses a country's expenses, both current and capital on its armed forces, peace keeping forces, paramilitary etc and includes expenses on pensions for military retirees, procurement, and operations and maintenance. It is worth noting that government expenditure does not include military expenditures that are part of government capital formation.

War data comes from the PRIO Conflict Site dataset. This dataset is an extension of the PRIO Armed Conflict Dataset; it includes coordinates for conflict zones and the countries in which these zones are located. For the purposes of this research the data is modified by creating a dummy variable (with values zero and one) to correspond to any incident of conflict in a country within the time frame of the research. One denotes a recorded conflict and zero otherwise. See Hallberg (2012) for more information on the conflict dataset.

The data on socio-economic conditions also comes from ICRG's political risk ratings dataset. This risk rating is comprised of the following subcomponents: unemployment, consumer choice, and poverty. It assesses the socio-economic pressures in a country and how these pressures may induce social unrest and dissatisfaction, as well as reduce a government's effectiveness. The ratings are scored over 12 but are rescaled to percentages. Higher values connote very low risk hence good and favorable socio-economic pressures and vice versa.

Data on imports and exports as a percentage of GDP came World Bank database. They capture such exchanges related to merchandise, freight, transportation, construction, and royalties to and from the rest of the world. A measure of trade openness is calculated from this two variables using the formula:

$$\text{Trade Openness} = \frac{\text{Imports+Exports}}{\text{GDP}}$$

2.5.2 Empirical Model

To empirically test the theoretical model proposed, I use a fixed effects model with time effects with panel data. Fixed effects help to reduce any potential bias resulting from omitted variables. By using Panel data, the researcher has the advantage of using both cross sectional and time series information in analyzing empirical relationship. It also increases the number of observations, implying increased degrees of freedom and reduces any collinearity among the explanatory variables (Hurlin and Venet (2001)). The model is given as:

$$y_{it} = \alpha_i + \Gamma_t + \beta_1 x_{it} + \beta_2 x_{it}^2 + \gamma Z + U_{it} \tag{2.11}$$

with $i = 1, ..., N$(number of countries) and $t = 1, ..., T$(number of time periods) where α_i and Γ represent country specific effects and a time effects respectively. The individual effects (α_i) picks up any country specific influences which do no vary with time. Under the fixed effects model α_i is assumed to be correlated with the regressors. The time effects (Γ) control for certain phenomena that vary with time but common to all countries. Also, x and y represent income, in this case log of GDP and corruption respectively. Z represents all other control variables used in the empirical analysis. These control variables include war (internal conflict), socio-economic conditions, rent, military expenditure, and government expenditure. U_{it} is the error term.

In the model section, it was shown that under certain assumptions and conditions the corruption and income can have an inverted u-shaped relationship. The signs of β_1 and β_2 are important in ascertaining the possible existence of this relationship. Possible scenario for the signs of β_1 and β_2 include:

1. If $\beta_1 = \beta_2 = 0$, then in this case, no relationship exists between corruption and income.
2. If $\beta_1 \binom{>}{<} 0$ and $\beta_2 = 0$ then as income increases, the level of corruption in a country $\binom{\text{increases}}{\text{decreases}}$ monotonically.
3. if $\beta_1 < 0$ and $\beta_2 > 0$, then there exists a u-shaped relationship between corruption levels and income.
4. if $\beta_1 > 0$ and $\beta_2 < 0$, then the possibility of an inverted u-shaped relationship between corruption and income is validated.

In the case of socio-economic conditions, one would expect that with worsening socio-economic conditions (that is, a decrease in the index) corruption would increase. This is because bad socio-economic conditions are often associated with poverty, a deprivation of basic social amenities, and scarcity often induce corruption in a society (UN-Habitat and Transparency International, 2004). Thus, socioeconomic conditions and corruption level should have an inverse relationship.

The relationship between resource rents and corruption can be rather inconclusive. Some authors (see, for example, Treisman, 2000) argue that rents might induce corruption when it comes to their distribution. Ades and Di Tella (1999) assert that where countries have large resource endowments, officials have a higher tendency to be corrupt. On the contrary, one could also argue that if owners of resources receive higher and fairer rents, there would be a lesser propensity to be corrupt.

I use military expenditure as a proxy for law enforcement effectiveness. The expectation is that as law enforcement effectiveness increase (efficient monitoring institutions, as well as better renumeration for the police forces and the judiciary), then there should be less incentive for officials to be corrupt. Also, society would be deterred if they are scared monitoring institutions will be up on their corrupt activities. Tanzi (1998) explains the importance of increasing penalties in decreasing corruption. However, he cautions that higher punitive measures may increase demands for higher bribes.

From real life cases, war-torn countries are often associated with high incidences of corruption. This is because in the event of a war, most institutions breakdown, and law enforcement tends to be ineffective. Thus, people see this as an opportunity to amass wealth by taking advantage of broken down system. I would therefore expect a direct relationship between war and corruption. Transparency International's Corruption Perceptions Index (CPI) (Transparency International, 2010), which ranks countries by perceived levels of corruption in the public sector, shows that, war-torn, fragile and unstable countries like Somalia, Afghanistan, Myanmar, Sudan, and Iraq have the highest levels of corruption.

The sign of coefficient on government expenditure is inconclusive. One may expect that as governments spend more on social infrastructure and amenities, education, and health, corruption would fall. This should be the case if such spendings help reduce public upheavals and any societal agitations. Lindbeck (1998) suggests that low levels of corruption in Sweden may be partly attributed to high-level administrators earning roughly 12 to 15 times more in wages than the average factory worker. At the same time, Tanzi (1998) mentions that officials may find government spending on projects as an avenue to embezzle funds, in which case increased government expenditure may induce corrupt activities in officials.

A country's level of trade openness should have a direct effect on its corruption levels. The reason being that, trade restrictions often come in the form of higher tariffs, quotas, and import/export licenses; these inhibit the activities of importers and exporters. Mauro (1997) explains that local manufacturers in a bid to protect their business may lobby for the maintenance and establishment of import barriers by bribing corrupt officials. One should thus expect that if trade openness increases, corruption should decrease.

Another issue worth noting about equation 2.11 is the endogeneity of income in the model. The level of corruption and income levels are jointly determined in the model. This is because people's decision to either invest, consume or engage in anti-corruption activities inadvertently affects income. This would mean that the square of income is also endogenous. To get round this, I employ instrumental variables. For income, I use its lagged value as an instrument. I also use the lagged values of its square as instrument for the square of income. As Angrist and Pischke (2008) explain, by doing this, I do not commit the "forbidden regression." The instrumentation process is valid since it is exactly identified and lagged values are correlated with the endogenous regressors and theoretically sound.

As stated earlier, panel data comprises of both cross-sectional data and time series. This means that, in using panel data we have to ensure that the following phenomena are accounted or corrected for:

Cross-Sectional Dependence: Cross-sectional dependence arises when some of cross-sectional units (countries) are interdependent on each other. Using time dummies in a model can help in controlling for some forms of cross-sectional dependence so this should not be much of a problem in this model since its a two way fixed effects model. Baltagi (2008) explains that cross-sectional dependence is much of a concern in macro panels with long time series but no so much in micro panels.

Stationarity: A weak stationary process would have the constant mean, variance, and auto-covariance. This implies that, a stationary process has a higher tendency to converge towards the mean. The use of a non-stationary process in a regression can produce misleading result; regressions may show significant relationships when in actual fact there might not be any. This is explained in Granger and Newbold (1974). When a series or process is non-stationary its order of integration must be determined by differencing till it becomes stationary.

Heteroskedasticity and Serial Correlation: One fundamental assumption in equation 2.11 is the assumption that disturbances are homoskedastic. This means that they have the same variance across time and cross-sections. When this is violated, regressions may produce consistent but inefficient estimates. Serial correlation could also lead to inefficient but consistent estimates if it is ignored. Serial correlation is however not an issue in micro panels.

2.5.3 Empirical Results

In testing for cross-sectional independence in the equation 2.11, I use the method explained in Pesaran (2004). This method has the advantage of being robust to the presence of unit roots and structural breaks. Additionally, it is favored for its ability to handle both unbalanced and balanced panels with small T and large N. The test reveals that there is no cross-sectional dependence in the model.

I use a modified Wald statistics described in (Greene, 2003, p 598) in testing for heteskedasticitity in the model. The test reveals the presence of heteroskedasticity. Thus, for the estimation process, I use robust standard errors.

For the panel unit root test, I employ Choi (2001) P and Pm test statistics.[10] The advantage of this test as Choi (2001) points out is that each panel can have a different

[10] This was originally developed by Fisher (1932).

stochastic and non-stochastic components, as well as different time series dimensions, i.e., it works well for both balanced and unbalanced panels. The test shows that all variables except "war" are stationary. The war variable is a dummy variable and as such its stationarity does not pose a problem for the analysis.[11]

I employ Schaffer (2012) module in the estimation process.[12] The results for the estimation of equation 2.11 is presented in Table 2.E.4. The first model estimates equation 2.11 without considering time effects whilst the second model does. The results show that the log of GDP which measures average income is very significant in both models. It has the appropriate positive sign. This implies that holding all else constant and for this particular sample of countries, a percentage increase in GDP will result in 0.6228 unit increase in corruption on the average.[13] This value does not change much in the second model when time effects are controlled for.

The coefficient of the squared log of GDP is also very significant and has the expected sign. This, as well as the positive and significant coefficient of the log of GDP validate the possibility of an inverted u-shaped relationship between corruption and income. This suggests that a higher income level leads to higher corruption at low levels of income, but the converse is true at high levels of income. My model explains that at lower levels of income, people care very little about contributing to anti-corruption. They are more interested in diverting their resources towards consumption, and investment in capital but as income increases, anti-corruption mechanisms become more affordable.

The results also indicate a negative coefficient for government spending. It is significant at the 10% level. This implies that corruption decreases with government spending. This further buttresses the view that as government spends more on public sector wages, social infrastructure and amenities, as well as strengthening the judiciary, and law enforcement agencies, then corruption should reduce. The argument that increases in government expenditure may provide avenues for public officials to be corrupt, may not necessarily hold true if monitoring activities of the law enforcement agencies and the judiciary are strengthened.

[11] All the tests are presented in the appendix section of this paper.

[12] For the first stage estimation results see Table 4..2.

[13] $\frac{62.28}{100} = \frac{\text{unit}\Delta\text{Corruption}}{\%\Delta\text{GDP}}$

Government fiscal policy may thus play an important role in reducing corruption provided there is accountability and transparency (see Kopits et al., 1998).

From Table 2.E.4, one can see that the coefficient for military expenditure has a positive sign. This goes contrary to what was expected. Military expenditure is used as a proxy for law enforcement expenditure and effectiveness. One would expect that as law enforcement expenditure and effectiveness increases, corruption should reduce. Some literature argue that law enforcement effectiveness may not necessarily lead to a decline in corruption but could rather cause people do seek higher compensations for their corrupt activities. Criminals may also increase their level of sophistication to counter the increased effectiveness of law enforcement. These could explain the positive relationship between corruption and law enforcement expenditure. In any case, this relationship is not significant in this model.

The estimations also show that rents are very significant. The coefficients bear a negative sign. This implies that as the proportion of rents in the GDP goes up, corruption declines. This can be interpreted in two ways: the first may be that as the prices of natural resources, and rents to owners increase (the proportion of rents in GDP increases), there may be less incentive for natural resource owners to engage in illicit activities provided law enforcement monitoring activities remain effective. The second could be that the percentage of rents in GDP has increased because of increased mining and exploitation of natural resources. This would mean more jobs, implying increased wages, which in turn reduce any forms of public upheavals and reduce incidences of corruption in the economy.

Table 2.E.4 also confirms a priori expectations about incidences of war and their effects on corruption levels. The coefficient of war has a positive sign and it is very significant. According to the estimates, holding all other things constant, an incidence of conflict, any ethnic tensions or war would increase a country's corruption index by 8.3 units. When wars occur, there is normally a breakdown of institutions which often means that monitoring system are weak or almost inexistent. This could possibly explain why war-torn countries like Iraq and Afghanistan are relatively more corrupt than other more politically stable countries.

The estimation results also indicate that socioeconomic conditions are significant in the model. Its coefficient also has a negative sign. This implies that as the socioeconomic conditions in a country improve so that schools, hospitals, and other basic social amenities are provided, coupled with improved governance, democracy and judicial transparency, then one would expect that inhabitants of a country will be less likely to engage in corruption.

For trade the estimation results suggest that when a country opens up to trade, corruption declines. This is so because the coefficient has a negative sign and it is significant at the 10% level. This means that holding all other things constant, an increase in trade openness (import and export intensities) lead to a 0.04 point decline in the corruption index. This finding concurs with findings in Larraín et al. (2000) where they find that a one standard deviation increase in import intensity causes a 0.3 point reduction in the corruption index. Ades and Di Tella (1999) also find that openness may lead to less competition.

2.6 Conclusion

This research focuses on corruption as economies move through different phases of development. It presents a possible way in which society makes decisions pertaining to corruption. I use a neoclassical growth model to show that at low levels of income, individuals allocate their income towards consumption and investment and care less about anti-corruption activities. The model shows the possibility of an inverted u-shaped relationship between corruption and income.

This paper also conducts empirical analyses to ascertain the possible existence of an inverted u-shaped relationship between corruption and income. I use panel data on 75 countries covering a period of eight years from 2001 to 2008 and employ a two way fixed effect model to establish and investigate empirical relationships.

The estimation results show that log of GDP has a positive and significant sign whilst its square has a negative and significant coefficient. This thus confirms the existence of an inverted u-shaped relationship between corruption and income and hence validates the afore mentioned theoretical model.

This chapter also establishes that trade openness could possibly lead to a reduction in corruption. This lends support to similar findings in some literature about import intensities and anti-corruption. I also establish the well accepted notion that an incidence of war, ethnic tensions, and conflicts would lead to an increase in corruption in the stipulated countries. The estimates show that such incidences increase the corruption index of a country by about 8.3 points.

Government expenditure is also significant in the empirical model. It shows that as government expenditure increases the level of corruption in a country reduces. This is contrary to what has been suggested in some literature that increases in government expenditure may provide more incentives for people to be corrupt. In this essay, military expenditure is used as a proxy for law enforcement. The results show that this is not significant.The paper also shows that as the proportion of natural resource rents in the GDP increases, corruption decreases. It also establishes that socioeconomic conditions in a country is very important in controlling corruption in a country.

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Appendices

2.A Proof that $\frac{\partial A}{\partial C} > 0$ and $\frac{\partial A}{\partial K} > 0$

$$U_C(1 - F_R R_A) - U_R R_A = 0$$

$$D = U_C(1 - F_R R_A) - U_R R_A$$

$$\frac{\partial A}{\partial K} = -\frac{D_K}{D_A} = -\frac{-U_C F_{RR} R_K R_A - U_{RR} R_K R_A}{-U_C F_{RR} R_A^2 - U_{RR} R_A^2} > 0$$

$$\frac{\partial A}{\partial C} = -\frac{D_C}{D_A} = -\frac{U_{CC}(1 - F_R R_A)}{D_A} > 0$$

2.B Test For Cross-sectional Dependence and Heteroskedasticity

Test for cross-sectional dependence

Pesaran's test of cross sectional independence = −1.175, Pr = 0.2401

Average absolute value of the off-diagonal elements = 0.480

Test for heteroskedasticity

Modified Wald test for groupwise heteroskedasticity in fixed effect regression model

H_0: $\sigma_i^2 = \sigma_i^2$ for all i

$\chi^2_{71} = 7907.60$

Prob $> \chi^2_{71} = 0.0000$

2.C Panel Unit Root Test

Ho: All panels contain unit roots

Ha: At least one panel is stationary

Table 2.C.1: Panel Data Unit Root Test

Variables	P	P-value	Pm	P-value
Log of GDP	1137.527	0.0000	57.0149	0.000
Square log of GDP	1153.88	0.0000	57.9591	0.000
Trade Openness	833.7115	0.0000	39.4741	0.000
Government Expenditure	223.5415	0.0001	4.2459	0.000
Military Expenditure	558.0388	0.0000	24.6874	0.000
Rent	304.1797	0.0000	8.9016	0.000
Corruption	641.9233	0.0000	28.4012	0.000
Socio-economic Conditions	613.9051	0.0000	26.7836	0.000
War	2.1775	1.0000	-8.5345	1.000

2.D Hausman Test

Table 2.D.1: Stored Regression Estimates for Hausman Test

	Coefficients			
	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Log of GDP	62.28307	42.60741	19.67566	6.026778
Square log of GDP	-1.23942	-0.86726	-0.37216	0.122586
Government Expenditure	-0.49508	-0.91811	0.42303	0.185061
Military Expenditure	0.478037	0.775782	-0.29774	0.823748
Rent	-0.33328	-0.11326	-0.22002	0.056768
War	8.293735	6.748923	1.544812	0.824304
Socioeconomic Conditions	-0.17403	-0.27406	0.100028	0.030625
Trade Openness	-0.04631	-0.06846	0.022141	0.024117

b = consistent under Ho and Ha

B = inconsistent under Ha, efficient under Ho

Test: Ho: difference in coefficients not systematic

$$\chi^2_8 = (b - B)'[(V_b - V_B)^{-1}](b - B) = 34.48$$

$$\text{Prob} > \chi^2_8 = 0.0000$$

2.E Tables and Figures

Table 2.E.1: List of Countries

Argentina	Denmark	Ireland	Nigeria	Switzerland
Australia	Ecuador	Israel	Norway	Tanzania
Austria	Egypt	Italy	Pakistan	Thailand
Azerbaijan	El Salvador	Japan	Panama	Tunisia
Bangladesh	Estonia	Jordan	Peru	Turkey
Belgium	Finland	Kazakhstan	Philippines	Uganda
Bolivia	France	Kenya	Poland	Ukraine
Brazil	Ghana	Latvia	Portugal	United Kingdom
Bulgaria	Greece	Lithuania	Romania	Uruguay
Cameroon	Guatemala	Luxembourg	Russia	Venezuela
Canada	Honduras	Malawi	Senegal	Zambia
Chile	Hong Kong	Malaysia	Singapore	
China	Hungary	Mexico	Slovenia	
Colombia	Iceland	Namibia	South Africa	
Costa Rica	India	Netherlands	Spain	
Croatia	Indonesia	Nicaragua	Sweden	

Table 2.E.2: Summary Statistics for Variables

Variable	Observations	Mean Std.	Dev.	Min	Max
GDP	600	3.53E+11	7.13E+11	1.72E+09	4.85E+12
Government Expenditure	600	15.69921	5.069147	4.506118	28.58926
Military Expenditure	565	1.880184	1.247784	0.371024	9.636058
Rent	600	6.807774	11.14173	0	68.46915
War	600	0.135	0.342009	0	1
Corruption	600	52.07945	20.48455	0	91.66666
Socioeconomic Conditions	600	53.06192	20.63711	12.5	91.66666
Exports	600	44.59458	34.47649	9.55879	230.269
Imports	600	45.78814	30.62406	8.480795	209.3877
Trade Openness	600	90.38272	64.26983	18.03959	439.6567

Table 2.E.3: First Stage Regression Results

Variables	(1) Log of GDP	(2) Square log of GDP	(3) Log of GDP	(4) Square log of GDP
Government Expenditure	-0.00643	-0.342	-0.00614	-0.330
	(0.00463)	(0.228)	(0.00411)	(0.204)
Military Expenditure	-0.0653***	-3.301***	-0.0276	-1.427*
	(0.0238)	(1.182)	(0.0171)	(0.830)
Rent	0.00933***	0.458***	0.00630***	0.309***
	(0.00172)	(0.0865)	(0.00157)	(0.0780)
War	0.0332	1.517	0.0263	1.132
	(0.0223)	(1.124)	(0.0288)	(1.438)
Socioeconomic Conditions	0.00413**	0.215**	0.00481***	0.249***
	(0.00186)	(0.0967)	(0.00150)	(0.0787)
Trade Openness	-0.000439	-0.0236	-0.00329***	-0.165***
	(0.000611)	(0.0298)	(0.000793)	(0.0398)
year 2003			0.112***	5.709***
			(0.0208)	(1.057)
year 2004			0.173***	8.732***
			(0.0308)	(1.591)
year 2005			0.191***	9.544***
			(0.0445)	(2.308)
year 2006			0.252***	12.50***
			(0.0561)	(2.905)
year 2007			0.334***	16.69***
			(0.0654)	(3.404)
year 2008			0.382***	19.04***
			(0.0837)	(4.354)
lagged log of GDP	1.250***	13.58	1.265***	14.24
	(0.267)	(13.06)	(0.251)	(12.30)
lagged square log of GDP	-0.00616	0.676**	-0.0126**	0.360
	(0.00542)	(0.268)	(0.00559)	(0.280)
Observations	495	495	495	495
R-squared	0.925	0.926	0.951	0.951
Number of id	71	71	71	71

Robust standard errors in parentheses

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

Table 2.E.4: Estimation Results

Variables	(1) Corruption	(2) Corruption
Log of GDP	62.28***	62.48***
	(16.16)	(16.09)
Square Log of GDP	-1.239***	-1.242***
	(0.324)	(0.333)
Government Expenditure	-0.495*	-0.455*
	(0.273)	(0.275)
Military Expenditure	0.478	0.689
	(1.140)	(1.158)
Rent	-0.333***	-0.344***
	(0.103)	(0.105)
War	8.294***	8.565***
	(2.892)	(2.814)
Socio-economic Conditions	-0.174***	-0.181***
	(0.0534)	(0.0569)
Trade Openness	-0.0463*	-0.0505*
	(0.0253)	(0.0284)
year 2003		-1.403
		(1.179)
year 2004		0.0500
		(1.353)
year 2005		-0.156
		(1.545)
year 2006		0.279
		(1.906)
year 2007		-0.450
		(2.422)
year 2008		-0.615
		(3.025)
Observations	495	495
R-squared	0.159	0.167
Number of id	71	71

Robust standard errors in parentheses

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

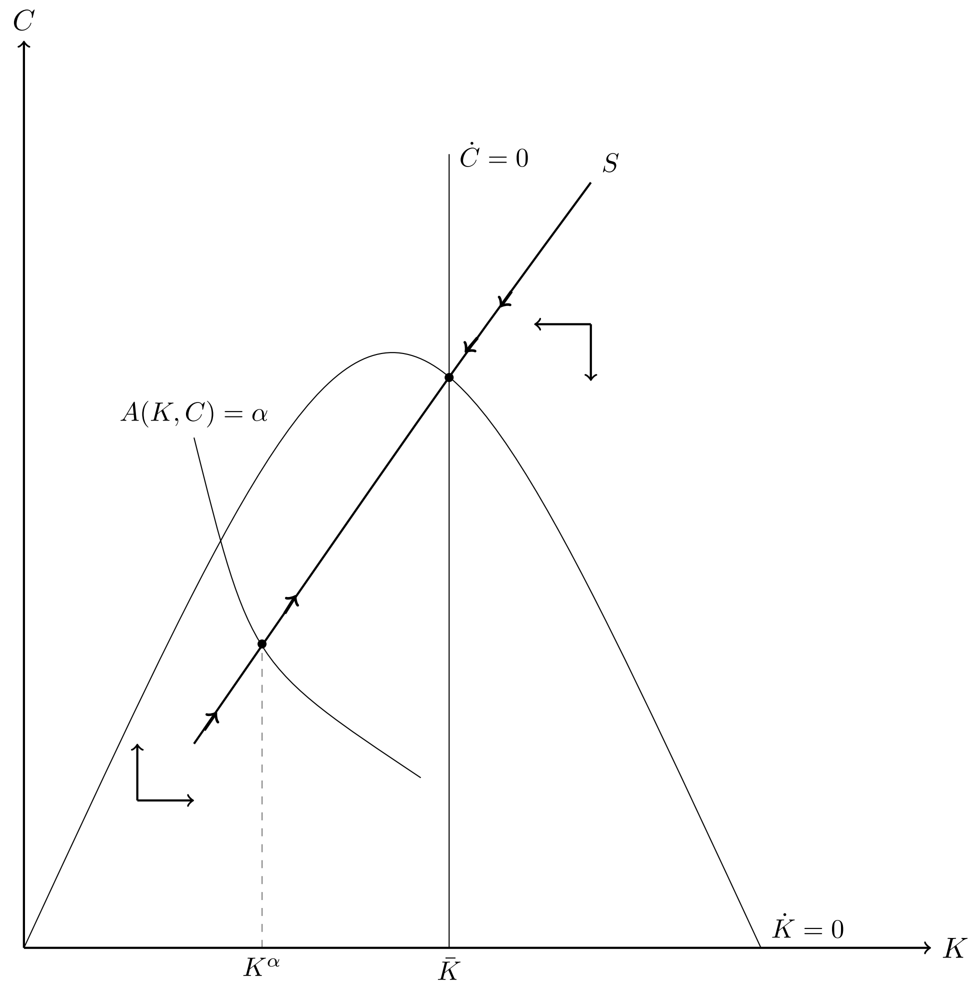

Fig. 2.E.1: Phase Diagram For Consumption and Capital with $A(K, C) = \alpha$

CHAPTER 3
TRADE IN MERCHANDISE AND SERVICES: A GRAVITY APPROACH

3.1 Abstract

This chapter explores the determinants of merchandise and services trade both theoretically and empirically using the gravity approach. It uses a general equilibrium framework to show that merchandise and service trade may be simultaneously determined. Our empirical analysis indeed supports this proposition regarding the simultaneity of merchandise and service trade.

3.2 Introduction

The gravity model as used in international trade is analogous to Newton's law of gravity, which purports that all objects attract each other with a force that is directly proportional to their masses and inversely proportional to the square of the distance from their respective centers. In economic terms, the gravity model may help explain trade flows between two countries, as a function of their respective economic masses (often GDP), population, and distances. That is, the trade flow from country i to country j, denoted by X_{ij}, is directly proportional to their respective incomes Y_i and Y_j and inversely proportional to the square of the distance from their centers D_{ij}. This is expressed as:

$$X_{ij} = \frac{Y_i Y_j}{D_{ij}^2} \quad i \neq j \tag{3.1}$$

The gravity model has been adopted to solve a host of issues ranging from assessing trip distribution (Voorhees, 1956) to studying migration (Ravenstein, 1885; Karemera et al., 2000). However, Tinbergen (1962) was the first to use the gravity model in explaining bilateral trade flows. Though the gravity equation may be said to draw analogies from the traditional Newton law of gravity, seminal works such as Anderson (1979), Anderson and

Van Wincoop (2001), Baier and Bergstrand (2001), Bergstrand (1985, 1989), and Eaton and Kortum (2002) provide theoretical basis for the multiplicative form of the gravity model as used in international trade.

The exponents on the mass variables and the bilateral distance in equation 3.1 as defined by the traditional gravity model need not always be 1 and -2, respectively. As Anderson (2010) explains, many applications have seen the estimated coefficients on the mass variables and distance coefficient cluster to 1 and -1 respectively. Equation 3.1 can thus be transformed into

$$X_{ij} = \frac{Y_i^{\beta_1} Y_j^{\beta_2}}{D_{ij}^{\beta_3}} \tag{3.2}$$

where $\beta_1 > 0$, $\beta_2 > 0$, and $\beta_3 > 0$ as seen in Tinbergen (1962). The coefficients β_1 and β_2 can be seen as country i's own-income elasticity of exports and its export elasticity to country j's income, respectively. Equations 3.1 and 3.2 may be too simple in assuming that trade flows from country i to country j are influenced only by their bilateral trade restrictions. Anderson (2010) explains that trade from i to j is also influenced by the remoteness or restriction on trade movements to i's other possible trade partners or destinations as well as restriction on trade movements from j's alternative suppliers of imports (potential import origins). Some current literature have thus used remoteness indexes ($\sum_i \frac{D_{ij}}{Y_i}$) as explanatory variables in traditional gravity models. The distance or remoteness of a country is however not the only form of resistance to trade. There could be various trade policies that could potentially restrict or facilitate the flow of goods into or out of a country. How easily accessible a country is, in terms of it being landlocked or it having a harbor may present significant or additional trade cost to an exporter or importer (Limao and Venables, 2001). Differences in currency between two countries may also present a significant barrier to trade; see Rose (2000). Anderson and Van Wincoop (2001) demonstrates that including "multilateral resistance" can substantially improve the estimation of a gravity model and argue that distance measures do not fully incorporate the effects of multilateral resistance. They advice that gravity models should account for the effects of trade cost or barriers on prices. Feenstra (2004) shows that using fixed effects can solve the above problem of multilateral resistance raised by Anderson and Van Wincoop (2001).

Berthelon and Freund (2008) also use disaggregated bilateral trade data to analyze the effect of distance on trade. They find that the elasticity of trade with respect to distance has increased by 10% since 1985. This would suggests that trade flows to and from remote places have increased in spite of their distance. They show that changes in freight costs and tariffs may lessen the effects of distance on trade.

Over the years, the success of the gravity model in economic empirical analysis has led to a plethora literature attempting to validate its theoretical basis. Head et al. (2013) provides three different variants of the gravity equations based on surveyed theoretical literature on the subject. Others such as Anderson (2010), Anderson and Van Wincoop (2004), Baldwin and Taglioni (2006), as well as Bergstrand and Egger (2011) provide extensive analysis of various theoretical derivation of the gravity model.

In spite of the abundance of literature on the theoretical justification and applications of the gravity model, literature on its application to services is rather scanty. Francois (1993) can be considered as one of the very first applications of the gravity model to trade in services. He uses data on US producer services for the year 1986 to estimate his gravity model. He finds that import and exports of services are positively related to the GDP per capita, and the population of the trading partners. He also finds that having a common language significantly increases exports.

Walsh (2006) uses a gravity model to evaluate the effects of barriers, and other factors on trade in services. He extends previous literature on services trade by focusing on the following four disaggregated services sectors: government, travel, transport, and other commercial services. Walsh (2006) uses import data on 27 OECD countries and about 50 of their trading partners and employs a Hausman-Taylor estimator in the empirical analysis. He finds that common language, GDP per capita, and population of the importing country positively influence the import of travel services. GDP per capita, population of both importer and exporter, distance, adjacency, and EU membership are positively related to the import of transport services. For government services, he finds that only the GDP per capita of the exporting country is significant. For all other commercial services not captured by the afore mentioned categories, the GDP per capita of both the importer and exporter as well as language have positive and significant coefficients.

Another application of the gravity model to trade in services is presented in Grünfeld and Moxnes (2003). Grunfeld and Moxnes use the gravity model to explore the determinants of international service trade and foreign affiliate. They employ data on 22 OECD countries and use a trade restrictiveness index developed by the Australian Productivity Commission as a measure of barriers to service trade and FDI. Their results indicate the presence of a home market effect in the services trade. Their findings also confirm the widely accepted view that trade barriers negatively affect trade. This negative effect is even more severe in the case of foreign affiliate sales. They also show that a removal of trade barriers increases trade by 50%.

Mirza and Nicoletti (2004) present another perspective on bilateral trade in services. Their model is based on a framework initially developed by Kremer (1993). They also employ data on bilateral trade in services for OECD countries. Their findings reveal that labor cost and infrastructure in both the exporting and importing countries affect bilateral trade in services interactively.

Schwellnus (2007) also use the gravity model and data from the Eurostat ITS database in analyzing the effects of domestic regulations on services trade, for both cross-sectional and panel data analysis. The result of their estimation lends support to literature that an inverse and significant relationship exist between domestic regulations and services trade.

Kimura and Lee (2006) employ the gravity model to analyze and evaluate the determinants of bilateral service trade in comparison to the bilateral goods trade. In their analysis, they employ data on services and goods trade on 10 OECD member countries and 47 member and nonmember trading partners. They find, by using R^2 as measure of goodness of fit that the gravity model performs better for the bilateral trade in services than for the trade in goods. They interestingly find that transports cost for services are generally higher than those for goods and that a country being landlocked affects the trade of goods more significantly than it does services.

For this paper, I intend to show by way of a both theoretical framework and empirical analysis that trade in services and merchandise may not be independent of each other and that the two go in tandem. The theoretical framework uses a general equilibrium model with n countries, n finished goods, and n producer services. It assumes that each country is endowed with fixed units of services and that goods are produced in an assembly technology. The empirical model uses a panel data on 24 OECD counties and covers the periods 2000 to 2006. It considers a number of fixed effects specifications in controlling for any unobserved factors that may exist.

3.3 Theoretical Framework

Consider a monopolistic competition world of n countries, n finished goods, and n producer services. I assume that all goods and services are tradable. Each country i is endowed with constant α_i units of service i and 0 unit of service $j \neq i$.[1] This indicates that country i has comparative advantage in service i and disadvantage in all other services. Every country i also produces a traded finished good in a constant elasticity assembly technology given by:

$$X_i = \Sigma_j^n S_{ji}^{\theta} \quad \theta \in (0,1), \quad i = 1,2,3,...,n \tag{3.3}$$

where X_i is the production of the finished good in country i and S_{ji} is usage of service j by country i. Moreover, $\sigma = 1/(1-\theta)$ is the constant elasticity of substitution for a pair of producer services. Turning now to the demand side of the world economy, assume that the consumer's preference is identical across the globe and is represented in each country $i = 1,2,3,..,n$, by the following utility function.

$$u_i = \Sigma_{k=1}^n C_{ki}^{\delta} \quad \delta \in (0,1) \tag{3.4}$$

where C_{ki} is the aggregate consumption of good k by country i and $\eta = 1/(1-\delta)$ is the

[1] This specification of the model is similar to Krugman (1980).

constant demand elasticity. The first order conditions for consumption side of each economy $i = 1, 2, 3, ..., n$ are given by:

$$\delta C_{ki}^{\delta-1} = \lambda p_{ki} \quad k = 1, 2, 3, ..., n \tag{3.5}$$

$$\Sigma_{k=1}^{n} p_{ki} C_{ki} = r_{ii}\alpha_i \tag{3.6}$$

where λ is the Lagrange multiplier (the shadow price), p_{ki} is the price of good k and r_{ii} is the price of service i in country i. Note that $r_{ii}\alpha_i$ is the national income measured from the factor side. I assume that $p_{ki} = d_{ki}p_{kk}$ for all $i, k = 1, 2, 3, .., n$, where d_{ki} is the distance from country k to country i. I further assume that $d_{ki} = d_{ik}$ and normalize the distance from a country to itself to unity, i.e., $d_{ii} = 1$ and $d_{ik} > 1$.

Given the service and good prices, the consumption side of each economy i has $n + 1$ equations and unknowns. These systems could be solved to obtain a system of finished good demand functions. By doing so, I obtain:

$$C_{ji} = \left(\frac{d_{ki}p_{kk}}{d_{ji}p_{jj}}\right)^{\eta} \left(\frac{r_{ii}\alpha_i}{p_{ki}} - \Sigma_{m=1,2,...,k-1,k+1,...,n} \frac{d_{mi}p_{mm}C_{mi}}{d_{ki}p_{kk}}\right) \quad j = 1, 2, 3, ..., n. \tag{3.7}$$

Hence given a numeraire good k, the demand for finished good j in country i depends on the relative price of the good, the relative distance of country j to country i, a measure of real national income in country i and a measure of global relative price index for finished goods.

To complete the general equilibrium model, I now turn to production side of each economy i. The first order conditions for the finished good problem in every country i can be written as:

$$\theta P_{ii} S_{ji}^{\theta-1} = r_{ji} \quad j = 1, 2, 3, ..., n \tag{3.8}$$

where $r_{ji} = d_{ij}r_{jj}$ is the price of the producer service j in country i. Equation (3.8) gives us the demand for producer service j in country i and could be rewritten as:

$$S_{ji} = \left(\frac{p_{ii}\theta}{d_{ji}r_{jj}}\right)^{\sigma} \quad j = 1, 2, 3, ..., n \tag{3.9}$$

This system of n equations depend on $2n$ commodity and service prices. To close the general equilibrium system, I introduce the following $2n$ conditions that clear all global good and service markets, resulting in $2n$ equilibrium good and service prices.

$$\Sigma_{j=1}^{n} C_{ij} = X_i \quad i = 1, 2, 3, ..., n \tag{3.10}$$

$$\Sigma_{j=1}^{n} S_{ij} = \alpha_i \quad i = 1, 2, 3, ..., n \tag{3.11}$$

The left hand sides of these equations are the global aggregate demand while the right hand sides are the global aggregate supply of goods and services. The free entry and exit conditions of monopolistic markets for finished goods imply the following zero-profit conditions.

$$p_{ii}X_i - \Sigma_{j=1}^{n} r_{ji}S_{ji} = 0 \quad i = 1, 2, 3, .., n \tag{3.12}$$

Finally, the trade balance condition for each country i is given by:

$$\Sigma_{j \neq i}^{n} r_{ji}S_{ji} + \Sigma_{j \neq i}^{n} p_{ji}C_{ji} = r_{ii}\Sigma_{j \neq i}^{n} S_{ij} + p_{ii}\Sigma_{j \neq i}^{n} C_{ij} \tag{3.13}$$

I substitute the equilibrium price of finished good i in country i, derived from equation (3.12), in equation (3.9) to obtain:

$$S_{ji} = \left(\Sigma_{k \neq i}\frac{\theta d_{ki}r_{kk}S_{ki}}{d_{ji}r_{jj}C_{ik}} + \Sigma_{k \neq i}\frac{\theta d_{ki}p_{kk}C_{ki}}{d_{ji}r_{jj}C_{ik}} - \Sigma_{k \neq i}\frac{\theta r_{ii}S_{ik}}{d_{ji}r_{jj}C_{ik}}\right)^{\sigma} \tag{3.14}$$

Note that the first term is a measure of relative service price of j and relative distance from i to j. The second term could be read as a measure aggregate consumption expenditure (i.e. national income), while the third term is the relative price of home service.

Equation (3.14) could be rewritten as:

$$(3.15)\quad S_{ji} = \left[\frac{\theta}{r_{jj}}\left(\frac{\Sigma_{k\neq i}(r_{kk}S_{ki}/C_{ik})d_{ki}}{dji} + \frac{\Sigma_{k\neq i}(P_{kk}C_{ki}/C_{ik})d_{ki}}{dji} - \frac{\Sigma_{k\neq i}(r_{ii}S_{ik}/C_{ik})}{dji}\right)\right]^{\sigma}$$

Another interpretation is that the imports of service by country i from country j depends on the relative price service j (in country j), the average share of imported services per $ of finished good export for all trade partners (weighted by relative distance), the relative distance of between i and j (with respect to a measure of average distance, $\hat{d_i} = \Sigma_{k\neq i}(p_{kk}C_{ki}/C_{ik})d_{ki}$, and the average share of imported services per $ of finished good export for all trade partners (weighted by relative distance).

I could alternatively use equation (3.9) and (3.12) to get the following equation for imports of service j (from country j) by country i:

$$(3.16)\qquad S_{ji} = [\theta(\frac{r_{kk}}{r_{jj}})(\frac{1}{\frac{d_{ji}}{\bar{d_i}}})]^{\sigma}$$

where $\bar{d_i} = \Sigma_{k=1}^{n}(S_{ki}/X_i)d_{ki}$ is the weighted average distance to country i. Interestingly, the weights are the relative importance of each service factor, i.e. the the service per unit of country i's finished good. According to (3.14), the imports of service by country i from country j depends on a measure of relative prices, and the distance.

Hence, I conclude from (3.7) and (3.14) that merchandise trade and service trade are simultaneously determined. That is:

$$(3.17)\qquad C_{ji} = f(S_{ji}, d_{ji}, P_{ji}, r_{ji})$$

$$(3.18)\qquad S_{ij} = g(C_{ji}, d_{ji}, P_{ji}, r_{ji})$$

In the remaining sections of this chapter, I shall provide empirical support for this proposition.

3.4 Empirical Analysis

For the empirical analysis I use panel data to estimate the gravity equation established in the preceding section. A fixed effects model helps to reduce any potential bias resulting from omitted variables. By using panel data, the researcher also has the advantage of using both cross sectional and time series information in analyzing empirical relationship. It also increases the number of observations, implying increased degrees of freedom and reduces any collinearity among the explanatory variables (Hurlin and Venet, 2001). One drawback of using panel data is that one has to deal with issues such as attrition and non response. The data spans seven years from 2000 to 2006 and covers 24 OECD countries and 175 trading partners which includes both OECD and non-OECD countries; the data is however unbalanced. This is mainly due to the fact that there is a variation in the number of trading partners for each reporter of merchandise and service trade. Thus, there is a total of 12,803 observations with 2882 bilateral trade pairs in this dataset.

3.4.1 Data

Tables 3.E.1 and 3.E.2 present a list of all 24 reporting countries and their partner countries. Data availability for service and merchandise trade was the main criterion for selecting these countries. A list of all variables employed in the analysis and their summary statistics can be found in Table 3.E.3. The data on electricity consumption has the most number of missing values. The source of the data on distance between trading partners, common colonizer dummy, Gross Domestic Product (GDP), Regional Trade Agreement (RTA), population, common official language, and contiguity is the CEPII gravity dataset. The CEPII dataset provides a "square" dataset of all possible world trade country pairs from 1948 to 2006. GDP data is presented in current US dollars. RTA is a dummy variable; 1 for when the two trading countries are part of a regional trade agreement and 0 otherwise. The common colonizer dummy signifies trading partners that have a common colonizer post 1945. The contiguity dummy represents bilateral trade pairs that share a common border. Common official language works in a similar fashion when both parties speak the same language. See Head et al. (2010) for a complete description of the CEPII dataset and methodologies used in their derivation.

Data on electricity consumption, mobile and internet subscription come from the World Bank's database. Internet usage is expressed per 100 people. Electricity consumption is expressed in kilowatt-hour per capita; it measures total production by power and heat plants net of losses from transmission, transformation, distribution and through their own use. The mobile variable represents subscription to public mobile telephone service measured per 100 people. This includes both post-paid and prepaid subscription.

Data on service imports come from the OECD statistics database. Service imports aggregate all service imports by a reporter from a specific trading partner and is measured in million US dollars. Merchandise data comes from the United Nations' COMTRADE data. They are also of an aggregated form and are measured in current US dollars.

3.4.2 Empirical Model

3.4.2.1 Model Specification

I use a fixed effects model for the estimation process. In estimating an empirical model one often wonders if all explanatory variables are included in the estimation. There could be omitted bias if some explanatory variables are excluded from the estimation. There could also be time-invariant unobservable factors that affect both the left-hand and right-hand side of a model simultaneously which could also cause bias. A fixed effects model helps control for these. This also helps account for the issue of multilateral resistances raised by Anderson and Van Wincoop (2001) as suggested by Baldwin and Taglioni (2006), Feenstra (2004), and Rose and Van Wincoop (2001). Adam and Cobham (2007) argue that including only country specific fixed effects is only a partial solution to controlling for multilateral resistances. They assert that unless these fixed effects are interacted with time, then country fixed effects will only be accounting for the average trade resistance over time. Discussions about what the appropriate form of fixed effect specification and the best way to control for unobserved factors has been ongoing for some time. Egger and Pfaffermayr (2003), and Glick and Rose (2002) incorporate individual fixed effects in their specification. Other fixed effect specifications used in gravity models can be found in Cheng and Wall (2005). Baltagi et al. (2003) recommend that one should control for as much heterogeneity as possible and that the omission of significant interaction terms may lead to biases. They recommend adding individual effects, and importer and exporter specific time-variant effects.

For the empirical analysis I use the model specification proposed by Egger and Pfaffermayr (2003). Since the developed model in the theory section puts forward the possibility of a simultaneous relationship between merchandise and service trade, I estimate the following equations:

$$\begin{aligned} \log X_{ijt} &= \beta_1 \log S_{ijt} + \beta_2 \log Y_{it} + \beta_3 \log Y_{jt} + \beta_4 \log D_{ij} \\ &\quad + \beta_5 \log P_{it} + \beta_6 \log P_{jt} + \alpha_i + \gamma_j + \delta_{ij} + \theta_t + x + \epsilon_{ijt} \end{aligned} \tag{3.19}$$

$$\log S_{ijt} = \eta_1 \log X_{ijt} + \eta_2 \log Y_{it} + \eta_3 \log Y_{jt} + \eta_4 \log D_{ij} + \eta_5 \log P_{it} + \eta_6 \log P_{jt} + \alpha_i + \gamma_j + \delta_{ij} + \theta_t + x + \mu_{ijt} \tag{3.20}$$

where S_{ijt} and X_{ijt} denote country i's service imports and merchandise exports respectively from country j at time t. D_{ij} represents the distance between the respective trading countries. Y_{mt} and P_{mt} for $m = i, j$ represent the GDPs and populations of the trading countries respectively at time t. x represents a vector of other variables, including regional trade agreement (RTA), common language, common colonial relationship, and contiguity. δ_{ij} captures country-pair fixed effects and I assume that $\delta_{ij} \neq \delta_{ji}$, this implies that country-pair effects may vary with the direction of trade. δ_{ij} controls for any unobserved bilateral influences on trade. θ_t represents time effects. It captures time varying effects such as changes in openness and business cycles across countries. α_i and γ_j represent country specific effects. These account for unobserved country specific attributes that impact a country's decision to engage in trade. Egger and Pfaffermayr (2003) explain that these may reflect or capture a country's propensity to import or export. μ_{it} and ϵ_{it} are the log normally distributed idiosyncratic error terms.

The advantage of using a log transformation in estimating the gravity model lies in the ease of interpreting the estimated coefficients. With the log-linear estimation, β_i as well as η_i for $i = 1, 2, 3, 4, 5, 6$ represent elasticities of merchandise exports and service imports respectively, with respect to the corresponding explanatory variables. The GDP variables may be seen as a measure of economic size and for that reason, one should expect that as the economies of countries expand, they engage in more trade. The coefficients β_2 and β_3 as well as η_2 and η_3 should all have positive signs. The coefficients on distance β_4 and η_4 are expected to be negative. This is because the farther a country is from its trading partner the higher the transportation costs. The elasticities of merchandise and service trade with respect to the population of the reporting country and its trading partner may be either positive or negative. A large domestic market, even in the presence of an increasing population may be less inclined to trade if domestic production is absorbed by its economic agents. In which case the coefficients will be negative. On the other hand, a large domestic market may enjoy economies of scale so that it produces a variety of goods and gains comparative advantage in others. In this case the sign on the coefficients will be positive. The sign of the population coefficients thus depends on which of these (whether absorption or economies of scale) is more prominent. Bergstrand (1989) provides an alternative explanation as to why the population coefficients may have a negative sign. He explains that the signs may depend on whether the goods in question are capital or labor intensive so that the sign for the exporter's population is negative when traded goods are capital intensive. The effects of common colonizer post 1945, contiguity, and RTA on the merchandise and services trade are expected to be positive.

To estimate a fixed-effects model one could either use the within estimation or the least square dummy variable method (LSDV). The within transformation works well for a gravity model with balanced panel and is useful in eliminating any monadic effects that may exist. However in the case of an unbalanced panel, the demeaning process may ensure that units that have only one time period are excluded from the estimation process. Baltagi (1995) also explains that within transformation may not be appropriate for unbalanced panels. In such a situation the LSDV approach may be viable option, however this approach can be cumbersome when you have to deal with a large number of dummies. More importantly, the use of large number of dummies may represent a significant decline in degrees of freedom. In my analysis, there are 2882 country-pairs, using the LSDV approach would require 2882 dummies to control for unobserved country-pair effects.[2]

3.4.2.2 Unbalanced Panels and Zeros

Most bilateral trade data are unbalanced. This means data for some cross-sections for certain time periods are not available. For example, one country may trade with another country in one particular year, but not in subsequent years. If the data for this country pair data is missing at random, in which case the reason for being missing is uncorrelated with the idiosyncratic errors then unbalanced panels pose no problems. Also Wooldridge (2012)

[2] The STATA program reghdfe implements the fixed-point iteration proposed by Guimarães and Portugal (2009). It uses an algorithm that is mainly based on the Frisch-Waugh-Lovell theorem.

explains that using fixed effects has the advantage of allowing attrition to be correlated with the unobserved effects.

It is not uncommon to find zero trade flows in bilateral trade data even in the case of aggregated data. Zeros in trade data may be attributed to non-reporting or omission often associated with small or insignificant values of trade or the absence of actual trade between two countries. The consequence of estimating equation 3.19 and 3.20 using a log-linear model is that zero-trade flows are automatically dropped out of the estimation process because the log of zero is undefined. This could potentially lead to an estimation bias. To mitigate this issue of zeros, one may simply truncate the sample by dropping these observations. As noted earlier this method can lead to estimation bias if these are not randomly distributed, especially since zero-trade may reflect hindrances to trade due to distance or a country being landlocked.

Another way of handling zero trade flows often used in literature is to add a very small positive number to all trade flows so that logs are no longer undefined. There is however no rule of thumb as to how small or large this "small positive value" should be. This method is only appropriate if we have real zeros or almost zero trade flows. However using this method has its disadvantages. Flowerdew and Aitkin (1982) as well as King (1988) demonstrate how variations in the value of this "small positive constant" can drastically change estimation results. In some instances, one can generate any desired value for his estimates by simply altering the value of this constant Burger et al. (2009).

Alternatively, to get around the issue of zeros, one might consider not using a log-linear specification at all and only estimate the gravity model in its multiplicative form. Silva and Tenreyro (2006) propose using either the Non-Linear Least Squares (NLS) or the Pseudo Poisson Maximum Likelihood Estimator (PPML) in estimating the gravity model. They however, show that the PPML has more desirable properties. They argue that due to the Jensen's Inequality $\mathrm{E}(\ln \epsilon_{ij}) \neq \ln(\mathrm{E}(\epsilon_{ij}))$ the variance of the estimated parameters is biased. Another nonlinear estimator often used is the Tobit estimator on the log of trade and a constant with left-censoring at zero. The Tobit estimator has been criticized on the grounds that it is only appropriate in situations where small trade values are rounded to zero. A number of other nonlinear estimators that have been used in literature include the Gamma Pseudo Maximum Likelihood (GPML) as used in Manning and Mullahy (2001) and Feasible Generalized Least Squares proposed by Martínez-Zarzoso (2013).

For the empirical analysis in this paper, the Heckman (1979) sample selection model is used. The intuition here is that zero trade flows may result from or reflect a country's (or its firms) decision not to export/import to/from certain markets (Bacchetta et al., 2012). Zero-trade may also reflect huge fixed cost of trade. In this case positive trade flows between two countries can be said to be correlated with certain unobserved characteristics specific to that country-pair. This procedure involves a two step method of estimation; the first steps involves determining the probability of positive or non-zero trade flows between any trading pair. This requires running a probit model to determine whether two countries trade or not then computing the inverse mills ratios. The second step involves estimating the gravity equation given that there is positive on non-zero trade. The inverse mills ratio is included as a variable in the second step. A significant coefficient on the mills ratio justifies correcting for sample bias. It should be noted however that, the first step involves using a variable that explains only the decision to trade but not the value or level of trade. Helpman et al. (2007) use common language and common religion dummies as selection variables. Semykina and Wooldridge (2010) advice including all independent regressors used in the second step in the selection process. Table 3.E.4 shows the proportion of zeros in the service and merchandise variables. The services variable has 12% of observations being zeros. This is not surprising even for aggregate service data since some countries may not import services from all countries in the sample.

3.4.3 Empirical Results

In estimating equation 3.20, the Heckman two step procedure was implemented. In the first step the probability of non-zero trade is determined using a probit model. Common official language dummies as well as dummies that represent when a country is landlocked were used to explain a country's decision to engage in trade. The results for the first step is presented in Table 3.E.5. As expected the GDPs of the trading countries are significant in the selection process. They both have the expected positive signs which signify that as the incomes of countries improve they are more likely to engage in trade. Distance poses as a barrier to trade since a trading partner's remoteness translates into huge transportation costs. One will thus expect distance to have an inverse relationship with a country's decision to trade. The results show that the distance coefficient has a negative sign and is significant. The coefficient for regional trade agreement is also positive and significant. This indicates that regional trade agreements may increase a country's or its firms' likelihood to engage in trade. The estimation results also reveal that the population of the country's partner decreases its likelihood to engage in trade. The coefficient for the reporting country's population is positive but not significant. Table 3.E.5 also indicates that if a partner is landlocked it reduces a country's likelihood of trading with that particular partner holding all else constant. However, a country being landlocked has no significant effect on its decision to trade. Common language, common colonizer post 1945, and contiguity are not significant in a country's decision to trade.

Since the theory postulates that service and merchandise trade may be jointly determined and hence endogenous, there is a need to instrument for merchandise in the services equation and do same for services in the merchandise equation. A valid instrumenting process requires that the instruments be correlated with the endogenous variables but not with the error term. Also there should be at least as many instruments as there are endogenous variables so that the equation is either identified or over-identified. I used the lag of merchandise trade and electricity consumption in the reporting country to instrument for merchandise in equation 3.20. Similarly, the lag of services, and mobile phone subscription, as well as internet subscription of the reporting country are used as instruments for services in equation 3.19. A Sargan-Hansen test was used to evaluate the validity of the instruments used. At the 1% level, I cannot reject the null hypothesis that the instruments used for merchandise and services are valid instruments. A Hausman test for the endogeneity of merchandise and services reveals that the estimate are consistent. The results for the

Sargan-Hansen and Hausman tests are presented in the Appendix section of this paper. The first stage results are also presented in Table 3.E.6.

Table 3.E.8 shows the estimation results for equation 3.20. For comparison purposes the results for the OLS and random effects estimation are included. The first model is an OLS regression with merchandise being an exogenous regressor whilst in the second model is the OLS regression ran with merchandise treated as an endogenous variable. The third model is a random effects model. The fourth and fifth models are OLS estimations with dummy variables; in the fifth model however, Guimarães and Portugal (2009) algorithm is used in estimating the OLS with dummy variables. Merchandise is significant in all models except for model two. It has a positive sign signifying that merchandise trade may be directly related to trade in services. The GDPs of both trading countries are significant in all the models and bear the expected signs. This lends support to the fundamental gravity theory that the income of the trading countries has a positive impact on trade flows. Distance is only significant in the first three models and has the expected negative sign except in the fixed effects model. Contiguity and common colonizer post 1945 are both not significant in any of the models and do not seem to affect services trade. The impact of the importing country's population on bilateral services trade is negative and significant in all models. Correspondingly, the influence of the exporting country's population is also negative but only significant in the first two models. If the importing and exporting country are members of a regional trade agreement then bilateral service trade increases in the OLS models but decreases in the random and fixed effects models. Regional trade agreements are however not significant in the fixed effects models. In all the models except the second model, the coefficient of the inverse mills ratio is significant. This implies that correcting for sample selection bias is valid. For comparison purposes, Table 3.E.9 presents the result for the fixed effects model without correcting for selection bias. Evidently, the results do not change significantly when zero-trade values are dropped from the estimation process.

The estimation results for equation 3.19 are presented in Table 3.E.7. The coefficient for services is positive and significant in all the models. The elasticities in this case are generally smaller than what they were in the services equation. This will suggest that services have a higher effect on bilateral merchandise trade than in the reverse case. The GDPs of both exporting and importing countries are significant in all the models. As expected distance has a negative impact on bilateral merchandise trade but is only significant in the OLS and random effects models. Contiguity is only significant in the OLS model. The population of the exporting country has a positive and significant impact in model one but has a significant negative impact in the fixed and random effects model. The coefficient of the importing country's population is significant and has a negative sign in the fixed effects model. Regional trade agreement has a positive and significant coefficient in all the models except for the OLS model. If the trading parties share a common colonizer, the results indicate that bilateral merchandise trade is positively impacted; this is so in all the models.

Also included in this chapter are the estimation results for alternative fixed effects specification used in literature. They are included to aid comparison with the fixed effects specification used in equation 3.19 and 3.20. Table 3.E.10 and Table 3.E.11 present the results for the alternative fixed effects estimation for services and merchandise respectively. Model 1 implements the fixed effects specification used in Matyas (1998) and Rose and Van Wincoop (2001). It incorporates exporter, importer and time effects. Model 2 is a fixed effects model that controls for unobservable time invariant characteristics and includes only time dummies. This fixed effects specification is seen in Micco et al. (2003). In a like manner, Model 3 uses a fixed effect model suggested in Glick and Rose (2002) and Henderson and Millimet (2008); it captures unobserved country-pair effects. Bussière and Schnatz (2009) include country-pair and time fixed effects in their model. This specification is presented in Model 4. Model 5, 6, and 7 include reporter-period, reporter and country-pair, and partner and country-pair dummies, respectively.[3]

For the bilateral services trade estimation, the coefficient of bilateral Merchandise trade is significant and positive in all the fixed effects specifications used except in Model 3 where only unobserved country-pair effects are captured. Bilateral services' elasticity with respect

[3] Gómez-Herrera (2013) provides a comprehensive list of publications on gravity model estimations and the fixed effects specifications used in them.

to the income (GDP) of the importing country is significant in all the specifications and bears the appropriate sign. The income of the exporting country however has the wrong sign in the first model but it is not significant. All the other specifications produce the appropriate sign and the coefficients are significant. The impact of distance is also negative and significant. The population of the importing country is negative and significant whilst the population of the exporting country is negative and significant only in the first, second, and fifth fixed effects specification. The influence of regional trade agreements is only positive and significant in the second, fifth, and seventh models. The coefficient of the inverse mills ratio is also significant in all models except Model 3, providing validity for the correction of sample selection bias.

From the estimation results of bilateral merchandise trade presented in Table 3.E.11, one can see that bilateral service trade is significant in the second, third, fourth, and seventh fixed effects specifications. The elasticity of merchandise trade with respect to the importer is positive and very significant. Similarly, in the case of the exporter's income, it is only insignificant in the first model. Distance, contiguity, regional trade agreement, and common colonizer are significant and possess the appropriate signs. The coefficient for the population of the exporter is negative but only significant in the third, fourth, and seventh specification. That of the importing country is negative as well but not significant in the first and third fixed effects specifications.

3.5 Conclusion

This paper investigates the relationship between merchandise and service trade. It provides a theoretical framework as well as empirical analysis to evaluate this relationship. The theoretical analysis uses a general equilibrium model with n countries, n finished goods, and n producer services. The theoretical findings suggest that merchandise and service trade may be simultaneously determined.

The empirical section of this paper uses a panel data on 24 OECD and their trading partners. To estimate the proposed theoretical model, the data for the periods 2000 to 2006 was considered. The fixed effects estimation method was based on the Least Square Dummy variable approach. In addition unobserved country-pair, exporter, importer, and time effects were controlled for. In the estimation process alternative fixed effects specifications used in existing literature were considered. Also, since the proposed theoretical model suggests that bilateral merchandise trade and bilateral services are simultaneous determined, I control for endogeneity in the estimation by using the lag of services, mobile and Internet subscription of the reporting country as instruments for bilateral services flows in the merchandise trade estimations. Likewise, electricity, and lag of merchandise are used as instruments for merchandise trade in the bilateral service trade estimation. To control for zero-trade flows this study employs a two-step Heckman procedure in the estimation of bilateral services trade. A Hausman test was done to validate the proposed simultaneous relationship between service and merchandise trade.

In addition to the income of both trading countries, distance, the population of the partner country, and regional trade agreement, the first stage (selection process) results of the Heckman indicates that a partner country being landlocked has a bearing on a country's decision to trade. The Hausman test shows that treating merchandise and services as endogenous regressors yields consistent estimates. The results also indicates that correcting for sample selection bias is valid. However, they do not change much when selection bias is ignored. The empirical analysis finds support for the proposed theoretical model as services is positive and significant in determining merchandise trade and vice versa. The results also suggest that having a common colonizer post 1945, is more likely to boost trade in merchandise, than for services trade.

A possible extension of this work would involve performing the same analysis at the firm or industry level using disaggregated data to investigate the relationship between services and merchandise by sectors.

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Appendices

3.A Testing Instruments for Merchandise

Underidentification Test

Ho: Equation is underidentified

Kleibergen-Paap rk LM statistic = 196.733 P-value = 0.000

Sargan-Hansen test for overidentifying restrictions

Ho: Instruments are valid

Hansen J statistic = 0.186 P-value = 0.6665

3.B Testing Instruments for Services

Underidentification Test

Ho: Equation is underidentified

Kleibergen-Paap rk LM statistic = 195.478 P-value = 0.000

Sargan-Hansen test for overidentifying restrictions

Ho: Instruments are valid

Hansen J statistic = 3.954 P-value = 0.1385

3.C Test of Endogeneity for Services

Table 3.C.1: Hausman Test for Endogeneity for Services

	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	endogenous	exogenous	Difference	S.E.
Merchandise	0.1310761	0.105612	0.0254637	0.0287812
GDP_R1	1.776826	1.341419	0.4354071	0.0976158
GDP_P1	0.4199906	0.283429	0.1365615	0.0544962
POP_R	-10.45209	-7.90604	-2.546047	0.8144019
POP_P	-0.7125357	-1.1345	0.4219595	0.39555
RTA	-0.0378677	-0.20319	0.1653221	0.0429147
Mills Ratio	1.265605	-0.28868	1.55428	0.3227836

b = consistent under Ho and Ha

B = inconsistent under Ha, efficient under Ho

Test: Ho: difference in coefficients not systematic

$$\chi^2_8 = (b-B)'[(V_b - V_B)^{-1}](b-B) = 49.43 \qquad \text{Prob} > \chi^2_7 = 0.0000$$

3.D Test of Endogeneity for Merchandise

Table 3.D.1: Hausman Test for Endogeneity for Merchandise

	Coefficients			
	(b) endogenous	(B) exogenous	(b-B) Difference	sqrt(diag(V_bV_B)) S.E.
Service	0.04296	0.0534881	-0.0105283	0.00917
GDP_R1	0.668881	0.6445382	0.0243432	0.033206
GDP_P1	0.624916	0.5770407	0.0478751	0.014853
POP_R	-4.75852	-5.191421	0.4329015	0.267265
POP_P	-0.69501	-0.5361267	-0.1588788	0.147163
RTA	0.136106	0.0858876	0.0502183	0.010787

b = consistent under Ho and Ha

B = inconsistent under Ha, efficient under Ho

Test: Ho: difference in coefficients not systematic

$$\chi^2_8 = (b-B)'[(V_b - V_B)^{-1}](b-B) = 38.54 \qquad \text{Prob} > \chi^2_6 = 0.0000$$

3.E Tables

Table 3.E.1: List of O.E.C.D Reporting Countries

Czech Republic	France	Ireland	Germany
Italy	Luxembourg	Austria	Australia
Netherlands	Slovenia	Japan	Portugal
Estonia	Finland	Canada	Norway
Denmark	Greece	Hungary	New Zealand
Belgium	Poland	Slovak Republic	Korea, Rep.

Table 3.E.2: List of Partner Countries

Afghanistan	Congo, Rep.	Indonesia	Nepal	Thailand
Albania	Costa Rica	Iran, Islamic Rep.	Netherlands	Togo
Algeria	Croatia	Iraq	New Zealand	Tonga
Andorra	Cuba	Ireland	Nicaragua	Trinidad and Tobago
Angola	Cyprus	Israel	Niger	Tunisia
Antigua and Barbuda	Czech Republic	Italy	Nigeria	Turkey
Argentina	Denmark	Jamaica	Norway	Turkmenistan
Armenia	Djibouti	Japan	Oman	Uganda
Australia	Dominica	Jordan	Pakistan	Ukraine
Austria	Dominican Republic	Kazakhstan	Palau	United Arab Emirates
Azerbaijan	Ecuador	Kenya	Papua New Guinea	United Kingdom
Bahamas, The	Egypt, Arab Rep.	Kiribati	Paraguay	United States
Bahrain	El Salvador	Korea, Dem. Rep.	Peru	Uruguay
Bangladesh	Equatorial Guinea	Korea, Rep.	Philippines	Uzbekistan
Barbados	Eritrea	Kuwait	Poland	Venezuela, RB
Belarus	Estonia	Kyrgyz Republic	Portugal	Vietnam
Belgium	Ethiopia	Lao PDR	Qatar	Yemen, Rep.
Belize	Faeroe Islands	Latvia	Russian Federation	Zambia
Benin	Fiji	Lebanon	Rwanda	Zimbabwe
Bermuda	Finland	Lesotho	Samoa	
Bhutan	France	Liberia	San Marino	
Bolivia	Gabon	Libya	Saudi Arabia	
Bosnia and Herzegovina	Gambia, The	Lithuania	Senegal	
Botswana	Georgia	Luxembourg	Sierra Leone	
Brazil	Germany	Madagascar	Singapore	
Brunei Darussalam	Ghana	Malawi	Slovak Republic	
Bulgaria	Greece	Malaysia	Slovenia	
Burkina Faso	Greenland	Maldives	Solomon Islands	
Burundi	Grenada	Mali	Somalia	
Cabo Verde	Guatemala	Malta	South Africa	
Cambodia	Guinea	Mauritania	Spain	
Cameroon	Guinea-Bissau	Mauritius	Sri Lanka	
Canada	Guyana	Mexico	Suriname	
Cayman Islands	Haiti	Moldova	Swaziland	
Central African Republic	Honduras	Mongolia	Sweden	
Chad	Hong Kong SAR, China	Morocco	Switzerland	
Chile	Hungary	Mozambique	Syrian Arab Republic	
China	Iceland	Myanmar	Tajikistan	
Colombia	India	Namibia	Tanzania	

Table 3.E.3: Summary Statistics

Variable	**Mean**	**Std. Dev.**	**N**
year	2003.745	1.754	12803
electricity(Partner)	4754.071	5204.554	10521
electricity(Reporter)	8114.63	4312.297	12803
Distance	5707.711	4051.696	12803
mobile(Partner)	45.685	36.945	12751
internet	22.864	24.174	12478
mobile_R	89.206	20.106	12803
Internet(Reporter)	47.673	18.545	12704
Contiguity	0.034	0.182	12803
Common Official language	0.075	0.263	12803
Common Colonizer	0.004	0.061	12803
Population(Reporter)	20.755	25.06	12803
GDP(Reporter)	558113.13	797043.614	12803
Population(Partner)	52.797	169.269	12652
GDP(Partner)	424483.741	1409435.706	12034
RTA	0.288	0.453	12803
Merchandise	1739399602.327	9236736415.089	12803
Services	420.919	1875.349	12803
landlocked(Reporter)	.2307272	.4213146	12803
landlocked(Partner)	.1780052	.382532	12803

Table 3.E.4: Proportion of Zeros

Variable	Observations	Missing	Zeros	% zero
Services	12803	0	1598	12%
Merchandise	12803	0	0	0%

Table 3.E.5: Probit Model

	selection(*Service Trade*)
GDP(Importer)	0.196***
	(0.03)
GDP(Exporter)	0.437***
	(0.02)
Distance	-0.287***
	(0.04)
Contiguity	0
	(.)
Population(Importer)	0.0350
	(0.03)
Population(Exporter)	-0.0461**
	(0.02)
RTA	0.563***
	(0.11)
Common Colonizer	0
	(.)
Landlocked(Importer)	-0.0688
	(0.04)
Landlocked(Exporter)	-0.237***
	(0.05)
common Official language	0.00321
	(0.07)
_cons	-11.61***
	(0.86)
N	11511

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.E.6: First Stage Results

Variables	*Merchandise*	*Service*
GDP(Reporter)	0.819***	1.654***
	(10.05)	(12.47)
GDP(Partner)	0.670***	0.448***
	(16.27)	(6.76)
Population(Reporter)	-5.344***	-9.629***
	(-8.02)	(-7.98)
Population(Partner)	-0.269	-1.210*
	(-0.82)	(-2.15)
RTA	0.160***	-0.117*
	(4.33)	(-2.15)
Mills Ratio	0.841*	
	(2.35)	
Lag of Merchandise	0.464***	
	(23.67)	
Electricity(Reporter)	-0.0000116	
	(-0.59)	
Internet(Reporter)		0.00244
		(1.58)
Lag of Service		0.479***
		(22.97)
Mobile(Reporter)		0.000871
		(0.81)
_cons	-6.276*	-11.13*
	(-2.22)	(-2.32)
N	7722	7771
R-sq	0.462	0.454

Table 3.E.7: Estimation Results for Merchandise Trade

Merchandise	(1) OLS	(2) OLS/IV	(3) FE	(4) RE	(5) Fixed/HD
Service	0.34***	0.10*	0.04**	0.03**	0.04*
	(0.01)	(0.04)	(0.01)	(0.01)	(0.02)
GDP(Exporter)	0.55***	0.96***	0.67***	0.62***	0.67***
	(0.02)	(0.08)	(0.09)	(0.05)	(0.1)
GDP(Importer)	0.61***	0.85***	0.62***	0.71***	0.62***
	(0.01)	(0.04)	(0.04)	(0.04)	(0.04)
Distance	-0.74***	-0.89***	-4.71	-1.26***	
	(0.02)	(0.04)	(4.76)	(0.05)	
Contiguity	0.11**	0.34***	-1.62	0.24	
	(0.04)	(0.06)	(2.23)	(0.12)	
Population(Exporter)	0.23***	0.06	-4.76***	-4.27***	-4.76***
	(0.02)	(0.04)	(0.66)	(0.71)	(0.78)
Population(Importer)	0.01	-0.06***	-0.70*	-0.17	-0.70*
	(0.01)	(0.02)	(0.3)	(0.31)	(0.35)
RTA	0.02	0.09**	0.14***	0.12***	0.14***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Common Colonizer	1.26***	1.74***	4.01***	1.85***	
	(0.14)	(0.2)	(0.33)	(0.28)	
_cons	-11.66***	-22.39***	51.13	7.48***	-1.93
	(0.64)	(1.97)	(54.51)	(1.79)	(3.24)
N	10564	7771	7771	7771	7771
adj. R2	0.875	0.865	0.986		0.986

Table 3.E.8: Estimation Results for Service Trade

Service	(1)	(2)	(3)	(4)	(5)
	OLS	OLS/IV	RE	FE	FE/HD
Merchandise	0.55***	0.08	0.11***	0.13**	0.13*
	(0.01)	(0.08)	(0.03)	(0.04)	(0.05)
GDP(Importer)	1.25***	1.82***	1.39***	1.78***	1.78***
	(0.03)	(0.1)	(0.09)	(0.14)	(0.16)
GDP(Exporter)	0.62***	1.00***	0.36***	0.42***	0.42***
	(0.02)	(0.07)	(0.07)	(0.08)	(0.1)
Distance	-0.32***	-0.75***	-1.16***	2.06	
	(0.02)	(0.08)	(0.07)	(31.27)	
Contiguity	0		0		
	(.)		(.)		
Population(Importer)	-0.78***	-0.83***	-7.86***	-10.45***	-10.45***
	(0.02)	(0.03)	(1.27)	(1.09)	(1.29)
Population(Exporter)	-0.25***	-0.28***	-0.33	-0.71	-0.71
	(0.01)	(0.02)	(0.55)	(0.56)	(0.66)
RTA	0.11*	0.11*	-0.17**	-0.04	-0.04
	(0.04)	(0.05)	(0.06)	(0.07)	(0.08)
Common Colonizer	0		0		
	(.)		(.)		
Mills Ratio	0.98***	0.35	-1.49***	1.27*	1.27*
	(0.14)	(0.21)	(0.29)	(0.55)	(0.64)
_cons	-36.50***	-48.66***	3.51	-39.58	-15.55**
	(0.72)	(2.2)	(3.11)	(358.3)	(5.56)
N	10085	7722	7722	7722	7722
adj. R2	0.807	0.777		0.961	0.961

Table 3.E.9: Truncated Sample Services Estimation

Service	(1) Fixed Effects
Merchandise	0.13*
	(0.05)
GDP(Importer)	1.65***
	(0.16)
GDP(Exporter)	0.33***
	(0.09)
Population(Importer)	-9.82***
	(1.24)
Population(Exporter)	-1.06
	(0.64)
RTA	-0.10
	(0.07)
_cons	-10.20*
	(5.20)
N	8114
adj. R^2	0.964

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.E.10: Results for Alternative Fixed Effects Specification for Service Trade

Services	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Merchandise	0.15*	0.24***	0.10	0.13*	0.17*	0.12*	0.15**
	(0.06)	(0.07)	(0.05)	(0.05)	(0.07)	(0.05)	(0.05)
GDP(Importer)	0.71**	1.71***	1.43***	1.78***			1.96***
	(0.23)	(0.09)	(0.10)	(0.16)			(0.16)
GDP(Exporter)	-0.07	0.86***	0.51***	0.42***	0.92***	0.44***	
	(0.13)	(0.06)	(0.08)	(0.10)	(0.06)	(0.09)	
Distance	-1.00***	-0.59***			-0.69***		
	(0.09)	(0.07)			(0.07)		
Population(Importer)	-5.77**	-0.91***	-9.56***	-10.45***			-10.62***
	(2.02)	(0.03)	(1.27)	(1.28)			(1.33)
Population(Exporter)	-2.31*	-0.27***	0.11	-0.71	-0.26***	-0.72	
	(0.98)	(0.01)	(0.59)	(0.65)	(0.01)	(0.66)	
RTA	-0.07	0.15**	-0.09	-0.04	0.23***	-0.00	-0.25*
	(0.07)	(0.05)	(0.08)	(0.08)	(0.05)	(0.08)	(0.12)
Mills Ratio	-2.95***	0.80***	0.51	1.27*	1.08***	1.70**	2.53
	(0.31)	(0.19)	(0.64)	(0.64)	(0.19)	(0.63)	(1.29)
_cons	25.90**	-46.60***	-12.40***	-15.55**	-2.87***	5.57	-11.62**
	(8.65)	(2.02)	(1.98)	(5.55)	(0.52)	(3.00)	(4.25)
<u>Effects</u>							
Importer	Yes	No	No	No	No	No	No
Exporter	Yes	No	No	No	No	No	No
Time	Yes	Yes	No	Yes	No	No	No
Country-Pair	No	No	Yes	Yes	No	Yes	Yes
Reporter-period	No	No	No	No	Yes	Yes	No
Partner-period	No	No	No	No	No	No	Yes
N	7722	7722	7722	7722	7722	7722	7722
adj. R^2	0.873	0.801	0.961	0.961	0.819	0.963	0.963

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.E.11: Fixed Effects Estimation for Merchandise

Merchandise	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Service	-0.00278	0.0996*	0.0367*	0.0430*	0.00213	0.0333	0.0357*
	(0.03)	(0.04)	(0.02)	(0.02)	(0.04)	(0.02)	(0.02)
GDP(Exporter)	0.361	1.024***	0.626***	0.669***			0.621***
	(0.19)	(0.08)	(0.06)	(0.10)			(0.10)
GDP(Importer)	0.682***	0.836***	0.701***	0.625***	0.926***	0.636***	
	(0.09)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	
Distance	-1.223***	-0.882***			-0.958***		
	(0.05)	(0.04)			(0.04)		
Contiguity	0.244***	0.339***			0.418***		
	(0.06)	(0.06)			(0.06)		
Population(Exporter)	-3.098	-0.0150	-4.472***	-4.759***			-5.111***
	(1.60)	(0.04)	(0.77)	(0.77)			(0.73)
Population(Importer)	-1.351	-0.0588***	-0.123	-0.695*	-0.0807***	-0.770*	
	(0.73)	(0.02)	(0.33)	(0.35)	(0.02)	(0.34)	
RTA	0.101*	0.104**	0.132***	0.136***	0.143***	0.144***	0.182***
	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)
Common Colonizer	1.955***	1.869***			1.974***		
	(0.19)	(0.21)			(0.22)		
_cons	13.22	-23.67***	-4.821***	-1.929	3.395***	4.157**	14.13***
	(7.28)	(2.17)	(1.16)	(3.24)	(0.26)	(1.46)	(2.50)
Effects							
Importer	Yes	No	No	No	No	No	No
Exporter	Yes	No	No	No	No	No	No
Time	Yes	Yes	No	Yes	No	No	No
Country-Pair	No	No	Yes	Yes	No	Yes	Yes
Reporter-period	No	No	No	No	Yes	Yes	No
Partner-period	No	No	No	No	No	No	Yes
N	7771	7771	7771	7771	7771	7771	7771
adj. R^2	0.919	0.868	0.986	0.986	0.881	0.986	0.988

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

CHAPTER 4
ENVIRONMENT, GROWTH, AND FOREIGN DIRECT INVESTMENT IN DEVELOPING COUNTRIES

4.1 Abstract

This chapter examines the effects of foreign direct investment inflows and environmental aid disbursements on environmental degradation using panel data for some selected developing countries. Using a fixed effects model, the estimates suggest the existence of an Environmental Kuznets Curve for carbon dioxide as well as total green house gas emissions from the energy and industrial sectors but there was no evidence of this phenomenon for nitrous oxide and total Green House Gas emissions from the waste sector. I also find a hint of a technique effect, and investigate it further by exploring the responsiveness of capital and labor to investment inflows in the respective developing countries.

4.2 Introduction

The world community has paid more attention to climatic issues and the effects of green house gases in recent decades. The Kyoto protocol is an example, which is aimed at reducing six green house gases through three mechanisms enshrined in the protocol. Under the protocol Non-Annex I Parties have no commitment to reducing their green house gas emissions. This could be a possible factor in the "migration" of dirty industries to less developed countries. To put the difference between emissions from developed countries and those of the developing ones into perspective, Carbon Dioxide Information Analysis Center (CDIAC) ranked countries by their per capita fossil-fuel carbon dioxide emissions in 2009. Accordingly, developing countries like Mali, Chad, and Burundi emitted 0.01 metric tons of carbon each, whilst developed countries like Australia, United States and Canada produced 4.98, 4.64, 4.16 metric tons of carbon, respectively.

Environmental quality can be considered as a normal good. This can explain why developing countries have more lax environmental regulation stringencies or weaker environmental monitoring systems and institutions than developed countries. The pollution haven hypothesis (PHH, hereafter) posits that a country with lax environmental regulations in comparison to its trading partners could see an influx of investments to its dirty industries. According to UNCTAD STAT FDI inflows to developing countries have increased from about 34,762 million dollars in 1990 to 702,825 million dollars in 2012, i.e., about 1921% increase in inflows. Developing Asian economies receive the largest portion of these inflows. Inflows to developed countries have also increased however by a much smaller margin of 225%. Consequently, developing countries have overtaking the developed countries in FDI receipts as of 2012.

Within the aforementioned time frame, Blanco et al. (2013) report that carbon emissions from developing countries have almost doubled. This could suggest that investment may be causing an increase in emissions in developing countries, especially if firms in a quest to avoid the higher cost associated with using greener technology relocate to less developed countries.[1]Interestingly, foreign aid to developing countries aimed at pollution abatement activities have increased significantly within the period of study. These have also motivated us to investigate the effects of FDI and environmental aid on carbon dioxide and total green house gas emissions in developing countries.

4.3 Literature Review

The literature on the environment is extensive and can be traced back to pioneering works such as Baumol (1971) and Crocker (1966). The paper is particularly related to two strands of literature: pollution haven hypothesis (for example, see Eskeland and Harrison, 2003 and Taylor, 2004) and the literature on the relationship between economic growth and development and environmental degradation (see Arrow et al., 1995 and Stern et al., 1996).

Following the seminal work of Kuznets (1955) that suggested an inverted u-shaped relationship between income inequality and economic growth, Panayotou (1993) suggested an apparent inverted u-shaped relationship between environmental degradation and economic

[1]FDIs inflow to less developing countries may also be due to the expected rate of return on investment foreign firms believe they can obtain.

development, known in the literature as Environmental Kuznets Curve (EKC). Although Panayotou (1993) first coined the term EKC, Grossman and Krueger (1991) established EKC relationship using cross-sectional data for 42 countries' urban areas and three pollutants to study the relationship between air quality and economic growth.

The pollution haven hypothesis posits that weaker environmental regulations should be an influencing factor in the location of polluting industries. Becker and Henderson (2000) uses plant data during 1963-1992 to study the unintended consequence of environmental regulation on plant location. Greenstone (2001) analyzes the impacts of environmental regulation on industrial activities in the US during 1967-1987 by using data on both regulations from the Clean Air Act Amendments and manufacturing activities. Similarly, List et al. (2003) empirically show that birth of pollution-intensive plants respond to environmental regulations, using New York State county-level data during 1980-1990.
Similarly, international and Cross-border aspect of pollution haven hypothesis suggests that pollution-intensive industries will migrate to countries with lower environmental standards. On the theoretical side, numerous authors have considered the effects of environmental policies on international movement of capital (see for example, Copeland and Taylor, 1997; Beladi et al., 2000; and Beladi and Oladi (2005)). On the empirical side, Xing and Kolstad (2002) explore how lax environmental regulations and policies attract FDIs and influence the location of polluting plants. Other empirical works such as Bradford et al. (2000), Kahn (1998), List and Gallet (1999), and Selden and Song (1994) lend credence to the existence of the EKC for gases such SO_2, nitrous oxide, CO , and SPM.

The current essay contributes to the above branches of literature by empirically analyzing the relationship between FDIs and the environment as well as examining the effect of environmental aid to developing countries on their emissions. The relationship between the environment and FDI stems from two perspectives: pollution haven hypothesis and the EKC (Blanco et al., 2013). I employ these two perspectives simultaneously in the analyses. I carry out the analyses on two gases; carbon dioxide and nitrous oxide. Also, I investigate the existence of an EKC on total green house gas emissions for the energy, industrial and waste sectors and the effects of FDI and environmental aid on these emissions. Therefore, the paper also contributes to a strand of literature that deals with foreign environmental aid (see, for example, Copeland and Taylor, 1994; Chao and Yu, 1999, and more recently Oladi and Beladi, 2015).

The rest of this chapter is organized as follows. Following this introduction, I will discuss the data in Section 4.2. Section 4.3 presents the empirical model. I present the empirical results in Section 4.4. Section 4.5 concludes the paper.

4.4 Data

For the analyses of my model, I collected data on 27 developing countries.[2] I employed the World Bank's definition of "developing country" in choosing the countries represented in the model. The World Bank (2014) classifies countries into four main groups based on per capita GNP: low income (0-$1,035), lower middle income ($1,036 - $4,085), upper middle income ($4,086 - $12,615) and high income ($12,616 and above). Countries from the two lower groups are classified as developing countries.[3] Data was collected for the period 2002 to 2008 for these countries; I thus have a total of 189 observations for each variable of interest employed in the analyses.

Data on environmental aid comes from the PLAID19 database and uses the environmental coding scheme developed by Hicks et al. (2008). Aid projects can be classified dirty, neutral or environmental. Dirty aid might cause harm to the environment whiles environmental aid seeks to positively impact the environment. They can be sub-classified "strictly" or "broadly" based on the intensity of the benefits or harm posed to the environment. Dirty Strictly Defined (DSD) are "Projects that cause significant and immediate environmental harm." Dirty Broadly Defined (DBD) can be described as "Projects that will cause moderate environmental harm over the long term." Environmental Broadly Defined (EBD) refers to "Projects that are preventive in nature or that produce less immediate, more long term

[2] See Table 4..5 for a list of these countries. I include Russia whose status has been upgraded to "developed" recently but within the time frame employed in this paper Russia was classified as "developing."

[3] "The use of this term is convenient; it is not intended to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development. Classification by income does not necessarily reflect development status."

environmental benefits." Environmental Strictly Defined (ESD) are "Projects expected to produce significant, immediate environmental benefits". Environmental aid projects can be classified as brown or green: brown denotes environmental aid that goes towards projects that produce environmental benefits for the recipient whilst green is used for projects that have global benefits.[4] Since I am interested in environmental aid, I use aid data classified as EBD and ESD regardless of being green or brown. The environmental aid data was in constant year 2000 US dollars so it needed to be converted to current US dollars. I did this conversion using GDP deflator from the Bureau of Labor Statistics.

The data on corruption and investment profile of a country come from the political risk component of the International Country Risk Guide (ICRG) data. The corruption rating captures the extent of corruption in the political system. This index is more concerned with corruption such as excessive patronage, nepotism, job reservations, and secret party funding though it also considers other forms of corruption encountered by businesses such as bribes associated with export licenses and exchange controls. I rescale this rating so that it ranges from zero to one; where one denotes a very transparent country and zero denotes a very corrupt country. The investment profile index captures all other factors that inhibit investments that are not covered by other political, economic and financial risk components. It is made up of the following subcomponents: contract viability, profits repatriation, and payment delays. The investment profile is rescaled to range from 0 to 1 with the latter denoting very low risk and the former denoting very high risk.

My data for nitrous oxide (N_2O) emissions come from the World Resource Institute CAIT database. Nitrogen emissions are measured in metric tons of carbon dioxide equivalent ($mtco_2e$). Data on total Green House Gas (GHG) emissions by sectors of an economy, which is also measured in $mtco_2e$, are obtained from the World Resource Institute database (WRI-CAIT (2014)). Total GHG comprises the six following gases; carbon dioxide (CO_2), nitrous oxide, methane (CH4), Hydrofluorocarbons, Perfluorocarbons, and Sulfur Hexafluoride. I use Environmental Performance Index (EPI) as a proxy for environmental regulation

[4] Hicks et al. (2008) provide a thorough framework for classifying aid data by donor, recipient and the intended purpose of the aid.

stringency. I believe that environmental regulations and EPI move hand in hand. The EPI data comes from SEDAC but was initially prepared by Yale Center for Environmental Law and Policy.

I collected the data on population density, carbon dioxide, GNP per capita, manufacturing percentage of GDP, exports, imports, and total reserve from the World Bank. I use total trade as a percentage of GDP to measure trade openness. Data on employment and capital stock is from Penn World Trade (PWT 8.0). Data on net FDI inflows in current US dollars were obtained from the UNCTAD STAT.Table 3.E.3 shows summary statistics for the variables employed in the analysis.

4.5 Empirical Model

In my model I explore a linkage between emissions, net FDI inflows, and environmental regulation stringency. Environmental regulation stringency influences the level of emissions in a country since if regulations are very stringent the cost of polluting is high and vice versa. That is, stringent environmental regulations can drive up production cost in a country. Xing and Kolstad (2002) explain that stringent environmental regulations are seen to increase production cost by requiring specialized equipment to comply with regulation. They also point out that very stringent regulations can decrease "waste disposal capacity". Environmental regulations also influence a country's emissions through its trading activities. If a country has lax environmental regulation vis-à-vis its trading partners, then it could see investment inflows directed towards its "dirty" industries as explained by the pollution haven hypothesis. The country with the lax environment regulation has comparative advantage in the production of goods that are pollution intensive (see Cole, 2004).

Foreign Direct Investments can affect emissions depending on a number of factors, some of which include: A) The sectors of the economy into which these funds flow; if investments target the manufacturing industries one would expect emissions to increase. B) The technology used in production in those factories also affects emissions in a country; if the production process employs clean technology then emission would be lowered. This is referred to as the technique effect (see Grossman and Krueger, 1991).[5] Environmental regulations can affect emissions directly by increasing the cost of production in a country and indirectly through FDIs and the pollution haven hypothesis.[6]

The relationship between FDI inflows and emissions (environment regulations) has long been known to be determined simultaneously. In exploring this endogenous relationship between FDI's and the level of pollution in a country, I consider two equations: The first being the Environmental Kuznets Curve (EKC). I consider the following equation to characterize the Kuznets curve.

$$\mathrm{E}_{\mathrm{it}} = \alpha_i + \mathrm{T}_t + \beta_0 \mathrm{FDI}_{\mathrm{it}} + \gamma \mathrm{FDI}_{\mathrm{it}} * C_{\mathrm{it}} + \beta_1 \mathrm{Y}_{\mathrm{it}} + \beta_2 \mathrm{Y}_{\mathrm{it}}^2 + \beta_* M + \mathrm{U}_{\mathrm{it}} \tag{4.1}$$

where E_{it} represents emissions for country i at time t. α_i is a time invariant individual (country) specific effect which is normally unobserved. I include year and time fixed effects as control variables. The intercept α_i can capture any individual heterogeneity that might exist in the model (factors that vary with each country present in the sample but not over time). T_t captures certain phenomena such as technological advancement that might vary over time independently of the sampled countries. $\mathrm{FDI}_{\mathrm{it}}$ denotes foreign direct investment inflow and C_{it} represents level of corruption[7] (corruptibility) with $\mathrm{FDI}_{\mathrm{it}} * C_{\mathrm{it}}$ representing an interaction between corruptibility and investment inflows as recommended in Cole et al. (2006). I include this interaction because I expect that the level of corruption, political stability and quality of government regulations could influence the impact of FDI on pollutions levels. y_{it} represents income of country i at time t. M contains other control variables I include in the analyses such as manufacturing percent of GDP, population density, corruption, an interaction term (a product of manufacturing percent of GDP and population density), environmental performance index and environmental aid.

The signs of the slope coefficients can help in exploring economic relationship as well as confirming a priori expectations gleaned from economic theory. The signs of β_1 and β_2

[5] Grossman and Krueger (1991) as well as Copeland and Taylor (1994) explain that trade liberalization can have a scale, technique and composition effect.

[6] See He (2006) for a more intricate relationship between FDI, emissions, and environmental regulation.

[7] My corruption variable ranges from 0 to 1 with high values denoting less corruptibility

are probably the most important as they assess the validity of the EKC. I could have the following combinations of β_1 and β_2:

1. $\beta_1 = \beta_2 = 0$. In this case there exists no relationship between emissions and economic development (Income).

2. If $\beta_1 > 0$ ($\beta_1 < 0$) and $\beta_2 = 0$ then emissions is a monotonically increasing (decreasing) function of income or economic development.

3. $\beta_1 > 0$ and $\beta_2 < 0$. This represents an inverted u-shaped relationship between emissions and income or development, which is what I want to see if the EKC holds true.

4. $\beta_1 < 0$ and $\beta_2 > 0$ give us a u-shaped relationship between emissions and income or development.

One would expect that the effect of FDIs (β_0) to have a positive effect on emissions. That is, as investment inflows continue, coupled with the emergence of manufacturing plants, emissions or environmental quality worsens. This however does not have to be the case since through the diffusion of cleaner technologies and technique effect can cause emissions to decrease even though investments increase. As stated earlier I expect $\beta_1 > 0$ and $\beta_2 < 0$ if inverted U-Shaped relationship exists.

The empirical validity of the EKC has been criticized quite extensively in some literatures. In the analyses I will tackle some of them as far as the analysis go. My empirical model also tests whether there is empirical support for relationship between environmental aid and emissions as stated by theoretical results of Chao and Yu (1999) and Oladi and Beladi (2015).

The econometric model presented by equation (4.1) may have endogeneity problem since endogenous relationship between FDI and emissions has been documented in both theoretical and empirical literature, characterized as the pollution haven hypothesis. In my analyses I get around the possible endogeneity of FDI in the EKC equation by instrumenting. I instrument FDI by using an equation, which stems from the pollution haven hypothesis.

This also enables us to analyze the effects of the PHH on the EKC.[8] The PHH equation I use in instrumenting FDI is given as:

$$\text{FDI}_{it} = \alpha_1 \text{EPI}_{it} + \alpha_2 \text{OPEN}_{it} + \alpha_3 \text{RES}_{it} + \alpha_4 \text{PRO}_{it} \tag{4.2}$$

where EPI, OPEN, RES, and PRO represent environmental performance index, trade openness, total reserves, and investment profile respectively. Also with FDI being endogenous I expect the interaction term $\text{FDI}_{\text{it}} * C_{\text{it}}$ to be endogenous as well. I therefore instrument this interaction term with lagged values of $\text{FDI}_{\text{it}} * C_{\text{it}}$. I argue the validity of the instrumenting process as follows.

First, my instruments are relevant: regulations, investment profile, total reserves and trade openness of a country influence the flow of foreign investment into it. If the PHH holds true the weaker environmental regulations should attract investments into the country. One's a priori expectations would be that the better a country's investment profile the more foreign investments that flow into that country. A country's openness to trade should affect FDI inflows. The more open a country is to trade the more attractive that country is to investors. A country's total reserves comprises its current and capital accounts and reflects its exchange rate policies and volatility. Thus, I would expect that a country with a more stable currency would attract more investments. Also, a lagged version of an endogenous variable is a valid instrument since I expect previous values of a phenomenon to be correlated with its current values. Second, the instruments are exogenous in that they influence emissions only through foreign investments. Third, the model is also over identified since the number of instruments exceeds the number of endogenous regressors I have in the model.

4.6 Empirical Results

In addition to ample theoretical support for endogeneoity of FDI, I used Davidson-MacKinnon test of exogeneity, which confirms the endogeneity of FDI in the empirical mode that at 5% level of significance. To ascertain the validity of the instruments, I carry out a

[8] Cole (2004) explains that for those who consider the cost of meeting environmental regulations to be hefty the PHH further buttresses the point that EKC's shape is caused by developed countries exporting pollution to developing countries where costs of meeting environmental regulations are cheaper.

Sargan-Hansen test for over identifying restrictions. I cannot reject the null hypothesis which states that the instruments are valid. I use robust standard errors in all of the estimated equations to control for heteroscedasticity.[9]

The result of my estimates with CO_2 emissions as the dependent variable is presented in Table 4..3. The first model is an instrumented fixed effects model without controlling for time effects.[10] The second model however captures the effects of time. The results for both models support the Environmental Kuznets curve with log of income as well as its square all having the appropriate positive and negative signs, respectively. Their estimates reveal that a one percent increase in GNP will lead to about 2.9 percent increase in average carbon dioxide emissions in both models. This seems to support the Grossman and Krueger (1991) idea of a scale effect that an increase in economic activity will lead to an increase in emission. Then, degradation is expected to reduce as structural changes take place in the economy. This can be evidenced from the sign on the square log of GNP. For both models I also see that corruption has the expected sign and is significant. This suggests that curbing corruption might be important in a government's attempt to reduce its emissions, as also claimed in López and Mitra (2000).

According to the estimates, the previous period's environmental regulation stringency seems to have no significant effect on the current investment inflows in both models. When I include time fixed effects however, lagged environmental performance index gets the appropriate sign (i.e., expected negative sign). A possible reason for why environmental performance index is not significant in either of the models may be due to it being a weak proxy for environmental regulation stringency. Another possibility might lie with the enforcement of environmental regulations in developing countries. Although the importance of regulations in ensuring environmental quality and economic development is emphasize in

[9]Perman and Stern (2003) state that EKC does not exist once one has accounted for certain econometric phenomena as serial dependence. However serial correlation is not a problem in micro panels and the test apply to macro panels with long time series of about 20 to 30 years (see Torres-Reyna, 2008). Hence, I are not concerned since I have a short time series. I then use the STATA user-written program "xttest3" to test homoscedastic errors. This program estimates a modified Wald statistic under the assumption of homoscedasticity. The results show that I have heteroscedasticity.

[10] Table4..2 shows the first stage results and all instruments used as well as other vital statistics.

the literature (see Panayotou, 1997, and Dasgupta et al., 2002), the enforcement of environmental regulations in developing economies is weak and almost absent in some cases (see Hettige et al., 1995).

The role of FDIs on the carbon dioxide emissions of the destination country is very significant for both models. Without evaluating the effect of corruptibility on investment inflows I see that FDI has a negative sign. This suggests that the inflow of foreign investment into a country can improve its environment. However, the total effect of FDI on carbon dioxide emission, once I account for corruptibility, is positive. The elasticity of carbon dioxide emissions evaluated at the mean of corruption is about 0.04%. This would suggest that emissions increase with the inflow of foreign investments, though this effect may be minimal.

The results also reveal that as the level of manufacturing in a country increases, emissions in the country decreases. This negative effect of manufacturing activities on carbon dioxide emissions is also significant. One possible explanation can be the existence of strong technique effect. That is, although the level of manufacturing activities may be increasing, cleaner technology is used in the production process due to technological diffusion from FDI. Thus, higher level of manufacturing reduces emission. However, tracking the growth in technology is quite difficult since it is difficult to find a very effective index that captures all the attributes of technology. Another possible explanation can be that due to adopting a more stringent environmental regulation, coupled with high punitive consequences for polluters, there might be an incentive for firms to adopt cleaner, efficient and environment friendly means of production.[11] Yet another possibility might be that foreign direct investment is channeled towards industries that are more labor-intensive. One way to investigate this would be to track the industries into which FDIs flow but this can be difficult to do for developing countries due to the unavailability of quality data. I thus explore this possibility by comparing the responsiveness of capital stock and employment to FDIs for the sampled countries. Table 4..5 shows a comparison of the elasticity of capital and employment. All

[11] Liang (2006) explains that due to foreign firms' superior and more energy efficient technology, foreign direct investment can improve environmental quality if foreign firms can crowd out local firms that cannot compete against superior technology.

countries except Botswana had the capital being more responsive to foreign investment than employment.

Environmental aid is not significant in either models but has the expected negative sign. The negative sign implies that as the environmental aid increases, emission reduces. Arvin et al. (2009) for instance show that industrialized developing countries with higher level of water pollution receive more environmental aid. Whereas Chao and Yu (1999) demonstrate theoretically that environmental aid can be beneficial for both donor and recipient, Kretschmer et al. (2010) corroborate my results that environmental aid might not be significant in alleviating environmental degradation. Their findings assert that though aid effectiveness may reduce energy intensity, this does not spillover to emissions. They conclude that aid might not help in mitigating climate change beyond reducing energy intensities and hint that for emissions intensities to be reduced donors may have to "tie the recipients' hand on how to use aid."

My estimates prove the existence of the EKC for CO_2 even though Lopez (1994) posits that the inverted U-shape relationship does not exist for global gases such as CO_2. Stern (2004), however, mentions that recent literature show that there is no significant difference between the effect on global and local emissions as far as income per capita is concerned. I also consider other forms of emissions, as well as total GHG emissions for specific sectors in my analyses. The estimates for those analyses are presented in the Table 4..4. A similar analyses on nitrous oxide suggest that there is no evidence of EKC, in contrast to findings of Selden and Song (1994). The coefficients of Log GNP and Square log GNP are of the appropriate and expected sign. However, they are not significant. Here, environmental aid also does not have the appropriate sign and it is not significant.

A look at Table 4..4 shows that EKC exists for total GHG emissions for the industrial sectors. The implications of this could be that better and much greener technologies are being used in those sectors as development and foreign investments increase. According to my estimates, the point of inflection ($\exp(\frac{-\beta_1}{2\beta_2})$) for total industrial GHG emissions is about \$7378. This figure lies within the range reported by existing literature. For example, Cole et al. (1997) in their analysis of emissions for 11 OECD countries had an inflection point of \$8232. Also, I see that the coefficient of environmental aid bears a negative sign. However, once again, it is not significant. There is also no indication of technique effect as manufacturing percent of GDP is not significant in the model. Moreover, although the coefficient of the Environmental Performance Index has the appropriate sign, it is not significant.

As for GHG from the energy sector, the results indicate a significant negative relationship between FDI and emission. But once I consider the effects of corruptions in imparting FDI and evaluate corruption at the mean, then one percent increase in FDI inflows will result in about a 0.02 percent average in GHG emissions.[12] The coefficient of corruption has the appropriate sign and is very significant. This suggest controlling corruption and improving fairness could be key in alleviating environmental degradation. I also find evidence supporting the existence of EKC for GHG emissions for Energy sector. My estimates reveal that a point of inflection of about \$30,219 which falls within some reported points of inflection. Stern and Common (2001) report an inflection point of about \$101,166 for their analysis on the emissions of 73 developed and developing countries. I also find that environmental aid is significant at the 10% level and it has the appropriate sign. This suggests that projects funded through environmental aid reduce GHG emissions in the energy sector. Manufacturing percent of GDP is significant at the 5% level and has an inverse relationship with GHG emissions. This testifies to the possible existence of a technique effect or the use of cleaner and more efficient technology in the production of energy.

The waste sector however shows no apparent EKC relationship between GHG and economic development. Even though log of GNP and its square bear the appropriate sign they are however not significant. This is not surprising as Shafik and Bandyopadhyay (1992) show that economic development cannot be associated with reductions in waste generation. All other variables are insignificant except for population density which is significant at the 1% level.

[12] It captures the net effect of FDI on emissions once I evaluate corruption at the mean. That is (-0.175+0.542(0.36)) where 0.36 is the mean value for corruption index

4.7 Conclusion

This essay studies the existence of the Environmental Kuznets Curve for CO_2, and GHG emissions in three specific sectors: industrial, waste, and energy for 27 developing countries. It also explores the possibility of a technique effect or a possible diffusion of cleaner and superior technology into the economy of developing countries. Moreover, it attempts to investigate the effects of environmental aid on emissions.

I find that the Environmental Kuznets Curve (EKC) exists for carbon dioxide (CO_2) even though some might consider it to be a global gas. I however find that contrary to what some researchers propose, an EKC does not exist for Nitrous oxide. I also discover that for these developing countries, as the level of manufacturing in the respective economies increases, emissions decline. I have multiple possible explanation for this result. First, this can be due to the technique effect. Second, it may be because of inflow of FDIs to industries that are more labor intensive. Third, firms may be adopting cleaner technology in order to avoid high punitive measures that come with more stringency environmental regulations. Another finding of this paper is that yesterday's environmental regulation seems to have no effect on the today's emissions. This can be due to weak enforcement and monitoring institutions in developing countries. Developing countries would have to focus on improving their enforcement and monitoring institutions if their environmental policies are to succeed.

For the Green House Gases (GHG), I find that an inverted u-shaped relationship does not exist between income and emissions for the waste sector. However, I find evidence of the EKC for the energy and industrial sector. There is also a hint of technique effect for the energy sector as I found GHG emissions diminish as manufacturing as a percentage GDP increases. I also discover that environmental aid is efficient in reducing emissions from the production of energy.

Environmental aid is not significant for all other forms of emissions or pollutants in the model. This would imply that in the case of developing countries, the disbursement of environmental aid should come with stringent condition and effective monitoring from donor countries. This would ensure that projects funded through environmental aid are completed and funds for such projects are not misappropriated. Also, if there is a "race to the bottom" by developing countries in order to attract more FDI inflows then an influx of environmental aid might not be enough to improve environmental quality or alleviate environmental degradation.

This essay can be extended in a couple of ways. One can focus on the sectors into which foreign investments flow and its effects on emissions in developing countries. As another avenue for future research, one may focus on tracking explicitly the development of technology and the impact of technology diffusion in developing countries and how they affect emissions in those countries.

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Appendices

Table 4..1: Variable Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Environmental Performance Index	189	50.86413	7.759704	35.03426	69.32507
Environmental Aid	188	2.04E+08	3.42E+08	484607.2	2.19E+09
Investment Profile	189	0.696834	0.143989	0.3125	0.958333
Corruption	189	0.361499	0.119692	0.166667	0.75
Population Density	189	128.7509	209.6938	1.572666	1136.744
Carbon Dioxide	189	431311.7	1121477	3043.61	7037710
GNP per capita	187	7028.182	3896.759	970	19850
Total Reserves	189	7.16E+10	2.17E+11	2.04E+08	1.97E+12
Nitrous oxide (N_20)	188	50.74923	87.01143	0.1968	403.5754
Waste(GHG)	188	24.8171	40.19456	0.144053	193.8494
Industrial(GHG)	188	39.4606	130.3029	0.003241	851.6931
Energy(GHG)	181	450.2939	1100.147	3.404504	6919.306
Trade Openness	189	77.51304	39.17147	25.20866	210.3743
Employment	189	6.53E+07	1.59E+08	861218.8	7.72E+08
Capital Stock	189	2.19E+12	4.60E+12	2.46E+10	3.24E+13
Manufacturing Percent of GDP	180	19.33189	6.75183	3.645126	35.63192
FDI	189	1.02E+10	2.28E+10	-5.97E+08	1.72E+11

Table 4..2: First Stage Results

VARIABLES	log FDI	FDI * corruption
Corruption	-1.436**	21.89***
	(0.647)	(0.407)
EPI	0.0124	-0.00614
	(0.0455)	(0.0204)
interaction1	-0.00024	-0.000367***
	(0.00035)	(0.00013)
Log of GNP	1.715	-0.892
	(3.014)	(1.169)
Square log GNP	0.00272	0.0977
	(0.184)	(0.0689)
Log of Environmental Aid	0.0415	0.0279
	(0.0352)	(0.0171)
Manufacturing per GDP	0.0609	0.0443*
	(0.0438)	(0.0239)
Population density	0.0101	0.0085
	(0.0184)	(0.00568)
Investment profile	3.179***	1.045**
	(0.812)	(0.436)
Trade Openness	0.00962*	0.00734***
	(0.00557)	(0.00211)
Total reserves	0.285*	-0.00358
	(0.154)	(0.0637)
FDI*corruption(t-1)	0.014	0.00862
	(0.0286)	(0.0122)
Observations	173	173
R-squared	0.73	0.988
F-Statistics	5.8	4.59
Number of countries	27	27

*** p<0.01, ** p<0.05, * p<0.1
Robust standard errors in parentheses

Table 4..3: Estimation Results

VARIABLES	(1) ln_co2	(2) ln_co2
Log of FDI	-0.163***	-0.170***
	(0.0591)	(0.0607)
FDI*corruption	0.565***	0.554***
	(0.151)	(0.153)
corruption	-12.74***	-12.54***
	(3.376)	(3.434)
EPI_{t-1}	0.00232	-0.000618
	(0.00542)	(0.00691)
Manufacturing percent*Population Density	0.000228***	0.000244***
	(6.77e-05)	(7.55e-05)
Log of GNP	2.891***	2.845***
	(0.659)	(0.650)
Square of log GNP	-0.144***	-0.142***
	(0.0350)	(0.0335)
Log of Environmental aid	-0.00738	-0.00717
	(0.00663)	(0.00627)
Manufacturing percent of GDP	-0.0258**	-0.0288**
	(0.0123)	(0.0142)
Population density	-0.00579**	-0.00622**
	(0.00252)	(0.00271)
Observations	173	173
R-squared	0.620	0.647
Number of countries	27	27

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4..4: Nitrous Oxide and GHG Emissions by Sector

VARIABLES	Log Nitrous oxide	Log Industrial (GHG)	Log Waste (GHG)	Log Energy (GHG)
Log FDI	0.0504	0.150	-0.0362	-0.175***
	(0.0379)	(0.121)	(0.0255)	(0.0543)
FDI*corruption	-0.166*	-0.0501	-0.0400	0.542***
	(0.0910)	(0.354)	(0.0743)	(0.117)
Corruption	3.590*	1.078	0.870	-12.27***
	(2.042)	(7.892)	(1.657)	(2.631)
$EPI_{(t-1)}$	-0.00534	-0.00293	-0.00138	0.000264
	(0.00390)	(0.0133)	(0.00368)	(0.00601)
Manufacturing percent*Population Density	-6.30e-05*	-6.88e-05	-4.74e-05	0.000209***
	(3.45e-05)	(0.000119)	(3.00e-05)	(5.88e-05)
Log GNP	0.792	3.901***	0.305	2.414***
	(0.528)	(1.238)	(0.350)	(0.574)
Square log GNP	-0.0417	-0.219***	-0.00732	-0.117***
	(0.0286)	(0.0713)	(0.0192)	(0.0300)
Log Environmental aid	0.00485	-0.00134	0.00209	-0.00958*
	(0.00303)	(0.0193)	(0.00265)	(0.00570)
Manufacturing percent of GDP	0.000996	0.00150	0.00314	-0.0260**
	(0.00569)	(0.0179)	(0.00510)	(0.0116)
Population density	0.00225	-0.00489	0.00238*	-0.00409*
	(0.00148)	(0.00498)	(0.00126)	(0.00245)
Observations	173	173	173	166
R-squared	0.424	0.301	0.519	0.680
Number of Countries	27	27	27	26

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4..5: Employment and Capital Elasticities

country	Average of elasticity of employment	Average of elasticity of capital
Argentina	0.159576	0.393595
Armenia	-0.0711	-0.1926
Bangladesh	-0.04068	-0.25337
Botswana	0.371389	0.214422
Brazil	0.040153	0.022029
Bulgaria	0.029955	0.158737
Chile	0.133096	-0.01139
China	0.563188	7.05001
Colombia	0.039746	0.149358
Costa Rica	0.17863	0.330358
Dominican Republic	0.099521	0.225808
Ecuador	-0.33738	-0.38598
Honduras	0.216667	0.392858
India	0.041056	0.196033
Indonesia	0.021498	0.114091
Malaysia	0.002844	-0.07503
Mexico	-0.28719	-3.90961
Mongolia	0.068461	0.139398
Pakistan	-0.16259	-0.26632
Paraguay	0.009247	0.010719
Philippines	0.092171	0.101793
Romania	-0.04876	0.263318
Russia	0.309334	2.051797
Thailand	0.079401	0.178437
Turkey	-0.02747	0.406852
Ukraine	0.016038	0.048066
Uruguay	-0.0314	-0.04085

CHAPTER 5

SUMMARY AND CONCLUSIONS

This dissertation focuses on issues pertaining to corruption, environmental degradation (emissions) and economic development as well as trade in merchandise and services. First, it studied how society may approach corruption at different facets of economic development. Using a neoclassical growth model in which individuals allocate their income to consumption, investment, and corruption reduction activities, the dissertation showed that corruption and income or economic development have an inverted u-shaped relationship. This suggests that at lower levels of income corruption tends to be increasing in income but the reverse holds at higher income levels. This is due to the fact that, at lower levels putting bread on the table takes priority over fighting corruption.

An empirical analysis on the proposed inverted u-shaped relationship between corruption and income was conducted. It employed a panel dataset on 75 countries for the periods 2001 to 2008 and a two-way fixed effects model. The estimation results lent support to the existence of an inverted u-shape relationship between corruption and income. Also confirmed by the results, is the view that corruption and war are directly related. The results indicate that incidences of war would increase the corruption index by 8.3 points. Trade openness is also found to be significant in determining corruption levels in a country. The results also point to the fact that trade openness leads to a reduction in a country's corruption.

Literature suggests that government expenditure may induce corrupt acts in a country. Contrarily, the results indicate that this may not necessarily be the case. The results reveal that corruption levels reduce with increased government spending. The results also indicate that socio-economic conditions and natural resource rents are significant factors in determining a country's level of corruption.

Additionally, this dissertation explores linkages between merchandise and service trade. It makes the argument that merchandise and service trade are simultaneously determined.

The theoretical framework employs a general equilibrium model in developing this proposition. In this model, countries are endowed with fixed amount of a specific service input and produce a traded commodity using these services.

The empirical investigation of this proposed simultaneity uses panel data on 24 OECD countries and their trading partners covering the periods 2000 to 2006. It uses a fixed effects estimation method and a Heckman selection model to account for zero-trade flows. The empirical investigation validates the proposed relationship between merchandise and service trade. The results also indicate that both merchandise and service trade are significant in determining each other. Distance, the population and income of the trading parties are confirmed to be significant in determining trade flows between countries. The results also show that having a common colonizer post 1945, is more likely to promote trade in merchandise that for services trade.

Lastly, the dissertation explored the impact of environmental aid on emissions in developing countries. It made use of two well known concepts; the pollution haven hypothesis and the environment Kuznets curve in studying empirically, the effects of foreign direct investment and income on emissions in developing countries. I was also interested in ascertaining whether developing countries benefited from trading with the more developed nations by way of a reduction in emissions through the diffusion of cleaner technologies. The dissertation considered emissions from the industrial, waste, and energy sectors.

The analysis was conducted on carbon dioxide, nitrous oxide and total Green House Gas emissions for 27 developing countries. The results confirm the existence of an EKC for carbon dioxide but reveal that an EKC may not exist for nitrous oxide. The results also hint at a positive impact of a technique effect on emissions in developing countries evidenced by the fact that emissions decline as manufacturing increases. This may also imply that firms may be employing cleaner technologies to avoid exorbitant fines from environmental regulation agencies. Interestingly, environmental regulations do not influence emissions in developing countries. This may be as a result of weak enforcement and monitoring institutions in the developing countries. Environmental aid is significant in reducing emissions in the energy sector but not significant for all other pollutants. The EKC was found to exist for GHG emissions from the energy and industrial sectors.

CURRICULUM VITAE

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Education

Ph.D in Economics, Utah State University (2015)

BA in Economics and Statistics, University of Ghana (2010)

Interests

Risk analytics and management, econometrics, panel data analysis, quantitative and statistical analytics, and financial modeling, international trade and development.

Manuscripts and Working Papers

Neequaye, N. A. and R. Oladi. "Corruption and Growth" [**Submitted**]
Abstract: This paper explores how society makes decisions pertaining to corruption at different levels of economic development. It proves the possibility of an inverted u-shaped relationship between corruption and income. The results of the empirical analysis indicate that trade openness, government fiscal policies, and an improvement in socioeconomic conditions may be significant in reducing a country's level of corruption. It also shows that the occurrence of war in a country adversely affects the country's level of corruption.

Neequaye, N.A. and R. Oladi. "Environment, Growth, and FDI Revisited" [**Revise and Resubmit Requested by International Review of Economics and Finance**]
Abstract: This paper examines the effects of foreign direct investment inflows and environmental aid disbursements on environmental degradation using panel data for some selected developing countries. Using a fixed effects model, our estimates suggest the existence of an Environmental Kuznets Curve for carbon dioxide as well as total Green House Gas emissions from the energy and industrial sectors but there was no evidence of this phenomenon for nitrous oxide and total Green House Gas emissions from the waste sector. We also find a hint of a technique effect, and investigate it further by exploring the responsiveness of capital and labor to investment inflows in the respective developing countries.

Neequaye, N.A. Gilbert, J. and R. Oladi. "International Trade in Merchandise and Services"
Abstract: This paper studies merchandise and services trade both theoretically and empirically using the gravity approach. It uses a general equilibrium framework to show that merchandise and service trade may be simultaneously determined. Our empirical analysis indeed supports our proposition regarding the simultaneity of merchandise and service trade.

Professional Exams and Awards
Society of Actuaries Exams

- Probability (P/1)
- Financial Mathematics (FM/2)
- Financial Economics (MFE/3F)
- Construction and Evaluation of Actuarial Models (C)
- Life Contingency (MLC)
- Validation of Educational Experience -VEE (Statistics and Economics)

Awards

- Recipient CFA Institute Access Scholarship 2014
- Utah State University Research Assistantship
- Recipient of International Association of Black Actuaries Foundation Scholarship, August 2012.
- Recipient of Actuarial Diversity Scholarship, August 2011

Experience
Research Assistant (August 2010 - Present)
Utah State University

- Analyzed data as part of my research project to evaluate the importance of agriculture to the economy of Utah.
- Collected and cleaned data to evaluate the impact federal lands will have on the economy of Utah.
- Assisting in grading homework and exam scripts.

Actuarial Intern (December 2013 - January 2014)
Vanguard Life, Ghana

- Assisted in pricing a new funeral and Family welfare policy for the year 2014
- Audited policyholders' accounts and crosschecked these values with the firm's accountants.

Teaching Assistant (August 2010 - August 2011)
University of Ghana

- Taught introductory probability, Actuarial statistics, and Introductory Statistics.
- Recitation leader for the above stated courses
- Graded assignments and exams as well as providing feedback to students on their performance.
- Sorted and analyzed data for my academic advisor – the research was to determine the effects of ethnicity, place of origin, schools attended and other demographic factors on the final GPA of students.

Computer Skills

Microsoft Word, Excel, PowerPoint, SAS, SPSS, STATA, MATLAB, R

Positions and Extra Curriculum Activities

- Vice Chairperson – University Of Ghana Statistics Students Research Committee, Ghana.
- Student Member - International Association of Black Actuaries (IABA).
- Member of African Students Association - Utah State University.
- Secretary – Legon, Pentecostals' Union Choir

Languages

English - Native

French - I am able to read, write, and speak at an intermediate level

References

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